

Live working — Voltage detectors —

Part 5: Voltage detecting systems (VDS)

The European Standard EN 61243-5:2001 has the status of a British Standard

ICS 13.260

National foreword

This British Standard is the official English language version of EN 61243-5:2001. It was derived by CENELEC from IEC 61243-5:1997.

The CENELEC common modifications have been implemented at the appropriate places in the text and are indicated by common modification tags **Ⓒ** **Ⓓ**

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

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Summary of pages

This document comprises a front cover, an inside front cover, the EN title page, pages 2 to 64, an inside back cover and a back cover.

The BSI copyright date displayed in this document indicates when the document was last issued.

Amendments issued since publication

Amd. No.	Date	Comments

© BSI 07-2001

ISBN 0 580 38089 0

EUROPEAN STANDARD

EN 61243-5

NORME EUROPÉENNE

EUROPÄISCHE NORM

May 2001

ICS 22.260.99

English version

Live working - Voltage detectors
Part 5: Voltage detecting systems (VDS)
(IEC 61243-5:1997, modified)

Travaux sous tension -
DéTECTEURS de tension
Partie 5: Systèmes détecteurs de tension
(VDS)
(CEI 61243-5:1997, modifiée)

Arbeiten unter Spannung -
Spannungsprüfer
Teil 5: Spannungsprüfsysteme (VDS)
(IEC 61243-5:1997, modifiziert)

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

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Ref. No. EN 61243-5:2001 E



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Foreword

The text of the International Standard IEC 61243-5:1997, prepared by IEC TC 78, Live working, together with the common modifications prepared by the Technical Committee CENELEC TC 78, Equipment and tools for live working, was submitted to the formal vote and was approved by CENELEC as EN 61243-5 on 2000-11-01.

The following dates were fixed:

- latest date by which the EN has to be implemented
at national level by publication of an identical
national standard or by endorsement (dop) 2001-11-01
- latest date by which the national standards conflicting
with the EN have to be withdrawn (dow) 2003-11-01

Annexes designated "normative" are part of the body of the standard.

Annexes designated "informative" are given for information only.

In this standard, annexes A, B, C and ZB are normative and annexes D, E, F and ZA are informative.

Annexes ZA and ZB have been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 61243-5:1997 was approved by CENELEC as a European Standard with agreed common modifications.

CONTENTS

	Page
INTRODUCTION	5
Clause	
1 Scope.....	6
2 Normative references	6
3 Definitions	8
4 Requirements	10
4.1 General	10
4.2 Threshold values for indication	11
4.3 Indication and perceptibility.....	12
4.4 Climatic requirements	13
4.5 Coupling dielectric	13
4.6 Measuring circuit components	14
4.7 Connecting lead	15
4.8 Interface and test point.....	15
4.9 Indicator	17
4.10 Terminal leads of separable indicators.....	17
4.11 Markings	17
4.12 Instructions for use	19
5 Tests.....	19
5.1 General	19
5.2 Arrangement, assembly, markings and instructions for use	20
5.3 Dielectric strength of the coupling system or integrated VDS	20
5.4 Maximum current from the coupling electrode	21
5.5 Interface conditions for separable VDS	21
5.6 Voltage limiting device	21
5.7 Temperature dependence of coupling systems of separable VDS and of integrated VDS	22
5.8 Phase rotation of the coupling system.....	22
5.9 Insulation resistance of the coupling system under pollution.....	23
5.10 Connecting leads.....	24
5.11 Clear indication in integrated VDS.....	24
5.12 Vibration resistance of the indicator for separable and integrated VDS	25
5.13 Drop and impact resistance	25
5.14 Dielectric strength of separable indicators.....	25
5.15 Threshold voltage and input impedance of indicators	26
5.16 Climatic dependence of threshold voltage	27

Clause	Page
5.17 Response time of indicator	28
5.18 Non-response to d.c. voltage	28
5.19 Efficiency of testing element	28
5.20 Indication until power source is exhausted	29
5.21 Temperature dependence of the separable indicator	30
5.22 Clear perceptibility of visual indication	30
5.23 Clear perceptibility of audible indication	31
5.24 Clear indication of phase comparators	32
5.25 Phase rotation of universal phase comparator	33
5.26 Maintenance test of the coupling system of separable VDS	33
5.27 Maintenance test of voltage indicators of separable VDS	34
5.28 Maintenance test of integrated VDS	34

Tables

1 Characteristics of separable voltage detecting systems (VDS)	35
2 Dimensional characteristics of interface and test point	36

Figures

1 Voltage detecting system with portable indicator (separable VDS)	37
2 Voltage detecting system with integrated indicator (integrated VDS)	37
3 Voltage detecting system with portable indicator and adaptor Example for HR-LR	38
4 Symbol for capacitive interface	39
5 Example for markings of an interface in the HR-system	39
6 Examples for measuring the response time	40
7 Test set-up for perceptibility of visual indication	41
8 Test set-up for perceptibility of audible indication	42
9 Test set-up for clear indication and phase rotation of phase comparators	43

Annexes

A Sequence of tests	44
B Instructions for use of the VDS	48
C Dimensional characteristics of plug arrangements	51
D Sampling test	52
E Tightness test for separable connectors containing LRP coupling systems	53
F Voltage indicating systems	54
Ⓒ ZASpecial conditions for voltage indicators which can be connected to a 230 V a.c. socket-outlet	55
ZB Normative references to international publications with their corresponding European publications	56



INTRODUCTION

Capacitive voltage detecting systems have already been used for a long time, especially on hermetically enclosed gas insulated switchgear in the medium voltage range. At the beginning this technique was used only for information about the voltage. With this part of IEC 61243, it is the intention to have the same level of safety for detection of the absence or presence of voltage as with conventional voltage detectors.

LIVE WORKING – VOLTAGE DETECTORS –

Part 5 : Voltage detecting systems (VDS)

1 Scope

This part of IEC 61243 is applicable to voltage detecting systems that are single-pole and are capacitively-coupled to live parts. They are used to detect the presence or absence of operating voltage on a.c. electrical systems for voltages from 1 kV to 52 kV, and for frequencies from $16^{2/3}$ Hz to 60 Hz.

This standard is also applicable to phase comparators designed for voltage detecting systems.

EMC tests are not included as, at the present time, not enough information about minimum requirements is available.

NOTES

- 1 Except where specified otherwise, 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 voltages are used to determine the operating voltage.
- 2 Voltage detecting systems based on fundamentally different principles (for example optical systems, resistive coupling elements) are not covered in this standard but should meet the requirements of this standard where applicable.
- 3 For frequencies differing from 50 Hz, the values C_s and U_t according to table 1 are valid. The threshold values for I_t have to be changed accordingly.
- 4 If in an electrical installation it is verified that the installation is dead by other means than using a voltage detecting system, a different device which can be termed voltage indicating system may be used for service information about the voltage state with reduced requirements concerning tests for clear and reliable indication. If so, this should be clearly stated and made explicit by the manufacturer (see annex F for further details).

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 61243. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and parties to agreements based on this part of IEC 61243 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 60050(151): 1978, *International Electrotechnical Vocabulary (IEV) – Chapter 151: Electrical and magnetic devices*

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

IEC 60068-2-3: 1969, *Environmental testing – Part 2: Tests – Test Ca: Damp heat, steady state*

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

IEC 60068-2-11: 1981, *Environmental testing – Part 2: Tests – Test Ka: Salt mist*

IEC 60068-2-14: 1984, *Environmental testing – Part 2: Tests – Test N: Change of temperature*

IEC 60068-2-63: 1991, *Environmental testing – Part 2: Tests – Test Eg: Impact, spring hammer*

IEC 60096-0-1: 1990, *Radio-frequency cables – Part 0: Guide to the design of detail specifications – Section 1: Coaxial cables*

IEC 60225: 1966, *Octave, half-octave and third-octave band filters intended for the analysis of sounds and vibrations*

IEC 60227-3: 1993, *Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V – Part 3: Non-sheathed cables for fixed wiring*

IEC 60352-1: 1983, *Solderless connections – Part 1: Solderless wrapped connections – General requirements, test methods and practical guidance*

IEC 60352-2: 1990, *Solderless connections – Part 2: Solderless crimped connections – General requirements, test methods and practical guidance*

IEC 60352-5: 1995, *Solderless connections – Part 5: Solderless press-in connections – General requirements, test methods and practical guidance*

IEC 60384, *Fixed capacitors for use in electronic equipment*

IEC 60529: 1989, *Degrees of protection provided by enclosures (IP code)*

IEC 60536: 1976, *Classification of electrical and electronic equipment with regard to protection against electric shock*

IEC 60603-11: 1992, *Connectors for frequencies below 3 MHz for use with printed boards – Part 11: Detail specification for concentric connectors (dimensions for free connectors and fixed connectors)*

IEC 60651: 1979, *Sound level meters*

IEC 60694: 1980, *Common clauses for high-voltage switchgear and controlgear standards*

IEC 60760: 1989, *Flat, quick-connect terminations*

IEC 60999: 1990, *Connecting devices – Safety requirements for screw-type and screwless-type clamping units for electrical copper conductors*

IEC 61010-2-031: 1993, *Safety requirements for electrical equipment for measurement, control and laboratory use – Part 2-031: Particular requirements for hand-held probe assemblies for electrical measurement and test*

QC 001005: 1992, *Register of firms, products and services approved under the IECQ System, including ISO 9000*

ISO 3740: 1980, *Acoustics – Determination of sound power levels of noise sources – Guidelines for the use of basic standards and for the preparation of noise test codes*

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*

ISO 3745: 1977, *Acoustics – Determination of sound power levels of noise sources – Precision methods for anechoic and semi-anechoic rooms*

ISO 3746: 1995, *Acoustics – Determination of sound power levels of noise sources using sound pressure – Survey method using an enveloping measurement surface over a reflecting plane*

3 Definitions

For the purpose of this part of IEC 61243 the following definitions apply:

3.1 voltage detecting systems (VDS): Devices used to detect the presence or absence of operating voltage. Where the design permits any other electrical tests can be performed, for example phase comparison (see figures 1 and 2).

Voltage detecting systems are classified into:

- integrated systems which are fixed and form an integral part of the equipment in which they are installed;
- separable systems in which a portable indicator can be connected to a fixed coupling system by means of an interface.

3.2 coupling electrode: Part which establishes the capacitance to the live part via the coupling dielectric.

3.3 coupling dielectric: Insulation between the live part and the coupling electrode.

3.4 indicator: That part of the detecting system which detects the signal delivered by the coupling electrode and indicates the voltage state and/or phase balance. Indicators may be designed as voltage indicators, phase comparators or as a combination of both.

The voltage indicator is fixed in an integrated VDS and portable in a separable VDS.

3.5 testing element: Built-in or external device, by means of which the functioning of the indicator can be checked by the user.

3.6 coupling system: That part of the separable voltage detecting system which is permanently fixed in the installation and provides the electrical signal for the indicator.

3.7 coupling electrode connection: Connecting point for the connecting lead which comes from the equipment containing the coupling capacitance. This connection may be common with the interface.

3.8 interface: Connecting point between the coupling system and the indicator of a separable VDS. It consists of two poles, one with the signal and one earthed.

3.9 test point (TP): Connecting point of an integrated VDS. It consists of one pole with the signal. It can be used for various purposes, for example phase comparison.

3.10 connecting lead: Electrical connection between the coupling electrode and the interface or the integrated indicator.

3.11 terminal lead: Electrical connection between interface or test point and the signal-processing circuit of portable voltage indicator or phase comparator.

3.12 voltage limiting device: Protective device that limits the voltage at the connection of the coupling electrode if the coupling dielectric fails.

3.13 short-circuiting device: Device which connects the coupling system to earth when the indicator is removed from the interface.

3.14 measuring circuit components: Components which establish the electrical interface conditions for the indicator. It can be made by discrete components or by the capacitance to earth of other parts of the coupling system.

NOTE – The coupling electrode has a capacitance (stray capacitance) to earth that is to be taken into account when determining the measuring circuit components.

3.15 measuring voltage (U_m): Power-frequency voltage transmitted from the live part to the coupling electrode via the coupling dielectric, when the indicator is connected to the interface.

3.16 threshold voltage (U_t): Value of the measuring voltage corresponding to the change of state from the indication "voltage not present" to the indication "voltage present".

3.17 maximum measuring voltage (U_{mm}): Highest operating frequency voltage at the interface that may occur, when the indicator is connected to the interface, for a long time in case of maximum permissible operating voltage and under worst power supply conditions and selected threshold conditions:

$$U_{mm} = U_{tmax} \times 1,2 \times U_n / U_{et}$$

where

U_{tmax} is the maximum threshold voltage, characterizing the threshold level according to table 1;

U_n is the nominal voltage of the power supply system;

U_{et} is the phase-to-earth voltage when the voltage U_{tmax} has been reached in the individual pole.

3.18 input impedance (X_c): Defined for separable voltage indicators with periodically changing input impedance as its maximum value.

3.19 Types of separable VDS

In the case of separable VDS five different systems are defined (see table 1).

3.19.1 HR-system: Separable voltage detecting system which is defined by a maximum threshold voltage of 90 V and a corresponding current of 2,5 μ A at 50 Hz on the interface.

3.19.2 MR-system: Separable voltage detecting system which is defined by a maximum threshold voltage level of 30 V and a corresponding current of 2,5 μ A at 50 Hz on the interface.

3.19.3 **LR-system:** Separable voltage detecting system which is defined by a maximum threshold voltage of 5 V and a corresponding current of 2,5 μ A at 50 Hz on the interface.

3.19.4 **LRM-system:** Separable voltage detecting system defined by the same threshold level as the LR-system on the interface, but with different dimensional characteristics.

3.19.5 **LRP-system:** Separable voltage detecting system which is defined by a maximum threshold voltage of 5 V and a corresponding current of 1 μ A at 50 Hz on the interface.

3.20 **adapter:** Device which provides for compatibility between the mechanical and electrical features of different voltage detecting systems (see figure 3). It is designated by the letters of the two relevant systems, the first being the designation of coupling system, the latter the indicator. There may be adapters HR-MR, HR-LR, HR-LRM, HR-LRP, MR-LR, MR-LRM, MR-LRP, LR-LRM, LR-LRP, LRM-LR, LRM-LRP.

3.21 **phase comparator:** Apparatus which indicates the phase balance or unbalance between interfaces and/or test points.

3.22 **universal phase comparator (UPC):** Apparatus designed to provide comparison between coupling systems of separable VDS covered by this standard. The types of VDS for which the UPC is suitable shall be specified in the instructions for use.

3.23 **specific phase comparator (SPC):** Apparatus designed to provide comparison between identical coupling systems or identical integrated VDS which shall be clearly specified in the instructions for use.

NOTE – Indication of an SPC may be dependent on voltage difference.

IEV definitions

3.24 **type test:** Test on one or more devices made to a certain design to show that the design meets certain specifications. [IEV 151-04-15]

3.25 **routine test:** Test to which each individual device is subjected during or after manufacture to ascertain whether it complies with certain criteria. [IEV 151-04-16]

3.26 **sampling test:** Test on a number of devices taken at random from a batch. [IEV 151-04-17]

3.27 **acceptance test:** Contractual test to prove to the customer that the device meets certain conditions of its specification. [IEV 151-04-20]

3.28 **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 151-04-22]

4 Requirements

4.1 General

4.1.1 Separable VDS shall include at least a coupling system and an indicator.

4.1.2 The coupling system of a separable VDS shall include as a minimum: the coupling dielectric, coupling electrode and interface. In addition, it may also include the connecting lead, voltage limiting device, short-circuiting device and measuring circuit components. One coupling system shall have only one interface.

4.1.3 The indicator shall include an indicating element and electrical connections to the interface or to the connecting lead.

4.1.4 Integrated VDS shall include at least the coupling dielectric, the coupling electrode and a built-in voltage indicator with test point. In addition, it may also include a connecting lead, a voltage limiting device and measuring circuit components.

4.1.5 Electrical connections shall be provided by secure bolting, compression, soldering, welding or secured spring pressure. Bolts providing a current path shall engage in metal threads.

4.2 Threshold values for indication

4.2.1 The indication "voltage present" shall appear:

- in three-phase systems when the actual line-to-earth voltage is in the range of 45 % to 120 % of the nominal voltage, and shall not appear when the actual line-to-earth voltage is less than 10 % of the nominal voltage;
- in single pole earthed single-phase systems when the actual line-to-earth voltage is in the range of 78 % to 120 % of the nominal voltage, and shall not appear when the actual line-to-earth voltage is less than 17 % of the nominal voltage;
- in mid-point earthed single-phase systems when the actual line-to-earth voltage is in the range of 39 % to 60 % of the nominal voltage, and shall not appear when the actual line-to-earth voltage is less than 9 % of the nominal voltage.

4.2.2 In a separable VDS, a current of less than I_{tmin} shall flow through a load impedance of X_{cmax} when the actual line-to-earth voltage is 10 % of the nominal voltage. If the actual line-to-earth voltage is 45 % of the nominal voltage a current of at least I_{tmax} shall flow through a load impedance of X_{cmin} , see table 1.

4.2.3 Separable voltage indicators shall have threshold values according to table 1.

4.2.4 Phase comparators shall indicate "phase unbalance" if the phase shift between line-to-earth voltages is greater than $\pm 60^\circ$, and shall indicate "phase balance" if the phase shift is lower than $\pm 15^\circ$.

4.2.5 Phase comparators or combined devices for voltage indication and phase comparison used on separable VDS shall comply with the requirements of 4.2.4 in the range of interface voltage (from U_{tmax} to U_{mm}). For voltages less than U_{tmin} , no indication shall appear.

Phase comparators used on integrated VDS shall comply with the requirements of 4.2.4 for line-to-earth operating voltages in the range of $U_n / \sqrt{3} \pm 20 \%$.

4.2.6 A UPC shall indicate, according to 4.2.4, the phase balance or unbalance between the voltages to be compared without being unduly influenced by the differences between capacitances of the two coupling systems.

4.2.7 A UPC shall indicate, according to 4.2.4, the phase balance or unbalance between the voltages to be compared, independent of the amplitude of the single voltages within the voltage range in which indication should appear. The input impedance X_C of UPC shall correspond to the VDS the UPC is built for.

4.2.8 The clear indication of an SPC, according to 4.2.4, shall not be affected by the difference between measuring voltages which can result from:

- a difference of up to 5 % between operating voltages;
- tolerances of construction between identical coupling systems or identical integrated VDS.

4.3 *Indication and perceptibility*

4.3.1 Indicators shall clearly indicate the voltage state or phase balance.

4.3.2 The indication shall be in a visual or, in case of separable VDS, an audible form or both. In indicators having both visual and audible indication, the audible indication is permitted to have a reduced sound pressure level.

Two classes of indicators with visual indication are specified: one restricted to indoor use, the other for indoor and outdoor use.

4.3.3 With a visual indication, the repetition frequency shall be at least 1 Hz. With an intermittent audible indication, the pulse frequency shall be between 1 Hz and 3 Hz, and the ratio of pulse/pause shall be 4/1. These requirements shall be met for an actual line-to-earth voltage equal to or greater than 45 % of the nominal voltage or, for separable voltage indicators, for a measuring voltage equal to or greater than U_{tmax} . For an actual line-to-earth voltage lower than 10 % of the nominal voltage or, for separable voltage indicators, for a measuring voltage lower than U_{tmin} , the indication shall be "voltage not present" with no active signal allowed for indicators having no built-in power source.

4.3.4 Voltage indicators with built-in power source shall indicate both states "voltage present" and "voltage not present" by means of active signals. The two active signals shall not rely solely on light of different colours for perceptibility. Additional characteristics such as spatial separation of the light sources, distinctive form of the light signals, flashing light or audible signals with full sound pressure level shall be used.

4.3.5 Voltage indicators shall not respond to a d.c. voltage.

4.3.6 Indicators shall indicate the change of the state of voltage or the phase relation within 1 s.

4.3.7 Phase comparators shall indicate the state "phase unbalance" by means of an active signal.

4.3.8 Phase comparators with built-in power source shall indicate both states "phase balance" and "phase unbalance" by means of active signals. The two active signals shall not rely solely on light on different colours for perceptibility. Additional characteristics such as spatial separation of the light sources, distinctive form of the light signals, flashing light or audible signals with full sound pressure level shall be used.

4.3.9 For phase comparators providing only one active signal, a voltage less than U_{tmin} on one side shall lead to the indication "phase unbalance". For phase comparators providing two or more active signals, absence of voltage on one side shall result in either no indication or a specific active signal.

4.3.10 The indication shall be clearly perceptible to the user when in the recommended operating position and under practical lighting and noise conditions.

4.3.11 Indicators with built-in power source shall give a clear indication until the source is exhausted, unless their usage is limited by an indication of non-readiness or automatic shut-off.

4.4 Climatic requirements

4.4.1 Indicators shall be resistant to anticipated changes in temperature.

4.4.2 Separable indicators shall operate correctly within a temperature range of -25°C to $+55^{\circ}\text{C}$.

Integrated VDS shall operate correctly within limits of temperature class corresponding to service conditions defined for the equipment in which they are installed.

4.4.3 The threshold voltages in accordance with 4.2.1 shall be maintained throughout the specified temperature range according to 4.4.2.

4.4.4 The threshold voltage limits according 4.2.1 shall be maintained during operating life under service conditions defined for equipment in which the integrated VDS is installed.

4.4.5 Insulation resistance of the coupling system of a separable VDS

The insulation resistance of parts with measuring voltage to earth shall be at least:

- 360 M Ω in the HR-system;
- 120 M Ω in the MR-system;
- 50 M Ω in the LRP-system;
- 20 M Ω in the LR- and LRM-systems.

This insulation resistance shall be maintained during operating life under service conditions defined for equipment in which the coupling system is installed.

4.5 Coupling dielectric

4.5.1 Equipment comprising coupling electrodes shall be constructed in accordance with their relevant standards. With subsequently installed coupling electrodes, a type test as well as an additional routine test of the combination of equipment and coupling electrode shall be performed.

4.5.2 To provide protection for operators against the presence of operating voltage on the interface or the test point, it shall be ensured that any insulation failure of the coupling dielectric will necessarily cause a permanent earth fault.

This shall be achieved by connecting the coupling electrode to earth via a voltage limiting device.

The voltage limiting device can be a specific component (for example gas discharger) or be one of the components permanently connected to the coupling electrode (for example measuring circuit component, short-circuiting device, etc.).

For the LRP-system, additional safety measures may be necessary.

4.5.3 For systems with insulated or resonant earthed neutral, earth fault currents are limited to low values and equipment can be maintained in operation for a long period of time under these conditions; in such cases additional precautions must be taken to ensure that:

- either earth fault condition can easily be observed by operators (for example separable connectors);
- or no dangerous voltage can occur on the interface or the test point for earth fault duration even during insertion of the indicator.

Otherwise, the use of manually removable short-circuiting plugs on the interface is not allowed on such a system.

4.5.4 The threshold voltage of the voltage limiting device shall comply with the following requirements:

- it shall be limited to a maximum 30 % of the nominal voltage of the power system;
- it shall be less than the lowest limiting value of the dielectric strength in the remaining coupling system;
- for coupling systems of separable VDS, it shall be limited to a maximum $18 \times U_{\text{tmax}}$.

4.5.5 The effects caused by the response of the voltage limiting device shall be taken into account when determining the protection concept of the installation.

4.5.6 The current during a short circuit between coupling electrode and earth with nominal frequency and rated voltage between conductor and earth shall not exceed 1 mA. In the case of coupling systems designed for several rated voltages, the highest rated voltage shall be used as a base. If the degree of protection of the interface or the test point is lower than IP2X according to IEC 60529, the current value shall be limited to 0,5 mA instead of 1 mA.

4.6 *Measuring circuit components*

4.6.1 If discrete parts are used for the measuring circuit components, these shall be passive.

4.6.2 The parts for the measuring circuit components shall maintain their technical data, even after a long period of operation. Components shall be chosen in the Qualified Products Lists of IECQ guide QC 001005. In the case of capacitors, a system of quality assessment in accordance with the IEC 60384 series, test class 40/85/56 is sufficient. Components shall be suitable at least for the same service conditions defined for the equipment in which the coupling system is installed.

4.6.3 The phase relation between the voltage of the live part and the voltage at interface shall not be changed by the coupling system of separable VDS by more than $\pm 5^\circ$.

4.7 Connecting lead

4.7.1 The connecting lead shall be of adequate mechanical strength, and shall withstand all expected electrical and thermal loads. The connecting lead of separable VDS shall be rated for at least the maximum possible measuring voltage, that is 12 times the interface voltage U_{tmax} .

4.7.2 Design of the connection

The connections of the connecting lead shall be reliable and durable. They shall be secured against unintentional separation. Examples of connections complying with those requirements are:

- wire wrap connections IEC 60352-1
- crimp connections IEC 60352-2
- press-in connections IEC 60352-5
- clamping points of bolted clamps IEC 60999
- flat quick-connect terminations IEC 60760
- boltless clamping points IEC 60999

Soldered connections for stranded conductors are not permitted.

4.7.3 The screen of screened connecting leads shall be earthed.

4.7.4 The connecting lead shall be protected against mechanical damage.

4.7.5 Transitions onto moving parts, such as doors, require additional protection against chafing or crushing. An unscreened connecting lead shall be fixed so that its position and its capacitance to earth or other lines cannot change noticeably.

4.7.6 If possible, a connecting lead shall be installed without it being cut. If connecting leads are to be guided through clamps, the clamps shall comply with IEC 60999.

4.7.7 A connecting lead to equipment which is separable from the installation may be provided with means for connection/disconnection. The connecting points shall be clearly marked.

4.7.8 The connecting leads of detecting system shall be constructed and installed so that the measuring voltages are not unduly influenced by one another or by other lines.

NOTE – When using coaxial lines, the screening against dielectric influences is generally ensured.

4.8 Interface and test point

4.8.1 Means for an effective electrical contact between the connecting lead and the terminal lead shall be provided at the interface. The points of contact shall be protected against corrosion. The interface shall consist of plug sockets according to table 2, and be arranged in accordance with that table.

4.8.2 The test point shall provide correct electrical contact. The points of contact shall be protected against corrosion. The test point shall consist of a single socket according to table 2, and be arranged in accordance with that table.

NOTE – For integrated VDS, at least one readily accessible earthing terminal should be provided at the front of the installation for connection of an earthing wire of any phase comparator, if required.

4.8.3 If the signal to the test point has been rectified, the positive going half-wave shall be supplied to the test point.

4.9 Indicator

4.9.1 Indicators shall be designed to give indication of an a.c. voltage with a nominal frequency of $16^{2/3}$ Hz, 50 Hz or 60 Hz, or of a.c. voltages with a nominal frequency range from 50 Hz to 60 Hz.

4.9.2 Indicators shall be of adequate dielectric strength.

4.9.3 The insulation resistance of the casing between the poles of the indicator shall be suitable for the purpose and shall not affect the indication.

4.9.4 Indicators shall comply with protection class IP2X according to IEC 60529. Indication shall not be affected by dust and/or moisture.

4.9.5 Indicators shall resist mechanical shocks. Separable indicators shall also resist mechanical falls.

4.9.6 Indicators shall be vibration resistant.

4.9.7 Indicators for the HR-system which can be connected to 230 V a.c. socket-outlet shall comply with protection class II according to IEC 60536.

[C] NOTE The use of such indicators is restricted by special patent rights (see annex ZA). **[C]**

4.9.8 Indicators shall not be able to be dismantled or shall have markings to show any signs of tampering, except for those parts intended to be replaced by the user, for example built-in power sources, indicator lamps.

4.9.9 The internal circuit of indicators without testing element shall be continuous, for example it shall not be interrupted by overload protective devices or switches.

4.9.10 Connections shall be made in such a manner that they cannot separate unintentionally, become detached, or change their position.

4.9.11 The connections of separable indicators shall ensure a correct electrical contact between terminal lead and interface. The contact points shall be protected against corrosion.

4.9.12 Voltage indicators of the HR- and MR-systems shall not have any flexible terminal leads. Voltage indicators for the HR-system shall be equipped with plugs providing protection against electric shock according to figure C.1.

4.9.13 Voltage indicators with built-in power source shall be equipped with a testing element. During the function test, the testing element shall be capable of testing all the components influencing the indication, including terminal leads with regard to their correct functioning, and shall clearly indicate their readiness for use, including that of the built-in power source. When all circuits cannot be tested, any limitation shall be clearly stated in the instructions for use, and these circuits shall be constructed in a manner so as to provide high reliability.

4.9.14 For voltage indicators without a built-in power source, an adequate testing device or a procedure for a functioning test (at least checking the indication) shall be provided by the manufacturer.

[C] NOTE See also annex ZA. **[C]**

4.10 *Terminal leads of separable indicators*

4.10.1 The terminal leads of voltage indicators of the LR- and LRM-systems, if any, shall be coaxial type cables.

4.10.2 The terminal lead shall be designed and guided so as to resist the forces occurring when used as intended.

4.10.3 The terminal lead shall be flexible and its end shall be protected against buckling.

4.10.4 Terminal leads of phase comparators shall have a total length of at least 2 m and shall be provided with suitable plugs for connection to the interfaces or test points.

4.11 *Markings*

4.11.1 Markings shall be legible and permanent. They may be printed, engraved or moulded.

4.11.2 *Markings on separable indicators*

Each separable indicator shall have at least the following markings with characters at least 2 mm high:

- IEC 61243-5;
- sign of detecting system (HR, etc.);
- type of indicator, unless only voltage indicator;
- manufacturer or trademark;
- year of production;
- nominal frequency or nominal frequency range, if other than 50 Hz;
- type or serial number;
- for HR-system indicators: symbol of insulation protection class II, if applicable;
- last maintenance test: (year).

4.11.3 *Markings on interface*

At least the following markings shall be assigned to interfaces of separable VDS in a perceptible manner, with characters at least 3 mm high:

- symbol for capacitive interface in accordance with this standard (see figure 4);
- sign of detecting system: (HR, etc.);
- last maintenance test: (year);
- on each interface: phase designation (L1, L2, L3 and for HR-, MR- and LRM-systems additionally: earthing symbol) (see figure 5).

For LRP coupling systems the markings, except the symbol for capacitive interface, may be attached to the equipment to which the separable connectors are connected.

4.11.4 *Markings on indicators of integrated VDS*

At least the following markings shall be assigned to the test point and indicating element in a perceptible manner with characters at least 3 mm high:

- IEC 61243-5;
- phase designation (L1, L2, L3).

4.12 *Instructions for use*

4.12.1 *Instructions for use of separable indicators*

Separable indicators shall be accompanied by the manufacturer's instructions for use. They shall include as a minimum: instructions regarding inspection, maintenance, storage, transport, assembly, voltage range for clear indication, function test and use (see annex B).

4.12.2 *Instructions for use of coupling systems and integrated VDS*

Coupling systems and integrated VDS shall be accompanied by the manufacturer's instructions for use (see annex B). These instructions may be included in the instructions for use of the equipment in which they are installed.

5 Tests

5.1 *General*

5.1.1 The tests for coupling systems are given in table A.1, those for separable voltage indicators in table A.2, those for integrated VDS in table A.3 and those for phase comparators in table A.4. The tests shall be carried out in the sequence given in these tables. All tests shall be carried out on the same coupling systems, indicators, or integrated VDS.

Where the following test requirements do not allow tests on individual parts, the respective tests shall be performed on complete devices.

Single-phase tests are normally sufficient. Three-phase tests are prescribed where needed.

5.1.2 Type tests shall be performed on three test pieces and/or three complete devices. If a test piece does not pass one of the type tests, the entire type test programme shall be repeated on three more pieces. If a piece again does not pass one type test, the equipment has failed the test.

5.1.3 Sampling tests shall be performed with test pieces, and according to annex D.

5.1.4 Voltage tests shall, if not otherwise specified below, be performed with a.c. voltages at a frequency of 50 Hz.

5.1.5 In all tests affecting clear indication, the r.m.s. value of the harmonics of the test voltage shall not exceed 3 % of the fundamental frequency.

5.1.6 Unless otherwise specified in the individual test subclauses, the electrical tests shall be performed under the following standard atmospheric conditions:

- ambient temperature: 15 °C to 35 °C;
- relative humidity: 45 % to 75 %;
- atmospheric pressure: 86 kPa to 106 kPa.

For dielectric tests, atmospheric correction factors according to IEC 60060-1 shall be used when applicable.