

Australian/New Zealand Standard™

## Safety of portable inverters



## **AS/NZS 4763:2011**

This Joint Australian/New Zealand Standard was prepared by Joint Technical Committee EL-002, Safety of Household and Similar Electrical Appliances and Small Power Transformers. It was approved on behalf of the Council of Standards Australia on 4 April 2011 and on behalf of the Council of Standards New Zealand on 21 April 2011.

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# Australian/New Zealand Standard™

## Safety of portable inverters

Originated as AS/NZS 4763(Int):2006.  
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## AUSTRALIA/NEW ZEALAND STANDARD

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### SAFETY OF PORTABLE INVERTERS

#### FOREWORD

This Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee EL-002 - Safety of Household and Similar Electrical Appliances and Small Power Transformers to supersede AS/NZS 4763 (Int):2006 and its amendments from the date of its publication.

The objective of this Standard is to provide manufacturers, designers, regulatory authorities, testing laboratories and similar organizations with safety requirements designed to give the user protection against hazards that might occur during normal operation and abnormal operation of an **inverter** and which may be used as the basis for approval for sale in Australia and New Zealand.

In converting the Interim edition of this Standard to a full joint Australia/New Zealand Standard, the opportunity has been taken to update the normative references.

The essential safety requirements in AS/NZS 3820 that could be applicable to **portable inverters** have been taken into account in the drafting of this Standard. Furthermore, it has been assumed that the execution of its provisions is entrusted to appropriately qualified and experienced persons.

The term 'normative' has been used in this Standard to define the application of the appendix to which it applies. A 'normative' appendix is an integral part of this Standard.

The following print types are used:

- requirements: in roman type;
- *test specifications: in italic type;*
- notes: in small roman type.

Words in **bold** in the text are defined in clause 3. When a definition concerns an adjective, the adjective and associated noun are also in bold.

As this Standard follows the form of an International Standard, a full point substitutes for a comma when referring to a decimal marker.

# AUSTRALIA/NEW ZEALAND STANDARD

## SAFETY OF PORTABLE INVERTERS

### 1 Scope

This Standard applies to single-phase or polyphase, air-cooled (natural or forced) **portable inverters** having a **rated supply voltage** not exceeding 60 V ripple-free d.c. and an alternating current (a.c.) output where:

- the **rated output** does not exceed 3 kVA;
- the **rated output voltage** is within the range 50 – 500 V a.c;
- the **rated frequency** of the output is within the range 40 – 100 Hz.

NOTE 1 **Portable inverters** may be provided with facilities for fixing to a surface.

This Standard is applicable to **inverters** of the following types :

**isolated inverters**

**equipotentially bonded inverters**

**RCD protected inverters**

These **inverters** are for

household and similar use,

use on construction sites, or

providing an independent supply to electrical installations in buildings, vehicles, caravans, boats and the like.

They may be fitted with terminals for the connection of d.c. supply or a **external flexible cord** fitted with battery clips or an automobile cigarette lighter plug or other d.c. plug.

NOTE 2 Examples of these types of **inverters** are

- **inverters** powered by a battery or other d.c. supply;
- **inverters** powered by a battery in a vehicle where the **body** of the vehicle is connected to the battery;
- **inverters** powered by a battery, where other circuits connected to the battery are accessible.

NOTE 3 Examples of devices excluded are

- AC semiconductor motor controllers and starters (IEC 60947-4-2)
- **inverters** used in an UPS system (IEC 62040 series);
- grid connected **inverters** (AS 4777.2);
- **inverters** in emergency escape lighting and exit signs for buildings; (AS 2293)
- electronic equipment used in power installations (IEC 62103)
- **inverter** - chargers

NOTE 4 This Standard is concerned only with the safety of **inverters**. It does not cover matters relating to **inverter** performance, efficiency, the output wave shape or prevention of electrolysis on steel hull boats

### 2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply.

| International Standard   | Year         | Title                                                                                                               | AU/NZ Standard | Year |
|--------------------------|--------------|---------------------------------------------------------------------------------------------------------------------|----------------|------|
|                          |              | <i>Approval and test specification - Plugs and socket-outlets</i>                                                   | AS/NZS 3112    |      |
|                          |              | <i>Approval and test specification - Cord extension sockets</i>                                                     | AS/NZS 3120    |      |
|                          |              | <i>Approval and test specification - Plugs, socket-outlets and couplers for general industrial application</i>      | AS/NZS 3123    |      |
|                          |              | <i>Approval and test specification - Residual current devices (current-operated earth-leakage devices)</i>          | AS/NZS 3190    |      |
|                          |              | <i>Approval and test specification - Electric flexible cords</i>                                                    | AS/NZS 3191    |      |
|                          |              | <i>In-service safety inspection and testing of electrical equipment</i>                                             | AS/NZS 3760    |      |
| IEC 60050 (421)          |              | <i>International Electrotechnical Vocabulary (IEV) – Chapter 421: Power inverters and reactors</i>                  |                |      |
| IEC 60068-2-2            | 2007         | <i>Environmental testing – Part 2: Tests – Test B: Dry heat</i>                                                     |                |      |
| IEC 60068-2-6            | 2007         | <i>Environmental testing - Part 2: Tests - Test Fc: Vibration (sinusoidal)</i>                                      |                |      |
| IEC 60068-2-52           | 1996         | <i>Environmental testing - Part 2: Tests - Test Kb: Salt mist, cyclic (sodium, chloride solution)</i>               |                |      |
| IEC 60068-2-75           |              | <i>Environmental testing - Part 2-75: Tests - Test Eh: Hammer tests</i>                                             |                |      |
| IEC 60085                |              | <i>Electrical insulation - Thermal classification</i>                                                               |                |      |
| IEC 60112<br>Amendment 1 | 2003<br>2009 | <i>Method for the determination of the proof and the comparative tracking indices of solid insulating materials</i> |                |      |
| IEC 60127 (All parts)    |              | <i>Miniature fuses</i>                                                                                              |                |      |

|                       |      |                                                                                                                                                                               |
|-----------------------|------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| IEC 60127-3           | 1988 | <i>Miniature fuses - Part 3: Sub-miniature fuse-links</i>                                                                                                                     |
| Amendment 1           | 1991 |                                                                                                                                                                               |
| Amendment 2           | 2002 |                                                                                                                                                                               |
| IEC 60216             |      | <i>Guide for the determination of thermal endurance properties of electrical insulating materials</i>                                                                         |
| IEC 60227             |      | <i>Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V</i>                                                                                    |
| IEC 60245             |      | <i>Rubber insulated cables of rated voltages up to and including 450/750 V</i>                                                                                                |
| IEC 60252-1           |      | <i>AC motor capacitors – Part 1: General – Performance testing and rating – Safety requirements – Guide for installation and operation</i>                                    |
| IEC 60269-2           |      | <i>Low voltage fuses – Part 2: Supplementary requirements for fuses for use by authorized persons (fuses mainly for industrial application)</i>                               |
| IEC 60269-2-1         |      | <i>Low voltage fuses – Part 2: Supplementary requirements for fuses for use by authorized persons (fuses mainly for industrial application) – Sections I to III</i>           |
| IEC 60269-3           |      | <i>Low voltage fuses – Part 3: Supplementary requirements for fuses for use by unskilled persons (fuses mainly for household and similar applications)</i>                    |
| IEC 60269-3-1         |      | <i>Low voltage fuses – Part 3: Supplementary requirements for fuses for use by unskilled persons (fuses mainly for household and similar applications) – Sections I to IV</i> |
| IEC 60309 (All parts) |      | <i>Plugs, socket-outlets and couplers for industrial purposes</i>                                                                                                             |

|                           |                                                                                                                                                                                              |                   |
|---------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|
| IEC 60320-1               | <i>Appliance couplers for household and similar general purposes - Part 1: General requirements</i>                                                                                          | AS/NZS 60320.1    |
| IEC 60320-2-3             | <i>Appliance couplers for household and similar general purposes - Part 2-3: Appliance couplers with a degree of protection higher than IPX0</i>                                             |                   |
| IEC 60384-14              | <i>Fixed capacitors for use in electronic equipment - Part 14: Sectional specification: Fixed capacitors for electromagnetic interference suppression and connection to the supply mains</i> |                   |
| IEC 60417-DB <sup>1</sup> | <i>Graphical symbols for use on equipment. Index, survey and compilation of the single sheets</i>                                                                                            |                   |
| IEC 60529                 | <i>Degrees of protection provided by enclosures (IP Code)</i>                                                                                                                                |                   |
| IEC 60664-1               | <i>Insulation co-ordination for equipment within low voltage systems – Part 1: Principles, requirements and tests</i>                                                                        |                   |
| IEC 60664-3               | <i>Insulation co-ordination for equipment within low voltage systems – Part 3: Use of coating to achieve insulation co-ordination of printed board assemblies</i>                            |                   |
| IEC 60691                 | <i>Thermal-links – Requirements and application guide</i>                                                                                                                                    |                   |
| IEC 60695-2-11            | <i>Fire hazard testing - Part 2-11: Glowing/hot-wire based test methods - Glow-wire flammability test method for end-products</i>                                                            | AS/NZS 60695.2.11 |
| IEC 60695-2-12            | <i>Fire Hazard testing – Part 2-12: Glowing/hot wire based test methods – Glow-wire flammability test method for materials</i>                                                               | AS/NZS 60695.2.12 |

<sup>1</sup> DB refers to the IEC on-line database.

|                 |      |                                                                                                                                                                                                          |                    |      |
|-----------------|------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|------|
| IEC 60695-2-13  |      | <i>Fire Hazard testing – Part 2-13: Glowing/hot wire based test methods – Glow-wire ignitability test method for materials</i>                                                                           | AS/NZS 60695.2.13  |      |
| IEC 60695-10-2  |      | <i>Fire hazard testing - Part 10-2: Abnormal heat - Ball pressure test</i>                                                                                                                               | AS/NZS 60695.10.2  |      |
| IEC 60695-11-5  | 2004 | <i>Fire hazard testing - Part 11-5: Test flames - Needle-flame test method - Apparatus, confirmatory test arrangement and guidance</i>                                                                   | AS/NZS 60695.11.5  | 2005 |
| IEC 60695-11-10 |      | <i>Fire hazard testing - Part 11-10: Test flames - 50 W horizontal and vertical flame test methods</i>                                                                                                   | AS/NZS 60695.11.10 |      |
| IEC 60730-1     | 2010 | <i>Automatic electrical controls for household and similar use – Part 1: General requirements</i>                                                                                                        |                    |      |
| IEC 60738-1     |      | <i>Directly heated positive step-function temperature coefficient thermistors – Part 1: Generic specification</i>                                                                                        |                    |      |
| IEC 60898–1     |      | <i>Electrical accessories - Circuit-breakers for overcurrent protection for household and similar installations - Part 1: Circuit-breakers for a.c. operation</i>                                        | AS/NZS 60898.1     |      |
| IEC 60990       | 1999 | <i>Methods of measurement of touch current and protective conductor current</i>                                                                                                                          | AS/NZS 60990       | 2002 |
| IEC 60998-2-2   |      | <i>Connecting devices for low-voltage circuits for household and similar purposes - Part 2-2: Particular requirements for connecting devices as separate entities with screwless-type clamping units</i> | AS/NZS 60898.2.2   |      |
| IEC 61008-1     |      | <i>Residual current operated circuit-breakers without integral overcurrent protection for household and similar uses (RCCBs) - Part 1: General rules</i>                                                 | AS/NZS 61008.1     |      |

|                |      |                                                                                                                                                                                                                                                         |                   |      |
|----------------|------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|------|
| IEC 61032      |      | <i>Test probes to verify protection by enclosures</i>                                                                                                                                                                                                   |                   |      |
| IEC 61058-1    | 2000 | <i>Switches for appliances – Part 1: General requirements</i>                                                                                                                                                                                           | AS/NZS 61058.1    | 2008 |
| Amendment 1    | 2001 |                                                                                                                                                                                                                                                         |                   |      |
| Amendment 2    | 2007 |                                                                                                                                                                                                                                                         |                   |      |
| IEC 61558-1    | 2005 | <i>Safety of power transformers, power supplies, reactors and similar products - Part 1: General requirements and tests</i>                                                                                                                             | AS/NZS 61558.1    | 2008 |
| Amendment 1    | 2009 |                                                                                                                                                                                                                                                         | Amendment 1       | 2009 |
| IEC 61558-2-1  |      | <i>Safety of power transformers, power supplies, reactors and similar products - Part 2-1: Particular requirements and tests for separating transformers and power supplies incorporating separating transformers for general applications</i>          |                   |      |
| IEC 61558-2-4  |      | <i>Safety of transformers, reactors, power supply units and similar products for supply voltages up to 1 100 V - Part 2-4: Particular requirements and tests for isolating transformers and power supply units incorporating isolating transformers</i> | AS/NZS 61558.2.4  |      |
| IEC 61558-2-16 | 2009 | <i>Safety of transformers, reactors, power supply units and similar products for voltages up to 1 100 V - Part 2-16: Particular requirements and tests for switch mode power supply units and transformers for switch mode power supply units</i>       | AS/NZS 61558.2.16 | 2010 |
|                |      |                                                                                                                                                                                                                                                         | Amendment 1       | 2010 |
| IEC 61180-1    |      | <i>High-voltage test techniques for low-voltage equipment. Part 1: Definitions, test and procedure requirements</i>                                                                                                                                     |                   |      |
| ISO 8820       |      | <i>Road vehicles – Blade type fuse-links</i>                                                                                                                                                                                                            |                   |      |
| ISO 9772       | 2001 | <i>Cellular plastics – Determination of horizontal burning characteristics of small specimens subjected to a small flame</i>                                                                                                                            |                   |      |
| Amendment 1    | 2003 |                                                                                                                                                                                                                                                         |                   |      |

### 3 Definitions

When the terms voltage and current are used, they imply, for alternating voltages and currents, the true r.m.s. values, unless otherwise specified; for direct voltages and currents, they imply the arithmetic mean value, unless otherwise specified.

For the purpose of this Standard, the following definitions apply:

#### 3.1 Inverters

##### 3.1.1 inverter

device that uses semi-conductor devices to transfer power between a d.c. source and an a.c. load

##### 3.1.2 electrical separation

unless otherwise specified the following terms apply

separation of **input circuits** from **output circuits** by **basic insulation**, **reinforced insulation** or **double insulation**

separation of the **output circuit** from the **inverter** frame by **basic insulation**, **reinforced insulation** or **double insulation**

separation of the socket equipotential bonding terminal from the **output circuit** by at least **basic insulation**

separation of the socket equipotential bonding terminal from **accessible conductive parts** by at least **basic insulation**

These definitions apply under all conditions of operation, including switching and for overcurrent protection.

NOTE A socket equipotential bonding terminal is the conventional protective earth terminal on a socket outlet.

##### 3.1.3 isolated inverter

**inverter** with protection by **electrical separation**, using **double insulation** or **reinforced insulation** between **input circuits** and **output circuits** and between **output circuits** and **accessible conductive parts**

##### 3.1.4 equipotentially bonded-inverter (EPB inverters)

**inverter** with protection by **electrical separation**, equivalent to at least **basic insulation**, between **input circuits** and **output circuits** and between **output circuits** and **accessible conductive parts**; except equipotential bonding of the earthing terminal of the a.c. output connector with **input circuits** and **accessible conductive parts**.

NOTE 1 This type of **inverter** may have **accessible conductive parts** that are separated from the **output circuits** by **double** or **reinforced insulation** – these parts do not need to be bonded.

NOTE 2 Where the d.c. **input circuit** is such that the input terminals are effectively connected together by a low impedance (e.g. internal impedance of a secondary battery), equipotential bonding of a single input terminal is considered to satisfy the requirement for all such input terminals.

##### 3.1.5 RCD protected inverter (RCDP inverter)

**inverter** that is fitted with a residual current device (RCD) in the **output circuit** and with equipotential bonding of the earthing terminal of the a.c. output connector with **input circuits** and the **accessible conductive parts** and with polarized **output circuits** achieved by connecting of the earthing terminal of the a.c. output connector to either

(a) the upstream side of the RCD on the pole that is connected to the neutral terminal of the a.c. output connector or

(b) the centre tap of the **output circuit** supply on the upstream side of the RCD

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NOTE 1 This type of **inverter** may have **accessible conductive parts** that are separated from the **output circuits** by **double** or **reinforced insulation** – these parts do not need to be bonded.

NOTE 2 Where the d.c. **input circuit** is such that the input terminals are effectively connected together by a low impedance (e.g. internal impedance of a secondary battery), equipotential bonding of a single input terminal is considered to satisfy the requirement for all such input terminals.

### 3.1.6

#### **portable inverter**

**inverter** that is intended to be moved while in operation or an **inverter** having a mass less than 18 kg

## 3.2 General terms

### 3.2.1

#### **external flexible cord**

flexible cord for external connection to the **input circuit** or **output circuit**, fixed to or assembled with the **inverter** according to one of the following methods of attachment:

- **type X attachment**, a method of attachment so that the **flexible cord** can be replaced easily;

NOTE 1 The supply cord may be especially prepared and only available from the manufacturer or his service agent.

NOTE 2 A specially prepared cord may also include a part of the **inverter**.

- **type Y attachment**, a method of attachment so that any replacement is intended to be made by the manufacturer, his service agent, or similar qualified person;

NOTE 3 **Type Y attachments** may be used either with ordinary flexible cords, or with special flexible cords.

- **type Z attachment**, a method of attachment so that the **flexible cord** cannot be replaced without breaking or destroying a part of the **inverter**.

### 3.2.2

#### **body**

this term is used in this Standard as a general term; it includes all **accessible conductive parts**, shafts, handles, knobs, grips and the like, accessible metal fixing screws and metal foil applied on **accessible surfaces** of non-metallic material; it does not include non-accessible conductive parts

### 3.2.3

#### **accessible part**

this term is used in this Standard as a general term; it includes all parts which may be touched with the Standard test finger after correct installation of the **inverter**

### 3.2.4

#### **detachable part**

part which can be removed without the aid of a **tool** or a part that may be removed in accordance with the instructions for use

### 3.2.5

#### **non-detachable part**

part which can be removed only with the aid of a **tool**

### 3.2.6

#### **tool**

screwdriver, a coin, or any other object which may be used to operate a screw or similar fixing means

### 3.2.7

#### **enclosure**

part providing protection of the **inverter** against certain external influences and, in any direction, protection against direct contacts

NOTE Examples of external influences are mechanical impacts, corrosion, fungus, vermin, solar radiation, icing and moisture.

### 3.2.8

#### **live part**

part from which a current can be drawn

### 3.2.9

#### **hazardous live part**

**live part** which, under certain conditions of external influences, can give an electric shock

### 3.2.10

#### **electronic component**

part in which conduction is achieved principally by electrons moving through a vacuum, gas or semiconductor.

NOTE Neon indicators are not considered to be **electronic components**.

## 3.3 Operations and protections

### 3.3.1

#### **thermal cut-out**

temperature sensitive device which limits the temperature of a **inverter**, or of parts of it, during abnormal operation by automatically opening the circuit or by reducing the current, and which is so constructed that its setting cannot be altered by the user

### 3.3.2

#### **self-resetting thermal cut-out**

**thermal cut-out** which automatically restores the current after the relevant part of the **inverter** has cooled down sufficiently, or the load has been removed

### 3.3.3

#### **non-self-resetting thermal cut-out**

**thermal cut-out** which requires resetting by hand, or replacement of a part, in order to restore the current

### 3.3.4

#### **thermal-link**

**thermal cut-out** which operates only once and then requires partial or complete replacement

### 3.3.5

#### **overload release**

current-operated switch which protects a circuit from overload by opening when the current in that circuit reaches a predetermined value and which remains in the open position

### 3.3.6

#### **working voltage**

maximum voltage to which the part under consideration is subjected when the **inverter** is connected to **rated supply voltage** and loaded with an impedance which would give **rated output** or under a **no-load output** condition if this is a more unfavourable situation

NOTE 1 The different positions of controls and switching devices are taken into account.

NOTE 2 **Working voltage** takes into account resonant voltages.

NOTE 3 When deducing the **working voltage**, the effect of transient voltages is ignored.

### 3.3.7

#### **continuous operation**

operation for an unlimited period

**3.3.8****short-time operation**

operation for a specified period, starting from cold, the intervals between each period of operation being sufficient to allow the **inverter** to cool down to approximately ambient temperature

**3.3.9****intermittent operation**

operation in a series of specified identical cycles

**3.4 Circuits****3.4.1****input circuit**

circuit intended to be connected to the supply

**3.4.2****output circuit**

circuit to which the load is to be connected

**3.4.3****electronic circuit**

circuit incorporating at least one **electronic component**

**3.5 Ratings****3.5.1****rated supply voltage**

supply voltage assigned to the **inverter** by the manufacturer for the specified operating conditions of the **inverter**

NOTE Where the **inverter** is intended of supply from batteries the **rated supply voltage** shall equal the nominal voltage of available batteries, for example 12 V, 24 V or 48 V

**3.5.2****rated supply voltage range**

supply voltage range assigned to the **inverter** by the manufacturer, expressed by its lower and upper limits

**3.5.3****rated frequency**

frequency assigned to the **inverter** by the manufacturer for the specified operating conditions of the **inverter**

**3.5.4****rated output current**

output current at **rated supply voltage** and **rated frequency**, assigned to the **inverter** by the manufacturer for the specified operating conditions of the **inverter**

**3.5.5****rated output voltage**

output voltage (for polyphase supply, the phase-to-phase voltage) at **rated supply voltage**, **rated frequency** and **rated output current** assigned to the **inverter** by the manufacturer for the specified operating conditions of the **inverter**

**3.5.6****rated output**

product of the **rated output voltage** and the **rated output current** or, for polyphase **inverters**,  $\sqrt{n}$  times the product of the **rated output voltage** and the **rated output current**,  $n$  being the number of phases. If the **inverter** has more than one **output circuit** or a tapped **output circuit**, the **rated output** denotes the maximum sum of the products of **rated output voltage** and **rated output current** for such circuits that may be loaded simultaneously

**3.5.7****rated power factor**

power factor assigned to an **inverter** with an a.c. output, by the manufacturer for the specified operating conditions of the **inverter**

**3.5.8****rated impulse voltage**

voltage derived from the **rated output voltage** and the overvoltage category of the **inverter**, characterizing the specified withstand capability of its insulation against transient overvoltages

**3.6 No-load values****3.6.1****no-load output**

output of the **inverter** when connected to **rated supply voltage** with no load on the **output circuit**

**3.6.2****no-load output voltage**

output voltage when the **inverter** is connected to **rated supply voltage** with no load on the output

**3.7 Insulation****3.7.1****basic insulation**

insulation applied to **hazardous live parts** to provide basic protection against electric shock

NOTE **Basic insulation** does not necessarily include insulation used exclusively for functional purposes, for example wire enamel.

**3.7.2****supplementary insulation**

independent insulation applied in addition to **basic insulation** in order to provide protection against electric shock in the event of failure of the **basic insulation**

**3.7.3****double insulation**

insulation comprising both basic insulation and supplementary insulation

**3.7.4****reinforced insulation**

single insulation system applied to **hazardous live parts**, which provides a degree of protection against electric shock equivalent to **double insulation**

NOTE – The term "insulation system" does not imply that the insulation is one homogeneous piece. It may comprise several layers which cannot be tested singly as **supplementary** or **basic insulation**.

**3.7.5****clearance**

shortest distance in air between two conductive parts

NOTE For the purpose of determining a **clearance** to **accessible parts**, the **accessible surface** of a non-metallic **enclosure** is to be considered conductive as if it were covered by a metal foil wherever it can be touched by the Standard test finger (see figure 2).

**3.7.6****creepage distance**

shortest distance (through air) along the surface of an insulating material between two conductive parts

NOTE For the purpose of determining a **creepage distance** to **accessible parts**, the **accessible surface** of a non-metallic **enclosure** is to be considered conductive as if it were covered by a metal foil wherever it can be touched by the Standard test finger (see figure 2).

### 3.7.7

#### **pollution**

addition of foreign matter, solid, liquid, or gaseous, that can result in a reduction of dielectric strength or surface resistivity of the insulation

### 3.7.8

#### **micro-environment**

immediate environment of the insulation, which particularly influences the dimensioning of the **creepage distances** or **clearances**

NOTE The **micro-environment** of the **creepage distance** or **clearance** and not the environment of the equipment determines the effect on the insulation. The **micro-environment** might be better or worse than the environment of the equipment. It includes all factors influencing the insulation, such as climatic and electromagnetic factors and generation of **pollution**, etc.

### 3.7.9

#### **pollution degree 1**

no **pollution** or only dry, non-conductive **pollution** occurs. The **pollution** has no influence

### 3.7.10

#### **pollution degree 2**

only nonconductive **pollution** occurs, except that occasionally a temporary conductivity caused by condensation is to be expected

### 3.7.11

#### **pollution degree 3**

conductive **pollution** occurs, or dry nonconductive **pollution** occurs which becomes conductive due to the condensation which is to be expected

## 4 General requirements

**Inverters** shall be so designed and manufactured that when used, installed and maintained according to the manufacturer's instructions, they cause no danger which could reasonably be foreseen to persons or surroundings, even in the event of such careless use as may occur in normal service.

*In general, compliance is checked by carrying out all the relevant tests.*

NOTE Verification tests for **inverters** are detailed in annex F, these tests are not type tests.

## 5 General notes on tests

### 5.1 Tests according to this Standard are type tests.

*Each sample **inverter** shall comply with all the relevant tests. In order to reduce the testing time and allow for any tests which may be destructive, the manufacturer may submit additional **inverters** or parts of **inverters**, provided that they are of the same materials and designs as the original **inverter**, and that the results of the tests are the same as if carried out on an identical **inverter**. Where the test for compliance is shown as being "by inspection", this shall include any necessary handling.*

**Inverters** intended to be used with **non-detachable flexible cords** are tested with the **flexible cord** connected to the **inverter**.

### 5.2 Tests are carried out on specimens as delivered and installed as in normal use taking into account the manufacturer's installation instructions.

*For components tested under conditions prevailing in the **inverter**, the number of specimens is that required by the relevant Standard.*

NOTE 1 Additional specimens may also be necessary if other tests require partial destruction of the **inverter**.

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NOTE 2 In case of non-replaceable and non-resettable protective devices the compliance is checked on a specially prepared specimen.

**5.3** Tests are carried out in the order of the clauses and subclauses, unless otherwise specified.

**5.4** If the test results are not influenced by the temperature of the ambient air, the ambient temperature is, in general, maintained at  $20\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$ . Otherwise and if, however, the temperature attained by any part is limited by a temperature-sensitive device, or is influenced by the temperature at which a change of state occurs, the ambient temperature is, in case of doubt, maintained at  $23\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$ .

The tests are carried out with the **inverter**, or any movable part of it, placed in the most unfavourable position that may occur in normal use.

**5.5** For a.c., test voltages are of substantially sine wave form, and, if not otherwise specified, have a frequency of 50 Hz.

**5.6** **Inverters** designed for more than one **rated supply voltage** or for a **rated supply voltage range**, are tested, unless otherwise specified in this Standard, at the supply voltage that imposes the most severe conditions for the **inverter** in the test concerned.

**5.7** As far as possible, measurements are made with instruments which do not appreciably affect the values to be measured; if necessary, corrections for their influence are made.

**5.8** Unless otherwise specified, **inverters** intended to be used with **external flexible cords** are tested with a cord(s) connected to the **inverter**.

**5.9** If **equipotentially bonded inverters** or **RCD protected inverters** have **accessible conductive parts** which are not connected to the equipotential bonding system, and which are not separated from **output circuits** by an intermediate metal part which is connected to the equipotential bonding system, such parts are checked for compliance with the appropriate requirements specified for **isolated inverters** in this Standard.

## 6 Classification

**6.1** **Inverters** shall be classified as follows

- **isolated inverter**
- **equipotentially bonded inverter**
- **RCD protected inverter**

Note Examples of these configurations are shown in Figure 1.

**6.2** **Inverters** shall also be classified as follows, according to their time of operation:

- **continuous operation;**
- **short-time operation;**
- **intermittent operation.**

## 7 Marking and other information

**7.1** **Inverters** shall be marked with:

- a) input current for **continuous operation**
- b) **rated supply voltage** in volts d.c.;

**Inverters** having a range of rated values and which can be operated without adjustment throughout the range, shall be marked with the lower and the upper limits of the range separated by a hyphen.

**Inverters** having different rated values, and which have to be adjusted for use at a particular value by the user or installer, shall be marked with the different values separated by an oblique stroke.

- c) **rated output voltage(s)** in volts;
- d) **rated output** for **continuous operation** in volt-amperes;
- e) **rated output current** in amperes for **continuous operation** as an alternative to the marking of the **rated output**;
- f) **rated frequency** of the output in hertz;
- g) name or trade mark of the manufacturer or responsible vendor;
- h) model or type reference;
- i) **inverter** classification in accordance with Clause 6.1 or by the relevant diagram shown in Figure 1 for the different types of **inverter**.
- j) the IP rating if applicable;
- k) **Inverters** may have **short-time operation** or **intermittent operation** and if so shall be marked with the rated operating time or with the rated operating time and the rated resting time respectively. They shall also be marked with the **rated output** or **rated output current** for these conditions of operation, if applicable.

The marking of **intermittent operation** shall be such that the rated operating time precedes the rated resting time, both markings being separated by an oblique stroke.

NOTE Additional markings are allowed provided they do not give rise to misunderstanding.

**7.2** If the **inverter** can be adjusted to suit different **rated supply voltages**, the voltage to which the **inverter** is adjusted shall be easily and clearly discernible.

**7.3** **Inverters** with tapped or multiple **outputs** shall be marked with:

- the **rated output voltage** for each tapping;
- the **rated output** for each tapping, unless it is the same for every tapping.

The arrangement of the connections necessary to obtain the various output voltages shall be clearly indicated on the **inverter**.

**7.4** **Inverters** with incorporated fuses and **inverters** designed to be protected by fuses shall, be marked with the rated current of the protecting fuse-link, followed or preceded by the symbol for the time current characteristics of the fuses in accordance with the relevant fuse Standard, if applicable.

**Inverters** with incorporated replaceable protective devices other than fuses, **inverters** designed to be protected with protective devices other than fuses shall, in addition, be marked with the manufacturer's model or type reference of the device, and/or rating of the device.

NOTE **Inverters** with non-replaceable devices need no additional marking regarding the protective device.

The marking shall be sufficient to ensure correct replacement of the protective device.

In the case where replaceable protective devices other than fuses are used, information about its installation shall be given in an instruction sheet or the like accompanying the **inverter**.

**7.5** The input connections shall be suitably identified. The polarity is to be identified by:

- a) By the symbols “+” for positive and “-” for negative, or
- b) The words “positive” and “negative”, or

NOTE The words “positive” and “negative” may be abbreviated to “Pos” and “Neg” respectively.

c) The use of a polarised connector having its polarity identified on the product or in the instructions.

**7.6** For **inverters** with type **X**, **Y** and **Z attachments**, the instruction sheet shall contain the substance of the following information:

- for **type X attachments** having a specially prepared cord:

"If the **external flexible cord** of this **inverter** is damaged, it shall be replaced by a special cord or assembly available from the manufacturer or its service agent";

- for **type Y attachments**:

"If the **external flexible cord** of this **inverter** is damaged, it shall be replaced by the manufacturer or its service agent or a similar qualified person in order to avoid a hazard";

- for **type Z attachments**:

"The **external flexible cord** of this **inverter** cannot be replaced; if the cord is damaged, the **inverter** should be scrapped".

**7.7** **Inverters** with a rating of less than IPX3 shall be marked with the words "For indoor use only".

**7.8** When symbols are used on equipment or in instructions, they shall be as follows:

| Symbol                                                                                                                                                                                                                                                                                                                            | Explanation                                             | IEC 60417 |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------|-----------|
| V*                                                                                                                                                                                                                                                                                                                                | Volts                                                   |           |
| A*                                                                                                                                                                                                                                                                                                                                | Amperes                                                 |           |
| VA*                                                                                                                                                                                                                                                                                                                               | Volt amperes                                            |           |
| Hz*                                                                                                                                                                                                                                                                                                                               | Hertz                                                   |           |
|                                                                                                                                                                                                                                                | Direct current                                          | 5031      |
|                                                                                                                                                                                                                                                | Fuse-link (add symbol for time-current characteristics) | 5016      |
| IPXX                                                                                                                                                                                                                                                                                                                              | IP number**                                             |           |
| <p>* Multiple or submultiples are allowed.</p> <p>** The X used in the IP number in this scheme indicates a missing numeral in the example, but both of the appropriate numerals shall be marked on the <b>inverter</b>, if applicable. Additional and supplementary letters mentioned in IEC 60529 may be used if necessary.</p> |                                                         |           |

NOTE 1 Additional symbols are allowed provided that they do not give rise to misunderstanding.

NOTE 2 Symbols specified in IEC 60417 and ISO 7000 may be used.

**7.10** The different positions of regulating devices and the different positions of switches shall be indicated by figures, letters or other visual means.

If figures are used for indicating the different positions, the "off" position shall be indicated by the figure 0 and the position for a greater output, input, etc. shall be indicated by a higher figure.

The figure 0 shall not be used for any other indication. Indications used shall be comprehensible without a knowledge of languages, national Standards, etc.

**7.11** Marking shall not be placed on screws or other easily removable parts.

Marking shall, with the exceptions mentioned below, be clearly discernible when the **inverter** is ready for use.

Marking related to terminals shall be so positioned that it is clearly discernible, if necessary after removal of the cover; it shall be such that there can be no confusion between input terminals and output terminals.

Marking related to interchangeable protective devices shall be positioned adjacent to the bases of these devices, and shall be clearly discernible after removal of any cover and the protective device.

*Compliance with the requirements of 7.1 to 7.11 is checked by inspection.*

**7.12** If it is necessary to take special precautions for installation or use, details of these shall be supplied.

*Compliance is checked by inspection.*

**7.13** Marking shall be durable and easily legible.

*Compliance is checked by inspection and by rubbing the marking by hand for 15 s with a piece of cotton cloth soaked with water and again for 15 s with a piece of cotton cloth soaked with petroleum spirit.*

*The petroleum spirit to be used for the test is aliphatic solvent hexane.*

*Marking made by moulding, pressing or engraving is not subjected to this test.*

*After all the tests of this Standard, the marking shall be easily legible, it shall not be possible to remove labels easily, and they shall show no curling.*

## **8 Protection against accessibility to hazardous live parts**

**Inverters** shall be constructed and enclosed so that there is adequate protection against accidental contact with **hazardous live parts**.

*Compliance is checked by the requirements in 8.1 and the tests of 8.2 and 8.3.*

**8.1** The **input circuits** are regarded as **accessible conductive parts**.

The **output circuits** are regarded as **hazardous live**.

A **live part** is not a **hazardous live part** if it is separated from the **output circuits** by **double insulation** or **reinforced insulation**.

**Accessible conductive parts** separated from **hazardous live parts** by **double** or **reinforced insulation** are not regarded as **hazardous live** provided the conditions of 15.6 are met where relevant.

Auxiliary ports such as USB ports or RS232 ports are considered to be **accessible conductive parts** and shall be separated from **hazardous live parts** by **double insulation** or **reinforced insulation**.

**8.2** The voltage measured from the **accessible conductive parts** and shafts, handles, operating levers, knobs and the like of all **inverters** to any pole of the output, shall not exceed the following when measured with the measuring network according to annex A, expressed as voltage  $U_2$  or current derived by dividing the voltage  $U_2$  by 500 ohms .

$$U_2 = 2,5 \text{ V (peak)}$$

$$\text{Current} = 5 \text{ mA (peak)}$$

*For a smooth sine wave output the ac rms value is  $0.707 \times \text{peak}$  and an RMS indicating meter may be used.*

NOTE For this test, the neutral/earth connection in **RCDP inverters** is removed.

**8.3** **Inverters** shall be so constructed and enclosed that there is adequate protection against accidental contact with **hazardous live parts** and metal parts separated from **hazardous live parts** by **basic insulation** only. This requirement applies even after removal of **detachable parts**, except for lamps with caps other than E10.

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*The insulating properties of lacquer, enamel, paper, cotton, oxide film on metal parts and sealing compound shall not be relied upon to give the required protection against accidental contact with **hazardous live parts**.*

NOTE 1 Self-hardening resins are not regarded as sealing compound.

*Shafts, handles, operating levers, knobs and the like shall not be **hazardous live**.*

*The test is made with the Standard test finger shown in figure 2 only.*

*In addition, apertures other than apertures in metal parts connected to a socket equipotentially bonding terminal, are tested with the test pin shown in figure 3.*

*The test finger and the test pin are applied, without appreciable force, in every possible position.*

*The test finger of figure 2 is applied without appreciable force, the **inverter** being in every possible position except that **inverters** normally used on the floor and having a mass exceeding 40 kg are not tilted. Through openings, the test finger is applied to any depth that the finger will permit and is rotated or angled before, during and after insertion to any position. If the opening does not allow the entry of the finger, the force on the finger in the straight position is increased to 20 N. If the finger then enters the opening, the test is repeated with the finger in the angled position.*

*It shall not be possible to touch bare **hazardous live parts** or **hazardous live parts** protected only by lacquer, enamel, paper, cotton, oxide film or **sealing compound**, with the test finger. It shall not be possible to touch metal parts separated from **hazardous live parts** by **basic insulation** only with the test finger, unless those **accessible conductive parts** are connected to the socket equipotentially bonding terminal.*

*It shall not be possible to touch bare **hazardous live parts** with the test pin.*

NOTE 2 This requirement does not apply to lamp caps or socket-outlets.

NOTE 3 In case of doubt, an electrical contact indicator, with a voltage not less than 40 V, is used with a test pin.

## 9 Output voltage and output current

**9.1** When the **inverter** is connected at **rated supply voltage**, and loaded with any load from **no-load output** to **rated output** the output voltage shall not differ from the rated value by more than 10 % and the peak value of the output voltage shall not be greater than 110 % the peak value of a sinusoidal waveform having a value equal to the **rated output voltage**.

*Compliance is checked by measuring the output voltage when steady state conditions are established, the **inverter** being connected to **rated supply voltage**, and loaded with any load from **no-load output** to **rated output**.*

**9.2** When the **inverter** is connected at any input voltage within the **rated supply voltage range** and loaded with **rated output current** the output voltage shall not differ from the rated value by more than 10 % and the peak value of the output voltage shall not be greater than 110 % the peak value of a sinusoidal waveform having a value equal to the **rated output voltage**.

*Compliance is checked by measuring the output voltage when steady state conditions are established, the **inverter** being connected to any input voltage within the **rated supply voltage range** and loaded to give **rated output**.*

## 10 Heating

**10.1** **Inverters** and their supports shall not attain excessive temperature in normal use.

*Compliance is checked by the test of 10.2.*

**10.2** *Temperatures are determined under the following conditions*

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**Inverters** are operated continuously until steady state is established.

In addition, **inverters** rated for **short-time operation** or **intermittent operation** are operated for the rated operating time; or

for the rated operating time followed by the rated resting time until steady state is established.

The test and the measurements are made in a draught-free location having dimensions such that the test results are not influenced.

**Portable inverters** are placed on a dull black painted plywood support. The support is approximately 20 mm thick, and has dimensions which are at least 200 mm in excess of those of the projected dimensions of the specimen on the support.

**Inverters** with terminals for **type X attachment** with a specially prepared cord and for **type Y attachments** and **type Z attachments** shall have the connections subjected to a pull of 5 N immediately before the heating test is carried out.

**Inverters** are connected to **rated supply voltage** and loaded with an impedance which would give **rated output**, at **rated output voltage** and for a.c. at **rated power factor**; then the d.c. supply voltage is adjusted to obtain the maximum **inverter** power dissipation within the range 0.9 to 1.3 times the nominal voltage of the d.c. supply. After this voltage adjustment, no change is made in the circuit. The test is repeated under the **no-load output** condition if this is a more unfavourable situation.

If the temperatures of windings are determined by the resistance method, the value of the temperature rise of a winding is calculated from the formula:

$$\Delta t = \frac{R_2 - R_1}{R_1} (x + t_1) - (t_2 - t_1)$$

where

$x = 234,5$  for copper;

$x = 225$  for aluminium;

$\Delta t$  is the temperature rise, above  $t_2$  so that the maximum temperature equals  $\Delta t + t_2$ ;

$R_1$  is the resistance at the beginning of the test, at temperature  $t_1$ ;

$R_2$  is the resistance at the end of the test, when steady conditions have been established;

$t_1$  is the ambient temperature at the beginning of the test;

$t_2$  is the ambient temperature at the end of the test.

NOTE 1 One of the methods consists of measuring each winding separately, and of determining the resistance of windings at the end of the test by taking resistance measurements, as soon as possible after switching off, and then at short intervals, so that a curve of resistance against time can be plotted to ascertain the resistance at the instant of switching off.

At the beginning of the test, the windings shall be at ambient temperature.

The ambient temperature is measured at such a distance from the specimen so as not to influence the temperature reading. At this point, the temperature of the air shall not vary by more than 10 °C during the test.

For **inverters** with more than one **input circuit** or one **output circuit**, or a tapped **input circuit** or tapped **output circuit**, the results to be considered are those showing the highest temperature.

If temperatures are determined by means of thermocouples, the thermocouple shall be so chosen and positioned that they have the minimum effect on the temperature of the part under test.

*Thermocouples used for determining the temperature of the surface of supports are attached to the back of small blackened discs of copper or brass of 1 mm thick and 15 mm diameter which are flush with the surface.*

*The temperature of electrical insulation (other than that of windings) is determined on the surface of the insulation at places where failure could establish a contact between **hazardous live parts** and **accessible conductive parts**, or a reduction of **creepage distances** or **clearances** below the values specified in clause 21.*

*During the test, the temperature shall not exceed the values shown in table 1 when the **inverter** is operated at its reference ambient temperature (25 °C). In those cases where the temperature in the test area differs from the reference ambient temperature, this difference shall be taken into account when applying the limits in table 1 and when establishing the test temperatures in 22.1.*

**Table 1 – Values of maximum temperatures in normal use**

| Parts                                                                                                      | Temperature<br>°C |
|------------------------------------------------------------------------------------------------------------|-------------------|
| Windings <sup>1)</sup> , (bobbins and laminations in contact therewith), if the insulation system is:      |                   |
| – of class 105 material                                                                                    | 100               |
| – of class 120 material                                                                                    | 115               |
| – of class 130 material                                                                                    | 120               |
| – of class 155 material                                                                                    | 140               |
| – of class 180 material                                                                                    | 165               |
| – of class 200 material                                                                                    | 185               |
| – of class 220 material                                                                                    | 205               |
| – of class 250 material                                                                                    | 235               |
| External <b>enclosures</b> <sup>2)</sup> , handles and the like:                                           |                   |
| • of metal                                                                                                 | 70                |
| • of other material                                                                                        | 80                |
| Terminals for external conductors and terminals of switches                                                | 70                |
| Insulation of internal and external wiring <sup>3)</sup> :                                                 |                   |
| – of rubber                                                                                                | 65                |
| – of polyvinyl chloride                                                                                    | 75                |
| – with temperature rating (T)                                                                              | T                 |
| Parts, the deterioration of which could affect safety <sup>3)</sup> :                                      |                   |
| – of rubber (other than insulation of wiring)                                                              | 75                |
| – of phenolformaldehyde                                                                                    | 105               |
| – of ureaformaldehyde                                                                                      | 85                |
| – of impregnated paper and fabric                                                                          | 85                |
| – of impregnated wood                                                                                      | 85                |
| – of polyvinyl chloride (other than insulation of wiring), polystyrene and similar thermo-plastic material | 65                |
| – of varnished cambric                                                                                     | 75                |
| – other materials <sup>3)</sup>                                                                            |                   |
| Supports                                                                                                   | 85                |
| Printed boards <sup>3)</sup> :                                                                             |                   |
| – bonded with phenol-formaldehyde, melamine-formaldehyde, phenol-furfural or polyester                     | 105               |
| – bonded with epoxy                                                                                        | 140               |