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INTERNATIONAL STANDARD

NORME INTERNATIONALE

Electrical safety in low voltage distribution systems up to 1 000 V a.c. and 1 500 V d.c. – Equipment for testing, measuring or monitoring of protective measures – Part 9: Equipment for insulation fault location in IT systems

Sécurité électrique dans les réseaux de distribution basse tension au plus égale à 1 000 V c.a. et 1 500 V c.c. – Dispositifs de contrôle, de mesure ou de surveillance de mesures de protection – Partie 9: Dispositifs de localisation de défauts d'isolement pour réseaux IT

IEC 61557-9:2014-12(en-fr)

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ELECTRICAL SAFETY IN LOW VOLTAGE DISTRIBUTION SYSTEMS UP TO 1 000 V AC AND 1 500 V DC – EQUIPMENT FOR TESTING, MEASURING OR MONITORING OF PROTECTIVE MEASURES –

Part 9: Equipment for insulation fault location in IT systems

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International Standard IEC 61557-9 has been prepared by IEC technical committee 85: Measuring equipment for electrical and electromagnetic quantities.

This third edition cancels and replaces the second edition published in 2009. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) the scope, normative references, terms and definitions have been complemented;
b) abbreviations are listed and explained;
c) requirements, marking and operating instructions have been revised;
d) mandatory and optional functions have been defined and their terminology has been adapted to IEC 61557-15;

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e) mechanical requirements have been added;

f) Clause 6 “Tests” has been revised;

g) new Tables have been added.

The text of this standard is based on the following documents:

FDIS	Report on voting
85/486/FDIS	85/503/RVD

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

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

This part of IEC 61557 shall be used in conjunction with Part 1.

A list of all parts in the IEC 61557 series, published under the general title *Electrical safety in low voltage distribution systems up to 1 000 V a.c. and 1 500 V d.c. – Equipment for testing, measuring or monitoring of protective measures,* can be found on the IEC website.

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

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The contents of the corrigenda 1 (May 2016) and 2 (January 2017) have been included in this copy.

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ELECTRICAL SAFETY IN LOW VOLTAGE DISTRIBUTION SYSTEMS UP TO 1 000 V AC AND 1 500 V DC – EQUIPMENT FOR TESTING, MEASURING OR MONITORING OF PROTECTIVE MEASURES –

Part 9: Equipment for insulation fault location in IT systems

1 Scope

This part of IEC 61557 specifies the requirements for the insulation fault location system (IFLS) which localizes insulation faults in any part of the system in unearthed IT a.c. systems and unearthed IT a.c. systems with galvanically connected d.c. circuits having nominal voltages up to 1 000 V a.c., as well as in unearthed IT d.c. systems with voltages up to 1 500 V d.c., independent of the measuring principle.

IT systems are described in IEC 60364-4-41 amongst other literature. Additional data for a selection of devices in other standards should be noted.

NOTE Further information on insulation fault location can be found in the following standards: IEC 60364-4-41:2005, 411.6, and IEC 60364-5-53:2001, 531.3.

2 Normative references

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

IEC 60068-2-1, *Environmental testing – Part 2-1: Tests – Test A: Cold*

IEC 60068-2-2, *Environmental testing – Part 2-2: Tests – Test B: Dry heat*

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

IEC 60068-2-27, *Environmental testing – Part 2-27: Tests – Test Ea and guidance: Shock*

IEC 60364-7-710:2002, *Electrical installations of buildings – Part 7-710: Requirements for special installations or locations – Medical locations*

IEC 60529, *Degree of protection provided by enclosures (IP Code)*

IEC 60664 (all parts): *Insulation coordination for equipment within low-voltage systems*

IEC 60721-3-1, *Classification of environmental conditions – Part 3: Classification of groups of environmental parameters and their severities – Section 1: Storage*

IEC 60721-3-2, *Classification of environmental conditions – Part 3: Classification of groups of environmental parameters and their severities – Section 2: Transportation*

IEC 60721-3-3, *Classification of environmental conditions – Part 3-3: Classification of groups of environmental parameters and their severities – Stationary use at weatherprotected locations*

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IEC 61010-1:2010, *Safety requirements for electrical equipment for measurement, control, and laboratory use – Part 1: General requirements*

IEC 61010-2-030, *Safety requirements for electrical equipment for measurement, control, and laboratory use – Part 2-030: Particular requirements for testing and measuring circuits*

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

IEC 61010-2-032, *Safety requirements for electrical equipment for measurement, control, and laboratory use – Part 2-032: Particular requirements for hand-held and hand-manipulated current sensors for electrical test and measurement*

IEC 61326-2-2, *Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 2-2: Particular requirements – Test configurations, operational conditions and performance criteria for portable test, measuring and monitoring equipment used in low-voltage distribution systems*

IEC 61326-2-4, *Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 2-4: Particular requirements – Test configurations, operational conditions and performance criteria for insulation monitoring devices according to IEC 61557-8 and for equipment for insulation fault location according to IEC 61557-9*

IEC 61557-1:2007, *Electrical safety in low voltage distribution systems up to 1 000 V a.c. and 1 500 V d.c. – Equipment for testing, measuring or monitoring of protective measures – Part 1: General requirements*

IEC 61557-8, *Electrical safety in low voltage distribution systems up to 1 000 V a.c. and 1 500 V d.c. – Equipment for testing, measuring or monitoring of protective measures – Part 8: Insulation monitoring devices for IT systems*

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

3 Terms, definitions and abbreviations

3.1 Terms, definitions, symbols and units

For the purposes of this document, the terms and definitions given in IEC 61557-1 and IEC 61557-8 and the following apply.

3.1.1
insulation fault location system
IFLS
device or combination of devices used for insulation fault location in IT systems, where the insulation fault location system is used in addition to an insulation monitoring device and is used to locate insulation faults

Note 1 to entry: An IFLS injects a locating current between the electrical system and earth.

3.1.2
locating current
I_L
r.m.s. value of the current that is injected by the locating current injector during the location process. The locating current can be generated by

– an independent locating voltage source, or

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– an independent locating current source, or
– it can be driven directly from the system to be monitored

3.1.3
locating voltage
U_L
r.m.s. value of the voltage present at the measuring terminals of the locating current injector during the measurement when the device has an independent locating voltage or current source

Note 1 to entry: In a fault-free, de-energized system, this represents the voltage present between the terminals of the locating device to the system to be monitored and the terminals for the connection to the PE conductor.

3.1.4
response sensitivity
value of the evaluating current or insulation resistance at which the evaluator responds under specified conditions

Note 1 to entry: Response sensitivity can either be a fixed threshold or a response curve.

3.1.5
insulation fault locator
device or part of a device for the location of the insulation fault

3.1.6
locating current sensor
sensor for the detection of the locating current used for the location of the insulation fault

3.1.7
locating current injector
device or part of a device, which function it is to inject the locating current in the IT system in order to locate the insulation fault

3.1.8
passive locating current injector
locating current injector that generates the locating current directly from the system to be monitored

3.1.9
active locating current injector
locating current injector that generates the locating current from a locating voltage source which is independent from the system to be monitored

3.1.10
equipment for insulation fault location in medical locations
specific insulation fault location equipment dedicated to locating insulations faults in IT systems of group 2 medical locations complying with Annex A

3.1.11
response time
t_{al}
time required by insulation fault location equipment to respond under the conditions of A.2.2.4

3.1.12
group 2 medical locations
medical locations, where applied parts are intended to be used in applications such as intracardiac procedures, operating theatres and vital treatment, where discontinuity (failure) of the supply can cause danger to life

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Note 1 to entry: An intracardiac procedure is a procedure, whereby an electrical conductor is placed within the cardiac zone of a patient or is likely to come into contact with the heart, such conductor being accessible outside the patient's body. In this context, an electrical conductor includes insulated wires, such as cardiac pacing electrodes or intracardiac ECG-electrodes, or insulated tubes filled with conducting fluids.

[SOURCE: IEC 60364-7-710:2002, 710.3.7]

3.1.13
portable equipment for insulation fault location
equipment used for temporary insulation fault location in IT systems instead of, or additionally, to fixed installed insulation fault location equipment

3.2 Abbreviations

For the purposes of this document, the terms and abbreviations given in Table 1 apply.

Table 1 – Abbreviations

Abbreviation	Term	Clause (in this part 9)	Other referenced standard
C_{Ld}	System leakage capacitance downstream of the evaluating current sensor	Figure C.2	
C_{Lu}	System leakage capacitance upstream of the evaluating current sensor	Figure C.2	
EMC	Electromagnetic Compatibility	4.5	IEC 60050-161:1990, 161-01-07
FE	Functional Earth	4.6.3	IEC 61010-1
IFL	Insulation Fault Locator	3.1.5, C.1	
IFLS	Insulation Fault Location System	3.1.1, Annex C	
I_L	Locating current	4.4.2, C.1	
IMD	Insulation Monitoring Device	Annex C	IEC 61557-8, 3.1.14
IP	Degree of protection of enclosure	4.8.3	IEC 60050-246:2008, 426-04-02
LCI	Locating Current Injector	3.1.7, C.2	
LCS	Locating Current Sensor	3.1.6, C.1	
LLW	Local Location Warning	4.2.2	
PE	Protective Earth	4.6.3	IEC 60050-195:1998, 195-02-09
PIFL	Portable Insulation Fault Locator	Annex C	
PLCS	Portable Locating Current Sensor	B.2.2.1	
R_F	Insulation resistance	6.2.2, C.2	IEC 61557-8, 3.1.2
RLW	Remote Location Warning	4.2.3	
T	Transformer in an IT system	Annex C	

4 Requirements

4.1 General requirements

In addition to the requirements of Clause 4 of IEC 61557-1:2007, the requirements of Clause 4 apply.

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Equipment for insulation fault location shall be capable of localizing symmetrical as well as asymmetrical insulation faults in an IT system and to give a location warning, if the insulation resistance in a part of the installation falls below the response sensitivity.

If equipment for insulation fault location has a self-test function, the self-test shall not produce an insulation fault to earth.

NOTE 1 See also IEC 61557-8.

NOTE 2 Insulation monitoring devices (IMDs) can be deactivated during the location process.

NOTE 3 Warning indication can be done by a lamp, a buzzer or by any other kind of indication.

NOTE 4 An IFLS can have a self-test function. Checking the response sensitivity is not necessary.

NOTE 5 An IFLS with an active locating current source can also be used for insulation fault location in de-energized systems.

4.2 Mandatory functions provided by an IFLS

4.2.1 Location warning

An IFLS shall contain a visual warning device, which indicates if an insulation fault is detected or allow connection to such a device for the indication of a fault. If externally connectable audible signalling devices are provided, they may be fitted with a resetting facility. In this case, after clearing a fault or resetting the device, the audible signal shall sound if a new fault occurs. The location warning shall be either a local location warning or a remote location warning or both together.

4.2.2 Local location warning (LLW)

This functions aims at issuing a warning signal when the insulation resistance between the system and earth falls below the response sensitivity.

This function will include the localization of an insulation fault in an IT system including symmetrical and asymmetrical insulation faults, an assessment of this fault and a local warning.

A local warning should be made by visual indicators or audible signals generated by the product implementing the function.

NOTE Usually this function is provided by the IFLS.

4.2.3 Remote location warning (RLW)

This functions aims at issuing a remote warning signal if the insulation resistance between the system and earth falls below the response sensitivity.

This function will include the localization of an insulation fault in an IT system including symmetrical and asymmetrical insulation faults, an assessment of this fault and a remote warning.

A relay contact output or an electronic switching output or a data communication can be used to report the warning remotely.

NOTE The warning output could also be used in some applications for switching.

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4.3 Optional functions provided by IFLS

4.3.1 Indication of the insulation value

When an IFLS includes means for the indication of the insulation value, the uncertainty of the indicated value shall be stated by the manufacturer.

4.3.2 Performance of the IFLS in case of the interruption of the connection to the locating current sensor (LCS)

If provided an indication if the connection to one or more LCSs is lost in a manner that the location function is not ensured shall be issued.

4.4 Performance requirements

4.4.1 Response sensitivity

An IFLS shall be designed in such a manner that the response sensitivity stated by the manufacturer will be met under the specified system conditions, at a total symmetrical system leakage capacitance of 1 μF upstream the evaluating current sensor (C_{Lu} = 1 μF, C_{Ld} = 0 μF according to Figure C.2).

Information on the influence of the system leakage capacitances higher than 1 μF on the response sensitivity as well as possible interference from the distribution system on the insulation fault location process shall be stated by the manufacturer.

NOTE The system leakage capacitance is the sum of the leakage capacitances of all phase conductors, including the neutral conductor to PE.

4.4.2 Locating current I_L

The maximum locating current I_L shall be limited to 500 mA r.m.s., to ensure that the locating current does not produce touch voltages above the conventional voltage limit (50 V a.c., 120 V d.c.) under the first fault in the distribution system. The locating current shall not increase above 500 mA r.m.s., under foreseeable component failures in the locating current injector (LCI). When the locating current is adjustable, unintentional changes of the setting shall be prevented by suitable means.

If an active locating voltage U_L above 50 V a.c. or 120 V d.c. is used the locating current shall not exceed 3,5 mA a.c. (r.m.s.) or 10 mA d.c. through a pure resistance of 2 kΩ.

If an active locating voltage U_L equal or below 50 V a.c. or 120 V d.c. is used, the locating current shall not exceed 500 mA r.m.s. through a shunt.

4.4.3 Locating voltage U_L

If an active locating voltage or locating current is used, the locating voltage U_L shall be equal or below 50 V a.c. or 120 V d.c. (see IEC 60364-4-41) under no load conditions.

4.5 Electromagnetic compatibility (EMC)

An IFLS shall comply with the EMC requirements in accordance with IEC 61326-2-4.

4.6 Safety requirements

4.6.1 General

In addition to the safety requirements of IEC 61010-1 and IEC 61010-2-030 the following safety requirements apply.

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4.6.2 Clearances and creepage distances

An IFLS shall have minimum clearances and creepage distances in accordance with IEC 61010-1 and IEC 61010-2-030.

Clearances and creepage distances for fixed installed equipment according to Table 3 can be dimensioned in accordance with IEC 60664 series.

Clearances and creepage distances shall be selected for:

– overvoltage or measuring category III or II, depending on the overvoltage or measuring category in the system to be monitored;
– pollution degree 2.

NOTE Pollution degree 3 can be used for accessible parts on the outside of the housing.

A division into circuits with different nominal insulation voltages is permissible in device combinations for example for IT systems with nominal voltages U_n higher than 1 000 V a.c. and 1 500 V d.c., when the electrical connection is made via resistive, capacitive or inductive voltage dividers and if, in the case of a fault, the occurrence of inadmissibly high touch voltages or inadmissibly high currents to earth are prevented by circuit design features. Such circuit design features (see IEC 61140) can be, for example, additionally provided in the form of reliable voltage dividers or a duplication of the resistors (protective impedance) in the voltage divider.

4.6.3 Protection class and earth connection of the IFLS

Contrary to IEC 61557-1, the PE connection of an IFLS (LCI) is a measuring connection and shall be treated as functional earth connection (FE). If the IFLS has accessible parts which are earthed for protective purposes, these connections shall be treated as protective earth connections (PE).

4.7 Climatic environmental conditions

The IFLS shall operate at least under the following climatic conditions:

– operation: class 3K5 according to IEC 60721-3-3, -5 °C to +45 °C, except condensation and formation of ice,
– transport: class 2K3 according to IEC 60721-3-2, -25 °C to +70 °C,
– storage: class 1K4 according to IEC 60721-3-1, -25 °C to +55 °C.

4.8 Mechanical requirements

4.8.1 General

Instead of the requirements of 4.10 of IEC 61557-1:2007 the requirements of 4.8.2 and 4.8.3 apply.

4.8.2 Product mechanical robustness

Requirements of Table 2 shall be tested as type-tests.

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Table 2 – Product mechanical requirements

Mechanical robustness, in operation test	Standard and level	Test parameters	Other information
Behaviour to vibrations	IEC 60068-2-6 Test Fc	2 Hz to 13,2 Hz- amplitude ± 1 mm 13,2 Hz to 100 Hz – acceleration ± 0,7 g. For severe vibration conditions such as e.g. diesel engines, air compressors etc.: 2,0 Hz to 25,0 Hz – amplitude ± 1.6 mm 25,0 Hz to 100 Hz – acceleration ± 4 g NOTE More severe conditions may exist for example on exhaust manifolds of diesel engines especially for medium and high speed engines Values may be required to be in these cases 40 Hz to 2 000 Hz – acceleration ± 10,0g at 600 °C, duration 90 min.	Duration in case of no resonance condition 9 min at 30 Hz. Duration at each resonance frequency at which Q ≥ 2 is recorded – 90 min. During the vibration test, functional tests are to be carried out. Tests to be carried out in three mutually perpendicular planes. As a guide, it is recommended that Q does not exceed 5. Where a sweep test is to be carried out instead of the discrete frequency test and a number of resonant frequencies are detected close to each other, duration of the test is to be 120 min. Sweep over a restricted frequency range between 0,8 times and 1.2 times the critical frequencies can be used where appropriate. NOTE Critical frequency is a frequency at which the equipment being tested can exhibit: – Malfunction and/or performance deterioration – Mechanical resonances and/or other response effects occur, e.g. chatter
Behaviour to shocks	IEC 60068-2-27 Test Ea	10 gn / 11 ms, 3 pulses	

4.8.3 IP protection class requirements

The manufacturer shall document equipment IP protection class according to IEC 60529. The minimum requirements are given in Table 3, which specifies minimum IP requirements for the different kinds of IFLS housings.

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Table 3 – Minimum IP requirements for IFLS

Kind of IFLS	Front panel	Housing, except front panel
Fixed installed IFLS panel mounted devices.	IP 40	IP 2X
Fixed installed IFLS modular devices snapped on DIN rails within distribution panel.	IP 40	IP 2X
Fixed installed IFLS housing devices snapped on DIN rails within distribution panel.	IP 2X	IP 2X
Portable IFLS	IP 40	IP 40

5 Marking and operating instructions

5.1 Marking

In addition to the marking in accordance with Clause 5 of IEC 61557-1:2007, the following information shall be provided on the IFLS, if applicable.

– type of device as well as mark of origin or name of the manufacturer,
– type of IT system to be monitored (if the IFLS is designed for a specific type of IT system),
– nominal system voltage U_n or range of the nominal voltage,
– nominal value of the rated supply voltage U_S or range of the rated supply voltage,
– nominal frequency of the rated supply voltage U_S and the nominal voltage U_n or working range of frequencies for the rated supply voltage or nominal voltage,
– the serial number, the year of manufacture or the type designation mandatory on the outside and, if necessary, on the inside.

All data of 5.1 shall be indelibly marked on the IFLS.

5.2 Operating instructions

The operating instructions shall state the following information in addition to the requirements given in 5.2 of IEC 61557-1:2007.

– maximum value of the locating voltage U_L in case when it is independent from the voltage in the system to be monitored;
– maximum value of the locating current I_L in cases where it is independent from the voltage in the system to be monitored;
– response sensitivity;
– technical data of the interface for the connection of an external warning device, including rated voltage and rated current, rated insulation voltage and explanation of the interface function;
– wiring diagram,
– information on the influence of system leakage capacitances, of the system voltage and of the type of distribution system on the response sensitivity;
– locating voltage according to 4.4.3 and conformity to the relevant EMC standards;
– functional description of the IFLS;
– an indication that the system to be monitored including any connected appliances might be influenced by the IFLS, for example influence on residual current devices (RCDs);
– an indication that IMDs may be influenced by the IFLS, if applicable;

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– if the IMD is deactivated during the fault indication, it shall be explained in the operating instructions;
– the maximum operating uncertainty for the response sensitivity under specified conditions;
– the maximum operating uncertainty for the indication of the insulation value, if applicable.

Information for contact circuits should be in accordance with IEC 61810-2 or IEC 60947-5-1 and IEC 60947-5-4.

6 Tests

6.1 General

The tests according to Clause 6 of IEC 61557-1:2007 and the tests detailed in 6.2 and 6.3 shall be performed.

6.2 Type tests

6.2.1 General

Operation within the following climatic environmental conditions shall be verified according to Table 4. The environmental conditions for storage tests (product not powered) are shown in Table 5.

Table 4 – Reference conditions for tests in operation

Climatic characteristics	Basic standard	Level / Class	Test specification
Exposed to the cold	IEC 60068-2-1	Ad	–5° C; 96 h;voltage tests
Exposed to dry heat	IEC 60068-2-2	Bd	+45° C; 96 h; voltage tests

Table 5 – Reference conditions for storage tests

Climatic characteristics	Basic standard	Level / Class	Test specification
Exposed to the cold	IEC 60068-2-1	Ab	–25° C; 96 h
Exposed to dry heat	IEC 60068-2-2	Bb	+70° C; 96 h

6.2.2 Test of response sensitivity of the IFLS

The response sensitivity shall be tested at the lowest and at the highest value of the nominal system voltage U_n and of the rated supply voltage U_S and under the conditions of 4.4.1.

For this test, the insulation resistance shall be simulated as follows:

– single pole resistor (from one phase of U_n);
– symmetrically (same resistor from all phases of U_n).

The measuring device used for testing shall be able to accommodate slow continuous or fine-step changes of the insulation resistance as well as a connection of system leakage capacitances according to 4.4.1. Capacitors with an insulation resistance of at least 100 MΩ and a tolerance limit of ± 10 % maximum shall be used for simulating system leakage capacitances.

During testing, the insulation faults are simulated by externally connected test resistors. The response sensitivity shall be determined at the lower and the upper value of the voltage of the

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system to be monitored by reducing the test resistances slowly. The response sensitivity shall be determined with symmetrical and single pole test resistances. If the measuring principle depends on the magnitude of the system leakage capacitance, the specified response sensitivity shall be tested by connecting capacitors step by step.

When the IFLS is provided with adjustable response sensitivity, the tests shall be performed at the lowest and at the highest value for a value which is adjustable continuously and for all values with fixed selectable response sensitivities.

The tests shall be performed under the climatic environmental conditions of 4.7.

The response sensitivity shall be compared with the values stated by the manufacturer.

6.2.3 Test of the locating current I_L

Compliance with the requirements in 4.4.2 shall be verified.

The locating current shall be measured in an IT system with no system leakage capacitance and with an insulation resistance >100 MΩ as follows:

- If the locating current is driven directly from the system to be monitored:
  - set the voltage of the IT system to the maximum nominal system voltage of the device;
  - connect an amperemeter or an appropriate device between one phase conductor and the PE conductor and measure the r.m.s value of the locating current, as specified in Figure 1. The measured value shall not be higher than the value stated by the manufacturer in the operating instructions and shall not be higher than 500 mA.
- If an independent locating voltage source is used with a locating voltage equal or below 50 V a.c or 120 V d.c.:
  - connect a shunt in series with an amperemeter or an appropriate device between the interconnected system terminals and the earth terminal and measure the r.m.s. current of the locating current, as specified in Figure 2. The measured value shall not be higher than the value stated by the manufacturer in the operating instructions and shall not be higher than 500 mA.
- If an independent locating voltage source is used with a locating voltage above 50 V a.c. or 120 V d.c.:
  - connect a resistor of 2 kΩ in series with an amperemeter or an appropriate device between the interconnected system terminals and the earth terminal and measure the a.c. r.m.s. or the d.c. current of the locating current, as specified in Figure 3. The measured value shall not be higher than 3,5 mA a.c. r.m.s. or 10 mA d.c.

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