BS EN 61557-8:2015

BSI Standards Publication

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

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National foreword

This British Standard is the UK implementation of EN 61557-8:2015. It is identical to IEC 61557-8:2014. It supersedes BS EN 61557-8:2007 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee PEL/85, Measuring equipment for electrical and electromagnetic quantities.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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Sécurité électrique dans les réseaux de distribution basse tension de 1 000 V c.a. et 1 500 V C:C - Dispositifs de contrôle, de mesure ou de surveillance de mesures de protection - Partie 8: Contrôleur permanent d'isolement pour réseaux IT (CEI 61557-8:2014)

Elektrische Sicherheit in Niederspannungsnetzen bis AC 1 000 V und DC 1 500 V - Geräte zum Prüfen, Messen oder Überwachen von Schutzmaßnahmen - Teil 8: Isolationsüberwachungsgeräte für IT-Systeme (IEC 61557-8:2014)

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Foreword

The text of document 85/485/FDIS, future edition 3 of IEC 61557-8, prepared by IEC/TC 85 "Measuring equipment for electrical and electromagnetic quantities" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 61557-8:2015.

The following dates are fixed:

• latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2015-10-15
• latest date by which the national standards conflicting with the document have to be withdrawn	(dow)	2018-01-15

This document supersedes EN 61557-8:2007.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC [and/or CEN] shall not be held responsible for identifying any or all such patent rights.

This standard covers the Principle Elements of the Safety Objectives for Electrical Equipment Designed for Use within Certain Voltage Limits (LVD).

Endorsement notice

The text of the International Standard IEC 61557-8:2014 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC 60364-4-41	NOTE	Harmonized as HD 60364-4-41.
IEC 60664-1	NOTE	Harmonized as EN 60664-1.
IEC 60664-3	NOTE	Harmonized as EN 60664-3.
IEC 61140	NOTE	Harmonized as EN 61140.
IEC 60027-7	NOTE	Harmonized as EN 60027-7.
IEC 61557-9	NOTE	Harmonized as EN 61557-9.
IEC 60364-7-712	NOTE	Harmonized as HD 60364-7-712.

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

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.

NOTE 1 When an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cenelec.eu.

Publication	Year	Title	EN/HD	Year
IEC 60068-2-1	-	Environmental testing -- Part 2-1: Tests - Test A: Cold	EN 60068-2-1	-
IEC 60068-2-2	-	Environmental testing -- Part 2-2: Tests - Test B: Dry heat	EN 60068-2-2	-
IEC 60068-2-6	-	Environmental testing -- Part 2-6: Tests - Test Fc: Vibration (sinusoidal)	EN 60068-2-6	-
IEC 60068-2-27	-	Environmental testing -- Part 2-27: Tests - Test Ea and guidance: Shock	EN 60068-2-27	-
IEC 60364-7-710 (mod)	2002	Electrical installations of buildings -- Part 7-710: Requirements for special installations or locations - Medical locations	HD 60364-7-710	2012
			+AC	2013
IEC 60691	-	Thermal-links - Requirements and application guid	-	-
IEC 60721-3-1	-	Classification of environmental conditions -- Part 3: Classification of groups of environmental parameters and their severities -- Section 1: Storage	EN 60721-3-1	-
IEC 60721-3-2	-	Classification of environmental conditions -- Part 3: Classification of groups of environmental parameters and their severities -- Section 2: Transportation	EN 60721-3-2	-
IEC 60721-3-3	-	Classification of environmental conditions -- Part 3: Classification of groups of environmental parameters and their severities -- Section 3: Stationary use at weatherprotected locations	EN 60721-3-3	-
IEC 60947-5-1	-	Low-voltage switchgear and controlgear -- Part 5-1: Control circuit devices and switching elements - Electromechanical control circuit devices	EN 60947-5-1	-
			+EN 60947-5-1:2004/corrigendum Jul. 2005	2005
			+EN 60947-5-1:2004/corrigendum Nov. 2004	2004
IEC 60947-5-4	-	Low-voltage switchgear and controlgear -- Part 5-4: Control circuit devices and switching elements - Method of assessing the performance of low-energy contacts - Special tests	EN 60947-5-4	-

IEC 61010-1	2010	Safety requirements for electrical equipment for measurement, control and laboratory use -- Part 1: General requirements	EN 61010-1	2010
IEC 61010-2-030:2010/corrigendum May 2011	-	Safety requirements for electrical equipment for measurement, control and laboratory use -- Part 2-030: Particular requirements for testing and measuring circuits	-	-
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 61557-8	EN 61326-2-4	-
IEC 61557-1	-	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	EN 61557-1	-
IEC 61810-2	-	Electromechanical elementary relays -- Part 2: Reliability	EN 61810-2	-
IEC 62109-2	2011	Safety of power converters for use in photovoltaic power systems -- Part 2: Particular requirements for inverters	EN 62109-2	2011
CISPR 11	-	Industrial, scientific and medical equipment - Radio-frequency disturbance characteristics - Limits and methods of measurement	EN 55011	-

CONTENTS

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 8: Insulation monitoring devices for IT systems

1 Scope

This part of IEC 61557 specifies the requirements for insulation monitoring devices (IMD) which permanently monitor the insulation resistance R_F to earth of unearthed a.c. IT systems, of a.c. IT systems with galvanically connected d.c. circuits having nominal voltages up to 1 000 V a.c., as well as of unearthed d.c. IT systems with voltages up to 1 500 V d.c. independent from the method of measuring.

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

NOTE Various standards specify the use of IMDs in IT systems. In such cases, the objective of the equipment is to signal a drop in insulation resistance R_F below a minimum limit.

IMDs according to this part of IEC 61557 can also be used for de-energized TT, TN and IT systems or appliances.

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 60691, *Thermal-links – Requirements and application guide*

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: Classification of groups of environmental parameters and their severities – Section 3: Stationary use at weatherprotected locations*

IEC 60947-5-1, *Low-voltage switchgear and controlgear – Part 5-1: Control circuit devices and switching elements – Electromechanical control circuit devices*

IEC 60947-5-4, *Low-voltage switchgear and controlgear – Part 5-4: Control circuit devices and switching elements – Method of assessing the performance of low-energy contacts – Special tests*

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 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, *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 61810-2, *Electromechanical elementary relays – Part 2: Reliability*

IEC 62109-2:2011, *Safety of power converters for use in photovoltaic power systems – Part 2: Particular requirements for inverters*

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

3 Terms, definitions and abbreviations

3.1 Terms and definitions

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

3.1.1
extraneous d.c. voltage
U_{fg}
d.c. voltage occurring in a.c. systems between the a.c. conductors and earth (derived from d.c. parts)

3.1.2
insulation resistance
R_F
resistance in the system being monitored, including the resistance of all the connected appliances to earth

3.1.3
response value
R_a
value of the insulation resistance at which the device responds under specified conditions

3.1.4
specified response value
R_{an}
value of the insulation resistance, permanently set or adjustable, on the device and monitored if the insulation resistance falls below this limit

Note 1 to entry: R_{an} is the value declared by the manufacturer.

3.1.5
relative uncertainty
relative percentage uncertainty
A
response value R_a minus the specified response value R_{an}, divided by the specified response value R_{an}, multiplied by 100 and stated as a percentage

$$A = \frac{R_a - R_{an}}{R_{an}} \cdot 100[\%]$$

3.1.6
system leakage capacitance
C_e
maximum permissible value of the total capacitance to earth of the system to be monitored, including any connected appliances, up to which value the insulation monitoring device can work as specified and within a response time t_{an} not exceeding 30 min

3.1.7
rated contact voltage
voltage for which a relay contact is rated to open and close under specified conditions

3.1.8
response time
t_{an}
time required by an insulation monitoring device to respond under specified conditions

3.1.9
measuring voltage
U_m
voltage present at the measuring terminals during the measurement

Note 1 to entry: In addition to the definition in IEC 61557-1, the measuring voltage U_m is the voltage present in a fault-free and de-energized system between the terminals of the system to be monitored and the terminals of the protective conductor.

3.1.10
measuring current
I_m
maximum current that can flow between the system and earth, limited by the internal d.c. resistance R_i from the measuring voltage source of the insulation monitoring device

Note 1 to entry: Measuring current I_m is designated as injected current in IEC 60364-7-710.

3.1.11
internal impedance
Z_i
total impedance of the insulation monitoring device between the terminals to the system being monitored and earth, measured at the nominal frequency f_n

3.1.12
internal d.c. resistance
R_i
resistance of the insulation monitoring device between the terminals to the system being monitored and earth

3.1.13
functional earthing
FE
earthing a point or points in a system or in an installation or in equipment for purposes other than electrical safety

Note 1 to entry: For IMDs this is the measuring connection to earth.

3.1.14
insulation monitoring device
IMD
device which permanently monitors the insulation resistance to earth of unearthed a.c. IT systems, a.c. IT systems with galvanically connected d.c. circuits having nominal voltages up to 1 000 V a.c., as well as monitoring the insulation resistance of unearthed d.c. IT systems with voltages up to 1 500 V d.c., independent from the method of measuring

3.1.15
type AC IMD
device which permanently monitors the insulation resistance to earth of unearthed a.c. IT systems

Note 1 to entry: Extraneous d.c. voltages which could occur when an insulation fault behind galvanically connected rectifiers appears can influence the monitoring function in a way that the required uncertainty for the measurement increases beyond the requirements or in some cases the monitoring process is even not guaranteed.

3.1.16
type DC IMD
device which permanently monitors the insulation resistance to earth of unearthed d.c. IT systems

3.1.17
type AC/DC IMD
device which permanently monitors the insulation resistance to earth of unearthed a.c/d.c. IT systems, d.c/a.c. IT systems or d.c. IT systems

Note 1 to entry: The insulation monitoring function is active for insulation faults in all parts of the IT system which are galvanically connected.

3.1.18
insulation fault
defect in the insulation of an electrical installation or of an equipment which can create a resistive path to earth

Note 1 to entry: The insulation fault can appear as a single fault from one line conductor or as a symmetrical fault from all line conductors.

[SOURCE: IEC 60050-604:1987, 604-02-02, modified – Term definition has been adapted to suit electrical installations which can result in another fault type. Note added.]

3.1.19
symmetrical insulation fault
defect in the insulation of an electric installation or equipment creating a resistive path to earth having approximately the same resistance from all phase conductors to earth

3.1.20
asymmetrical insulation fault
defect in the insulation of an electric installation or equipment creating a resistive path to earth having different resistances from the phase conductors to earth

3.1.21
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

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, 710.3.7, modified – Note to entry has been added.]

3.1.22
medical insulation monitoring device
MED-IMD
specific insulation monitoring device (IMD) dedicated to monitor medical IT systems of a group 2 medical location

3.1.23
medical IT system
electrical IT system having specific requirements for medical applications

[SOURCE: IEC 60364-7-710:2002, 7.3.11]

3.1.24
overload current
overload current of an electrical circuit
overload current occurring in an electric circuit according to this standard is overload current which is caused by connected loads

[SOURCE: IEC 60050-826:2004, 826-11-15, modified – The definition is about overload current instead of overcurrent, which is not caused by a short-circuit or an earth fault.]

3.1.25
PV installation
erected equipment of a photovoltaic power (PV) supply system

3.1.26
PV electrical installation
the electrical installation of a PV system starts from a PV module or a set of PV modules connected in series with their own cables, up to a distribution network or to a customer installation

3.1.27
d.c. side
part of a PV installation from the PV modules to the d.c. terminals of the PV inverter

3.1.28
a.c. side
part of a PV installation from the a.c. terminals of the PV inverter to the point of connection of the PV supply cable to the electrical installation

3.1.29
PV inverter
device which converts d.c. voltage and d.c. current of the PV generator into a.c. voltage and a.c. current

3.1.30
system leakage capacitance of the PV installation
sum of the leakage capacitances C_e of the individual PV modules to earth including the leakage capacitances C_e of the complete PV installation

3.1.31
insulation monitoring device for photovoltaic systems
PV-IMD
insulation monitoring device suitable to monitor the insulation resistance of photovoltaic electrical installations to earth

3.1.32
insulation monitoring function of a PV inverter
PV-IMF
function integrated in the PV inverter to monitor the insulation resistance R_F of the PV input (array) to earth

3.2 Abbreviations

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

Table 1 – Abbreviations

Abbreviation	Term	Clause/Subclause	Referenced standard
EMC	Electromagnetic compatibility	4.5	IEC 60050-161:1990,161-01-07
IMD	Insulation monitoring device	3.1.14	IEC 61557-8
LIW	Local insulation warning	4.2.2.2	IEC 61557-8
LTMW	Local transformer monitoring warning	4.3.2	IEC 61557-8
MED-IMD	Medical insulation monitoring device	Annex A	IEC 61557-8
PTC	Positive temperature coefficient	Annex B	IEC 61557-8
PV-IMD	Photovoltaic IMD (IMD for photovoltaic systems)	Annex C	IEC 61557-8
PV-IMF	Photovoltaic insulation monitoring function	Annex D	IEC 61557-8
RIW	Remote insulation warning	4.2.2.3	IEC 61557-8
REDC	Remote enabling / disabling command	4.3.4	IEC 61557-8
RTMW	Remote transformer monitoring warning	4.3.3	IEC 61557-8

4 Requirements

4.1 General requirements

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

IMDs shall be capable of monitoring the insulation resistance R_F of IT systems including symmetrical and asymmetrical allocation of the insulation resistance R_F and to give an insulation warning if the insulation resistance R_F between either the system and earth or the

system and the PE-connection or the system and another reference point for equipotential bonding falls below the specified response value R_a, including the relative uncertainty of R_{an}.

So-called earth fault relays using a voltage asymmetry (voltage shift) in the presence of an earth fault as the only measurement criterion and, as a consequence, detecting only asymmetrical insulation faults, are not insulation monitoring devices according to this standard.

A combination of several measurement methods, including asymmetry monitoring, may become necessary for fulfilling the task of monitoring under special conditions on the IT system.

NOTE These requirements are independent from the method of measurement. The methods of measurement can use a measuring voltage or measuring current source which is independent from the system to be monitored or they can use a measuring voltage or measuring current which is driven directly from the voltage of the system to be monitored.

4.2 Types of IMDs

4.2.1 General

The measuring principle of IMDs shall have the ability to monitor the insulation resistance R_F of IT systems for which they are designated under the requirements set by this standard.

IMDs are divided into the following types:

– type AC IMD for pure a.c. IT systems,

– type AC /DC IMD for a.c. IT systems with directly connected rectifiers and for pure d.c. IT systems and for d.c. IT systems with directly connected a.c. inverters,

– type DC IMD only for pure d.c. IT systems,

NOTE Directly connected means that there is no isolation between the a.c. part and the d.c. part of the IT system (both a.c. and d.c. parts are galvanically connected).

4.2.2 Mandatory functions provided by IMDs

4.2.2.1 General

IMDs shall comprise a visual warning device with local insulation warning (LIW) and/or shall be provided with means for connecting such a device which indicates its operation with remote insulation warning (RIW). This device shall not be provided with means for being switched off. Built-in or externally connectable audible signalling devices may be fitted with a resetting facility. It shall be ensured that an insulation warning is sent off in the case of a newly occurring insulation fault, following an insulation fault that has been cleared and after the devices may have been reset. The insulation warning shall be either a local insulation warning (LIW) or a remote insulation warning (RIW) or both.

This function aims to issue a warning signal when the insulation resistance R_F between the system and earth falls below the response value R_a.

An indication of the value of the insulation resistance R_F by means of a measuring facility is, in itself, not sufficient as a facility for visual signalling.

4.2.2.2 Local insulation warning (LIW)

This function includes the measurement of the insulation resistance R_F of an IT system including symmetrical and asymmetrical components, an assessment of this resistance and a local warning.

A local insulation warning (LIW) should be made by visual indicators and/or audible signals generated by the device that has implemented the function.

4.2.2.3 Remote insulation warning (RIW)

This function includes the measurement of the insulation resistance R_F of an IT system including symmetrical and asymmetrical insulation faults, an assessment of this insulation resistance R_F and a warning output.

The warning output shall be reported remotely with an output signal.

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

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

4.2.3 Mandatory service function provided by the IMD – Test function

An IMD shall comprise a test device, or be provided with means for the connection of a test device, for detecting whether the IMD is capable of fulfilling its warning functions. The IT system to be monitored shall not be directly earthed when the test function is activated and the test function shall not negatively influence the IMD and the IT system. This test is not intended for checking the uncertainty of the response value.

The IMD shall provide an indication during or after the test whether or not the IMD is capable of issuing an insulation warning. The reaction shall be in form of an indication on a display or on another visual indication or via a remote output signal.

During the activation of the test the response time t_{an} can be extended.

4.3 Optional functions provided by IMD

4.3.1 General

The following are additional optional functions for IMDs, provided that these are not mandatory according to the annexes of this standard.

4.3.2 Local transformer monitoring warning (LTMW)

With this function a local warning signal is issued when the isolating transformer for IT systems is working in abnormal conditions, which means that either the current at the secondary side of the transformer or the temperature of the transformer exceeds the specified limits.

This function includes monitoring of the rated output current, monitoring of the temperature of the transformer, an assessment of these measurements and a local warning.

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

4.3.3 Remote transformer monitoring warning (RTMW)

With this function a remote warning signal is issued when the isolating transformer for IT systems is working in abnormal conditions, which means that either the current at the secondary side of the transformer or the temperature of the transformer exceeds the specified limits.

This function includes monitoring of the rated output current, monitoring of the temperature of the transformer, an assessment of these measurements and a remote warning.

The warning output shall be reported remotely with an output signal.

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

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

4.3.4 Remote enabling and disabling command (REDC)

These functions take into account a remote command, either to enable the measurement of the insulation resistance R_F of an IT system or to disable this measurement.

An input contact, an electronic input signal or a data communication can be used to enable or disable the IMD.

NOTE The remote enabling / disabling command is used when two IT systems which are isolated from each other, each of them having its own IMD interconnected temporarily to supply one single IT system.

4.4 Performance requirements

4.4.1 Specified response value R_{an}

The specified response value of an IMD shall be permanently set as a fixed value; or it shall be adjustable within a response range. When the specified response value R_{an} of the IMD is adjustable, it shall be designed in such a way that it is impossible to modify the settings, except by the use of a key, a tool or a password.

Adjustable response values of R_{an} can be of continuously or stepwise adjustable values.

NOTE Standards for the installation of IT systems define the lowest value of R_{an} that is permissible as a setting on IMDs with variable response values.

4.4.2 System leakage capacitance C_e

IMDs shall be capable of monitoring the insulation resistance R_F as specified in this standard up to the system leakage capacitance C_e for which they are designated by the manufacturer. This includes symmetrical and asymmetrical distribution of the system leakage capacitance C_e.

4.4.3 Relative percentage uncertainty A of the specified response value R_{an}

The maximum operating uncertainty of the specified response value R_{an} of IMDs is expressed by the relative percentage uncertainty A. The relative percentage uncertainty A of IMDs shall be ≤ ± 15 % under reference conditions.

The reference conditions are:

– operation temperature: -5 °C to +45 °C,
– at nominal voltage U_n between 0 % to 115 %,
– at supply voltage U_s between 85 % and 110 %,
– at nominal frequency f_n of the nominal voltage,
– at system leakage capacitance C_e of 1 µF.

If the response value is adjustable, the range of response values which are not within the specified limits of relative uncertainty shall be marked for example by dots at the limits of the range or the ranges. Information about the relative uncertainty within the working range specified by the manufacturer, but for leakage capacitances above the rated values as well as for frequencies below or above the nominal frequency or frequency range, shall be included in the documentation.

4.4.4 Response time t_{an}

The response time t_{an} under reference conditions shall be as follows:

– ≤ 10 s for type AC IMD,
– ≤ 100 s for type AC/DC IMD and for type DC IMD.

The reference conditions are:

– operation temperature: -5 °C to +45 °C,
– at nominal voltage U_n between 0 % to 115 %,
– at supply voltage U_s between 85 % and 110 %,
– at nominal frequency f_n of the nominal voltage U_n,
– at system leakage capacitance C_e of 1 µF.

Information about the response time t_{an} over the range of system leakage capacitances C_e and over the specified range of frequencies f_n shall be included in the documentation.

The system leakage capacitance C_e of 1 µF represents a reference value for testing. In addition, during the test of IMDs for higher system leakage capacitance C_e the maximum value of the system leakage capacitance C_e specified by the manufacturer shall be tested.

The response time t_{an} under reference conditions but with the maximum value of the system leakage capacitance C_e shall be as follows:

– ≤ 30 min for all types of IMDs.

The reference conditions are:

– same reference conditions as for 1 µF,
– but with the maximum system leakage capacitance specified by the manufacturer instead of 1 µF.

NOTE In IT systems, where the voltage is altered at low speed (e.g. converter systems with low speed control procedures or d.c. motors with low speed variation), the response time t_{an} can depend on the lowest operational frequency between the IT system and earth. These response times t_{an} can differ from the above-defined response times t_{an}.

4.4.5 Measuring voltage U_m and measuring current I_m

The peak value of the measuring voltage U_m and the peak value of the measuring current I_m shall not exceed the following values at 110 % of the nominal voltage U_n and at 110 % of the supply voltage U_s:

– The peak value of the measuring voltage U_m shall not exceed 120 V at an infinite value of the insulation resistance.
– The peak value of the measuring current I_m shall not exceed 10 mA at a value of the insulation resistance R_F = 0 Ω.

This applies for all waveforms of the measuring voltage U_m and of the measuring current I_m and for positive and negative values.

4.4.6 Internal d.c. resistance R_i and internal impedance Z_i

The internal d.c. resistance R_i of the IMD shall be at least 30 Ω/V of the nominal system voltage, but shall have a minimum of 15 kΩ. The internal impedance Z_i of the IMD shall be at least 30 Ω/V of the nominal system voltage, but shall have a minimum of 1,8 kΩ for type AC and type AC/DC IMD.

4.4.7 Indication of the value of the insulation resistance R_F

When IMDs include facilities for indicating the value of the insulation resistance R_F, the relative percentage uncertainty of these facilities under rated operating conditions shall be stated by the manufacturer.

4.4.8 Permanently admissible nominal voltage U_n

The permanently admissible nominal voltage U_n shall be at least 110 % of the highest nominal voltage U_n.

NOTE For some small specific systems 105 % of U_n is sufficient.

The permanently admissible nominal voltage U_n applies between the system connections of the IMD and between the system connections and earth.

For type AC/DC IMDs the permanently admissible voltage includes a.c. voltages with superimposed d.c. components and d.c. voltage with superimposed a.c. components.

If type AC IMDs and type AC/DC IMDs are applicable in IT systems with frequencies different from main nominal frequency, the manufacturer shall provide information of the permanently admissible system voltages at the relevant frequency range in the operating instructions.

4.4.9 Permanently admissible extraneous d.c. voltage U_{fg}

The peak value of the permanently admissible extraneous d.c. voltage U_{fg} shall be at least 115 % of the highest nominal a.c. voltage U_n for type AC/DC IMDs in a.c. IT systems and for type AC/DC IMDs in d.c./a.c IT systems (not applicable in pure d.c. IT systems).

NOTE 1 For some small specific systems 105 % of U_n is sufficient.

The manufacturer shall indicate U_{fg} for type AC IMDs in the operating instructions including the influence of U_{fg} on the measurement.

NOTE 2 In pure a.c. IT systems, extraneous d.c. voltage can appear between the a.c. system and earth during insulation faults inside of protection class I consumers when insulation faults behind galvanically connected rectifiers occur (e.g. in switched-mode power supplies).

4.4.10 Supply voltage U_S

For IMDs without separate supply connections where the supply voltage U_S is taken out of the system voltage U_n, the working range of the supply voltage U_S shall be equal to the voltage range of the system voltage U_n.

For IMDs with separate connections for the supply voltage U_S, the manufacturer shall provide information about the admissible range of supply voltage U_S.

4.5 Electromagnetic compatibility (EMC)

IMDs 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 detailed in 4.6 to 4.8 apply.

4.6.2 Clearances and creepage distances

IMDs 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 the IEC 60664 series.

Clearances and creepage distances shall be selected for:

– overvoltage or measurement category III or II, depending on the overvoltage or measurement 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 an IMD

IMDs shall provide protection class I or II.

Contrary to IEC 61557-1, the earth connection of IMDs with protection class II is a measuring connection and can be treated as a functional earth connection (FE).

The functional earth connection (FE) can use protective impedance according to 6.5.4 of IEC 61010-1:2010.

The protective conductor connection (PE) of a protection class I IMD shall be treated a as protective earth connection.

4.7 Climatic environmental conditions

IMDs 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.

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 ± 0,7g. 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 ± 4g 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 ± 10,0 g at 600 °C,(duration 90 min)	Duration in case of no resonance condition 90 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 It is recommended as guidance that Q does not exceed 5 Where 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 and 1,2 times the critical frequencies can be used where appropriate. NOTE Critical frequency is a frequency at which the equipment being tested may 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 kind IMD of housings:

Table 3 – Minimum IP requirements for IMDs

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

5 Marking and operating instructions

5.1 Marking

Different to the marking in Clause 5 of IEC 61557-1:2007, the following information shall be provided on the IMD:

– type of IT system to be monitored (if the IMD is designed for a specific type of IT system); or

– type of the IMD marked with a pictogram according to Table 4.

– nominal system voltage U_n or range of the nominal voltage U_n;

– nominal value of the rated supply voltage U_S or working range of the rated supply voltage U_S;

– nominal frequency f_n of the rated supply voltage U_S or working range of frequencies for the rated supply voltage U_S;

– the serial number on the outside of the device and, if this is not possible, inside the device.

– specified response value R_{an} or minimum and maximum specified response value R_{an}.

Table 4 – Pictograms for marking the type of IMD

Type of IMD	Corresponding pictogram
AC IMD	
DC IMD	
AC/DC IMD	

5.2 Operating instructions

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

– internal impedance Z_i of the measuring circuit as a function of the nominal frequency f_n,

– peak value of the measuring voltage U_m in accordance with 4.4.5,

– internal d.c. resistance R_i of the measuring circuit,

– maximum value of the measuring current I_m in accordance with 4.4.5,

– for IMDs with remote insulation warning (RIW): technical data of the interface for the connection of an external warning device including rated voltage and current, rated insulation voltage and explanation of the interface function. For contact circuits, data shall reference to IEC 61810-2 or IEC 60947-5-1 and IEC 60947-5-4.

– information that insulation monitoring devices shall not be connected in parallel (e.g. when systems are coupled) or, if necessary, information on the interaction between IMDs when they are connected in parallel:

– wiring diagram when this is not marked on the devices in accordance with 5.1,

– information relating to the effects of the system leakage capacitances C_e on the response value and the response time and the permissible maximum value of the system leakage capacitance,

– extraneous d.c. voltage (U_{fg}) of any polarity that can be applied continuously to the insulation monitoring device without damaging it,

– test voltage according to 6.2.13,
– conformity to the relevant EMC standards,
– the range of specified response values where the relative percentage uncertainty is higher than that required in 4.4.3, if applicable,
– IP protection class according to 4.8.3,
– when IMDs include facilities for indicating the value of the insulation resistance R_f, the relative percentage uncertainty shall be stated by the manufacturer according to 4.4.7.

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 climatic environmental conditions according to Table 5 and Table 6 shall be verified.

Table 5 – Reference conditions for tests in operation

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

Table 6 – Reference conditions for storage tests (product not powered)

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 values

Response values shall be tested at the lowest and at the highest value of the specified nominal voltage U_n and of the rated supply voltage U_S.

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

– single pole (from each phase of U_n in turn to earth);
– symmetrically (same resistor from all phases of U_n to earth).

For the different IMD types, the insulation resistance R_F shall be simulated as follows:

– for type AC IMDs: from the a.c. conductors to earth,
– for type AC/DC IMDs: from the a.c. conductors and from the d.c. conductors to earth in turn,
– for type DC IMDs: from the d.c. conductors to earth in turn.

The test set-up shall be able to accommodate slow, continuous or fine step changes in the simulated insulation resistance R_F as well as an additional connection of symmetrical leakage capacitances. Capacitors with a tolerance limit of 10 % maximum shall be used for simulating system leakage capacitances C_e. The insulation resistance R_F of the capacitances shall not negatively influence the measurement. During testing, the test resistance shall be reduced slowly, starting from high values, while observing the operation of the insulation monitoring device. The insulation resistances R_F and intrinsic leakage capacitances presented by the test circuit shall be taken into account when determining the response value.

When the IMD is provided with a continuously variable specified response value, or digital setting without mechanical switches, the compliance with the requirements of 4.4.2, 4.4.3 and 4.4.4 shall be tested at a minimum of five points of the setting range. This test shall be performed at the end points as well as at approximately evenly distributed points in the setting range. This also applies to setting facilities without a switch.

If the specified response value can be set by means of a mechanical switch, each step shall be tested. The initial test shall be performed without any system leakage capacitances in circuit whilst the test resistance is reduced so slowly that the steady-state response value can be found.

If the measuring method is affected by the magnitude of the system leakage capacitance C_e, a test shall be carried out by means of an insertion of capacitors, in steps, to determine whether the limits of 4.4.3 are met over the range of system leakage capacitance stated by the manufacturer. The relative percentage uncertainty shall be determined.

The insulation warning functions according to 4.2.2 shall be tested.

6.2.3 Test of response time t_{an}

The following tests shall be performed:

With a symmetrical system leakage capacitance C_e of 1 μF and at the nominal system voltage U_n, the insulation resistance R_F shall be suddenly reduced from nearly infinity to 50 % of the minimum response value R_{an}, and the delay to the operation of the insulation warning shall be measured. The compliance with the requirements of 4.4.4 shall be tested.

For system leakage capacitances above 1 μF, the same test shall be performed, but with the maximum system leakage capacitance which is specified by the manufacturer.

6.2.4 Test of peak value of the measuring voltage U_m

A peak voltage measurement shall be used to test whether the requirements given in 4.4.5 are met. The internal resistance of the voltage measuring instrument shall be at least 20 times the internal d.c. resistance R_i of the IMD measuring circuit.

The uncertainty of the voltage measuring instrument shall not exceed 5 % under reference conditions.

6.2.5 Test of the peak value of the measuring current I_m

A peak current measurement shall be used to test whether the requirements given for the measuring current in 4.4.5 are met. The current measuring instrument shall have an internal resistance below 5 % of the internal resistance R_i of the insulation monitoring device (IMD). The uncertainty of the current measuring instrument shall not exceed 5 % under reference conditions.

6.2.6 Test of internal d.c. resistance R_i and internal impedance Z_i

6.2.6.1 General

The following tests shall be used to test whether the requirements given in 4.4.6 are met. These tests shall be performed with or without rated supply voltage U_S and an appropriate measuring voltage shall be applied between the interconnected system terminals and the earth terminal. The uncertainty limit of the measuring devices shall not exceed 5 % under reference conditions.

6.2.6.2 Test of internal impedance Z_i

For determining the internal impedance Z_i in accordance with 4.4.6, an impedance measuring voltage source with nominal system voltage U_n shall be used. The frequency of the measuring voltage source shall be identical to the nominal system frequency f_n; the distortion factor shall be below 5 %. The internal resistance of the measuring instrument shall be below 10 Ω. For IMD with a designated range of nominal frequencies f_n, the internal impedance Z_i shall be measured at the lowest and at the highest nominal frequency f_n.

The internal impedance Z_i shall be calculated from the peak-to-peak value I_{pp} of the resulting current by using the following equation:

$$Z_i = \frac{2 \cdot \sqrt{2} \cdot U_n}{I_{pp}}$$

6.2.6.3 Test of internal d.c. resistance R_i

For determining the internal d.c. resistance R_i in accordance with 4.4.6, the d.c. voltage shall have a magnitude in the order of the nominal system voltage U_n, but shall not exceed the permissible maximum extraneous d.c. voltage U_{fg}. The internal resistance R_i of the measuring voltage source shall be below 10 Ω.

The internal d.c. resistance R_i is calculated from the resulting current I by using the following equation:

$$R_i = \frac{U_n}{I} \left(U_n \leq U_{fg} \right)$$

6.2.7 Test of facilities for indicating the insulation resistance R_F

When IMDs are fitted with facilities for indicating the values of the insulation resistance R_F, a test shall be carried out to check whether the relative percentage uncertainty limits stated by the manufacturer in accordance with 4.4.7 are met.

6.2.8 Test of effectiveness of the test device

The internal test function and the external test function, if provided, shall be tested for correct operation and compliance with the requirements given in 4.2.3.

6.2.9 Test of permanently admissible nominal voltage U_n

The requirements of 4.4.8 shall be tested.

6.2.10 Test of permanently admissible extraneous d.c. voltage U_{fg}

The requirements of 4.4.9 shall be tested for type AC IMDs.

6.2.11 Test of supply voltage U_S

The requirements of 4.4.10 shall be tested.

6.2.12 Test of optional functions

If provided the additional optional functions of the IMD shall be tested.

6.2.12.1 Test of the performance of the remote enabling/disabling command (REDC)

The requirements of 4.3.4 shall be validated by the following tests:

– interconnect two different IT systems with two IMD one at each system,
– simulate an insulation resistance R_F at the interconnected IT system.

One or all of the IMDs shall respond as specified. None of the IMDs shall erroneously respond.

6.2.12.2 Test of the local transformer monitoring warning (LTMW)

The requirements of 4.3.2 shall be validated by the following tests:

– simulate overload current of the transformer,
– simulate over-temperature of the transformer.

The local transformer warning function shall respond as specified.

6.2.12.3 Test of the remote transformer monitoring warning (RTMW)

The requirements of 4.3.3 shall be validated by the following tests:

– simulate overload current of the transformer,
– simulate over-temperature of the transformer.

The remote transformer warning function shall respond as specified.

6.2.13 Voltage tests

The voltage tests of insulation monitoring devices shall be performed in accordance with Annex F of IEC 61010-1:2010 taking into account the requirements of 4.6.

6.2.14 Test of electromagnetic compatibility (EMC)

The EMC tests shall be performed in accordance with 4.5.

6.2.15 Inspection of the marking and operating instructions

The requirements of Clause 5 shall be checked.

6.2.16 Mechanical tests

6.2.16.1 Shock and vibration test

Shock and vibration tests shall be performed to verify the requirements of 4.8.2.

6.2.16.2 Test of the IP requirements

The requirements of 4.8.3 shall be verified by visual inspection.

6.3 Routine tests

6.3.1 General

Routine tests shall be performed on each IMD.

If by technical failure analysis and/or statistical analysis during the series production a low failure rate can be verified, routine tests can be limited to sampling tests instead of full production tests. All routine tests should be carried out either during the manufacturing process or at the end.

6.3.2 Test of response values

Routine tests of the relative percentage uncertainty of the response values shall be performed.

In this test the following conditions apply:

– room temperature (23 ± 3) °C at 1,0 times U_n and 1,0 times U_S or the lowest and highest rated value of U_n and U_S for a device with several rated voltages or with a range of rated voltages;
– at a minimum of three settings including the minimum, the maximum and at a point in the center of the setting of the response sensitivity for devices with continuously adjustable response sensitivity;
– at each step for devices with stepwise adjustment of the response sensitivity.

During this test, the limits shall be reduced to such a degree that the requirements are met.

The insulation warning function according to 4.2.2.2 and 4.2.2.3 shall be tested.

6.3.3 Test of effectiveness of the test function

The internal test device and the external test device, if provided, shall be tested for correct operation and compliance with the requirements.

6.3.4 Test of facility for indicating the insulation resistance R_F

When, in accordance with 4.4.7, the IMD comprises facilities for indicating the insulation resistance R_F, a test shall be carried out to determine if the relative percentage uncertainty limits stated by the manufacturer are met.

6.3.5 Voltage tests

Voltage tests for IMDs shall be performed in accordance with Annex F of IEC 61010-1:2010 under consideration of 4.6.2.

6.3.6 Compliance with tests of 6.3

The compliance with the tests of 6.3 should be recorded.

7 Overview of requirements and tests for IMDs

Table 7 gives an overview of the requirements and tests that shall be performed for IMDs.

Table 7 – Requirements and tests applicable to IMD

Characteristics	Requirements	Type tests	Routine tests
Types of IMD	4.2	6.2	Not applicable
Specified response values R_{an}	4.4.1	6.2.2	6.3.2
System leakage capacitance C_e	4.4.2	6.2.2, 6.2.3	Not applicable
Insulation warning function	4.2.2	6.2.2	6.3.2
Test function	4.2.3	6.2.8	6.3.3
Relative percentage uncertainty	4.4.3	6.2.7	Not applicable
Response time t_{an}	4.4.4	6.2.3	Not applicable
Measuring voltage U_m and measuring current I_m	4.4.5	6.2.4 6.2.5	Not applicable
Internal resistance R_i and internal impedance Z_i	4.4.6	6.2.6	Not applicable
Indication of the value of the insulation resistance R_F	4.4.7	6.2.7	6.3.4
Permanently admissible nominal voltage U_n	4.4.8	6.2.9	Not applicable
Permanently admissible extraneous d.c. voltage U_{fg}	4.4.9	6.2.10	Not applicable
Supply voltage U_s	4.4.10	6.2.11	Not applicable
Protection class and PE connection	4.6.3	Not applicable	Not applicable
Optional functions provided by IMD	4.3	6.2.12	Not applicable
Clearance and creepage distances	4.6.2	6.2.13	6.3.5
EMC	4.5	6.2.14	Not applicable
Climatic environmental conditions	4.7	6.1, 6.2	Not applicable
Mechanical requirements	4.8	6.2.16	Not applicable
Marking and operating instructions	Clause 5	6.2.15	Not applicable

Annex A
(normative)

Medical insulation monitoring devices (MED-IMD)

A.1 Scope and object

This annex specifies the requirements for insulation monitoring devices (MED-IMD) which permanently monitor the insulation resistance to earth of unearthed medical a.c. IT systems in group 2 medical locations according to 710.413.1.5 of IEC 60364-7-710:2002.

The information and requirements specified herein replace or supplement the relevant clauses and subclauses of the main text of this standard, as indicated.

A.2 Requirements

A.2.1 General

In addition to Clause 4, the requirements or modifications detailed in A.2.2 to A.2.5 apply.

A.2.2 Types of MED-IMDs

The following types of MED-IMDs can be used in medical IT systems:

– type AC MED-IMD for pure a.c. medical IT systems,
– type AC/DC MED-IMD for medical a.c. IT systems with directly connected rectifiers and for pure d.c. IT systems and for d.c. IT systems with directly connected a.c. inverters.

If the IT system includes galvanically connected d.c. circuits, the device shall be able to detect insulation resistances R_F within the entire IT system, as specified in this standard, even with insulation faults on the d.c. side (type AC/DC IMD).

To cover all types of connected devices, it is recommended to use type AC/DC MED-IMDs.

A.2.3 Mandatory functions provided by MED-IMD

A.2.3.1 General

The following mandatory functions shall be provided by a MED-IMD in addition to or instead of the requirements of 4.2. as detailed in A.2.3.

The insulation warning indication shall take place at the latest when the insulation resistance R_F has decreased to 50 kΩ. A test device shall be provided according to 4.2.3 of this standard. For MED-IMDs with adjustable response value the lowest setting shall be ≥ 50 kΩ.

A.2.3.2 Local insulation warning (LIW)

This function shall include the measurement of the insulation resistance R_F of an IT system including symmetrical and asymmetrical components, an assessment of this resistance R_F and a local warning.

For each medical IT system, an acoustic and visual alarm system incorporating the following components shall be arranged at a suitable place, so that it can be permanently monitored (audible and visual signals) by the medical staff:

– a green signal lamp to indicate normal operation;

– a yellow signal lamp which lights when the warning indication of the insulation monitoring device takes place. It shall not be possible for this light to be cancelled or disconnected;
– an audible alarm which sounds, when the minimum value set for the insulation resistance R_F is reached. This audible alarm may have provisions to be silenced under alarm conditions;
– the yellow signal and the audible alarm shall be cancelled on removal of the fault and when normal condition is restored.

A.2.3.3 Remote insulation warning (RIW)

This function shall include the measurement of the insulation resistance R_F of an IT system including symmetrical and asymmetrical components, an assessment of this resistance and a warning output.

The warning output shall be reported remotely with an output signal.

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

For each medical IT system, an acoustic and visual alarm system (external of the MED-IMD), incorporating the following components, shall be arranged at a suitable place, so that it can be permanently monitored (audible and visual signals) by the medical staff:

– a green signal lamp to indicate normal operation;
– a yellow signal lamp which lights when the warning indication of the insulation monitoring device takes place. It shall not be possible for this light to be cancelled or disconnected;
– an audible alarm which sounds, when the minimum value set for the insulation resistance R_F is reached. This audible alarm may have provisions to be silenced under alarm conditions;
– the yellow signal and the audible alarm shall be cancelled on removal of the fault and when normal condition is restored.

A.2.3.4 Indication of the interruption to the system to be monitored

An indication of the loss of the connection to the system to be monitored and of the connection between the IMD and earth shall be provided.

NOTE The monitoring function is no longer ensured as a consequence of the loss of the connection of the IMD to the system to be monitored or to earth.

A.2.3.5 Information about the value of the insulation resistance

The MED-IMD shall provide information about the value of the insulation resistance.

The information can be provided in form of a meter, a display or via data communication.

A.2.4 Performance requirements

A.2.4.1 Specified response value R_{an}

The specified response value of a MED-IMD shall be

– permanently set as a fixed value of 50 kΩ; or
– adjustable within a response range but with a lowest value of 50 kΩ. When the specified response value R_{an} of the MED-IMD is adjustable, it shall be designed in such a way that it is impossible to modify the settings, except by the use of a key, a tool or a password.

Adjustable response values can be continuously or stepwise adjustable values.

A.2.4.2 Response time t_{an}

The response time t_{an} shall be below 5 s for an insulation resistance R_F of 25 kΩ (50 % of 50 kΩ), if suddenly applied.

The alarm off-time clearing the fault shall be below 5 s for an insulation resistance R_F suddenly rising from 25 kΩ to 10 MΩ.

Response and alarm-off times shall be adhered to for a system leakage capacitance up to 0,5 μF.

If the system leakage capacitance in the medical IT system is higher than 0,5 μF, the response time t_{an} can be longer than 5 s.

For MED-IMDs, which perform an automatic, periodic self-test for the purpose of functional safety, the response time t_{an} can be extended during self-testing.

If the IMD includes means for the indication of loss of the connection to earth or to the system to be monitored, the response time for this function can be longer as defined in this clause.

The response time for the indication of loss of the connection shall be indicated in the operating instructions.

A.2.4.3 Measuring voltage U_m and measuring current I_m

The measuring voltage U_m shall not be greater than 25 V peak.

The measuring current I_m shall not be greater than 1 mA peak, even under fault conditions.

Measuring current I_m is designated as injected current in IEC 60364-7-710.

A.2.4.4 Internal impedance (Z_i)

The a.c. internal impedance Z_i shall be at least 100 kΩ.

A.2.5 Electromagnetic compatibility (EMC)

The EMC requirements according to IEC 61326-2-4 are applicable.

Radiated and conducted emissions shall be tested according to Table A.2.

A.3 Marking and operating instructions

In addition to the information of Clause 5, the following information shall be provided on the MED-IMD.

MED-IMDs shall be marked with the pictogram according to Figure A.1 and in addition with the pictogram for the respective type of IMD according to 5.1, Table 4.

If the MED-IMD is designed to fulfil requirements of Annex B, operating instructions according to Clause B.3 should be provided.

Figure A.1 – Pictogram for marking a MED-IMD

A.4 Tests

A.4.1 General

In addition to Clause 6, the tests detailed in Clause A.4 and A.5 shall be performed.

A.4.2 Type tests

A.4.2.1 Test of the maximum value of the measuring voltage U_m and of the measuring current I_m

The tests of 6.2.4 and 6.2.5 shall be performed with the requirements of A.2.4

A.4.2.2 Test of the function of the indication of the interruption to the system to be monitored

The indication that the earth connection is lost and that the connection to the system to be monitored is lost shall be tested.

An alarm shall take place, if the FE connection or the connection to the system or all connections together are disconnected.

A.5 Overview of requirements and tests for MED-IMDs

Table A.1 gives an overview of the additional requirements and tests applicable to MED-IMDs.

Table A.2 gives an overview of the emission tests required for MED-IMDs.

Table A.1 – Summary of additional requirements and tests applicable to MED-IMDs

Characteristic	Requirements	Type tests	Routine tests
Specified response value R_{an}	A.2.4.1	6.2.2	6.3.2
Response time t_{an}	A.2.4.2	6.2.3	Not applicable
Measuring voltage U_m	A.2.4.3	A.4.2.1	Not applicable
Measuring current I_m	A.2.4.3	A.4.2.1	Not applicable
Internal impedance Z_i	A.2.4.4	A.2.4.4	Not applicable
Insulation warning	A.2.3.2, A.2.3.3	A.2.3.2, A.2.3.3	A.2.3.2, A.2.3.3
EMC immunity tests	A.2.5	A.2.5	Not applicable

Table A.2 – Emission test for MED-IMDs

Test No.	Access	Test	Specification	Class	Comment	Basic standard
1	Complete device	Radiated disturbance emission	30 MHz to 230 MHz 230 MHz to 1 000 MHz	B	At rated voltage	CISPR 11
2	Supply connections and main connections	Conducted disturbance emission	150 kHz to 30 MHz	B	At rated voltage	CISPR 11

Annex B
(informative)

Monitoring of overload current and over-temperature

B.1 Scope and object

This annex specifies optional requirements for devices designed for monitoring overload current and temperature rise of the medical IT transformer according to 710.413.1.5 of IEC 60364-7-710:2002.

These functions can be incorporated in MED-IMDs as an option.

The information and requirements specified here replace or supplement the relevant clauses and subclauses of the main text of this standard, as indicated.

B.2 Requirements

B.2.1 General

The following functions should be provided for monitoring of overload current and over-temperature.

B.2.2 Local transformer monitoring warning (LTMW) and/or remote transformer monitoring warning (RTMW)

LTMW and RTMW include monitoring of overload current and over-temperature.

The warning should be issued as local transformer monitoring warning (LTMW) or as remote transformer monitoring warning (RTMW) or as both LTMW and RTMW.

In addition to 4.3.2 and 4.3.3, the following requirements should be considered.

B.2.3 Monitoring of overload current

The warning indication should take place at the latest when the load current exceeds the rated output current of the transformer.

It is recommended that the response value for load current monitoring is adjustable and the trip value can be set below the rated output current of the transformer, to take into account individual safety margins.

It is also recommended to have an indication if the connection to the load current sensor is open or short circuited.

The r.m.s. value of the load current should be measured at least with a crest factor of 2.

B.2.4 Monitoring of over-temperature of the IT system transformer

The warning indication should take place, if the temperature sensitive device (bimetal, PTC or similar) in the isolating transformer for the supply of medical locations signals over-temperature.

It is also recommended to have an indication if the connection to the load current sensor is open or short circuited.

It is also recommended to have an indication if the connection to the over-temperature sensor is open.

B.3 Operating instructions

In addition to 5.2, the following information should be provided in the operating instructions:

– specified response value or range of specified response values for load current monitoring;
– type of external load current sensor; relative percentage uncertainty of load current measurement;
– type of temperature-sensitive device according to IEC 60691 in the isolating transformer for the supply of medical locations that can be connected;
– response time for overload current and temperature rise alarm as well as for connection alarm for these functions.

B.4 Tests

B.4.1 General

The following tests in addition to those according to IEC 61557-1 should be performed.

B.4.2 Test of overload current and over-temperature monitoring

The trip value for overload current indication, indicated by the manufacturer, should be tested by simulation of the respective load current.

The over temperature alarm should be tested by the simulation of over temperature through the respective temperature-sensitive device (bimetal, PTC or similar).

Annex C
(normative)

Insulation monitoring devices for photovoltaic systems (PV-IMD)

C.1 Scope and object

This annex specifies requirements for insulation monitoring devices that continuously monitor the insulation resistance R_F to earth of unearthed photovoltaic IT systems.

NOTE The unearthed photovoltaic IT system consists of the PV array with PV modules that generate d.c. voltage and current, the inverter that converts d.c. to a.c. and the transformer that connects the a.c. part of the PV system to the mains.

The information and requirements of this annex replace or supplement the relevant clauses and subclauses of this standard as indicated.

C.2 Requirements for PV-IMDs for PV installations

C.2.1 General

The requirements of Clause 4, Clause 5 and Clause 6 apply for PV-IMDs and in addition the following requirements apply.

PV-IMDs shall be capable of monitoring the insulation resistance R_F of these installations taking into account their specific conditions.

NOTE 1 The value of system leakage capacitance C_e depends on the following influence factors:

– power of the PV system,
– technology of modules,
– environmental conditions,
– circuit topology,
– day or night,
– aging,
– leakage capacitance inside the inverter(s),
– filter leakage capacitances.

Measurements made on several sites show that the system leakage capacitance values C_e do not exceed 5 nF/kW peak in favourable conditions (e.g. during the day), and do not exceed 150 nF/kW peak in less favourable conditions (e.g. early mornings, in frost conditions).

NOTE 2 Usually the measured insulation resistance R_F is: ≥ 1 kΩ in less favourable conditions in PV systems of about 1 MW peak and is ≥ 100 kΩ in less favourable conditions in PV systems of about 100 kWpeak. In favourable conditions R_F is between 10 times and hundred times the value in less favourable conditions.

The insulation resistance depends on the following influence factors:

– power of the PV system,
– technology of modules,
– environmental conditions,
– circuit topology,
– day or night,
– aging.

NOTE 3 Other specific conditions in PV systems are:

– different grounding conditions of the PV modules,
– d.c. voltage at the PV array,
– a.c. voltage at the output of the inverter,

– high and dynamic voltage fluctuations of the monitored IT systems by shading of the PV system.

When PV-IMDs are used in combination with equipment for insulation fault location (IFLS) according to IEC 61557-9, parts of the IFLS functionality can be integrated in the PV-IMD.

PV-IMDs shall give a warning if the insulation resistance R_F between the PV system and earth falls below a predetermined level.

C.2.2 Types of PV-IMDs

The PV-IMD shall be of type AC/DC or of type DC depending on the type of converter.

The PV-IMD shall be capable of monitoring the insulation resistance R_F of PV installations including symmetric and asymmetric allocation of the insulation resistance R_F and give a warning if the insulation resistance R_F between the PV installation and earth falls below a predetermined value.

The measuring principle of the PV-IMD shall be capable of monitoring the insulation resistance R_F when the PV-IMD is connected to the DC side or to the AC side.

C.2.3 Mandatory functions provided by PV-IMDs

C.2.3.1 Local insulation monitoring warning (LIW) and remote insulation monitoring warning (RIW)

PV-IMDs shall provide means for local insulation monitoring warning and for remote insulation warning.

Alternatively to RIW according to 4.2.2.3 the remote output can be used to signal the actual measuring value.

NOTE In this case the measuring value will be processed further in the external PV data management system.

C.2.3.2 Test function

The requirements of 4.2.3 and in addition the following apply.

PV-IMD shall implement an automatic self-test function. The automatic self-test shall perform the tests according to 4.2.3 in appropriate time intervals. If a failure is detected during the self-test, a warning indication shall be made:

– on the device; and/or

– as electronic signal for remote indication.

NOTE PV systems are generally not continuously supervised during operation by personnel onsite. The automatic self-test of the PV-IMD is part of the automatic supervision and data acquisition of the entire PV system.

C.2.4 Performance requirements

C.2.4.1 Specified response values R_{an}

The response values of PV-IMDs shall be adjustable. The adjustment range shall be specified by the manufacturer. The adjustments shall not allow their modification without a tool, a key or a password.

C.2.4.2 System leakage capacitance C_e

The PV-IMD shall be capable of monitoring the insulation resistance R_F under consideration of the system leakage capacitance C_e which has been designated by the manufacturer.

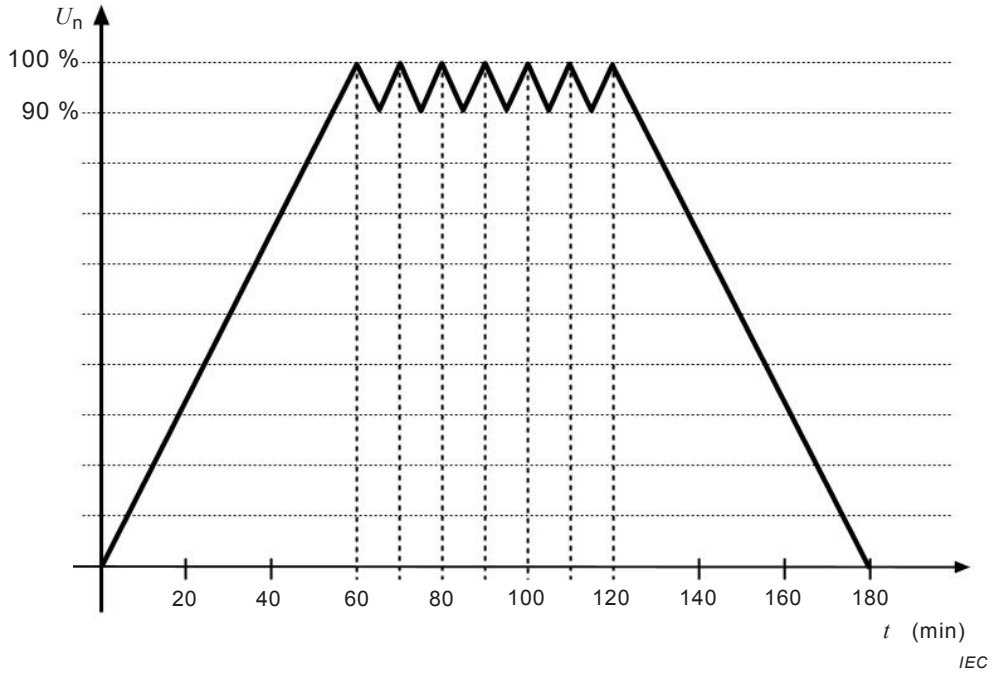
The PV-IMD shall not switch to the alarm state under no-fault conditions under the fluctuations of the system leakage capacitance C_e during the operation of the PV system.

NOTE 1 Usually, the fault free insulation resistance R_F is relatively low in large PV installations with high system leakage capacitance and is high in small PV installations with low system leakage capacitance.

NOTE 2 During the time of operation, the system leakage capacitance C_e of PV systems generally can widely but slowly fluctuate.

C.2.4.3 Permanently admissible nominal voltage U_n and characteristics of the d.c. PV system voltage

In addition to the requirements in 4.4.8, PV-IMD shall perform as intended under the dynamic reference characteristics of the d.c. voltage of the PV system.



NOTE The dynamic reference characteristics represent the fluctuations of the d.c. voltage of the PV array during the period of start up in the morning and shut down in the evening.

Figure C.1 – Dynamic reference characteristics of d.c. PV system voltage

The PV-IMD shall not switch to the alarm state under no fault conditions under the voltage changes of the reference characteristic of Figure C.1.

The PV-IMD shall operate normally under the voltage changes of the reference characteristics of Figure C.1:

– It shall not switch to alarm state under no fault conditions.
– It shall not switch to no-alarm state under fault conditions.
– It shall detect an insulation fault within the specified response time and switch to alarm state.
– It shall switch to no-alarm state when the alarm disappears.

C.3 Marking and operating instructions

C.3.1 Marking

The requirements of 5.1 and the following apply.

In addition of the marking with a pictogram according to 5.1, PV-IMD shall be marked with the pictogram according to Figure C.2.

Figure C.2 – Pictogram for marking a PV-IMD

C.3.2 Operating instructions

The requirements of 5.2 of this standard and the following apply.

An explanation of the function of the automatic self-test shall be included in the operating instructions. This shall include the time intervals in which the automatic self-test is performed and the warnings which are output in case of failure of the self-test;

An explanation of the remote warning function shall be included in the operating instructions.

C.4 Tests

C.4.1 General

The tests of Clause 6 of this standard and in addition the following type tests and routine tests shall be performed.

C.4.2 Additional type tests

C.4.2.1 General

The tests of 6.2 of this standard apply and additionally or alternatively the following type tests apply.

C.4.2.2 Test of the warning function

The test of 6.2.2 applies and in addition, the remote warning function shall be verified.

C.4.2.3 Test of the test function

In addition to testing the test function according to 6.2.8, the function of the automatic self-test according to C.2.3.2 shall be verified.

C.4.2.4 Test of the permanently admissible nominal voltage U_n and of the characteristics of the d.c. PV system voltage

In addition to the tests of 6.2.9 and 6.2.10, the following test shall be performed.

The PV-IMD shall be connected to a voltage source that simulates the reference characteristics of the d.c. voltage according to Figure C.1.

The PV-IMD shall not switch to the alarm state during the voltage changes according to Figure C.1 and under the following conditions:

– system leakage capacitance C_e = $C_{e\text{-}max}$ and
– insulation resistance R_F= 2 · R_{an}.

NOTE $C_{e\text{-}max}$ is the maximum system leakage capacitance for which the PV-IMD is designated by the manufacturer.

C.4.2.5 Inspection of marking and operating instructions

The requirements of Clauses 5 and C.3 shall be verified.

C.4.3 Additional routine tests

C.4.3.1 Test of the warning function

The tests of 6.3.3 apply and in addition the requirements of C.2.3.1 shall be tested..

C.4.3.2 Test of the test function

The tests of 6.3.3 apply and in addition the requirements of C.2.3.2 shall be tested.

C.5 Overview of requirements and tests for PV-IMDs

Table C.1 gives an overview of the requirements and tests to be performed for PV-IMDs.

Table C.1 – Requirements and tests for PV-IMDs

Characteristic	Requirements	Type tests	Routine tests
Measuring principle	C.2.2	C.2.2	Not applicable
Specified response value R_{an}	C.2.4.1	6.2.1	6.3.2
System leakage capacitance C_e	C.2.4.2	6.2.1, 6.2.2	Not applicable
Insulation warning function	C.2.3.1	C.4.2.2	C.4.3.1
Test function	C.2.3.2	C.4.2.3	C.4.3.2
Permanently admissible nominal voltage U_n and characteristics of the d.c. PV voltage	C.2.4.3	C.4.2.4	Not applicable
Marking and operating instructions	C.3	C.4.2.5	Not applicable

Annex D
(normative)

Insulation monitoring function of a photovoltaic inverter (PV-IMF) or in a charge controller

D.1 Scope and object

This annex specifies requirements for the insulation monitoring function that is integrated in a PV inverter (PV-IMF) according to IEC 62109-2.

IEC 62109-2 specifies the use of PV-IMFs for inverters for unearthed arrays and for inverters for functionally earthed arrays. The PV-IMF monitors the insulation resistance to earth of unearthed d.c. PV arrays. The response of the PV-IMF is processed inside the inverter.

NOTE 1 In IEC 62109-2, IMDs are named ‘devices for array insulation resistance detection’.

NOTE 2 According to IEC 62109 the PV-IMF measures the insulation resistance on the d.c. side (PV array) to earth before starting the operation (connection to the a.c. side). An insulation fault is processed inside of the PV inverter which means connecting or not connecting the PV inverter to the mains which depends on the insulation resistance in the system.

NOTE 3 For information: The terms ‘grounded’ and ‘ungrounded’ is US American English and equal the terms ‘earthed’ and ‘unearthed’ in IEC British English.

D.2 Requirements for PV-IMFs

D.2.1 General requirements for PV-IMFs

For insulation monitoring functions of PV inverters the requirements of Clause 4, Clause 5 and Clause 6 apply. In addition or exclusively, the requirements of this annex apply as specified.

Insulation monitoring functions of PV inverters (PV-IMF) shall be capable to monitor the insulation resistance R_F of the d.c. PV array to which the inverter is connected to earth taking into account the specific conditions of the PV installation.

NOTE 1 The value of system leakage capacitance C_e depends on the following influence factors:

– power of the PV system,
– technology of modules,
– environmental conditions,
– circuit topology,
– day or night,
– aging,
– leakage capacitance inside the inverter(s),
– filter leakage capacitance.

Measurements made on several sites show that the system leakage capacitance values C_e do not exceed 5 nF/kW peak in favourable conditions (e.g. during the day), and do not exceed 150 nF/kW peak in less favourable conditions (e.g. early mornings, in frost conditions).

NOTE 2 Usually the measured insulation resistance R_F is: ≥ 1 kΩ in less favourable conditions in PV systems of about 1 MW peak and is ≥ 100 kΩ in less favourable conditions in PV systems of about 100 kW peak. In favourable conditions R_F is between 10 times and hundred times the value of in less favourable conditions.

The insulation resistance depends on the following influence factors:

– power of the PV system,
– technology of modules,
– environmental conditions,

– circuit topology,
– day or night,
– aging.

NOTE 3 Other specific conditions in PV systems are:

– different earthing conditions of the PV modules,
– d.c. voltage at the PV array,
– a.c. voltage at the output of the inverter,
– high and dynamic voltage fluctuations of the monitored IT systems by shading of the PV system.

NOTE 4 PV-IMF can be designed as:

– separate electronic module that can be adapted inside of the inverter,
– function that is integrated into the inverter electronics.

The PV-IMF shall provide output signals about the measured insulation resistance R_F and/or response of the insulation monitoring function at a fixed or variable response value to the inverter that can be processed further inside of the inverter.

NOTE 5 When a PV-IMF is used in combination with an insulation fault location system (IFLS) according to IEC 61557-9, parts of the IFLS functionality can be integrated into the PV-IMF.

D.2.2 Types of PV-IMFs

The PV-IMF shall be of type DC or of type AC/DC.

The PV-IMF shall be capable of monitoring the insulation resistance R_F of d.c. PV arrays to earth including symmetric and asymmetric allocation of the insulation resistance R_F and signal the relevant information with regard to the insulation resistance R_F to the PV inverter.

The measuring principle of the PV-IMF shall be capable of monitoring the insulation resistance R_F of the unearthed PV installation on the d.c. side including a superimposition of a.c. components on the d.c. voltage.

The relevant output information is:

– analog or digital signal representing the insulation resistance R_F; and/or
– digital signal representing the response and non-response situation.

The measuring principle shall be capable to perform the measurement under the specific conditions of PV arrays including the superimposition of a.c. with mains frequency and with higher inverter frequencies on the d.c. voltage.

NOTE 1 In unearthed PV installations with transformer isolation to the mains (IT system), the PV-IMF can be used to monitor the insulation resistance of the entire IT system including the a.c. part.

NOTE 2 Generally, the PV-IMF is connected inside of the inverter between the d.c. input of the inverter and earth.

D.2.3 Mandatory functions provided by PV-IMFs

D.2.3.1 Remote insulation warning (RIW)

The following response to insulation faults shall be signalled from the PV-IMF to the inverter:

– digital warning signal if the insulation resistance R_F decreases below the response value (relay contact or electronic output); and/or
– analog signal representing the value of the insulation resistance R_F,
– signalling of warning or of the value of the insulation resistance R_F via bus interface.

The warning function according to 4.2.2.2 and 4.2.2.3 shall be performed by the inverter.

According to IEC 62109-2:2011, 3.9, the following warning function of PV-IMF shall be available on the inverter:

– a visible or audible indication, integral to the inverter and detectable from outside of the inverter;

and

– an electrical or electronic indication that can be remotely accessed and used.

D.2.3.2 Self-test function

The PV-IMF shall be equipped with a self-test function for detecting whether the insulation monitoring function is capable of fulfilling its monitoring function. The system to be monitored shall not be directly earthed. The test is not intended to verify the accuracy of the response value.

The self-test function shall be implemented as follows:

– test function initiated by an electronic signal from the inverter; and/or
– automatic execution of the test controlled by the PV-IMF in reasonable time intervals.

If failure is detected during the self-test, a warning indication shall be issued by the inverter.

NOTE PV systems are generally not continuously supervised during operation by onsite personal. The automatic self-test of the PV-IMF is part of the automatic supervision and data acquisition of the entire PV system.

D.2.4 Performance requirements for PV-IMFs

D.2.4.1 Specified response values R_{an}

The response values of the PV-IMF shall be represented by:

– a fixed value set inside the PV-IMF; and/or
– a variable value set by an interface signal from the inverter; and/or
– an analog or digital signal representing the value of the insulation resistance R_F, signalled from the PV-IMF to the inverter.

The response value shall be fixed adjusted in the PV-IMF or shall be selected from the inverter electronics via an electronic interface. The adjustments on the inverter shall not allow the modification without a tool, a key or a password.

NOTE The response value R_{an} according to IEC 62109 is as follows: $R_{an} = \frac{V_{may-pv}}{30mA}$.

Accordingly, $V_{max\text{-}PV}$ is the highest input voltage of the inverter. This means that for an input voltage of 600 V, the response value is 20 kΩ and for an input voltage of 1 000 V it is 33 kΩ.

D.2.4.2 System leakage capacitance C_e

The performance requirements of C.2.4.2 apply.

D.2.4.3 Indication of the value of the insulation resistance R_F

The performance requirements of 4.4.7 apply but the indication shall be available on the inverter.

D.2.4.4 Permanently admissible nominal voltage U_n and characteristics of the d.c. PV system voltage

The performance requirements of C.2.4.3 apply with the exception that the permanently admissible nominal voltage U_n corresponds to the permanently admissible nominal voltage U_n of the inverter.

D.2.4.5 Supply voltage U_S

Subclause 4.4.10 of this standard applies with the following exception.

If the supply voltage U_S of the PV-IMF is provided internally from the inverter, the working range of the supply voltage shall be equal to the internal voltage range.

D.2.5 Electromagnetic compatibility (EMC)

Subclause 4.5 of this standard applies with the exception, that the EMC requirements shall be compatible with the EMC requirements for the inverter. The performance criteria of IEC 61324-2-4 apply.

D.2.6 Safety requirements

D.2.6.1 Clearances and creepage distances

The requirements of 4.6.2 of this standard apply with the following differences:

– if the inverter includes measures to limit overvoltage to categories below overvoltage category III according to IEC 61010-1, the overvoltage category for the PV-IMF is reduced to category II respectively;

– the pollution degree corresponds to the degree inside the inverter.

D.2.7 Climatic environmental conditions

The requirements of 4.7 of this standard apply with the following exception:

– the climatic classes of the PV-IMF shall be adapted to the climatic classes inside of the inverter.

D.2.8 Mechanical requirements

The requirements of 4.8 of this standard apply with the following exception:

– the product mechanical robustness shall be adapted to the protection class required inside of the inverter,

– the IP protection class shall be adapted to the protection class required inside of the inverter.

D.3 Marking and operating instructions

D.3.1 Marking

The requirements of 5.1 of this standard apply with the following exceptions:

– PV-IMF modules shall be marked at least with the type designation and manufacturer identification code;

– marking is not required for PV-IMF integrated into the inverter electronics.

D.3.2 Operating instructions

The requirements of 5.2 of this standard apply with the following exception:

– the operating instructions for the PV-IMF can be included into the operating instructions for the inverter.

D.4 Tests

D.4.1 General

The tests of Clause 6 apply but shall be performed with the PV-IMF integrated in the inverter and with the following changes.

The type test shall be performed with the PV-IMF integrated in the inverter.

Alternatively, type tests on PV-IMFs modules can be performed without the inverter, if the inverter function which is related to the PV-IMF is simulated with a respective test setup.

D.4.2 Type tests

D.4.2.1 Test of the response values R_{an}

For a fixed response value the test of 6.2.2 shall be performed.

For a variable response value, the test of 6.2.2 shall be performed and the response value shall be varied by means of the inverter.

D.4.2.2 Test of the warning function

The requirements of D.2.3.1 shall be verified.

D.4.2.3 Test of the test function

The requirements of D.2.3.2 shall be verified.

D.4.2.4 Test of the permanently admissible nominal voltage U_n and characteristics of the PV system voltage

The tests of C.4.2.4 shall be performed under consideration of D.2.4.4.

D.4.2.5 Test of the supply voltage U_S

The test of 6.2.11 shall be performed under consideration of the requirements of D.2.4.5.

D.4.2.6 Voltage test

The tests of 6.2.13 shall be performed under consideration of D.2.6.1.

D.4.2.7 Test of the electromagnetic compatibility (EMC)

The test of 6.2.14 shall be performed under consideration of D.2.5.

D.4.2.8 Test under the specified environmental climatic conditions

The test under specific environmental climatic conditions shall be performed under consideration of the requirements of D.2.7.

D.4.2.9 Inspection of marking and operating instructions

The test of 6.2.15 shall be performed under consideration of the requirements of Clause D.3.

D.4.2.10 Mechanical test

Mechanical tests shall be performed with the PV-IMF integrated in the inverter. The requirements of D.2.8 shall be verified.

D.4.3 Routine tests

D.4.3.1 Test of the response values

The requirements of 6.2.2 apply under consideration of the requirements of D.4.2.1.

D.4.3.2 Test of the warning function

The requirements of D.4.2.2 apply.

D.4.3.3 Test of the test function

The requirements of D.4.2.3 apply.

D.4.3.4 Voltage test

The requirements of D.4.2.6 apply.

D.5 Overview of requirements and tests for PV-IMF

Table D.1 gives an overview of the requirements and tests to be performed for PV-IMF.

Table D.1 – Requirements and tests for PV-IMF integrated in the inverter

Characteristics	Requirements	Type tests	Routine tests
Types of PV-IMF	D.2.2	6.2	Not applicable
Specified response values R_{an}	D.2.4.1	D.2.4.1	D.4.3.1
System leakage capacitance C_e	D.2.4.2	6.2.1, D.4.2.2	Not applicable
Insulation warning	D.2.3.1	D.4.2.2	D.4.3.2
Self-test function	D.2.3.2	D.4.2.3	D.4.3.3
Permanently admissible nominal voltage U_n	D.2.4.4	D.4.2.4	Not applicable
Variation of the nominal voltage U_n and the characteristics of the PV system voltage	C.2.4.3	D.4.2.4	Not applicable
Supply voltage U_s	D.2.4.5	D.4.2.5	Not applicable
Clearance and creepage distances	D.2.6.1	D.4.2.6	D.4.3.4
EMC	D.2.5	D.4.2.7	Not applicable
Marking and operating instructions	D.3	D.4.2.9	Not applicable
Mechanical requirements	D.2.8	D.4.2.10	Not applicable

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