IEC 62040-1

Edition 2.1 2021-05
CONSOLIDATED VERSION

INTERNATIONAL STANDARD

colour inside

Uninterruptible power systems (UPS) – Part 1: Safety requirements

IEC 62040-1:2017-07+AMD1:2021-05 CSV(en)

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

ICS 29.200

ISBN 978-2-8322-9836-7

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IEC 62040-1

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REDLINE VERSION

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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UNINTERRUPTIBLE POWER SYSTEMS (UPS) –

Part 1: Safety requirements

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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This consolidated version of the official IEC Standard and its amendment has been prepared for user convenience.

IEC 62040-1 edition 2.1 contains the second edition (2017-07) [documents 22H/217/FDIS and 22H/218/RVD], its corrigendum (2019-10) and its amendment 1 (2021-05) [documents 22H/269/FDIS and 22H/271/RVD].

In this Redline version, a vertical line in the margin shows where the technical content is modified by amendment 1. Additions are in green text, deletions are in strikethrough red text. A separate Final version with all changes accepted is available in this publication.

International Standard IEC 62040-1 has been prepared by subcommittee 22H: Uninterruptible power systems (UPS), of IEC technical committee 22: Power electronic systems and equipment.

This second edition constitutes a technical revision.

This edition includes the following significant technical change with respect to the previous edition: the reference document has been changed from IEC 60950-1:2005 (safety for IT equipment) to IEC 62477-1 (group safety standard for power electronic converters).

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

This International Standard is to be read in conjunction with IEC 62477-1:2012.

The provisions of the general rules dealt within IEC 62477-1:2012 are only applicable to this document insofar as they are specifically cited. Clauses and subclauses of IEC 62477-1:2012 that are applicable in this document are identified by reference to IEC 62477-1:2012, for example, "Clause 4 of IEC 62477-1:2012 applies, except as follows".

The exceptions are then listed. The exceptions can take the form of a deletion, a replacement or an addition of subclauses, tables, figures or annexes.

Subclauses, tables and figures that are additional to those in IEC 62477-1:2012 are, in this document, identified by a suffix in the format of X.10x, for example 4.3.101.

Annexes that are additional to those in IEC 62477-1:2012 are, in this document, lettered AA, BB, etc.

In this document, the following print types are used:

- requirements and normative annexes: roman type
- compliance statements and test specifications: *italic type*
- notes and other informative matter: smaller roman type
- normative conditions within tables: smaller roman type
- terms that are defined in Clause 3: **bold**

A list of all parts in the IEC 62040 series, published under the general title *Uninterruptible Power Systems (UPS)*, can be found on the IEC website.

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

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

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

INTRODUCTION

IEC technical sub-committee 22H: Uninterruptible power systems (UPS) carefully considered the relevance of each paragraph of IEC 62477-1:2012 in UPS applications. This part of IEC 62040 utilizes IEC 62477-1:2012 as a reference document and references, adds, replaces or modifies requirements as relevant. This is because product-specific topics not covered by the reference document are the responsibility of the technical committee using the reference document.

IEC 62477-1:2012 relates to products that include power electronic converters, with a rated system voltage not exceeding 1 000 V AC or 1 500 V DC. It specifies requirements to reduce risks of fire, electric shock, thermal, energy and mechanical hazards, except functional safety as defined in IEC 61508 (all parts). The objectives of this document are to establish a common terminology and basis for the safety requirements of products that contain power electronic converters across several IEC technical committees.

IEC 62477-1:2012 was developed with the intention:

- to be used as a reference document for product committees inside IEC technical committee 22: Power electronic systems and equipment in the development of product standards for power electronic converter systems and equipment;
- to replace IEC 62103 as a product family standard providing minimum requirements for safety aspects of power electronic converter systems and equipment in apparatus for which no product standard exists; and

  NOTE The scope of IEC 62103 contains reliability aspects, which are not covered by this document.

- to be used as a reference document for product committees outside TC 22 in the development of product standards of power electronic converter systems and equipment intended for renewable energy sources. TC 82, TC 88, TC 105 and TC 114, in particular, have been identified as relevant technical committees at the time of publication.

The reference document, being a group safety standard, will not take precedence over this product-specific standard according to IEC Guide 104. IEC Guide 104 provides information about the responsibility of product committees to use group safety standards for the development of their own product standards.

UNINTERRUPTIBLE POWER SYSTEMS (UPS) –

Part 1: Safety requirements

1 Scope

This part of IEC 62040 applies to movable, stationary, fixed or built-in **UPS** for use in low-voltage distribution systems and that are intended to be installed in an area accessible by an **ordinary person** or in a restricted access area as applicable, that deliver fixed frequency AC output voltage with port voltages not exceeding 1 000 V AC or 1 500 V DC and that include an energy storage device. It applies to pluggable and to permanently connected **UPS**, whether consisting of a system of interconnected units or of independent units, subject to installing, operating and maintaining the **UPS** in the manner prescribed by the manufacturer.

NOTE 1 Typical **UPS** configurations, including voltage and/or frequency converters and other topologies, are described in IEC 62040-3, the test and performance product standard for **UPS**.

NOTE 2 **UPS** generally connect to their energy storage device through a DC link. A chemical battery is used throughout the standard as an example of an energy storage device. Alternative devices exist, and as such, where "battery" appears in the text of this document, this is to be understood as "energy storage device".

This document specifies requirements to ensure safety for the **ordinary person** who comes into contact with the **UPS** and, where specifically stated, for the **skilled person**. The objective is to reduce risks of fire, electric shock, thermal, energy and mechanical hazards during use and operation and, where specifically stated, during service and maintenance.

This product standard is harmonized with the applicable parts of group safety publication IEC 62477-1:2012 for power electronic converter systems and contains additional requirements relevant to **UPS**.

This document does not cover:

- UPS that have a DC output;
- systems for operation on moving platforms including, but not limited to, aircrafts, ships and motor vehicles;
- external AC or DC input and output distribution boards covered by their specific product standard;
- stand-alone static transfer systems (STS) covered by IEC 62310-1;
- systems wherein the output voltage is directly derived from a rotating machine;
- telecommunications apparatus other than **UPS** for such apparatus;
- functional safety aspects covered by IEC 61508 (all parts).

NOTE 3 Even if this document does not cover the applications listed above, it is commonly taken as a guide for such applications.

NOTE 4 Specialized **UPS** applications are generally governed by additional requirements covered elsewhere, for example **UPS** for medical applications.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

Clause 2 of IEC 62477-1:2012 applies, except as follows:

Add the following normative references:

IEC 60364-4-42, *Low-voltage electrical installations – Part 4-42: Protection for safety – Protection against thermal effects*

IEC 60384-14, *Fixed capacitors for use in electronic equipment – Part 14: Sectional specification – Fixed capacitors for electromagnetic interference suppression and connection to the supply mains*

IEC TR 60755, *General requirements for residual current operated protective devices*

IEC 60947-2:2006*, Low-voltage switchgear and controlgear – Part 2: Circuit-breakers*[1]

IEC 60950-1:2005, *Information technology equipment – Safety – Part 1: General requirements*

IEC 61000-2-2:2002, *Electromagnetic compatibility (EMC) – Part 2-2: Environment – Compatibility levels for low-frequency conducted disturbances and signaling in public low-voltage power supply systems*

IEC 61008-1, *Residual current operated circuit-breakers without integral overcurrent protection for household and similar uses (RCCBs) – Part 1: General rules*

IEC 61009-1, *Residual current operated circuit-breakers with integral overcurrent protection for household and similar uses (RCBOs) – Part 1: General rules*

IEC 62040-2:2005, *Uninterruptible power systems (UPS) – Part 2: Electromagnetic compatibility (EMC) requirements*[2]

IEC 62477-1:2012, *Safety requirements for power electronic converter systems and equipment – Part 1: General*

3 Terms and definitions

Clause 3 of IEC 62477-1:2012 applies, except as follows:

Add the following new terms and definitions, and new notes:

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1 4th edition (2006). This 4th edition has been replaced in 2016 by a 5th edition IEC 60947-2:2016, *Low-voltage switchgear and controlgear – Part 2: Circuit-breakers*.

2 2nd edition (2005). This 2 nd edition has been replaced in 2016 by a 3rd edition IEC 62040-2:2016, *Uninterruptible power systems (UPS) – Part 2: Electromagnetic compatibility (EMC) requirements*.

Table 1 – Alphabetical list of terms

Terms	Term number		Terms	Term number	
	62040-1	62477-1		62040-1	62477-1
adjacent circuit		3.1	power semiconductor device		3.34
active power	3.111		primary power	3.108	
apparent power	3.112		prospective short-circuit current	3.122	
backfeed	3.127		protective equipotential bonding		3.36
backfeed protection	3.128		protective class I		3.37
basic insulation		3.2	protective class II		3.38
basic protection		3.3	protective class III		3.39
bypass	3.110		protective earthing (PE)		3.40
commissioning test		3.4	PE conductor		3.41
cord	3.109		protective impedance		3.42
decisive voltage class (*DVC*)		3.5	(electrically) protective screening		3.43
double insulation		3.6	protective separation		3.44
DVC As		3.7	PEC		3.45
DVC Ax		3.8	PECS		3.46
earth fault	3.131		rated conditional short-circuit current	3.120	
electrical breakdown		3.9	rated current	3.117	
(electrical) insulation		3.10	rated load	3.115	
(electronic) (power) conversion		3.11	rated peak withstand current	3.118	
enclosure		3.12	rated short-time withstand current	3.119	
enhanced protection		3.13	rating	3.113	
expected lifetime		3.14	rated value	3.114	
Extra Low Voltage (ELV)		3.15	rated voltage	3.116	
fault protection		3.16	reference non-linear load	3.126	
field wiring terminal		3.17	reference test load	3.125	
fire enclosure		3.18	reinforced insulation		3.47
functional insulation		3.19	restricted access area		3.48
hazardous energy	3.107		routine test		3.49
hazardous live part		3.20	sample test		3.50
hazardous voltage	3.106		SELV (systems)		3.51
installation		3.21	short-circuit backup protection		3.52
instructed person	3.103		service acces area	3.105	
linear load	3.123		short-circuit protective device (SCPD)	3.130	
live part		3.22	simple separation		3.53
low impedance path	3.121		single fault condition		3.54
low voltage		3.23	skilled person	3.102	
mains supply		3.24	startle reaction		3.55
muscular reaction (inability to let go)		3.25	supplementary insulation		3.56

Terms	Term number		Terms	Term number	
	62040-1	62477-1		62040-1	62477-1
non-linear load	3.124		surge protective device (SPD)		3.57
non-mains supply		3.26	system		3.58
open type		3.27	system voltage		3.59
ordinary person	3.104		stored energy mode	3.129	
output short-circuit current		3.28	temporary overvoltage		3.60
PELV (systems)		3.29	touch current		3.61
Permanently connected		3.30	type test		3.62
pluggable equipment type A		3.31	ventricular fibrillation		3.63
pluggable equipment type B		3.32	working voltage		3.64
port		3.33	uninterruptible power system (UPS)	3.101	
			zone of equipotential bonding		3.65

Note 1 to entry: Where the terms "voltage" and "current" are used, RMS values are implied unless otherwise specified.

Note 2 to entry: Non-sinusoidal signals are measured with appropriate true RMS measuring instruments.

3.101
uninterruptible power system
UPS
combination of convertors, switches and energy storage devices (such as batteries), constituting a power system for maintaining continuity of load power in case of input power failure

Note 1 to entry: Continuity of load power occurs when voltage and frequency are within rated steady-state and transient tolerance bands, and with distortion and interruptions within the limits specified for the output port. Input power failure occurs when voltage and frequency are outside rated steady-state and transient tolerance bands, or with distortion or interruptions outside the limits specified for the **UPS**.

3.102
skilled person
person with relevant education and experience to enable him or her to perceive risks and to avoid hazards which the equipment can create

Note 1 to entry: Such person has access to restricted access areas.

[SOURCE: IEC 60050-195:1998, 195-04-01, modified – The word "(electrically)" has been deleted from the term, and "electricity" has been replaced by "the equipment" in the definition. The note has been added.]

3.103
instructed person
person adequately advised or supervised by **skilled persons** to enable him or her to perceive risks and to avoid hazards which the equipment can create

Note 1 to entry: Such person has access to restricted access areas.

Note 2 to entry: Examples of activities performed by an **instructed person** can be found in IEC 61140:2001, Clause 8.

[SOURCE: IEC 60050-195:1998, 195-04-02, modified – The word "(electrically)" has been deleted from the term, and the notes have been added.]

3.104
ordinary person
person who is neither a **skilled person** nor an **instructed person**

Note 1 to entry: Such person does not have access to a restricted access area and is not trained to identify hazards. Such person may otherwise have access to the equipment or may be in the vicinity of the equipment. An ordinary person will not intentionally create hazards nor have access to hazardous parts under normal and **single fault conditions**.

[SOURCE: IEC 60050-195:1998, 195-04-03, modified – The note has been added.]

3.105
service access area
area accessible by **skilled person**s by the use of a tool, where it is necessary for **skilled person** to have access regardless of the equipment being energized

3.106
hazardous voltage
voltage exceeding 42,4 V peak, or 60 V DC, existing in a circuit that does not meet the requirements for either a limited current circuit or a TNV-1 circuit

Note 1 to entry: A limited current circuit is understood in the context of "protection by means of protective impedance" as described in IEC 62477-1:2012, 4.4.5.4.

[SOURCE: IEC 60950-1:2005, 1.2.8.6 modified – TNV has been replaced by TNV-1.]

3.107
hazardous energy
available power level of 240 VA or more, having a duration of 60 s or more, or a stored energy level of 20 J or more (for example, from one or more capacitors), at a potential of 2 V or more

Note 1 to entry: See IEC 62477-1:2012, 4.5.1.2.

3.108
primary power
power supplied by an electrical utility company or by a local generator

3.109
cord
flexible cable with a limited number of conductors of small cross-sectional area

[SOURCE: IEC 60050-461:2008, 461-06-15.]

3.110
bypass
alternative power path, either internal or external to the **UPS**

3.111
active power
under periodic conditions, mean value, taken over one period T, of the instantaneous power p

$$P = \frac{1}{T}\int_0^T p\,\mathrm{d}t$$

Note 1 to entry: Under sinusoidal conditions, the **active power** is the real part of the complex power $\underline{S}$, thus $\underline{P}$ = Re $\underline{S}$

Note 2 to entry: The coherent SI unit for **active power** is watt, W.

Note 3 to entry: DC, fundamental and harmonic voltages and currents contribute to the magnitude of the **active power**. Where applicable, instruments used to measure **active power** should therefore present sufficient bandwidth and be capable of measuring any significant non-symmetrical and harmonic power components.

[SOURCE: IEC 60050-131: 2013, 131-11-42, modified – A third note to entry has been added.]

3.112
apparent power
product of the RMS voltage and RMS current

3.113
rating
set of **rated values** and operating conditions of a machine, a device or equipment

[SOURCE: IEC 60050-151:2001, 151-16-11, modified – The words "of a machine, a device or equipment" have been added.]

3.114
rated value
value of a quantity used for specification purposes, generally established by a manufacturer for a specified set of operating conditions of a component, device, equipment, or system

[SOURCE: IEC 60050-151:2001, 151-16-08, modified – The word "established" has been expanded to read "generally established by a manufacturer".]

3.115
rated load
load or condition in which the output of the **UPS** delivers the power for which the **UPS** is rated

Note 1 to entry: The **rated load** is expressed in **apparent power** (VA) and **active power** (W) resulting in a (rated) power factor that includes the effect of any applicable combination of **linear** and of **non-linear load** as prescribed in Annex BB.

Note 2 to entry: **Rated load** is a value of load used for specification purposes, generally established by a manufacturer for a specified set of operating conditions of a component, device, equipment, or system

3.116
rated voltage
input or output voltage as declared by the manufacturer

Note 1 to entry: For a three-phase supply, the rated voltage corresponds to the phase-to-phase voltage.

3.117
rated current
input or output current of the **UPS** as declared by the manufacturer

3.118
rated peak withstand current
I_{pk}
value of peak short-circuit current, declared by the **UPS** manufacturer, that can be withstood under specified conditions

Note 1 to entry: For the purpose of this document, I_{pk} refers to the initial asymmetric peak value of the prospective test current listed in Table 104.

3.119
rated short-time withstand current
I_{cw}
RMS value of short-time current, declared by the **UPS** manufacturer, that can be carried under specified conditions, defined in terms of current and time

[SOURCE: IEC 61439-1:2011, 3.8.10.3, modified – The definition has been rephrased and the word "assembly" has been replaced by "**UPS**".]

3.120
rated conditional short-circuit current
I_{cc}
RMS value of **prospective short-circuit current**, declared by the **UPS** manufacturer, that can be withstood for the total operating time (clearing time) of the **short-circuit protective device** (**SCPD**) under specified conditions

Note 1 to entry: The **short-circuit protective device** does not necessarily form an integral part of the **UPS**.

[SOURCE: IEC 61439-1:2011, 3.8.10.4, modified – The word "RMS" has been added to "value", the word "assembly" has been replaced by "**UPS**", and the note has been rephrased.]

3.121
low impedance path
path containing devices that for **UPS** load purposes present negligible impedance, such as cabling, switching devices, protecting devices and filtering devices

Note 1 to entry: The devices in a **low impedance path** generally present current limiting characteristics under short-circuit conditions.

Note 2 to entry: Examples include current limiting fuses, current limiting circuit-breakers, transformers and inductors.

3.122
prospective short-circuit current
I_{cp}
RMS value of the current which would flow if the supply conductors to the circuit are short-circuited by a conductor of negligible impedance located as near as practicable to the supply terminals of the **UPS**

[SOURCE: IEC 61439-1:2011, 3.8.7, modified – The word "assembly" has been replaced by "**UPS**".]

3.123
linear load
load where the current drawn from the supply is defined by the relationship:

$$I = U/Z$$

where

I is the load current;

U is the supply voltage;

Z is the constant load impedance

Note 1 to entry: Application of a **linear load** to a sinusoidal voltage results in a sinusoidal current.

[SOURCE: IEC 62040-3:2011, 3.2.4]

3.124
non-linear load
load where the parameter Z (load impedance) is no longer a constant but is a variable dependent on other parameters, such as voltage or time

[SOURCE: IEC 62040-3:2011, 3.2.5]

3.125
reference test load
load or condition in which the output of the **UPS** delivers the **active power** (W) for which the **UPS** is rated

Note 1 to entry: This definition permits, when in test mode and subject to local regulations, the **UPS** output to be injected into the input AC supply.

[SOURCE: IEC 62040-3:2011, 3.3.5]

3.126
reference non-linear load
non-linear load that when connected to a **UPS**, consumes the **apparent power** at which the **UPS** shall be tested

Note 1 to entry: Refer to Clause BB.5 for test details.

[SOURCE: IEC 62040-3:2011, 3.3.6, modified – The expression "the apparent and active power for which the UPS is rated in accordance with Annex E" has been replaced by "the apparent power at which the **UPS** shall be tested", and the note has been added.]

3.127
backfeed
condition in which a voltage or energy available within the **UPS** is fed back to any of the input terminals, either directly or by a leakage path while operating in the **stored energy mode** and with **primary power** not available

[SOURCE: IEC 62040-3:2011, 3.2.3, modified – The words "while AC input power is" have been replaced by "with **primary power**".]

3.128
backfeed protection
control scheme that reduces the risk of electric shock due to **backfeed**

3.129
stored energy mode
stable mode of operation that the **UPS** attains under the following conditions:

a) AC input power is disconnected or is out of required tolerance;

b) all power is derived from the energy storage device;

c) the load is within the specified **rating** of the **UPS**

[SOURCE: IEC 62040-3:2011, 3.2.10, modified – The words "of UPS operation" have been deleted in the term, and the word "system" has been replaced by "device" in b).]

3.130
short-circuit protective device
SCPD
device intended to protect a circuit or parts of a circuit against short-circuit currents by interrupting them

[SOURCE: IEC 60947-1:2007, 2.2.21]

3.131
earth fault
occurrence of an accidental conductive path between a live conductor and the earth

[SOURCE: IEC 60050-826:2004, 826-04-14, modified – The second preferred term "ground fault" has been deleted, as well as the notes.]

4 Protection against hazards

Clause 4 of IEC 62477-1:2012 applies, except as follows:

4.2 Fault and abnormal conditions

Subclause 4.2 in IEC 62477-1:2012 applies, except as follows:

Replace the fourth paragraph of IEC 62477-1:2012, 4.2 by the following:

Compliance is checked by analysis or by test according to 5.2.4.6 of IEC 62477-1:2012.

Compliance through analysis only is permitted when such analysis conclusively shows that no hazard will result from failure of the component.

4.3 Short-circuit and overload protection

Subclause 4.3 in IEC 62477-1:2012 applies except as follows:

Add the following:

4.3.101 AC input current

The input current to the **UPS** shall not exceed that declared by the **UPS** manufacturer – see 6.2 a).

In determining the steady state input current, the consumption due to optional features offered or provided by the manufacturer for inclusion in or with the **UPS** shall be considered and adjusted to give the most unfavourable result.

NOTE Transient input current arising from dynamic occurences, for example inrush or overload current, is not considered.

Compliance is checked when highest current measured or calculated (as applicable) when performing the test described in 5.2.3.102 does not exceed the input current declared by the manufacturer (see 6.2).

4.3.102 Transformer protection

Transformers shall be protected against overtemperature.

NOTE Means of protection include:

- overcurrent protection,
- internal thermal cut-outs,
- use of current limiting devices.

Compliance is checked by the applicable tests of 5.2.3.104.

4.3.103 AC input short-circuit current

The **UPS** manufacturer shall specify the **rated conditional short-circuit current** (I_{cc}) or the **rated short-time withstand current** (I_{cw}) at each AC input port of the **UPS**. The UPS manufacturer may specify both. Individual AC input ports of a **UPS** may have individual **ratings**.

A **UPS** with AC input ports that may be configured with jumpers or busbars to present a single AC input port or multiple AC input ports shall be tested as having multiple AC input ports. Testing with installed jumpers or busbars that combine multiple AC input ports into a single

AC input port is not required when the construction of the jumpers or busbars is at least as robust as that of the phase conductors in terms of cross-sectional area, mechanical support and clearance.

A **UPS** with multiple AC input ports and different **ratings** for each port shall indicate, when configured as a single AC input port, a **rating** equal to the lowest **rating** of any port (see table 101).

Table 101 – UPS input port configuration

UPS input port configuration	AC input port(s)	I_{cc}/I_{cw} rating
Single input port	Port 1 e.g. combined rectifier and **bypass** input	I_{cc}/I_{cw}
Multiple input ports	Port 1 e.g. rectifier input	I_{cc1}/I_{cw1}
	Port 2 e.g. **bypass** input	I_{cc2}/I_{cw2}
	Combined ports 1 and 2	Lesser of I_{cc1}/I_{cw1} or I_{cc2}/I_{cw2}

Except where exempted in 5.2.3.103.4, conditional short-circuit **ratings** and withstand current **ratings** shall be verified by application of a short-circuit across the AC output port only in modes of operation wherein the output power is delivered by the AC input through a low impedance path. Refer to 5.2.3.103.1 for general procedure, and to Figures EE.1 to EE.3 for a typical circuit for implementation of the test of Clause EE.4.

The effects of faults that originate within the **UPS** are addressed in 4.2, except as follows.

Where a **UPS** has an AC input port with no **low impedance path** to the AC output port, compliance is checked by applying the short-circuit immediately before the point where the input path no longer presents negligible impedance. The point of application of the short-circuit may be internal to the **UPS**.

*Compliance shall be verified in the modes of operation wherein the output power is or, as a result of the short-circuit, becomes delivered, by the AC input through a **low impedance path**. Verification in **stored energy mode** is not required.*

NOTE 1 Examples of such modes of operation include:

– input voltage and frequency dependent (VFD) **UPS** operating in normal and/or **bypass** modes;
– input voltage independent (VI) **UPS** operating in normal and/or **bypass** modes;
– input voltage and frequency independent (VFI) **UPS** operating in **bypass** mode;
– **UPS** with built-in maintenance **bypass** switch when operating in maintenance **bypass** mode.

NOTE 2 **UPS** performance classifications VFD, VI and VFI are detailed in IEC 62040-3:2011.

4.3.104 Protection of the energy storage device

The energy storage device whether internal (integral) or external to the **UPS** unit shall be protected against fault current and against overcurrent.

An overcurrent protective device providing the functions of a disconnect device as stated in 4.101.2 shall be located in close proximity to the energy storage device, and the following requirements apply:

a) for the purpose of interrupting a fault current supplied by the energy storage device, the overcurrent protective device shall:
   – not require a current greater than the fault current available,
   – be rated to interrupt the maximum fault current available.

b) the cables interconnecting the energy storage device, the overcurrent protective device and the **UPS** unit shall be rated to support:

– the maximum current required by the **UPS** when operating in **stored energy mode,**

– the maximum fault current available.

The maximum fault current available shall be determined at the output of the fully charged energy storage device.

Compliance with requirements a) and b) above is verified by investigation of the characteristics of the protective device(s) and of the cables as supplied (or as specified for installation) while considering the energy storage device (or range of energy storage devices) to be supported.

NOTE Guidance for current **rating** of cables is found in IEC 60287-1-1.

4.3.105 Unsynchronised load transfer

This abnormal condition is to be simulated on a **UPS** which employs either a solid state or manual switch that connects the bypass source of supply to the **UPS** output.

Compliance is determined by conducting the test in 5.2.3.105.

NOTE This test is to simulate the effects of foreseeable wiring connection misplacements in the sources of supply to the **UPS**.

4.4 Protection against electric shock

Subclause 4.4 in IEC 62477-1:2012 applies, except as follows:

4.4.2.2.2 Selection tables for contact area and skin humidity condition

Subclause 4.4.2.2.2 in IEC 62477-1:2012 applies, except as follows:

Add the following text:

UPS within the scope of this document are by default specified for indoor dry environmental service conditions and for access by an **ordinary person**. For such default application, select the following area and condition:

a) body contact area: "Hand" (Table 3)

b) skin humidity condition: "Dry" (Table 4)

NOTE The area and condition above determine the decisive voltage category of the **UPS** to be DVC A, thus limiting the voltage on touchable parts to equal or less than 30 V RMS, 42,4 V peak or 60 V DC.

Different body contact area and/or skin humidity condition shall be applied where different environmental service conditions and/or operator access restrictions apply.

For equipment to be installed in a **restricted access area,** the following exceptions are permitted.

- Contact with bare parts of a circuit at **hazardous voltage** with the test finger is permitted (see Figure M.101). However, such parts shall be so located or guarded that unintentional contact is unlikely.
- Bare parts that present a **hazardous energy** level shall be located or guarded so that unintentional bridging by conductive materials that might be present is unlikely.
- No requirement is specified regarding contact with bare parts of circuits complying with the limits of decisive voltage classifications DVC A1, A2, A3, A or B (see Table A.101).

In deciding whether or not unintentional contact is likely, account is taken of the need to gain access past, or near to, the bare parts. For determination of a **hazardous energy** level, see 4.5.1.2 in IEC 62477-1: 2012.

Compliance is checked by inspection and measurement.

4.4.3.3 Protection by means of enclosures or barriers

Replace the existing title and text of 4.4.3.3 in IEC 62477-1: 2012 by the following:

4.4.3.3 Openings

Accessible openings in enclosures shall comply with minimum protection degree IP2X in accordance with IEC 60529 when installed in accordance with manufacturer's instructions unless a greater level of protection is stated by the manufacturer.

Openings shall not exceed 5 mm in any dimension when such openings are located in the top of an enclosure not exceeding a height of 1,8 m and when located above bare parts presenting a **hazardous voltage**, unless the construction prevents vertical access to such parts, for example, by means of design (see Figure 101).

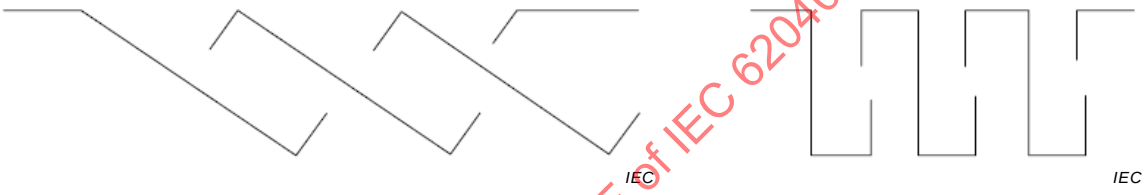


Figure 101 – Examples of design of openings preventing vertical access

Compliance is checked by inspection as per 5.2.2.2 in this document.

4.4.7.1.1 Influencing factors

Subclause 4.4.7.1.1 in IEC 62477-1:2012 applies, except as follows:

Add the following text:

The working voltage can also be measured in accordance with Annex A.

4.4.7.1.2 Pollution degree

Subclause 4.4.7.1.2 in IEC 62477-1:2012 applies, except as follows:

Add the following text:

Unless otherwise specified by the **UPS** manufacturer, the **UPS** shall be suitable for installation in environments in which the pollution degree is 2 (PD2), see IEC 62477-1: 2012, Table 8.

4.4.7.1.3 Overvoltage category (OVC)

Subclause 4.4.7.1.3 in IEC 62477-1:2012 applies, except as follows:

Add the following text:

As a minimum, the **UPS** shall be suitable for installation in environments presenting overvoltage categories listed in Table 102.

For **UPS** units designed to be part of a parallel configuration, the current to be considered in Table 102 is that provided by the parallel configuration.

Table 102 – Overvoltage categories

Rated UPS output current I (RMS) A	**Overvoltage category** **OVC**[a]
$I \leq 16$	II
$16 < I \leq 75$	II
$75 < I \leq 400$	II
$400 < I \leq 500$	III
$500 < I$	III
NOTE In general and depending on the mode of operation, the OVC to which the critical load is subjected is that of the **UPS** input. This can be reduced through overvoltage reduction techniques (see Annex I of IEC 62477-1:2012). [a] The OVC specified represent those of typical installations in accordance with 4.4.7.1.3. Different OVC can apply under special conditions (see Annex I of IEC 62477-1:2012).	

If measures are provided to reduce impulses of overvoltage category III to values of category II, or values of category II to values of category I, appropriate insulation may be designed to the reduced values, provided that following a single failure, e.g. of the reduction measure, at least the basic insulation requirements for the original overvoltage category shall be fulfilled.

NOTE For guidance on overvoltage category reduction, see Annex I of IEC 62477-1:2012.

4.4.7.1.7 Components bridging insulation

Subclause 4.4.7.1.7 in IEC 62477-1:2012 applies, except as follows:

Add the following text:

A capacitor connected between two line conductors in a primary circuit, or between one line conductor and the neutral conductor or between the primary circuit and protective earth shall comply with one of the subclasses of IEC 60384-14 or with the requirement of 4.4.7.1.7 of IEC 62477-1: 2012 and shall be used in accordance with its rating for voltage and current.

For equipment to be connected to IT power distribution systems components connected between line and earth shall be rated for the line-to-line voltage. However, capacitors rated for the applicable line-to-neutral voltage are permitted in such applications if they comply with subclass Y1, Y2 or Y4 of IEC 60384-14.

4.4.7.2.2 Circuits connected to mains supply

Subclause 4.4.7.2.2 in IEC 62477-1:2012 applies, except as follows:

Add the following text:

A preventive maintenance plan is an alternative to monitoring, as long as the continuity of the overvoltage reduction remains the same.

4.4.7.7 PWB spacings for functional insulation

Subclause 4.4.7.7 in IEC 62477-1:2012 applies, except as follows:

Replace, in the second paragraph, the first sentence by the following text:

Decreased spacing for components mounted on PWB or decreased spacing on PWB are permitted when all the following are satisfied:

4.4.9 Capacitor discharge

Clause 4.4.9 of IEC 62477-1: 2012 applies except as follows:

Replace, in the first paragraph, the two bullet points by the following text:

- for pluggable **UPS** type A, the discharge time shall not exceed 1 s or the hazardous live parts shall be protected against direct contact by at least IPXXB (see 4.4.3.3);
- for pluggable **UPS** type B, the discharge time shall not exceed 5 s or the hazardous *live parts* shall be protected against direct contact by at least IPXXB (see 4.4.3.3);
- for permanently connected **UPS**, the discharge time shall not exceed 15 s.

4.5 Protection against electrical energy hazards

4.5.2 Service access areas

Subclause 4.5.2 in IEC 62477-1:2012 applies except as follows:

Add, after the second paragraph, the following text:

This requirement does not apply to terminals covered by 4.4.9.

In a **service access area**, the following requirements apply.

Bare parts at **hazardous voltage** shall be located or guarded so that unintentional contact with such parts is unlikely during service operations involving other parts of the equipment. Bare parts at **hazardous voltage** shall be located or guarded so that accidental shorting to parts at non-hazardous potentials (for example, by **tools** or test probes used by a **service person**) is unlikely.

Compliance is checked by inspection.

4.6 Protection against fire and thermal hazards

Subclause 4.6 in IEC 62477-1:2012 applies, except as follows:

4.6.2.2 Components within a circuit representing a fire hazard

Subclause 4.6.2.2 in IEC 62477-1:2012 applies, except as follows:

Add the following text:

Batteries shall have a flammability class HB or better.

4.6.3.1 General

Subclause 4.6.3.1 in IEC 62477-1:2012 applies, except as follows:

*Replace "PECS" by "**UPS**".*

Replace, in the second paragraph, the first bullet point by the following text:

- circuits inside of an enclosure are within the limits of limited power sources in 4.6.5 of this document.

4.6.3.2 Flammability of enclosure materials

Subclause 4.6.3.2 in IEC 62477-1:2012 applies, except as follows:

Replace the second paragraph with the following new paragraph:

Materials are considered to comply without test if, in the minimum thickness used, the materials are of flammability class 5VB or better, according to IEC 60695-11-20.

Add, after the second paragraph, the following new paragraph:

For movable **UPS** having a total mass not exceeding 18 kg, materials are considered to comply without test if, in the minimum thickness used, the materials are of flammability class of V-1 or better, according to IEC 60695-11-10.

4.6.3.3.2 Openings in the top and side of fire enclosures

Subclause 4.6.3.3.2 in IEC 62477-1:2012 applies, except as follows:

Replace the third paragraph by the following text:

The test requirements are found in 5.2.2.2 of this document.

Replace, in the fourth paragraph, "IP3X" by "IP2X".

4.6.4 Temperature limits

4.6.4.1 Internal parts

Subclause 4.6.4.1 in IEC 62477-1:2012 applies, except as follows:

*Replace, in the first paragraph, the words "*when tested in accordance with*" by "*when tested in normal mode in accordance with*".*

Add, after the first paragraph, the following text:

Magnetic components shall not attain temperatures in excess of those in Table 103 when tested in stored energy mode in accordance with the ratings of the equipment.

NOTE Table 103 provides additional temperature limits for infrequent and occasional occurrences.

Table 103 – Maximum temperature limits for magnetic components during stored energy mode of operation

Insulation class °C	Temperature by average resistance method °C	Temperature by thermocouple methods °C
105	127	117
120	142	132
130	152	142
155	171	161
180	195	185
200	209	199
220	216	206
250	234	224

4.6.5 Limited power sources

Subclause 4.6.5 in IEC 62477-1:2012 applies, except as follows:

Add, at the end of the first paragraph, the following text:

Compliance to both the maximum allowed current and maximum **apparent power** available from the power source is required.

Replace, in the second paragraph, letter b) by the following text:

b) a linear or non-linear impedance limits the output in compliance with Table 16. If a positive temperature coefficient device (PTC) is used, it shall pass the tests specified in IEC 60730-1, Clauses 15, 17, J.15 and J.17; or

4.7 Protection against mechanical hazards

Subclause 4.7 in IEC 62477-1:2012 applies, except as follows:

Add the following subclause:

4.7.101 Protection in service access area

Moving parts that can cause injury to persons during service operations shall be located, or protection shall be provided, such that unintentional contact with the moving parts is not likely.

Compliance is checked by inspection.

4.8 Equipment with multiple sources of supply

Replace the existing text of 4.8 in IEC 62477-1:2012 by the following:

4.8.101 General

If equipment is provided with more than one supply connection (for example, with different voltages or frequencies or as backup power), the design shall be such that all of the following conditions are met:

- separate means of connection are provided for different circuits;

- supply plug connections, if any, are not interchangeable if a hazard could be created by incorrect plugging;
- hazards, within the meaning of this document, shall not be present under normal or **single fault condition**s due to the presence of multiple sources of supply. Actions such as disconnection or de-energizing of a supply are considered a normal condition.

Compliance is checked by evaluation in accordance with IEC 62477-1:2012, 4.2.

Information is to be provided with the equipment indicating the presence of multiple sources of supply and disconnection procedures (see IEC 62477-1:2012, 6.5.5).

NOTE Examples of the types of hazards considered are:

a) **Backfeed**;

b) Unintentional islanding;

c) Higher touch current levels with multiple sources connected simultaneously (if that is a normal condition for the equipment);

d) Hazard resulting from damage to one or more connected sources due to energy from another source, such as from the mains to a generator;

e) Damage to wiring due to currents higher than the wiring is designed for flowing from another source.

4.8.102 Backfeed protection

A **UPS** shall prevent **hazardous voltage** or **hazardous energy** from being present on the **UPS** input AC terminals after interruption of the input AC power.

No shock hazard shall exist at AC input terminals when measured 1 s after de-energization of AC input for pluggable **UPS**, or 15 s for permanently connected **UPS**.

For permanently connected **UPS**, **backfeed protection** may be implemented external to the **UPS** with the use of an AC input line isolation device.

In this case, the **backfeed protection** requirement applies to the input terminals of the isolation device. The **UPS** supplier shall provide or specify a suitable isolating device which shall include additional labelling and instructions in accordance with 6.4.3.101.

Compliance is checked by inspection of the equipment and relevant circuit diagram, and by simulating fault conditions in accordance with 5.2.3.101.

When an air gap is employed for **backfeed protection**, the provision of IEC 62477-1:2012, Table 10 and Table 11 for creepage and clearance distances applies in addition to the following.

a) Subject to confirmation from the manufacturer, the **UPS** output, in **stored energy mode**, may be considered a transient free circuit of overvoltage category I (for this purpose identify the overvoltage category I value in IEC 62477-1:2012, Table 9, by using the appropriate **UPS** RMS system output voltage). An impulse voltage withstand test is not required since there is no transient overvoltage present when the AC main input supply is not available. Therefore, the overvoltage category values apply without an impulse test.

b) The creepage and clearance distances shall meet the requirements for pollution degree 2 (see IEC 62477-1:2012, Table 10 and Table 11).

c) Reinforced or equivalent insulation of the **UPS** output to the **UPS** input applies if during **stored energy mode** of operation not all input poles are isolated by the **backfeed protection** device. In all other cases, basic insulation is acceptable. Impulse withstand voltage is not required since there is no impulse when the AC main input supply is not available. Therefore, the pollution degree values apply without an impulse test.

NOTE 1 A contactor is an example of an isolation device presenting an air gap.

NOTE 2 One method of obtaining insulation equivalent to reinforced insulation is to combine an air gap meeting the basic insulation requirements and a solid-state power isolation device(s) as described in 5.2.3.101.5.

Compliance is checked by inspection

4.9 Protection against environmental stresses

Subclause 4.9 in IEC 62477-1:2012 applies, except as follows:

Add the following text:

The **UPS**, as a minimum, shall comply with the following indoor conditions: climatic, pollution degree, and humidity condition of the skin as part of the environmental service condition 3K2 of Table 18 of IEC 62477-1:2012. The manufacturer may elect to comply with environmental service conditions more onerous than 3K2 subject to the **UPS** being marked accordingly (see 6.2).

4.10 Protection against sonic pressure hazards

Replace the existing text of 4.10 in IEC 62477-1:2012 by the following:

The requirements for protection against sonic pressure hazards are considered to be beyond the scope of this document because such requirements are dependent on local regulations.

4.11 Wiring and connections

Subclause 4.11 in IEC 62477-1:2012 applies, except as follows:

4.11.8.2 Connecting capacity

Subclause 4.11.8.2 in IEC 62477-1:2012 applies, except as follows:

Add the following text:

The **UPS** manufacturer shall indicate whether the terminals are suitable for connection of copper or aluminium conductors, or both. The terminals shall be such that the external conductors may be connected by a means (screws, connectors, etc.) which ensures that the necessary contact pressure corresponding to the current **rating**, the short-circuit strength of the apparatus and the circuit are maintained.

In the absence of a special agreement between the **UPS** manufacturer and the purchaser, terminals shall be capable of accommodating copper conductors from the smallest to the largest cross-sectional areas corresponding to the appropriate **rated current** (see Annex AA).

Compliance is checked by inspection, by measurement and by fitting at least the smallest and largest cross-sectional areas of the appropriate range in Annex AA.

Add the following subclauses:

4.11.101 Non-detachable cords

4.11.101.1 Cord guard

A **cord** guard shall be provided at the **cord** inlet opening of equipment that has a non detachable **cord** and is intended to be moved while in operation. Alternatively, the inlet or bushing shall be provided with a smoothly rounded bell-mouthed opening having a radius of curvature equal to at least 150 % of the overall diameter of the **cord** with the largest cross-sectional area to be connected.

Cord guards shall:

- be so designed as to protect the **cord** against excessive bending where it enters the equipment,
- be of insulating material,
- be fixed in a reliable manner, and project outside the equipment beyond the inlet opening for a distance of at least five times the overall diameter or, for flat **cords**, at least five times the major overall cross-sectional dimension of the **cord.**

4.11.101.2 Cord anchorages and strain relief

For equipment with a non-detachable **cord**, a cord anchorage shall be supplied such that:

- the connecting points of the **cord** conductors are relieved from strain, and
- the outer covering of the **cord** is protected from abrasion.

It shall not be possible to push the **cord** back into the equipment to such an extent that the **cord** or its conductors, or both, could be damaged or internal parts of the equipment could be displaced.

For non-detachable **cords** containing a protective earthing conductor, the construction shall be such that, if the **cord** should slip its anchorage, placing a strain on conductors, the protective earthing conductor shall be the last to take the strain.

The cord anchorage shall either be made of insulating material or have a lining of insulating material complying with the requirements for supplementary insulation. However, where the cord anchorage is a bushing that includes the electrical connection to the screen of a screened **cord,** this requirement shall not apply.

The construction of the cord anchorage shall be such that:

- **cord** replacement does not impair the safety of the equipment,
- for replacement **cords**, it is clear how relief from strain is to be obtained,
- the **cord** is not clamped by a screw that bears directly on the cord, unless the cord anchorage, including the screw, is made of insulating material and the screw is of comparable size to the diameter of the **cord** being clamped,
- methods such as tying the **cord** into a knot or tying the cord with string are not used, and
- the **cord** cannot rotate in relation to the body of the equipment to such an extent that mechanical strain is imposed on the electrical connections.

*Compliance is checked by inspection and by applying the following tests that are made with the type of **cord** supplied with the equipment.*

*The **cord** is subjected to a steady pull of the following value, applied in the most unfavourable direction:*

a) *30 N for **UPS** of mass up and to including 1 kg;*

b) *60 N for **UPS** over 1 kg and including 4 kg;*

c) *100 N for **UPS** over 4 kg.*

*The test is conducted 25 times, each time for duration of 1 s. During the tests, the **cord** shall not be damaged. This is checked by visual inspection, and by AC or DC voltage test (dielectric strength test) between the **cord** conductors and accessible conductive parts, at the test voltage appropriate for reinforced insulation.*

*After the tests, the **cord** shall not have been longitudinally displaced by more than 2 mm nor shall there be appreciable strain at the connections, and clearances and creepage distances shall not be reduced below the values specified in IEC 62477-1:2012, 4.4.7.4. and 4.4.7.5.*

Add the following subclauses:

4.101 UPS isolation and disconnect devices

4.101.1 Emergency switching (disconnect) device

A **UPS** shall be provided with an integral single emergency switching device (or terminals for the connection of the remote emergency switching device), which prevents further supply to the load by the **UPS** in any mode of operation. If reliance is placed on additional disconnection of supplies in the building wiring installation, the installation instructions shall so state. The requirement is not mandatory for pluggable **UPS** if permitted by national regulations.

NOTE In some countries, an emergency switching device is called "EPO" (emergency power off).

Compliance is checked by inspection and analysis of relevant circuit diagrams.

4.101.2 Normal disconnect devices

Means shall be provided to disconnect the **UPS** from the AC and DC supplies for service and testing by **skilled person**.

Means of isolation and disconnect devices for internal and external DC supplies, for example a battery bank, shall open all ungrounded conductors connected to the DC supply.

Means of isolation and disconnect devices for external AC supplies shall open all ungrounded conductors connected to the AC supply.

NOTE 1 Unless applicable for functional use, the means of disconnection are generally located either in the **service access area** or external to the equipment, and specified in the installation instructions. For further guidance about selection of disconnect devices, refer to IEC 60947-3:2008, Table 2.

NOTE 2 Disconnect devices for service and test purposes are generally designed for operation under no-load, provided that the critical load can be transferred as applicable by other means, for example by using a static transfer switch.

If operation of a disconnect device alters the **UPS** output voltage with respect to the protective earth potential, then operation of that device shall be alarmed. Alternatively, an appropriate warning label shall be located adjacent to that disconnect device or to its command.

NOTE 3 Such a situation arises upon opening of a 4-pole input isolator that provides neutral reference to the **UPS**.

If the operating means of the disconnection device is operated vertically rather than rotationally or horizontally, the "UP" position of the operating means shall be the "ON" position.

Where a permanently connected **UPS** receives power from more than one external source, there shall be a prominent marking at each disconnect device giving adequate instructions for the removal of all power from the unit.

4.102 Stored energy source

4.102.1 General

Batteries, when selected as the stored energy source for use with **UPS**, shall be installed taking into account the requirements prescribed in 4.102.

Batteries can be installed in:

- separate battery rooms or buildings, or
- separate cabinets or compartments, indoor or outdoor, or
- battery bays or compartments within the **UPS** enclosure.

NOTE Requirements for installation of valve regulated batteries in a separate room, cabinet or compartment are subject to local regulation.

4.102.2 Accessibility and maintainability

When deemed necessary, access to battery poles and battery connectors shall be provided so that their fittings can be tested for correct tightening (torque) and be readjusted if required. Batteries with liquid electrolyte shall be so located that the battery cell caps are accessible for electrolyte tests and readjustment of electrolyte levels.

Compliance is checked by inspection and application of the tools and measuring equipment supplied or recommended by the battery manufacturer for the prevailing conditions.

4.102.3 Distance between battery cells

Battery cells or blocks, as applicable, shall be mounted for the purpose of complying with ventilation, battery temperature and insulation requirements in accordance with the requirements from the battery manufacturer.

The batteries shall be so located and mounted that the terminals of cells are prevented from coming into undesirable contact with terminals of adjacent cells, or with metal parts of the battery compartment, as the result of shifting of the battery.

Compliance is checked by inspection and by analysis of the battery manufacturer data-sheet.

4.102.4 Case insulation

Cells in conductive casings shall have adequate insulation between each other and to cabinets or compartments. The insulation shall meet the AC or DC voltage test (dielectric strength test) requirements of IEC 62477-1:2012, 5.2.3.4.

Compliance is checked by test.

4.102.5 Electrolyte spillage

To prevent effects of electrolyte spillage from the battery, adequate protection such as an electrolyte-resistive coating on the battery trays and cabinets shall be provided.

This requirement does not apply to valve regulated lead-acid batteries.

Compliance is checked by inspection.

4.102.6 Ventilation and hydrogen concentration

A **UPS** enclosure or compartment housing a vented battery

- shall comply with the ventilation requirements of Annex CC,
- may contain arc-producing elements such as open fuse links and the contacts of circuit breakers, relays, switches, disconnectors, switch-disconnectors and fuse-combination units, only if any such parts are mounted at least 100 mm below the lowest battery vent, and
- shall not vent into other closed spaces where arc-producing elements are located.

For the purpose of 4.102.6, the following components are not considered arc-producing elements: connectors, monitoring sensors (such as thermistors) and sand enclosed fuses. For battery rooms, proper information on the required flow of air shall be provided in the installation instructions where the battery installation is supplied with the **UPS**.

Compliance is checked by inspection, calculation or measurement.

4.102.7 Charging voltages

The **UPS** shall protect the batteries against excessive voltages, including under a single fault condition within the charger. Protection may be accomplished by turning off the charger or by interrupting the charging current.

Compliance is checked by circuit evaluation or test.

4.102.8 Battery circuit protection

4.102.8.1 Overcurrent and earth fault protection

A battery supply circuit shall be provided with overcurrent and **earth fault** protection, and shall comply with the requirements described in 4.102.8.

NOTE Earth-fault in the context of 4.102.8 differs from residual, leakage or touch current, covered in IEC 62477-1:2012, 4.4.8.

4.102.8.2 Location of protective devices

The protective device shall be constructed and positioned so that arc-producing elements in this device, if any, are not subject to operation where hazardous levels of hydrogen mixture with air may be present. Where the batteries are installed in a separate room or cabinet, the overcurrent protective device shall be located in close proximity to the battery in accordance with the installation regulation applying.

NOTE Examples of locations where hazardous levels of hydrogen mixture with air can be present include those on top of battery vents and enclosed spaces where hydrogen can be trapped ("air-pockets").

Compliance is checked by inspection.

4.102.8.3 Rating of protective devices

The **rating** of the overcurrent protective device shall be such as to avoid hazards due to internal faults of the **UPS**, and circuit analysis shall be carried out for the battery circuit in accordance with IEC 62477-1:2012, 4.2.

For a **UPS** to be used with a separate battery supply, the **rating** of the overcurrent protective device shall be indicated in the instruction manual and shall take into account the current **rating** of the conductors to be connected between the **UPS** and battery supply, as well as the fault current capability of the battery supply.

Where the battery terminals are not directly grounded, the device shall protect all terminals.

Compliance is checked by analysis and inspection.

4.103 UPS connection to telecommunication lines

Terminals in the **UPS** that are intended for connection to telecommunication lines shall comply with the relevant telecommunication network voltage (TNV) classification. Refer to Table A.101 for a TNV classification comparison with decisive voltage classification (DVC).

Compliance is checked by analysis.

5 Test requirements

Clause 5 of IEC 62477-1 applies, except as follows:

5.1.5.3 Operating parameters for tests

Subclause 5.1.5.3 in IEC 62477-1:2012 applies, except as follows:

Replace the last bullet point by the following text:

- adjustments of thermostats, regulating devices or similar controls available to an **ordinary person**:
  - without the use of a tool,
  - with the use of a tool deliberately provided.

For **UPS** with external controls intended to be installed in a **restricted access area**, these controls shall be set to manufacturer's settings.

5.1.7 Test overview

Replace the existing text of 5.1.7 in IEC 62477-1:2012, including Table 22, by the following:

Table 22 provides an overview of the type, routine and sample testing.

5.1.7.101 UPS test overview

Table 22 – Test overview

Test	Type	Routine	Sample	Requirement(s)		Specification(s)	
				IEC 62040-1	IEC 62477-1	IEC 62040-1	IEC 62477-1
Visual inspection	X	X					5.2.1
Mechanical tests							
Clearance and creepage distances test	X				4.4.7.1, 4.4.7.5		5.2.2.1
Non-accessibility test, including energy hazard test after disconnection	X			4.4.3.3	4.5.1.1		5.2.2.2
Ingress protection test (IP **rating**)	X				4.12.1		5.2.2.3
Enclosure integrity test	X				4.12.1		5.2.2.4
Deflection test	X				4.12.1		5.2.2.4.2
Steady force test, 30 N	X				4.12.1		5.2.2.4.2.2
Steady force test, 250 N	X				4.12.1		5.2.2.4.2.3
Impact test	X				4.12.1		5.2.2.4.3
Drop test	X				4.12.1		5.2.2.4.4
Stress relief test	X				4.12.1		5.2.2.4.5
Stability test	X				4.12.1		5.2.2.5
Wall or ceiling mounted equipment test	X				4.12.1		5.2.2.6

Test	Type	Routine	Sample	Requirement(s)		Specification(s)	
				IEC 62040-1	IEC 62477-1	IEC 62040-1	IEC 62477-1
Rack mounted equipment test	X			Annex GG		5.2.2.6.102	
Handles and manual control securement test	X				4.12.1		5.2.2.7
Cord guard test	X			4.11.101		5.2.2.101	
Electrical tests							
Impulse voltage test	X[a,c,f]		X[b]		4.4.3.2, 4.4.5.4, 4.4.7.1, 4.4.7.10.1, 4.4.7.10.2, 4.4.7.8.3		5.2.3.2
AC or DC voltage test (dielectric strength test)	X[f]	X[e]			4.4.3.2, 4.4.5.4, 4.4.7.1, 4.4.7.10.1, 4.4.7.10.2, 4.4.7.8.4.2		5.2.3.4
Partial discharge test	X[a,f]		X[b]		4.4.7.1, 4.4.7.10.2, 4.4.7.8.3		5.2.3.5
Protective impedance test	X	X			4.4.5.4		5.2.3.6
Touch current measurement test	X				4.4.4.3.3		5.2.3.7
Capacitor discharge test	X				4.4.9		5.2.3.8
Limited power source, test including energy hazards test	X				4.5.1.2, 4.6.5		5.2.3.9
Temperature rise test	X				4.6.4		5.2.3.10
Backfeed protection test	X			4.8.102		5.2.3.101	
Protective equipotential bonding	X	X			4.4.4.2.2		5.2.3.11, 5.2.4.3
Input current	X			4.3.101		5.2.3.102	
Transformer protection	X			4.3.102		5.2.3.104	
Stored energy source tests							
Case insulation test	X	X		4.102.4			5.2.3.4
Ventilation and hydrogen concentration	X			4.102.6		Annex CC	
Charging voltages	X			4.102.7		Annex CC	
Wiring test	X			4.11.101	4.11		5.2.3.10
Abnormal operation tests							
Output short-circuit test	X				4.3.2.3		5.2.4.4
Short-time withstand current	X			4.3.103		5.2.3.103	
Unsynchronised load transfer test	X			4.3.105		5.2.3.105	

Test	Type	Routine	Sample	Requirement(s)		Specification(s)	
				IEC 62040-1	IEC 62477-1	IEC 62040-1	IEC 62477-1
Output overload test	X				4.3		5.2.4.5
Breakdown of components test	X				4.2		5.2.4.6
PWB short-circuit test	X				4.4.7.7		5.2.4.7
Loss of phase test	X				4.2		5.2.4.8
Cooling failure tests	X				4.2, 4.7.2.3.6		5.2.4.9
Inoperative blower test	X				4.2		5.2.4.9.2
Clogged filter test	X				4.2		5.2.4.9.3
Loss of coolant test	X				4.7.2.3.6		5.2.4.9.4
Material tests							
High current arcing ignition test	X[a]				4.4.7.8.2		5.2.5.2
Glow-wire test	X[a]				4.4.7.8.2		5.2.5.3
Hot wire ignition test	X[a]				4.4.7.8.2		5.2.5.4
Flammability test	X[a]				4.6.3		5.2.5.5
Flaming oil test	X				4.6.3.3.3		5.2.5.6
Cemented joints test	X				4.4.7.9		5.2.5.7
Environmental tests							
Dry heat test	X[d]				4.9		5.2.6.3.1
Damp heat test	X[d]				4.9		5.2.6.3.2
Hydrostatic pressure test	X	X			4.7.2.3.3		5.2.7

[a] Type testing of a component is not required when such type testing is performed by the supplier of the relevant component (see IEC 62477-1:2012, 5.1.5.2).

[b] Sample testing of a component only applies when required by the relevant component standard or where a component standard does not exist.

Sample testing is not required when such sample testing is performed by the supplier of the relevant component.

[c] Compliance with impulse voltage type test requirements may be satisfied in conjunction with IEC 62040-2:2005 immunity type tests (provided that the relevant safety criteria are observed).

[d] Compliance with dry and damp heat type test requirements is also satisfied in conjunction with IEC 62040-3:2011 dry and damp heat type tests (provided that the relevant safety criteria are observed).

[e] Preconditioning as described in IEC 62477-1:2012, 5.2.3.1, is not required.

[f] Multiple test are permitted following one single preconditioning as described in IEC 62477-1:2012, 5.2.3.1.

5.2 Test specification

Subclause 5.2 in IEC 62477-1:2012 applies, except as follows:

5.2.2.2 Non-accessibility test (type test)

Replace the existing text of 5.2.2.2 in IEC 62477-1:2012 by the following:

This test is intended to show that live parts protected by means of enclosures or barriers in compliance with 4.4.3.3 are not accessible.

This test shall be performed as a type test of the enclosure of a **UPS** as specified in IEC 60529 for the enclosure classification for protection against access to hazardous parts.

Except for openings preventing vertical access as noted below:

– A test probe for IP2X (12,5 mm Ø) shall not penetrate the top surface of the enclosure when probed from the vertical direction ±5° only.

Further, for **UPS** with a height not exceeding 1,8 m, such openings shall not exceed 5 mm in any direction as per 4.4.3.3.

Compliance is checked by inspection and test as above.

5.2.2.4.4 Drop test

Replace the existing text of 5.2.2.4.4 in IEC 62477-1:2012 by the following:

UPS with mass of 18 kg or less is subjected to the following test.

A sample of the complete equipment is subjected to three impacts that result from being dropped onto a horizontal surface in positions likely to produce the most adverse results.

The horizontal surface shall consist of hardwood at least 13 mm thick, mounted on two layers of plywood each 19 mm to 20 mm thick, all supported on a concrete or equivalent non-resilient floor.

The height of the drop shall be 750 mm.

Compliance is verified in accordance with the requirements in 5.2.2.4.1 of IEC 62477-1:2012.

5.2.2.6 Wall or ceiling mounted equipment test

Replace the existing title and text of 5.2.2.6 in IEC 62477-1:2012 by the following:

5.2.2.6 Wall, ceiling or rack mounted equipment test

5.2.2.6.101 Wall and ceiling mounted equipment test

The equipment is mounted in accordance with the manufacturer's instructions. A force in addition to the weight of the equipment is applied downwards through the geometric centre of the equipment, for 1 min. The additional force shall be equal to three times the weight of the equipment but not less than 50 N. The equipment and its associated mounting means shall remain secure during the test.

5.2.2.6.102 Rack mounted equipment test

Requirements for rack-mounted equipment are listed in Annex GG.

Add the following subclause:

5.2.2.101 Cord guard test

The equipment is so placed that the axis of the **cord** guard, where the **cord** leaves it, projects at an angle of 45° when the **cord** is free from stress. A mass equal to 10 D^2 g is then attached to the free end of the cord, where D is the overall diameter of, or for flat cords, the minor overall dimension of the cord, in millimeters. If the cord guard is of temperature-sensitive material, the test is made at 23 °C ± 2 °C. Flat cords are bent in the plane of least resistance. Immediately after the mass has been attached, the radius of curvature of the **cord** shall nowhere be less than 1,5 D.

*Compliance is checked by inspection, by measurement and, where necessary, by the test above with the **cord** as delivered with the equipment.*

5.2.3 Electrical tests

5.2.3.9 Limited power source test (type test)

Replace the existing text of 5.2.3.9 in IEC 62477-1:2012 by the following:

When required by 4.6.5, a limited power circuit shall be tested as below, with the equipment operating under normal operating conditions.

In case the limited power source requirement depends on overcurrent protective device(s) in Table 17, the device(s) shall be short-circuited.

With the limited power source in normal operating condition, and with a variable resistive load being the only load connected to the limited power source, the restive load shall be adjusted to obtain the maximum **apparent power**. Further adjustment is made, if necessary, to maintain the maximum **apparent power** for the time period indicated in Table 16 or Table 17, as applicable.

With the limited power source in normal operating condition, and with a variable resistive load being the only load connected to the limited power source, the restive load shall be adjusted to obtain the maximum current. Further adjustment is made, if necessary, to maintain the maximum current for the time period indicated in Table 16 or Table 17, as applicable.

Simulated faults in a regulating network, required according to 4.6.5, c), are applied under the above maximum measured values.

The test is passed, if after the test period the maximum available **apparent power** and maximum available current do not exceed the limits indicated in Table 16 or Table 17, as applicable.

5.2.3.10 Temperature rise test (type test)

Replace the existing ninth paragraph of 5.2.3.10 in IEC 62477-1: 2012 by the following:

No corrected temperature of the material or component shall exceed the temperature in Table 14 in IEC 62477-1: 2012 or Table 103 as applicable.

Add the following subclauses:

5.2.3.101 Backfeed protection test (type test)

5.2.3.101.1 General

A **UPS** shall not allow excessive touch currents to be available between any pairs of input supply terminals of the **UPS** during its **stored energy mode** of operation. Where the measured open-circuit voltage does not exceed 30 V RMS (42,4 V peak, 60 V DC), the touch current measurement need not be taken.

*Compliance is checked by tests as described in 5.2.3.101.2, 5.2.3.101.3 and 5.2.3.101.5, if applicable. The single-fault condition shall be determined by applying a short-circuit across any components where failure could adversely affect the **backfeed protection**, or by disconnecting such components.*

5.2.3.101.2 Test for pluggable UPS

The **UPS** shall initially operate in normal mode. The AC input terminals or plug(s) shall then be disconnected. This shall cause the **UPS** to operate in **stored energy mode**. When tested under no-load, under full-load and under load-induced change of reference potential conditions as described in 5.2.3.101.4, the following complying performance shall be verified:

a) the current shall not exceed 3,5 mA when measured between any two input terminals or parts accessible by an **ordinary person**, using the measurement instruments shown in Annex L;

b) the protection shall operate within 1 s for pluggable type A and within 5 s for pluggable type B **UPS** of the disconnection of the input terminals.

A single-fault condition shall then be applied. The test above shall be repeated and the compliance shall again be verified.

5.2.3.101.3 Test for permanently connected UPS

The **UPS** shall initially operate in normal mode. The AC input terminals, except for the protective earth conductor, shall then be disconnected from the AC supply. This shall cause the **UPS** to operate in **stored energy mode**. When tested under no-load and under full-load conditions, the following complying performance shall be verified:

a) the current shall not exceed 3,5 mA when measured between any two input terminals, using the measurement instruments shown in Annex L;

b) the protection shall operate within 15 s of the disconnection of the input terminals.

A single-fault condition shall then be applied. The test above shall be repeated and the compliance shall again be verified.

Where a **backfeed protection** isolation device is provided externally, compliance shall be determined by relevant circuit diagram inspection and by demonstrating that the means required to operate the external **backfeed** isolating device is within the **UPS** manufacturer's specifications for such circuit to operate.

5.2.3.101.4 Method to simulate the load-induced change of reference potential for pluggable UPS

The method detailed in 5.2.3.101.4 is used to create the change of reference potential required in 5.2.3.101.2. Change of reference potential can be caused by summation of otherwise complying load-induced earth currents and may arise when a **UPS** operate in **stored energy mode**. This condition is simulated by applying the test circuits of Figures 102 or 103. Figure 103 applies for 3-phase systems and simulates also the effect of asymmetrical single-phase loads.

NOTE 1 Some countries require the input neutral to be opened together with the phases either in the building installation or in the transmission system. In this case, the **UPS** voltage potential of neutral input is of concern unless it is clearly stated in the installation guide that the **UPS** is for use with symmetrical 3-phase loads only.

NOTE 2 5.2.3.101.4 applies to pluggable **UPS** (see 5.2.3.101.2).

NOTE 3 C simulates the capacitance of concern. The value of C is fixed as shown in Figures 102 and 103.

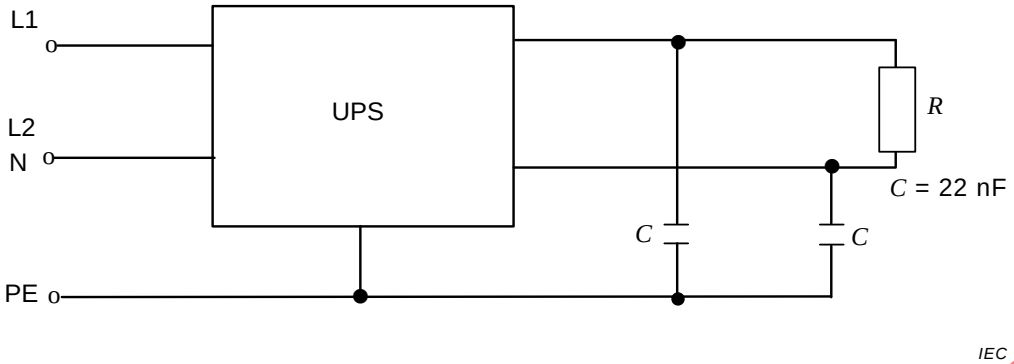


Figure 102 – Test circuit for load-induced change of reference potential – Single-phase output

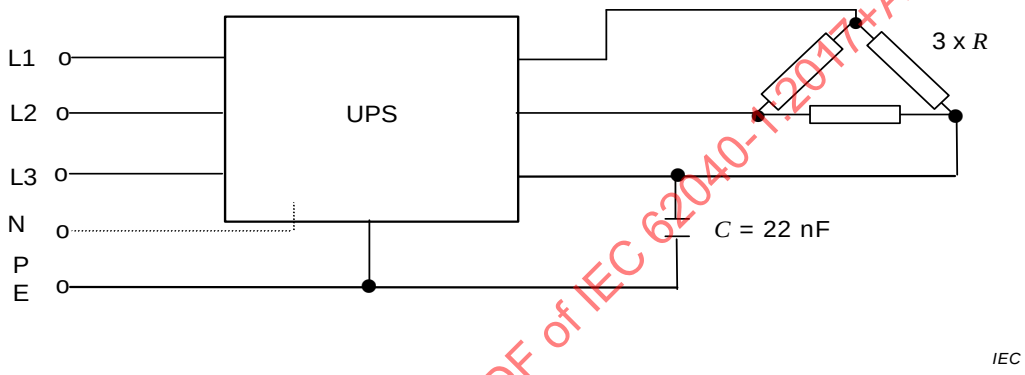


Figure 103 – Test circuit for load-induced change of reference potential – Three-phase output

The value of resistive load R shall be equal to that specified as the maximum load at unity power factor by the manufacturer.

5.2.3.101.5 Solid-state backfeed protection

In addition to 5.2.3.101.2 and 5.2.3.101.3 requirements, when **backfeed protection** relies on solid-state power isolation device(s), and if the isolation devices are not redundant, the components necessary to ensure **backfeed protection** shall withstand the effects of immunity requirements of IEC 62040-2:2005, Clause 7, and of environmental testing in IEC 62477-1:2012, 5.2.6.

5.2.3.102 Input current test

At rated input voltage in accordance with 6.2 a) and with the energy storage device disconnected (or fully charged), measure the steady state input current of the **UPS** when supplying its **rated load**.

Under the same rated load and input voltage conditions, measure or alternatively extrapolate the rated input current due to the combined effects resulting from battery recharge current at rated input voltage(s)

a) For **UPS** with separate **bypass** input, the **bypass** rated input current shall be evaluated.

b) For **UPS** with other inputs, the other rated input current shall be evaluated by test.

NOTE the manufacturer is alerted to the possible influence of input voltage tolerance on the input current being drawn.

Where the **UPS** has more than one rated input voltage, the input current is measured at each rated input voltage.

5.2.3.103 Short-time withstand current test (type test)

5.2.3.103.1 General procedure

The **UPS** AC input shall be connected to a supply capable of delivering the prospective test current in accordance with Table 104. The **UPS** shall be in the appropriate mode of operation (see 4.3.103.2) and otherwise operating without load and at rated input voltage and frequency. A short-circuit shall then be applied across the output terminals of the **UPS**. A **UPS** rated for multiple inputs may be tested at any of its rated input voltages, provided that applicable interrupting components have been certified or tested to interrupt the prospective test current at the highest rated input voltage. Each **UPS** AC input port shall be tested individually.

NOTE 1 The manufacturer can opt to perform additional tests at other **rated voltages** and currents.

NOTE 2 For consideration in a future edition of this document, the making capability of the short-circuit current into the **low impedance path** can be verified for safety purposes. Such verification could involve tests or analysis of component documentation. Examples include a **UPS** that, in normal mode of operation, does not supply the output terminals through a **low impedance path**, but that, upon application of a short-circuit across the output terminals, automatically transfers into a **low impedance path**.

NOTE 3 For consideration in a future edition of this document it will be evaluated whether tests would be permitted at voltages lower than rated and, subject to the phase current flowing throughout the minimum duration listed in Table 104, whether the manufacturer could then declare the I_{cw} to be the phase current recorded during the test.

UPS that provide single phase output shall be tested by applying a short-circuit across the output phase to neutral conductors.

UPS that provide multi-phase output shall be tested by applying a short-circuit across all output phase conductors. A single test with all phase conductors shorted together is an acceptable means of conducting the test.

UPS that provide multi-phase and a neutral output shall also be tested by placing a short-circuit across the neutral conductor and the phase conductor closest to the neutral terminal when the latter is provided. However, the phase-to-neutral test is not required when the neutral construction is at least as robust as that of the phase conductors in terms of cross-sectional area, mechanical support and clearance.

In the case where a **UPS** AC input port does not have a **low impedance path** between the input port and output port, the short-circuit shall be applied by means of a shorting cable or busbar of cross sectional area not less than the cross sectional area of the manufacturers recommended input wiring for one phase conductor. The length and installation of the shorting cable or busbar shall be selected so as to present negligible impedance.

The **UPS** shall be in the appropriate modes of operation (see 4.3.101.2) and otherwise operating without load and at rated input voltage and frequency.

A new **UPS** sample or a repaired **UPS** may be used for each short-circuit test.

Exception: It is acceptable to perform the test on an un-energized **UPS** if it can be shown by analysis that test results will not be affected.

NOTE 4 Examples of this exemption include testing of:

– a maintenance **bypass** path, and

– a **UPS** design that requires application of an internal short-circuit.

If the manufacturer declares a **rated short-time withstand current** higher than shown in Table 104, the declared value applies for test purposes.

The test setup is considered suitable when the prospective test current has been made available for the minimum duration listed in Table 104.

Table 104 – Short-time withstand current

Rated UPS output current I (RMS) A	**Prospective test current** [a]		**Initial asymmetric peak current ratio** [e] (I_{pk} / I_{cw})	**Minimum duration of prospective test current** [f] (cycles 50/60 Hz)
	I_{cp} (RMS) A [b]	**Typical power factor** [e]		
$I \leq 16$	1 000 [c d]	0,95	1,42	1,5
	3 000	0,9		
$16 < I \leq 75$	6 000	0,7	1,53	1,5
$75 < I \leq 400$	10 000	0,5	1,70	1,5
$400 < I \leq 500$	10 000	0,5	1,70	3,0
$500 < I$	$20 \times I$ or 50 kA whichever is the lower	0,5–0,3 × (I_{cp} / 20 – 500)/2000 or 0,2, whichever is the higher	(0,5 I_{cp}/20 + 3150) / 2000 or 2,2, whichever is the lower	3,0

NOTE 1 Depending on the characteristics of the **UPS**, the actual values observed during the test can be different from those listed in this table.

NOTE 2 Refer to 6.4.3.102 for conditions applying if the I_{cp} value declared is higher than that specified in this table.

NOTE 3 The minimum duration of prospective test current can be increased when required by national deviation.

[a] Prospective test current, in the context of this document, shall be understood as **prospective short-circuit current** (I_{cp}), see 3.122.

[b] Values compatible with IEC 60947-6-1: 2005/IEC 60947-6-1: 2005/AMD1:2013, Table 4.

[c] Pluggable **UPS** only.

[d] The typical fault current of public supply networks rated 75 A and below and intended to supply equipment with a **rated current** of 16 A or below can be calculated from the reference impedances in IEC TR 60725:2005: phase conductor 0,24 + j0,15 Ω and neutral conductor 0,16 + j0,10 Ω. For 230 V/400 V supplies, this results in typical fault currents of 0,5 kA (230 V) and 0,7 kA (400 V).

[e] From IEC 60947-1:2007, Table 16.

[f] From IEC 60947-6-1: 2005/IEC 60947-6-1:2005/AMD1:2013, 5.3.6.1.

Where a **UPS** has an AC input with no **low impedance path** between the AC input and the AC output, a short-circuit shall be applied immediately before the point where the input path no longer presents negligible impedance.

Compliance is checked when, at the conclusion of the test, the following criteria are satisfied.

a) *The UPS shall not have emitted flames, molten metal or burning particles, other than, for example, metal particles normally emitted from a circuit breaker when it clears a fault.*

NOTE 5 Further guidance, if applicable, is found in 4.6.

b) *There shall have been no arcing from live parts to the **UPS** chassis or enclosure.*

An intact enclosure test fuse as described in Annex EE indicates compliance.

*The use of an enclosure test fuse is not applicable for **UPS** with non conductive chassis or enclosure (e.g. plastic case).*

c) *Components, for example busbar supports, used for the mounting of live parts shall not break away from their initial position.*

d) *Any enclosure door shall not open rapidly (so as to cause injury) when protected only by its normal latch.*

e) *No conductor shall get pulled out of its terminal connector and there shall be no damage to the conductor or conductor insulation.*

f) *The **UPS** shall successfully pass the AC or DC voltage test (dielectric strength test) as specified in IEC 62477-1:2012, 5.2.3.4.*

5.2.3.103.2 Input port rated conditional short-circuit current

If the manufacturer declares a rated **conditional short-circuit current**, the **prospective short-circuit test current** (I_{cp}) shall be determined in accordance with Table 104.

If the manufacturer declares a rated **conditional short-circuit current rating** higher than shown in Table 104, the declared value shall be used as the **prospective short-circuit test current** (I_{cp}).

All **short-circuit protective device**s shall be installed within the **UPS** and, if applicable, external to the **UPS** in accordance with the manufacturers' instructions. If internal or external alternate **short-circuit protective device**s are specified by the manufacturer, testing shall be performed with each alternate **short-circuit protective device**.

NOTE 1 Multiple manufacturers or part numbers of molded case circuit breakers are examples of alternate **short-circuit protective devices**.

After the short-circuit test current is made available at the **UPS** input port, the test is considered complete when the minimum duration of the prospective test current listed in Table 104 has elapsed. This is irrespective of whether the current has ceased to flow upon opening of an internal or external protective device or mechanism, or due to the occurrence of a component failure.

The shorting switch SW or any installed shorting cables or busbars shall remain closed until the minimum duration of the prospective test current listed in Table 104 has elapsed.

Compliance is checked when, at the completion of the test, the following criteria are satisfied.

a) *The **UPS** shall not have emitted flames, molten metal or burning particles, other than, for example, metal particles normally emitted from a circuit breaker when it clears a fault.*

NOTE 2 Further guidance, if applicable, is found in 4.6.

b) *There shall have been no arcing from live parts to the **UPS** chassis or enclosure.*

An intact enclosure test fuse as described in Annex EE indicates compliance.

*The use of an enclosure test fuse is not applicable for **UPS** with non conductive chassis or enclosure (e.g. plastic case).*

c) *Components, for example busbar supports, used for the mounting of live parts shall not break away from their initial position.*

d) *Any enclosure door shall not open rapidly (so as to cause injury) when protected only by its normal latch.*

e) *No conductor shall get pulled out of its terminal connector and there shall be no damage to the conductor or conductor insulation.*

f) *The **UPS** shall successfully pass the AC or DC voltage test (dielectric strength test) as specified in IEC 62477-1:2012, 5.2.3.4.*

After testing the **UPS** is not required to be operational.

5.2.3.103.3 Input port short-time withstand current rating

If the manufacturer declares a short-time withstand current **rating**, the prospective short-circuit test current (I_{cp}) shall be determined in accordance with Table 104.

If the manufacturer declares a short-time withstand current **rating** higher than shown in Table 104, the declared value shall be used as the prospective short-circuit test current (I_{cp}).

The test is considered complete when the prospective test current has been made available for the minimum duration of the prospective test current listed in Table 104. Although the actual current flowing may be different from the prospective short-circuit test current (I_{cp}), the prospective short-circuit test current shall be the declared short-time withstand current **rating**.

Compliance is checked when, at the completion of the test, the following criteria are satisfied.

a) *The **UPS** shall not have emitted flames, molten metal or burning particles, other than, for example, metal particles normally emitted from a circuit breaker when it clears a fault;*

NOTE 1 Further guidance, if applicable, is found in 4.6.

b) *There shall have been no arcing from live parts to the **UPS** chassis or enclosure;*

An intact enclosure test fuse as described in Annex EE indicates compliance.

*The use of an enclosure test fuse is not applicable for **UPS** with non conductive chassis or enclosure (e.g. plastic case)*

c) *Components, e.g. busbar supports, used for the mounting of live parts shall not break away from their initial position;*

d) *Any enclosure door shall not open rapidly (so as to cause injury) when protected only by its normal latch;*

e) *No conductor shall get pulled out of its terminal connector and there shall be no damage to the conductor or conductor insulation;*

f) *The **UPS** shall successfully pass the AC or DC voltage test (dielectric strength test) as specified in IEC 62477-1:2012, 5.2.3.4.*

After testing the **UPS** is not required to be operational.

5.2.3.103.4 Exemption from testing

Exemption from short-time withstand current testing applies to:

a) **UPS** with declared $\boldsymbol{I_{cw}}$ and/or $\boldsymbol{I_{cc}}$ neither of which exceeding 10 kA;

b) **UPS** protected by current-limiting devices having a cut-off current not exceeding 17 kA with the maximum allowable **prospective short-circuit current** at the terminals of the incoming circuit of the **UPS**;

c) **UPS** intended to be supplied from transformers whose rated power does not exceed 10 kVA per phase for a rated secondary voltage of not less than 110 V, or 1,6 kVA per phase for a rated secondary voltage less than 110 V, and whose short-circuit impedance is not less than 4 %;

d) **UPS** variants of a reference design **UPS** tested compliant with the test requirements prescribed in 5.2.3.103.1.

For guidance on how to determine when a **UPS** is a variant of a reference design **UPS**, refer to IEC 61439-1:2011, 10.11.3 and Table 13, or 10.11.4.

NOTE The exemption conditions above align this document with IEC 61439-1:2011, 10.11.2.

Compliance is checked by satisfying at least one of the exemption conditions.

5.2.3.104 Transformer protection test

Transformers shall be tested in the **UPS** for overload, and abnormal tests.

The following conditions apply:

If the tests in 5.2.3.104 are conducted under simulated conditions on the bench, these conditions shall include any protective device that would protect the transformer in the complete equipment. Transformers for switch mode power supply units are tested in the complete power supply unit or in the complete equipment. Test loads are applied to the output of the power supply unit. A linear transformer or a ferro-resonant transformer has each secondary winding loaded in turn, with any other secondaries loaded between zero and their specified maxima to result in the maximum heating effect. The output of a switch mode power supply unit is loaded to result in the maximum heating effect in the transformer.

NOTE For examples of loading to give the maximum heating effect, see Annex FF.

Table 105 – Temperature limits for transformer windings

Maximum temperature°C

Method of protection	Thermal class [a]							
	105 (A)	120 (E)	130 (B)	155 (F)	180 (H)	200 (N)	220 (R)	250 (-)
Protection by inherent or external impedance	150	165	175	200	225	245	265	295
Protection by protective device that operates during the first hour	200	215	225	250	275	295	315	345
Protection by any protective device:								
– maximum after first hour	175	190	200	225	250	270	290	320
– arithmetic average during the 2nd hour and during the 72nd hour	150	165	175	200	225	245	265	295

[a] The designations A to R, formely assigned in IEC 60085 to thermal classes 105 to 220, are given in parentheses.

The test is limited to transformers that bridge basic, supplementary or reinforced insulation; or that provide power external to the product.

The text in 5.2.3.104 referencing transformer also applies to magnetic components in general.

Compliance is verified when the maximum temperature of the transformer does not exceed the values in Table 105 and determined as specified below:

– *with external overcurrent protection: at the moment of operation, for determination of the time until the overcurrent protection operates, it is permitted to refer to a data sheet of the overcurrent protective device showing the trip time versus the current characteristics;*

– *with an automatic reset thermal cut-out and after a test duration of 400 h.*

– *with a manual reset thermal cut-out: at the moment of operation or after temperature has stabilized;*

– *for current-limiting transformers: after temperature has stabilized.*

5.2.3.105 Unsynchronised load transfer test

5.2.3.105.1 General

The unsynchronised load transfer requirement specified in 4.3.105 shall be simulated with the UPS operating in normal mode and in stored energy mode while supplying its rated reference load.

The test in **normal mode** is waived for **UPS** wherein the load is normally supplied from the bypass source, for example for stand-by topology **UPS**.

The bypass source shall be set to its most unfavorable level of **rated voltage** if this creates a more onerous condition.

5.2.3.105.2 Phase displacement

The bypass source is to be displaced 120 electrical degrees with respect to the normal phase rotation for a 3-phase supply or 180 electrical degrees for a single phase supply. The solid state or manual switch is to be subjected to one operation of switching the load from the output of the **UPS** to the bypass source.

Compliance is determined by 5.2.4.2 of IEC 62477-1: 2012.

5.2.4 Abnormal operation and simulated faults tests

5.2.4.1 General

Subclause 5.2.4.1 in IEC 62477-1:2012 applies except, as follows:

*Replace, in the ninth paragraph of IEC 62477-1:2012, 5.2.4.1, "*PECS*" by "*UPS*".*

Add, after the ninth paragraph of IEC 62477-1:2012, 5.2.4.1, the following text:

Examples in which the lesser **prospective short-circuit current** available from the test supply may be used include situations wherein:

- the fault path of concern is not a **low impedance path**; or
- the resulting let-through current from the supply is equal or less than 10 kA; or
- the result is independent of the prospective short-circuit current available from the supply

5.2.6.4 Vibration test (type test)

Replace the existing text of 5.2.6.4 in IEC 62477-1: 2012 by the following:

The default environmental conditions applying to **UPS** within the scope of this document do not require compliance with vibration tests.

A vibration test is nevertheless to be considered if a different environmental service condition applies.

5.2.6.5 Salt mist test (type test)

Replace the existing text of 5.2.6.5 in IEC 62477-1:2012 by the following:

The default environmental conditions applying to **UPS** within the scope of this document do not require compliance with salt-mist tests.

A salt mist test is nevertheless to be considered if a different environmental service condition applies.

5.2.6.6 Dust and sand test (type test)

Replace the existing text of 5.2.6.6 in IEC 62477-1:2012 by the following:

The default environmental conditions applying to **UPS** within the scope of this document do not require compliance with dust and sand tests.

A dust and sand test is nevertheless to be considered if a different environmental service condition applies.

6 Information and marking requirements

Clause 6 of IEC 62477-1:2012 applies, except as follows:

6.1 General

Replace the existing text of 6.1 in IEC 62477-1:2012 by the following:

6.1.101 Durability

Any marking required by this document shall be durable and legible. In considering the durability of the marking, the effect of normal use shall be taken into account.

Compliance is checked by inspection and by rubbing the marking by hand for 15 s with a piece of cloth soaked with water and again either for 15 s with a piece of cloth soaked with petroleum spirit or for 30 s with a piece of cloth soaked with 70 % isopropyl alcohol. After this test, the marking shall be legible; it shall not be possible to remove marking plates easily and they shall show no curling.

The petroleum spirit to be used for the test is aliphatic solvent hexane having a maximum aromatics content of 0,1 % by volume, a kauributenol value of 29, an initial boiling point of approximately 65 °C, a dry point of approximately 69 °C and a mass per unit volume of approximately 0,7 kg/l.

As an alternative, it is permitted to use a reagent grade hexane with a minimum of 85 % as n-hexane.

NOTE The designation "n-hexane" is chemical nomenclature for a "normal" or straight chain hydrocarbon. This petroleum spirit is further identified as a certified ACS (American Chemical Society) reagent grade hexane (CAS No. 110-54-3).

6.1.102 Removable parts

Marking required by this document shall not be placed on removable parts that can be replaced in such a way that the marking would become misleading.

6.2 Information for selection

Replace the existing text of 6.2 in IEC 62477-1:2012 by the following:

Each **UPS** that is supplied as a separate product shall be provided with information relating to its function, electrical characteristics, and intended environment, so that its fitness for purpose and compatibility with other parts of the system can be determined.

This information includes, but is not limited to:

a) on the **rating** plate:

- the name or trademark of the manufacturer, supplier or importer;
- catalogue number or equivalent;
- electrical **rated values** for each power port, as applicable:
  - input voltage(s) or input voltage range(s);
  - input current(s) or input current range(s) (see 5.2.3.102);
  - output voltage(s);
  - output current(s);
  - output **apparent power**:
  - output **active power** or output power factor;
  - frequency(ies) or frequency range(s);
  - I_{cc} and/or I_{cw} (see 6.4.3.102).
- number of phases and neutral (e.g. 3 Ph + N);
- protective class, for class II UPS only (see 6.3.7.3.3);

b) on the **rating** plate or in the user manual:

- the type of electrical supply system (e.g. TN, IT,) to which the **UPS** may be connected;
- the type of electrical supply system (e.g. TN, IT) supplied to the load;
- the type of electrical supply system (e.g. TN, IT) supplied to the stored energy device;
- output short-circuit current in accordance with IEC 62477-1:2012, 4.3.2.3 and 5.2.4.4;
- protective device characteristics, in accordance with IEC 62477-1:2012, 4.3.2 and 5.2.4.4;
- liquid coolant type and design pressure for liquid cooled **UPS**;
- IP **rating** for enclosure;
- operating and storage environment;
- ambient operating temperature range (if other than 15 °C to 30 °C);
- reference(s) to relevant standard(s) for manufacture, test, or use;
- reference to instructions for installation, use and maintenance.

The range shall have a hyphen (-) between the minimum and maximum rated values and when multiple values or ranges are given, they shall be separated by a solidus (/);

Equipment with a **rated voltage** range shall be marked with either the maximum **rated current** or with the current range.

EXAMPLE

100-240 V; 2,8 A

or

100-240 V; 2,8-1,2 A

For equipment with multiple **rated voltages,** the corresponding **rated currents** shall be marked such that the different current ratings are separated by a solidus (/) and the relation between **rated voltage** and associated **rated current** appears distinctly.

EXAMPLE

100-120 V; 2,8 A / 200-240 V; 1,4 A

or

100-120 V; 2,8-2,4 A / 200-240 V; 1,4-1,2 A

6.3 Information for installation and commissioning

Subclause 6.3 in IEC 62477-1:2012 applies, except as follows:

Replace the existing text of 6.3.7.3.3 of IEC 62477-1:2012 by the following:

Equipment of protective class II shall be marked on the rating plate with symbol IEC 60417-5172 (2011-01) (see Annex C). Where such equipment has provision for the connection of an earthing conductor for functional reasons (see 4.4.6.3) this provision shall be marked with symbol IEC 60417-5018 (2011-01) (see Annex C).

Add the following subclause:

6.3.101 Guidance on UPS installation

The manufacturer shall provide guidance on the level of competence necessary for installation. Where appropriate, installation instructions should include reference to national wiring rules. Distinct instructions apply for:

- **UPS** designed for location in a **restricted access area** only: the installation instructions shall clearly state that the **UPS** may only be installed in accordance with the applicable requirements including those in IEC 60364-4-42. Such **UPS** may not meet the requirements for a fire enclosure as specified in IEC 62477-1:2012, 4.6.3.
- **UPS** designed for permanent connection by fixed wiring to the AC supply or to the load or to a separate energy storage device, for example batteries that are not installed when delivered: the installation instructions shall clearly state that only a **skilled person** may install the **UPS** and that, when the disconnect device for isolation of mains power is not incorporated in the equipment (see 4.101.2), an appropriate and readily accessible disconnect device shall be incorporated in the fixed wiring.
- pluggable type A or pluggable type B **UPS** with energy storage device, for example a battery, already installed by the supplier: the installation instructions shall be made available, for example in the user manual that shall state whether a **skilled person** is required for installation. When the disconnect device for isolation of mains power is not incorporated in the equipment (see 4.101.2), or when the plug on the **cord** is intended to serve as the disconnect device, the installation instructions shall state that the mains socket outlet that supplies the **UPS** shall be installed near the **UPS** and shall be easily accessible. When the **UPS cord** shall be connected to an earthed mains socket outlet for safety reasons, the **UPS** marking or installation instructions shall so state. The same requirement for marking applies to any special equipotential earth bonding to other connected **UPS** equipment or to class I loads.

NOTE Pluggable **cords** are normally 2 m in length or less.

6.4 Information for use

Subclause 6.4 in IEC 62477-1:2012 applies, except as follows:

6.4.3 Labels, signs and signals

Subclause 6.4.3 in IEC 62477-1:2012 applies, except as follows:

Add the following subclauses:

6.4.3.101 Distribution-related backfeed

A label shall be required for the purpose of warning the electrical service person, which shall be a **skilled person**, against **backfeed** situations not caused by the **UPS**. A **backfeed** situation can arise when a particular load fault is present while the **UPS** operates in **stored**

energy mode or while unbalanced loads are supplied through a particular power distribution system, for example an impedance grounded IT system.

The installation instructions for permanently connected **UPS** shall require the placement of a warning label

– by the **UPS** supplier, at the **UPS** input terminals, and
– by the installer**,** that shall be a **skilled person**, on all **primary power** isolators installed remote from the **UPS** area and on external access points, if any, between such isolators and the **UPS**

when

a) the automatic **backfeed** isolation (see 4.8.102) is provided external to the equipment, or
b) the **UPS** input is connected through external isolators that, when opened, isolate the neutral, or
c) the **UPS** is connected to an IT power distribution system (see IEC 62477-1:2012, 4.4.7.1.6.1).

The warning label shall carry the wording showed in Figure 104, or equivalent:

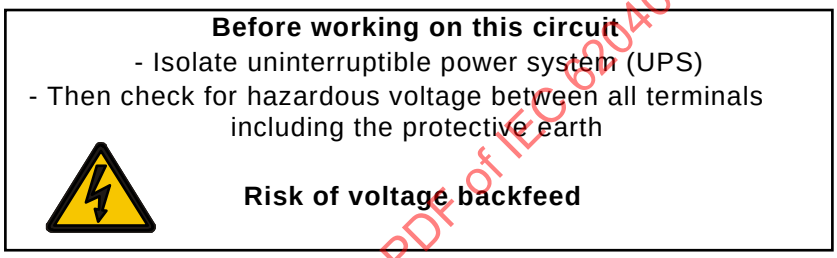


Figure 104 – Voltage backfeed warning label

NOTE **Backfeed protection** against faults occurring in the **UPS** is described in 4.8.102.

6.4.3.102 Protection in building installation

6.4.3.102.1 General

The **UPS** manufacturer shall state, as applicable, the **rated short-time withstand current** (I_{cw}) and/or **rated conditional short-circuit current** (I_{cc}). This current shall be equal to or higher than the **prospective short-circuit current** (I_{cp}) stated in Table 104.

The requirement above does not apply to **UPS** for which I_{cc} and/or I_{cw} is rated equal or less than 10 kA.

6.4.3.102.2 Rated conditional short-circuit current (I_{cc})

UPS with **rated conditional short-circuit current** (I_{cc}) that was verified using over-current protection device(s) not supplied with the **UPS** shall include information describing the over-current protective device as follows:

a) if the **short-circuit protective device** is specified in accordance with an IEC product standard, the following information shall be provided on the **UPS** or within the user manual:

Rated conditional short-circuit current (I_{cc}) requires the following installer supplied short-circuit protection device to be installed upstream the a.c input port(s) of the **UPS**:

- for example miniature circuit breaker (MCB) IEC 60947-2, trip curve C:

– characteristic or type of **short-circuit protective device** (e.g. three-pole, 40 A, 10 kA fault current interrupting capacity at 125 V/pole).

b) for all other **short-circuit protective devices**, the following information shall be provided on the **UPS** or within the user manual:

Rated conditional short-circuit current (I_{cc}) requires the following installer supplied short-circuit protection device to be installed before the a.c input port(s) of the **UPS**:

- name of short-circuit protection device manufacturer(s);
- characteristic or type of **short-circuit protective device**;
- manufacturer part number(s) of short-circuit protection device.

6.4.3.102.3 Prospective short-circuit current (I_{cp})

If an I_{cp} value higher than that specified in Table 104 is stated, the following applies:

a) if higher I_{cp} stated ≤ 10 kA: the values corresponding to the next higher applicable line of Table 104 apply;

b) if higher I_{cp} stated > 10 kA: values 16 kA, 20 kA, 25 kA, 35 kA, 50 kA, 65 kA, 85 kA, 100 kA are preferred, and the values corresponding to line 500 < I of Table 104 apply.

EXAMPLE When a higher I_{cp} is stated:

1) if a 50 A **UPS** is declared to sustain I_{cp} = 8 kA (instead of 6 kA), the values of line 75 < I < 400 in Table 104 are used;

2) if a 1 000 A **UPS** is declared to sustain I_{cp} = 85 kA (instead of 20 × 1 000 = 20 kA), the values of line 500 < I in Table 104 are used.

The installer can then verify that the **prospective short-circuit current** resulting at the AC input terminals of the unit is equal to or less than the value declared by the **UPS** manufacturer. Otherwise, subject to an agreement between the manufacturer and the purchaser, a solution shall be procured. Such a solution may consist in employing external current-limiting overcurrent protectors or customizing the **UPS** accordingly.

Irrespective of the **UPS** being a single unit or a unit in a paralleled system, the **prospective short-circuit current** of the AC input to be verified is that available at the relevant connection point of each unit.

6.4.3.102.4 Requirement for building installation

If pluggable equipment type B or permanently connected equipment relies on the building installation for the protection of internal wiring of the equipment, the equipment installation instructions shall so state and shall also specify the necessary requirements for short-circuit protection or overcurrent protection or, where necessary, for both.

If the protection against electric shock of the **UPS** relies on residual current devices in the building installation circuit and the design of the **UPS** is such that, in any normal or abnormal operating condition, a fault current to earth with DC component is possible, the installation instructions shall define the building residual current devices as type B according to IEC 60755 for three-phase **UPS** and as type A according to IEC 61008-1 or IEC 61009-1 for single-phase **UPS**.

NOTE National wiring rules, if any, are generally to be considered regarding requirements for public networks protection.

6.4.3.103 Batteries installed within the UPS enclosure

Batteries installed within the **UPS** enclosure shall be so arranged as to minimize risk of electric shock from inadvertent contact with terminals, and the interconnection method shall be such as to minimize risk of short-circuiting and electric shock during servicing and replacement.

The user manual shall inform to what extent, if any, battery maintenance can be performed by an **ordinary person**. The **UPS** construction shall then comply with 4.11.5 of IEC 62477-1:2012, and short-circuit shall be prevented (e.g. prevention from terminals short-circuit when put on a conductive surface).

Further, the following instructions or similar warning shall be included:

CAUTION:

- Do not dispose of batteries in a fire. The batteries may explode.
- Do not open or mutilate batteries. Released electrolyte is harmful to the skin and eyes. It may be toxic.
- A battery can present a risk of electric shock and burns by high short-circuit current.
- Failed batteries can reach temperatures that exceed the burn thresholds for touchable surfaces

The following precautions should be observed when working on batteries:

a) disconnect the charging source prior to connecting or disconnecting battery terminals;

b) do not wear any metal objects including watches and rings;

c) do not lay tools or metal parts on top of batteries;

and in addition, when the battery maintenance cannot be performed by an **ordinary person**, the following applies

d) use tools with insulated handles;

e) wear rubber gloves and boots;

f) determine if battery is either intentionally or inadvertently grounded. Contact with any part of a grounded battery can result in electric shock and burns by high short-circuit current. The risk of such hazards can be reduced if grounds are removed during installation and maintenance by a **skilled person**.

Compliance is checked by inspection.

6.5 Information for maintenance

Subclause 6.5 in IEC 62477-1:2012 applies, except as follows:

Add the following subclauses:

6.5.101 Battery information for maintenance

6.5.101.1 Labelling on battery

External battery cabinets or battery compartments within the **UPS** shall be provided with the following, clearly legible information in such a position as to be immediately seen by a **skilled person** when servicing the **UPS**:

a) battery type (lead-acid, NiCd, etc.) and number of blocks or cells;

b) nominal voltage of total battery;

c) nominal capacity of total battery (optional);

d) warning label denoting an energy or electrical shock and chemical hazard, and reference to the maintenance, handling and disposal requirements detailed in the user manual.

Exception: Pluggable equipment type A **UPS**, supplied with internal batteries or with separate battery cabinets, intended for location either under or over or alongside the **UPS**, connected

by plugs and sockets for installation by an **ordinary person** need only be fitted with the warning label (see item d above) on the outside of the unit.

6.5.101.2 Information in instruction manual(s)

6.5.101.2.1 General

The following instructions shall be provided depending on whether the battery is internally or externally mounted and whether the battery is provided by the **UPS** manufacturer or by others. The instructions shall be provided in the user manual or as otherwise described in this subclause.

a) Internally mounted battery:

- instructions shall carry sufficient information to enable the replacement of the battery with a suitable recommended type;
- safety instructions to allow access by a **skilled person** shall be stated in the installation/service handbook;
- if batteries are to be installed by a **skilled person,** instructions for interconnections including terminal torques shall be provided.

The user's manual shall include the following instructions:

- servicing of batteries should be performed or supervised by personnel knowledgeable about batteries and required precautions.
- when replacing batteries, replace with the same type and number of batteries or battery packs.

b) Externally mounted batteries:

- installation instructions shall state voltage, ampere-hour **rating**, charging regime and method of protection required on installation to coordinate with **UPS** protective devices, where the battery is not provided by the **UPS** manufacturer;
- instructions for the battery cells shall be provided by the battery manufacturer.

c) External battery cabinets:

- External battery cabinet(s) supplied with the **UPS** shall have adequate installation instructions to define cable sizes for connection to the **UPS** if the cabling is not supplied by the **UPS** manufacturer. Where the battery cells or blocks are not supplied pre-installed and wired, installation instructions for the battery cells or blocks shall be provided by the battery manufacturer, if not detailed in the **UPS** manufacturer's installation instructions. Protection against energy hazards shall comply with IEC 62477-1:2012, 4.5.

6.5.101.2.2 Instructions for battery replacement

The user manual shall inform to what extent, if any, battery maintenance can be performed by an **ordinary person**. The **UPS** construction shall then comply with 4.11.5 of IEC 62477 1:2012 and short-circuit shall be prevented (e.g. prevention from terminals short-circuit when put on a conductive surface).

Annexes

The annexes of IEC 62477-1:2102 apply, except as follows.

Annex A
(normative)

Additional information for protection against electric shock

Annex A in IEC 62477-1:2012 applies, except as follows:

Add the following clause:

A.101 Comparison of limits of working voltage

Table A.101 provides a comparison of the steady-state decisive voltage class limits used in this document to those defined in other standards.

Table A.101 – Comparison of limits of working voltage

Limits of working voltage V			Decisive voltage classification (DVC)	Electrical energy source classification [j] (ES)	Telecommunication network voltage classification [e] (TNV)
AC voltage (RMS)	AC voltage (peak)	DC voltage (mean)			
U_{ACL}	U_{ACPL}	U_{DCL}	(IEC 62477-1:2012)	(IEC 62368-1:2014)	(IEC 60950-1:2005)
8	11,3	22	A1	ES1 [b, h]	TNV-1 [f]
12	17	28	A2		
20	28,3	48	A3		
30	42,4	60	A[a]		
50	71	120	B	ES2 [c, i]	TNV-2 [g], TNV-3 [f]
> 50	> 71	> 120	C	ES3 [d]	

[a] Decisive voltage class DVC A voltage limits are considered for one circuit only. When more than one DVC A circuit of the **UPS** is accessible and the voltage of the two circuits can, subject to evaluation, add together under single fault condition, the limit is 25 V for AC voltage RMS

[b] ES1 or class 1 voltage limits for AC voltages at frequencies not exceeding 1 kHz under normal conditions, and abnormal conditions, and single fault conditions of a component, device or insulation not serving as a safeguard. At frequencies greater than 1 kHz, the limits for AC voltage RMS increase linearly as a function of frequency to a maximum of 70 V RMS at frequencies equal to or greater than 100 kHz.

[c] ES2 or class 2 voltage limits for AC voltages at frequencies not exceeding 1 kHz under normal conditions, and abnormal conditions, and single fault conditions. At frequencies greater than 1 kHz, the limits for AC voltage RMS increase linearly as a function of frequency to a maximum of 140 V RMS at frequencies equal to or greater than 100 kHz.

[d] ES3 or class 3 voltage limits exceed ES2 or class 2 voltage limits.

[e] Voltage limits of TNV circuits under normal operating conditions.

[f] Overvoltages from telecommunications networks and cable distribution systems are possible on TNV-1 and TNV-3 circuits under normal operating conditions.

[g] Overvoltages from telecommunications networks are not possible on TNV-2 circuits under normal operating conditions.

[h] ES1 or class 1 voltage limits for a repetitive pulse with an off time of less than 3 s is 42,4 V peak and with an off time of greater than or equal to 3 s is 60 V peak.

[l] ES2 or class 2 voltage limits for a repetitive pulse with an off time of less than 3 s is 70,7 V peak. For an off time of greater than 3 s the ES2 voltage limits depend also on the time period that the pulse is on with a lower limit of 120 V peak for an on time equal to or greater than 200 ms and an upper limit of 196 V peak for an on time equal to or less than 10 ms.

[j] Electrical energy sources derived from a capacitor and single pulses defined in IEC 62368-1:2014 are not considered here.

Annex M
(informative)

Test probes for determining access

Annex M in IEC 62477-1:2012 applies, except as follows:

Add the following figure after Figure M.3:

The following diagram is reproduced from IEC 60529 for convenience only.

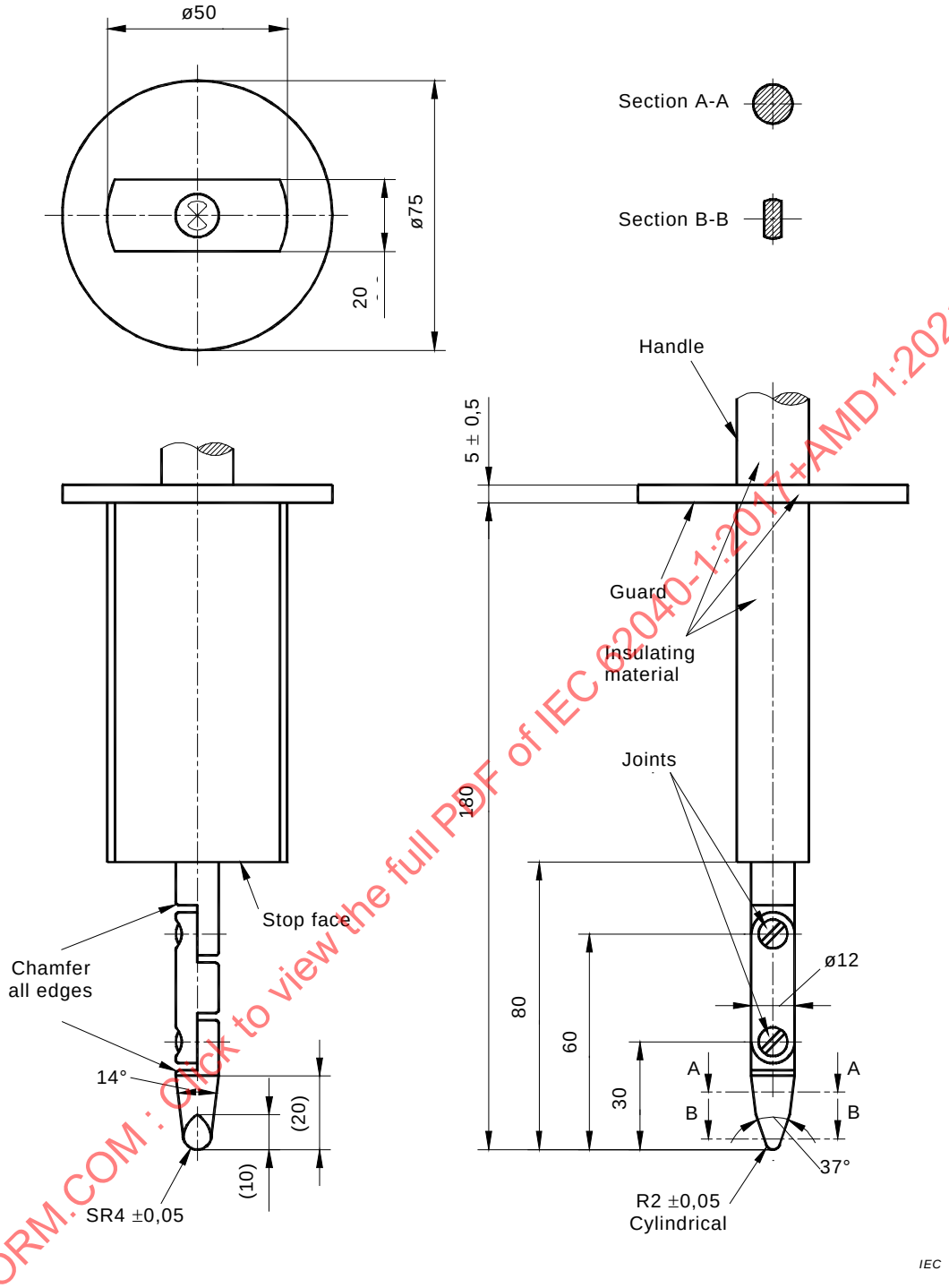


Figure M.101 – Jointed test finger (IP2X)

Add the following annexes:

Annex AA
(informative)

Minimum and maximum cross-section of copper conductors suitable for connection to terminals for external conductor

Table AA.1 provides guidance on minimum range of cable section that terminals should be designed to support when one copper cable is connected per terminal.

Table AA.1 – Conductor cross-sections
(extract from IEC 61439-1:2011)

Rated current	Solid or stranded conductors		Flexible conductors	
	Cross-sections		Cross-sections	
	Minimum	Maximum	Minimum	Maximum
A	mm^2		mm^2	
6	0,75	1,5	0,5	1,5
8	1	2,5	0,75	2,5
10	1	2,5	0,75	2,5
12	1	2,5	0,75	2,5
16	1,5	4	1	4
20	1,5	6	1	4
25	2,5	6	1,5	4
32	2,5	10	1,5	6
40	4	16	2,5	10
63	6	25	6	16
80	10	35	10	25
100	16	50	16	35
125	25	70	25	50
160	35	95	35	70
200	50	120	50	95
250	70	150	70	120
315	95	240	95	185

If the external conductors are connected directly to built-in apparatus, the cross-sections indicated in the relevant specifications are valid.

In cases where it is necessary to provide for conductors other than those specified in the table, special agreement shall be reached between the assembly manufacturer and the purchaser.

Annex BB
(normative)

Reference loads

BB.1 General

The **UPS** shall be loaded according to the manufacturer's **rated load** specification given in the instruction manual.

NOTE **Linear** and **non-linear loads** are described in this annex.

The most common types of **linear loads** are:

– resistive;
– inductive-resistive;
– capacitive-resistive.

A **non-linear load** could be:

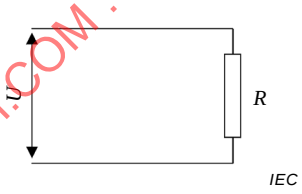
– rectified capacitive load;
– thyristor or transductor controlled load (phase control).

In the low power range < 3 kVA, the rectifier in bridge connection with capacitive load is the most common. The load is characterized by the following symbols:

S is the output **apparent power** in VA;
P is the output **active power** in W;
λ is the power factor = P/S;
U is the output voltage in V;
f is the frequency in Hz.

BB.2 Reference resistive load

For resistive loads, the **UPS** is loaded with a resistor up to nominal power, see Figure BB.1.



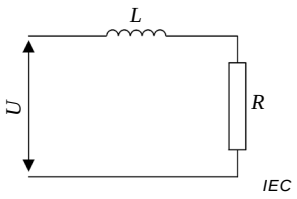
$$R = \frac{U^2}{P}$$

Figure BB.1 – Reference resistive load

BB.3 Reference inductive-resistive loads

For inductive-resistive loads, an inductance is connected in series or in parallel with a resistor. The resistor (R) and inductance (L) are given by the following formulae:

a) Series connection (See Figure BB.2)

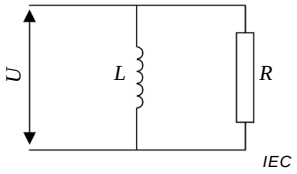


$$R = \frac{U^2}{S}\lambda \quad (\Omega)$$

$$L = \frac{U^2\sqrt{1-\lambda^2}}{2\pi f S} \quad (\mathrm{H})$$

Figure BB.2 – Reference inductive-resistive load (series)

b) Parallel connection (See Figure BB.3)



$$R = \frac{U^2}{S\lambda} \quad (\Omega)$$

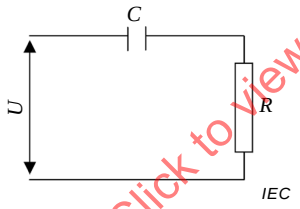
$$L = \frac{U^2}{2\pi f S\sqrt{1-\lambda^2}} \quad (\mathrm{H})$$

Figure BB.3 – Reference inductive-resistive load (parallel)

BB.4 Reference capacitive-resistive loads

For capacitive-resistive loads, a capacitance and a resistor are connected either in series or in parallel. The resistor *(R)* and capacitance *(C)* are given by the following formulae:

a) Series connection (See Figure BB.4)

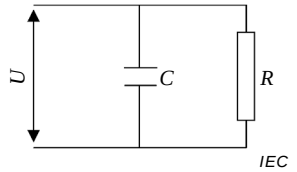


$$R = \frac{U^2\lambda}{S} \quad (\Omega)$$

$$C = \frac{S}{2\pi f U^2\sqrt{1-\lambda^2}} \quad (\mathrm{F})$$

Figure BB.4 – Reference capacitive-resistive load (series)

b) Parallel connection (See Figure BB.5)



$$R = \frac{U^2}{S\lambda} \quad (\Omega)$$

$$C = \frac{S\sqrt{1-\lambda^2}}{2\pi f U^2} \quad (\mathrm{F})$$

Figure BB.5 – Reference capacitive-resistive load (parallel)

BB.5 Reference non-linear load

BB.5.1 General

To simulate a single-phase steady-state rectifier/capacitor load, the **UPS** is loaded with a diode-rectifier bridge which has a capacitor and a resistor in parallel on its output, see Figure BB.6.

The total single-phase load may be formed by a single load or formed by multiple equivalent loads in parallel.

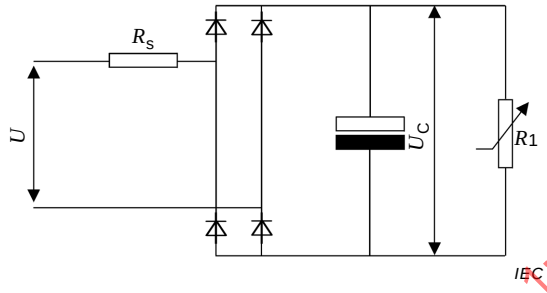


Figure BB.6 – Reference non-linear load

where

U_C is the rectified voltage in V;

R_1 is the load resistor, representing 66 % of **active power** of the total **apparent power** S;

R_S is the series line resistor; representing 4 % **active power** of the total **apparent power** S (simulating a 4 % voltage drop in the power lines – see IEC 60364-5-52)

NOTE 1 The following is related to the frequency of 50 Hz, to an output voltage distortion of maximum 8 % according to IEC 61000-2-2 and to power factor λ = 0,7 (i.e. 70 % of the **apparent power** S will be dissipated as **active power** in the two resistors R_1 and R_S).

A ripple voltage, 5 % peak to peak of the capacitor voltage U_C corresponds to a time constant of $R_1 \times C$ = 0,15 s.

Observing peak voltage, distortion of line voltage, voltage drop in line cables and ripple voltage of rectified voltage, the average of the rectified voltage U_C will be:

$$U_C = \sqrt{2} \times (0{,}92 \times 0{,}96 \times 0{,}975) \times U = 1{,}22 \times U$$

where the values of resistors R_S, R_1 and capacitor C are calculated by the following:

$R_S = 0{,}04 \times U^2/S$

$R_1 = (U_C)^2/(0{,}66 \times S)$

$C = 0{,}15 \text{ s}/R_1$

NOTE 2 Resistor R_S is placed in either the AC or DC side of the rectifier bridge.

NOTE 3 The actual value of the components used in the test is in the range with respect to the calculated values of:

R_S ±10 %

R_1 is adjusted during test to obtain rated output **apparent power**.

C –0 % / +25 %

NOTE 4 The value of capacitor C is valid for 50 Hz and mixed 50 Hz and 60 Hz designs.

NOTE 5 This document does not cover DC supplied electronic ballasts (IEC 61347 (all parts) and IEC 60925).

BB.5.2 Test method

The following test procedure applies.

a) The **reference non-linear load** circuit shall initially be connected to an AC input supply at the rated output voltage specified for the **UPS** under test.

b) The AC input supply impedance shall not cause a distortion of the AC input waveform greater than 8 % when supplying this reference load (see IEC 61000-2-2).

c) The resistor R_1 shall be adjusted to obtain the rated output **apparent power** (S) specified for the **UPS** under test.

d) After adjustment of resistor R_1, the **reference non-linear load** shall be applied to the output of the **UPS** under test without further adjustment.

e) The reference load shall be used, without further adjustment, whilst performing all tests to obtain parameters required under non-linear loading, as defined in the proper clauses.

BB.5.3 Connection of the reference non-linear load

The **reference non-linear load** is connected as follows.

a) For single-phase **UPS**, the **reference non-linear load** is used with **apparent power** S equal to the **UPS** rated **apparent power** up to 33 kVA.

b) For single-phase **UPS** rated above 33 kVA, the **non-linear load** is used with **apparent power** S of 33 kVA, plus **linear load** up to the **apparent** and **active power ratings** of the **UPS**.

c) For three-phase **UPS** designed for single-phase loads, equal single-phase **non-linear loads** shall be connected either line-neutral or line-to-line, depending upon the national power system configuration the **UPS** is designed for, up to 100 kVA **UPS apparent** and **active power rating**.

d) For three-phase **UPS** rated above 100 kVA, the loads according to Clause 3 shall be used, plus **linear load** up to the apparent and **active power rating**s of the **UPS**.

Annex CC
(normative)

Ventilation of lead-acid battery compartments

CC.1 General

The enclosure or compartment housing a battery where gassing is possible during heavy discharge, overcharging, or similar type of usage shall be vented. The means of venting shall provide airflow throughout the enclosure or compartment in order to reduce the risk of build-up of pressure or accumulation of a gas mixture, such as hydrogen-air, involving a risk of injury to persons.

The requirements in this annex assume the gas mixture to be hydrogen-air, which is lighter than air. Consequently, for compliance, in addition to air intake openings in the bottom portions of the battery enclosure or compartment, ventilation openings are required in the uppermost portions where such a gas mixture may accumulate.

CC.2 Normal conditions

The lower explosion level (LEL) of hydrogen in a (hydrogen-air) mixture, under normal conditions of pressure and temperature, is 4 % by volume. With reference to Clause CC.1, the venting means shall prevent hydrogen concentration, under normal operating and charging conditions, in excess of 0,8 % by volume which, as a provision for abnormal situations, includes a safety factor of 5.

A lead-acid battery at full charge, when most of the charging energy goes into gas, will generate approximately 0,0283 m^3 of hydrogen gas per cell for each 63 Ah of input (=0,45 × 10^{-3} m^3/Ah). If the adequacy of the ventilation required is not obvious, a determination shall be made by measurement of gas concentration under normal and abnormal conditions as specified in this annex.

Subject to the **UPS** being provided with a regulating circuit preventing an increase in battery charging current and voltage when the AC input voltage is increased within the limits specified for **UPS** operation, the formula listed below may be used to calculate the necessary air flow for a lead-acid battery compartment that complies with the ventilation requirements of this annex.

$$Q = v\ q\ s\ n\ I\ C$$

where

Q is the ventilation air flow, in m^3/h;

v is the necessary dilution of hydrogen (100 – 4)/4 = 24;

q = 0,45 × 10^{-3} m^3/Ah generated hydrogen;

s is the factor of safety;

n is the number of battery cells;

I = 2 A/100 Ah – conventional flooded cell batteries;

I = 1 A/100 Ah – flooded battery cells with low antimony alloy;

I = 0,5 A/100 Ah – flooded battery cells with recombination plugs;

I = 0,2 A/100 Ah – valve regulated lead-acid batteries;

C is the battery nominal capacity in Ah at the 10 h discharge rate.

NOTE 1 To allow for equalization (boost charging), in the case of valve-regulated batteries operating over a wider range of ambient temperatures, the factors of I correspond to typical 2,4 V/cell figures at 25 ºC.

NOTE 2 For batteries other than lead-acid technology, other values of I apply, and the appropriate value is obtained from the battery manufacturer.

By adopting safety factor s = 5, the formula for Q can be simplified by introducing the resultant value of

$v\ q\ s$ = 0,054 m^3/Ah

Q = 0,054 $n\ I\ C$

Q is the air flow, m^3/h

This amount of ventilation air flow shall preferably be ensured by natural air flow, otherwise by forced ventilation.

Inlet and outlet apertures shall allow for a free access of air flow. The mean speed of air through the apertures shall at least be in the region of 0,1 m/s (= 360 m/h).

With this amount of natural air flow, the battery compartment shall contain air inlet and outlet apertures with a free area of at least

$$A \geq Q/360\ [m^2]$$

NOTE 3 Natural ventilation is applicable where the electrical power for hydrogen generation keeps below certain limits. Otherwise, the ventilation air outlets would exceed acceptable dimensions. The limits for natural ventilation depend on the battery capacity and the number of cells, and also on the battery technology (vented cells, valve-regulated cells), and the battery charging voltage applied.

The above calculation method will result in a sufficient degree of safety against explosion, assuming hot (> 300°C) or sparking components are kept at adequate distance from battery vent plugs or gas pressure outlets. In battery rooms, a distance of 500 mm may be regarded as ensuring sufficient safety. In battery compartments or cabinets or batteries built-in with **UPS**, it is permitted to reduce this distance depending on the level of ventilation (see 4.102.6).

The most severe charging rate referred to above is the maximum charging rate that does not cause a thermal or overcurrent protective device to open.

CC.3 Blocked conditions

The ventilating means for an **enclosure** or a compartment housing a battery shall comply with the requirements in Clause CC.1 under test conditions as described in IEC 62477-1:2012, 4.2. During, and at the conclusion of the test, the maximum hydrogen gas concentration shall not be more than 2 % by volume.

CC.4 Overcharge conditions

If a measurement is needed to determine if a battery compartment complies with Clause CC.2, the battery charger shall be connected to a supply circuit adjusted to 106 % of nominal voltage and then subjected to 7 h of overcharging using a fully charged battery. Any controls associated with the charger or charging circuit that can be adjusted by an operator that may be an **ordinary person** shall be adjusted for the most severe charging rate.

Exception 1: This requirement does not apply to a **UPS** to be used with a battery charger that is not investigated with the **UPS**.

Exception 2: This requirement does not apply to a **UPS** provided with a regulating circuit preventing an increase in battery charging current and voltage when the AC input voltage is increased from **rated value** to 106 % of **rated value**.

During, and at the conclusion of the test, the maximum hydrogen gas concentration shall not be more than 2 % by volume. Measurements are to be made by sampling the atmosphere inside the battery compartment at the periods of 2 h, 4 h, 6 h and 7 h during the test. Samples of the atmosphere within the battery compartment shall be taken at the location where the greatest concentration of hydrogen gas is likely, using an aspirator bulb provided with the concentration measurement equipment, or other equivalent means.

Annex DD
(informative)

Guidance for disconnection of batteries during shipment

DD.1 Applicable products

This informative annex applies to **UPS** and battery cabinets containing internal batteries. Currently, the following provisions are for use as a guide only. The TC might decide to change this annex in a normative annex in the future.

DD.2 Battery disconnection

Manufacturers should provide a means to disconnect the battery for the purposes of shipment. The means shall be located as close to the battery as possible and before the battery circuit connects to any other electrical devices or circuits, including printed wiring assemblies.

DD.3 Package labelling/marking

A precautionary label should be affixed to the shipping carton to alert individuals as to whether the batteries within the package have been disconnected or not.

Manufacturers should use the label shown in Figure DD.1 for products that have had the battery disconnected prior to shipment.

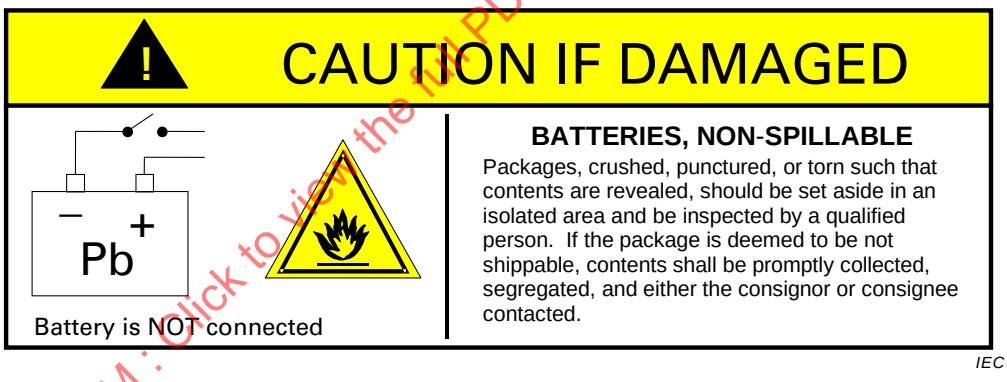


Figure DD.1 – Precautionary label for products shipped with the battery disconnected

Manufacturers shall use the label shown in Figure DD.2 for products that have not had the battery disconnected prior to shipment.

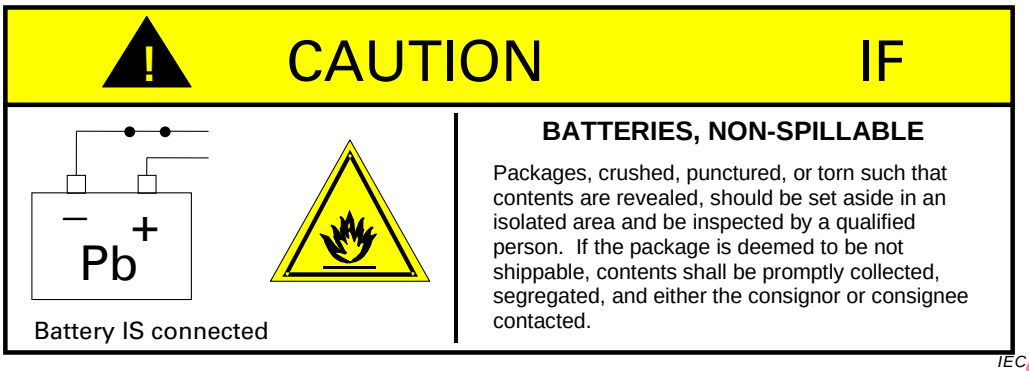


Figure DD.2 – Precautionary label for products shipped with the battery connected

The "Pb" in the battery symbol for Figure DD.1 and Figure DD.2 pertains to lead-acid batteries. The appropriate chemical symbol shall be substituted for other battery chemistries.

DD.4 Damage inspection

Cartons that have been crushed, punctured, or torn in such a way that contents are revealed shall be set aside in an isolated area and inspected by a **skilled person**. If the package is deemed to be not shippable, the contents shall be promptly collected, segregated, and either the consignor or consignee contacted. Manufacturers should communicate these guidelines to shippers and handlers of the applicable products.

DD.5 The importance of safe handling procedures

UPS manufacturers have conducted comprehensive tests to ensure the equipment they distribute around the world is safe for air transport. Nonetheless, it is important to understand that **UPS** and battery cabinets containing internal batteries can cause fire, smoke or other similar safety hazards if damaged. These products shall be handled with care and immediately inspected if visibly damaged.

Annex EE
(informative)

Short-time withstand current test procedure – Guidance and typical values

EE.1 General

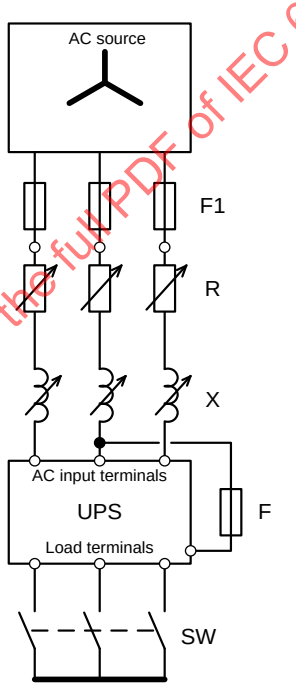
This annex presents circuits and methods that are typical for the implementation of the short-time withstand current test prescribed in 5.2.3.103. The test circuit in Figure EE.1, EE.2 or EE.3 as applicable can be used to carry out the test.

NOTE 1 Further guidance is found in IEC 61439-1:2011, 10.11.5.2.

The enclosure fuse may either consist of a copper wire of 0,8 mm diameter and of at least 50 mm length, or of an equivalent or faster acting fusible element (e.g. a 30 A type gL or CC non time delay fuse) for the detection of a fault current.

Alternatively, it is permitted to connect the enclosure fuse to the ungrounded center point of the AC source if available. See Figure EE.2

For single phase **UPS**, see Figure EE.3.

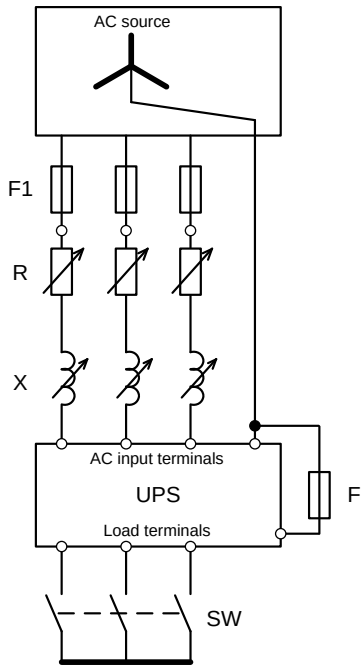


Key

AC source	rated voltage, ungrounded 3-wire
F1	conditional withstand protection device, for example fuses or circuit breaker if specified by the manufacturer
R	adjustable resistor
X	source reactance implemented with linear reactors that may be adjustable and of air-core technology
UPS	equipment under test
F	enclosure fuse (for positive verification of arcing to chassis, as applicable)
SW	closing switch – may be located as shown or ahead of limiting impedance

NOTE Since the transient recovery voltage characteristics of test circuits, including large air-core reactors, are not representative of usual service conditions, any air-core reactor in each phase is typically shunted by a resistor (not shown in the diagram) taking approximately 0,6 % of the current through the reactor.

Figure EE.1 – 3-wire test circuit for UPS short-time withstand current

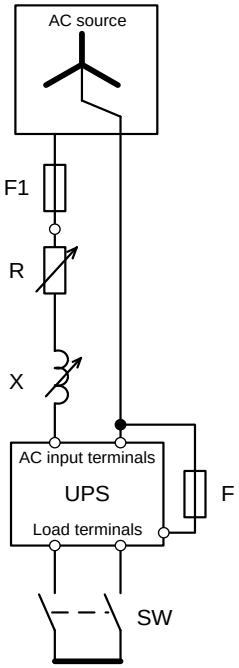


Key

AC source	rated voltage, ungrounded 4-wire
F1	conditional withstand protection device, for example fuses or circuit breaker if specified by the manufacturer
R	adjustable resistor
X	source reactance implemented with linear reactors that may be adjustable and of air-core technology
UPS	equipment under test
F	enclosure fuse (for positive verification of arcing to chassis, as applicable)
SW	closing switch – may be located as shown or ahead of limiting impedance

NOTE Since the transient recovery voltage characteristics of test circuits, including large air-core reactors, are not representative of usual service conditions, any air-core reactor in each phase is typically shunted by a resistor (not shown in the diagram) taking approximately 0,6 % of the current through the reactor.

Figure EE.2 – 4-wire test circuit for UPS short-time withstand current



Key

AC source	rated voltage, ungrounded 2-wire
F1	conditional withstand protection device, for example fuses or circuit breaker if specified by the manufacturer
R	adjustable resistor
X	source reactance implemented with linear reactors that may be adjustable and of air-core technology
UPS	equipment under test
F	enclosure fuse (for positive verification of arcing to chassis, as applicable)
SW	closing switch – may be located as shown or ahead of limiting impedance

NOTE Since the transient recovery voltage characteristics of test circuits, including large air-core reactors, are not representative of usual service conditions, any air-core reactor in each phase is typically shunted by a resistor (not shown in the diagram) taking approximately 0,6 % of the current through the reactor

Figure EE.3 – 2-wire test circuit for single phase UPS short-time withstand current

EE.2 Test set up

The **UPS** output should be set up as prescribed in 5.2.3.103.1.

EE.3 Calibration of the test circuit

The resistance and reactance of the test circuit, if applied to the rated AC input source, should provide the current listed in Table 104 and satisfy the test conditions specified in Table 104. The source reactance is represented by X and should be implemented with linear reactors that may be adjustable and of air-core technology. They should be connected in series with the resistors R. The parallel connecting of reactors is acceptable when these reactors have practically the same time constant. The leads to the unit under test should be included in the calibration.

EE.4 Test procedure

In summary, the test steps are as follows.

a) Adjust the impedance of the test facility for the purpose of providing the required prospective short-circuit test current (I_{cp}) without the **UPS** in accordance with table 102.

b) Insert the **UPS** or circuit to be tested and enable the corresponding current path.

c) Apply the short-circuit current.

d) Verify compliance.

The test should be performed as prescribed in 5.2.3.103.

The phase current(s) should be recorded during the test for the purpose of verifying that calibration test conditions were not exceeded.

The **UPS** manufacturer may declare a **rated conditional short-circuit current** (I_{cc}) and specify a protective device F1 to be used in conjunction with the unit under test, that should be placed between the **UPS** input terminals and the AC input source. The closing switch SW should be fitted at the load terminals of the **UPS**. When the switch SW is closed, the test current should be maintained until it is interrupted by F1 or until the prescribed duration of the test current has elapsed.

EE.5 Test verification criteria

Refer to 5.2.3.103.

Annex FF
(informative)

Maximum heating effect in transformer tests

Subclause 5.2.3.104 requires transformers to be loaded in such a way as to give the maximum heating effect. In this annex, examples are given of various methods of producing this condition. Other methods are possible, and compliance with 5.2.3.104 is not restricted to these examples.

FF.1 Determination of maximum input current

The value of the input current at **rated load** is established (I_r, see step A of Table FF.1). The value may be established by test or from manufacturer's data.

A load is applied to the output winding or to the output of the switch mode power supply unit while measuring the input current. The load is adjusted as quickly as possible to provide the maximum value of input current (I_m, see step B of Table FF.1) that can be sustained for approximately 10 s of operation. The test is then repeated according to step C and, if necessary, steps D to J of Table FF.1. The input current at each step is then noted and maintained until either:

a) the temperature of the transformer stabilizes without the operation of any component or protective device (inherent protection), in which case no further testing is conducted; or

b) component or protective device operates, in which case the winding temperature is noted immediately, and the test of Clause FF.2 is then conducted depending on the type of protection.

In case any component or protective device operates within 10 s after the application of the primary voltage then the value of I_m is that recorded just before the component or protective device operates. In conducting the tests described in steps C to J of Table FF.1, the variable load is adjusted to the required value as quickly as possible and readjusted, if necessary, 1 min after application of the primary voltage. The sequence of steps C to J may be reversed.

Table FF.1 – Test steps

Steps	Input current of the transformer or switch mode power supply unit
A	Input current at **rated load** (I_r)
B	Maximum value of input current after 10 s of operation (I_m)
C	$I_r + 0{,}75\ (I_m - I_r)$
D	$I_r + 0{,}50\ (I_m - I_r)$
E	$I_r + 0{,}25\ (I_m - I_r)$
F	$I_r + 0{,}20\ (I_m - I_r)$
G	$I_r + 0{,}15\ (I_m - I_r)$
H	$I_r + 0{,}10\ (I_m - I_r)$
j	$I_r + 0{,}05\ (I_m - I_r)$

FF.2 Overload test procedure

If the test of Clause FF.1 results in condition FF.1 b), the following applies depending on type of protection.

Electronic protection: The current is either reduced in steps of 5 % from the current of condition FF.1b) or increased in steps of 5 % from the **rated load** to find the maximum overload at which the temperature stabilizes without the operation of any electronic protection.

Thermal protection: An overload is applied such that the operating temperature remains a few degrees below the rated opening temperature of the thermal protection.

Overcurrent protection: An overload is applied such that a current flows in accordance with the current versus time trip curves of the overcurrent protective device.

Annex GG
(normative)

Requirements for the mounting means of rack-mounted equipment

GG.1 General

These requirements apply to the mounting means of equipment having a mass exceeding 7 kg and installed in a rack that can be extended away from the rack for installation, service and the like.

These requirements do not apply to equipment fixed in place and provided with equipment subassemblies or racks having a top installation position less than 1 m in height from the floor.

For the purpose of these requirements, the mechanical mounting means for such equipment will be referred to as slide rails. These requirements are intended to reduce the likelihood of injury by retaining the equipment in a safe position and not allowing the slide rails to buckle, the means of attachment to break, or the equipment to slide past the end of the slide rails.

NOTE 1 Slide rails include bearing slides, friction slides or other equivalent mounting means.

NOTE 2 Slide rail constructions of integrated parts/units of the end product (for example, pullout paper trays in copiers/printers) are not considered to be rack-mounted equipment.

Slide rails shall have end stops that prevent the equipment from unintentionally sliding off the mounting means.

GG.2 Mechanical strength test, variable force

The slide rails shall be installed in a rack with the equipment, or equivalent setup, in accordance with the manufacturer's instructions. With the equipment in its extended position, a force in addition to the weight of the equipment is to be applied downwards through the centre of gravity for 1 min by means of a suitable test apparatus providing contact over a circular plane surface of 30 mm in diameter. If applying this force could damage the equipment, a metal plate or other means to distribute the force may be placed under the test apparatus. The total force shall be calculated based on the mass of the equipment plus an additional mass as determined below.

NOTE This additional force is intend to take into account other items or devices that can be stacked on top of the installed rack-mounted equipment while in the extended position during installation of other equipment.

For slide-rail mounted equipment, where the slide rails are mounted horizontally on each side of the equipment, the total force applied to the slide rails shall be equal to the greater of the following two values:

- 150 % of the equipment mass plus 330 N; or
- 150 % of the equipment mass, plus an additional mass, where the additional mass is equal to the equipment mass, or 530 N, whichever is less.

For slide rail mounted equipment where the slide rails are mounted vertically on the top and bottom of the equipment in the rack, the total force applied to the slide rails shall be 150 % of the equipment mass, with a minimum force of 250 N and a maximum force of 530 N.

If the supporting surface is intended to be a shelf, then the distribution of force over a metal plate under the test apparatus does not apply. The manufacturer shall specify the maximum load intended to be placed on the shelf in order to determine the force that needs to be

applied to the shelf. A marking shall be provided on the shelf to indicate the maximum weight that can be added to the shelf. The force test shall be conducted at 125 % of the maximum weight stated by the manufacturer. The force is to be applied directly by means of the test apparatus providing contact over a circular plane surface of 30 mm in diameter.

GG.3 Mechanical strength test, 250 N force, including end stops

The slide rail mounted equipment is installed in a rack in accordance with the manufacturer's instructions. A 250 N static force is applied to the slide rail mounted equipment, in every direction except upward, to include the most unfavorable position of the slide rail mounted equipment, for a period of 1 min. The force is applied to the slide rail mounted equipment in its fully extended (service) position as well as its normally recessed (operating) position by means of a suitable test instrument providing contact over a circular plane surface of 30 mm in diameter. The force is applied with the complete flat surface of the test instrument in contact with the equipment. The test instrument need not be in full contact with uneven surfaces (for example corrugated or curved surfaces).

NOTE Additional requirements for a dynamic force test on the end stops are under consideration.

GG.4 Compliance

Compliance is checked by inspection and available manufacturer's data. If data is not available, then the tests according to Clauses GG.2 and GG.3 are conducted.

The equipment and its associated slide rails shall remain secure during the tests. One complete cycle of travel of the equipment on the slide rails shall be performed after completion of each test. If the mounting means is not able to perform one complete cycle without binding, a force of 100 N shall be applied horizontally to the front centre point of the equipment with the intent to completely retract the equipment into the rack. Should the equipment fail to fully retract, the mounting means shall not bend or buckle to any extent that could introduce an injury. End stops shall retain the equipment in a safe position and shall not allow the equipment to slide past the end of the slide rails.

Bibliography

The Bibliography of IEC 62477-1:2012 applies, except as follows:

Add the following references:

IEC 60076-11:2004, *Power transformers – Part 11: Dry-type transformers*

IEC 60287-1-1:2006, *Electric cables – Calculation of the current rating – Part 1-1: Current rating equations (100 % load factor) and calculation of losses – General*

IEC 60364-5-52, *Low-voltage electrical installations – Part 5-52: Selection and erection of electrical equipment – Wiring systems*

IEC 60925, *D.C. supplied electronic ballasts for tubular fluorescent lamps – Performance requirements*[3]

IEC 60947-1:2007, *Low-voltage switchgear and controlgear – Part 1: General rules*

IEC 60947-3:2008, *Low-voltage switchgear and controlgear – Part 3: Switches, disconnectors, switch-disconnectors and fuse-combination units*

IEC 60947-6-1:2005, *Low-voltage switchgear and controlgear – Part 6-1: Multiple function equipment – Transfer switching equipment*
IEC 60947-6-1:2005/AMD1:2013

IEC 61347 (all parts), *Lamp controlgear*

IEC 61439-1:2011, *Low-voltage switchgear and controlgear assemblies – Part 1: General rules*

IEC 61508 (all parts), *Functional safety of electrical/electronic/programmable electronic safety-related systems*

IEC 62040-3:2011, *Uninterruptible power systems (UPS) – Part 3: Method of specifying the performance and test requirements*

IEC 62103, *Electronic equipment for use in power installations*

IEC 62310-1, *Static transfer systems (STS) – Part 1: General and safety requirements*

IEC 62368-1:2014, *Audio/Video, Information and communication technology equipment – Part 1: Safety requirements*

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3 This document has been withdrawn, but for the purposes of this document it is given as a reference.

IEC 62040-1

Edition 2.1 2021-05
CONSOLIDATED VERSION

FINAL VERSION

colour inside

Uninterruptible power systems (UPS) – Part 1: Safety requirements

IEC 62040-1:2017-07+AMD1:2021-05 CSV(en)

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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UNINTERRUPTIBLE POWER SYSTEMS (UPS) –

Part 1: Safety requirements

FOREWORD

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This consolidated version of the official IEC Standard and its amendment has been prepared for user convenience.

IEC 62040-1 edition 2.1 contains the second edition (2017-07) [documents 22H/217/FDIS and 22H/218/RVD], its corrigendum (2019-10) and its amendment 1 (2021-05) [documents 22H/269/FDIS and 22H/271/RVD].

This Final version does not show where the technical content is modified by amendment 1. A separate Redline version with all changes highlighted is available in this publication.

International Standard IEC 62040-1 has been prepared by subcommittee 22H: Uninterruptible power systems (UPS), of IEC technical committee 22: Power electronic systems and equipment.

This second edition constitutes a technical revision.

This edition includes the following significant technical change with respect to the previous edition: the reference document has been changed from IEC 60950-1:2005 (safety for IT equipment) to IEC 62477-1 (group safety standard for power electronic converters).

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

This International Standard is to be read in conjunction with IEC 62477-1:2012.

The provisions of the general rules dealt within IEC 62477-1:2012 are only applicable to this document insofar as they are specifically cited. Clauses and subclauses of IEC 62477-1:2012 that are applicable in this document are identified by reference to IEC 62477-1:2012, for example, "Clause 4 of IEC 62477-1:2012 applies, except as follows".

The exceptions are then listed. The exceptions can take the form of a deletion, a replacement or an addition of subclauses, tables, figures or annexes.

Subclauses, tables and figures that are additional to those in IEC 62477-1:2012 are, in this document, identified by a suffix in the format of X.10x, for example 4.3.101.

Annexes that are additional to those in IEC 62477-1:2012 are, in this document, lettered AA, BB, etc.

In this document, the following print types are used:

- requirements and normative annexes: roman type
- compliance statements and test specifications: *italic type*
- notes and other informative matter: smaller roman type
- normative conditions within tables: smaller roman type
- terms that are defined in Clause 3: **bold**

A list of all parts in the IEC 62040 series, published under the general title *Uninterruptible Power Systems (UPS)*, can be found on the IEC website.

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

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

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

INTRODUCTION

IEC technical sub-committee 22H: Uninterruptible power systems (UPS) carefully considered the relevance of each paragraph of IEC 62477-1:2012 in UPS applications. This part of IEC 62040 utilizes IEC 62477-1:2012 as a reference document and references, adds, replaces or modifies requirements as relevant. This is because product-specific topics not covered by the reference document are the responsibility of the technical committee using the reference document.

IEC 62477-1:2012 relates to products that include power electronic converters, with a rated system voltage not exceeding 1 000 V AC or 1 500 V DC. It specifies requirements to reduce risks of fire, electric shock, thermal, energy and mechanical hazards, except functional safety as defined in IEC 61508 (all parts). The objectives of this document are to establish a common terminology and basis for the safety requirements of products that contain power electronic converters across several IEC technical committees.

IEC 62477-1:2012 was developed with the intention:

- to be used as a reference document for product committees inside IEC technical committee 22: Power electronic systems and equipment in the development of product standards for power electronic converter systems and equipment;
- to replace IEC 62103 as a product family standard providing minimum requirements for safety aspects of power electronic converter systems and equipment in apparatus for which no product standard exists; and

  NOTE The scope of IEC 62103 contains reliability aspects, which are not covered by this document.

- to be used as a reference document for product committees outside TC 22 in the development of product standards of power electronic converter systems and equipment intended for renewable energy sources. TC 82, TC 88, TC 105 and TC 114, in particular, have been identified as relevant technical committees at the time of publication.

The reference document, being a group safety standard, will not take precedence over this product-specific standard according to IEC Guide 104. IEC Guide 104 provides information about the responsibility of product committees to use group safety standards for the development of their own product standards.

UNINTERRUPTIBLE POWER SYSTEMS (UPS) –

Part 1: Safety requirements

1 Scope

This part of IEC 62040 applies to movable, stationary, fixed or built-in **UPS** for use in low-voltage distribution systems and that are intended to be installed in an area accessible by an **ordinary person** or in a restricted access area as applicable, that deliver fixed frequency AC output voltage with port voltages not exceeding 1 000 V AC or 1 500 V DC and that include an energy storage device. It applies to pluggable and to permanently connected **UPS**, whether consisting of a system of interconnected units or of independent units, subject to installing, operating and maintaining the **UPS** in the manner prescribed by the manufacturer.

NOTE 1 Typical **UPS** configurations, including voltage and/or frequency converters and other topologies, are described in IEC 62040-3, the test and performance product standard for **UPS**.

NOTE 2 **UPS** generally connect to their energy storage device through a DC link. A chemical battery is used throughout the standard as an example of an energy storage device. Alternative devices exist, and as such, where "battery" appears in the text of this document, this is to be understood as "energy storage device".

This document specifies requirements to ensure safety for the **ordinary person** who comes into contact with the **UPS** and, where specifically stated, for the **skilled person**. The objective is to reduce risks of fire, electric shock, thermal, energy and mechanical hazards during use and operation and, where specifically stated, during service and maintenance.

This product standard is harmonized with the applicable parts of group safety publication IEC 62477-1:2012 for power electronic converter systems and contains additional requirements relevant to **UPS**.

This document does not cover:

- UPS that have a DC output;
- systems for operation on moving platforms including, but not limited to, aircrafts, ships and motor vehicles;
- external AC or DC input and output distribution boards covered by their specific product standard;
- stand-alone static transfer systems (STS) covered by IEC 62310-1;
- systems wherein the output voltage is directly derived from a rotating machine;
- telecommunications apparatus other than **UPS** for such apparatus;
- functional safety aspects covered by IEC 61508 (all parts).

NOTE 3 Even if this document does not cover the applications listed above, it is commonly taken as a guide for such applications.

NOTE 4 Specialized **UPS** applications are generally governed by additional requirements covered elsewhere, for example **UPS** for medical applications.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

Clause 2 of IEC 62477-1:2012 applies, except as follows:

Add the following normative references:

IEC 60364-4-42, *Low-voltage electrical installations – Part 4-42: Protection for safety – Protection against thermal effects*

IEC 60384-14, *Fixed capacitors for use in electronic equipment – Part 14: Sectional specification – Fixed capacitors for electromagnetic interference suppression and connection to the supply mains*

IEC TR 60755, *General requirements for residual current operated protective devices*

IEC 60947-2:2006*, Low-voltage switchgear and controlgear – Part 2: Circuit-breakers*[1]

IEC 60950-1:2005, *Information technology equipment – Safety – Part 1: General requirements*

IEC 61000-2-2:2002, *Electromagnetic compatibility (EMC) – Part 2-2: Environment – Compatibility levels for low-frequency conducted disturbances and signaling in public low-voltage power supply systems*

IEC 61008-1, *Residual current operated circuit-breakers without integral overcurrent protection for household and similar uses (RCCBs) – Part 1: General rules*

IEC 61009-1, *Residual current operated circuit-breakers with integral overcurrent protection for household and similar uses (RCBOs) – Part 1: General rules*

IEC 62040-2:2005, *Uninterruptible power systems (UPS) – Part 2: Electromagnetic compatibility (EMC) requirements*[2]

IEC 62477-1:2012, *Safety requirements for power electronic converter systems and equipment – Part 1: General*

3 Terms and definitions

Clause 3 of IEC 62477-1:2012 applies, except as follows:

Add the following new terms and definitions, and new notes:

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1 4th edition (2006). This 4th edition has been replaced in 2016 by a 5th edition IEC 60947-2:2016, *Low-voltage switchgear and controlgear – Part 2: Circuit-breakers*.

2 2nd edition (2005). This 2 nd edition has been replaced in 2016 by a 3rd edition IEC 62040-2:2016, *Uninterruptible power systems (UPS) – Part 2: Electromagnetic compatibility (EMC) requirements*.

Table 1 – Alphabetical list of terms

Terms	Term number		Terms	Term number	
	62040-1	62477-1		62040-1	62477-1
adjacent circuit		3.1	power semiconductor device		3.34
active power	3.111		primary power	3.108	
apparent power	3.112		prospective short-circuit current	3.122	
backfeed	3.127		protective equipotential bonding		3.36
backfeed protection	3.128		protective class I		3.37
basic insulation		3.2	protective class II		3.38
basic protection		3.3	protective class III		3.39
bypass	3.110		protective earthing (PE)		3.40
commissioning test		3.4	PE conductor		3.41
cord	3.109		protective impedance		3.42
decisive voltage class (*DVC*)		3.5	(electrically) protective screening		3.43
double insulation		3.6	protective separation		3.44
DVC As		3.7	PEC		3.45
DVC Ax		3.8	PECS		3.46
earth fault	3.131		rated conditional short-circuit current	3.120	
electrical breakdown		3.9	rated current	3.117	
(electrical) insulation		3.10	rated load	3.115	
(electronic) (power) conversion		3.11	rated peak withstand current	3.118	
enclosure		3.12	rated short-time withstand current	3.119	
enhanced protection		3.13	rating	3.113	
expected lifetime		3.14	rated value	3.114	
Extra Low Voltage (ELV)		3.15	rated voltage	3.116	
fault protection		3.16	reference non-linear load	3.126	
field wiring terminal		3.17	reference test load	3.125	
fire enclosure		3.18	reinforced insulation		3.47
functional insulation		3.19	restricted access area		3.48
hazardous energy	3.107		routine test		3.49
hazardous live part		3.20	sample test		3.50
hazardous voltage	3.106		SELV (systems)		3.51
installation		3.21	short-circuit backup protection		3.52
instructed person	3.103		service acces area	3.105	
linear load	3.123		short-circuit protective device (SCPD)	3.130	
live part		3.22	simple separation		3.53
low impedance path	3.121		single fault condition		3.54
low voltage		3.23	skilled person	3.102	
mains supply		3.24	startle reaction		3.55
muscular reaction (inability to let go)		3.25	supplementary insulation		3.56

Terms	Term number		Terms	Term number	
	62040-1	62477-1		62040-1	62477-1
non-linear load	3.124		surge protective device (SPD)		3.57
non-mains supply		3.26	system		3.58
open type		3.27	system voltage		3.59
ordinary person	3.104		stored energy mode	3.129	
output short-circuit current		3.28	temporary overvoltage		3.60
PELV (systems)		3.29	touch current		3.61
Permanently connected		3.30	type test		3.62
pluggable equipment type A		3.31	ventricular fibrillation		3.63
pluggable equipment type B		3.32	working voltage		3.64
port		3.33	uninterruptible power system (UPS)	3.101	
			zone of equipotential bonding		3.65

Note 1 to entry: Where the terms "voltage" and "current" are used, RMS values are implied unless otherwise specified.

Note 2 to entry: Non-sinusoidal signals are measured with appropriate true RMS measuring instruments.

3.101
uninterruptible power system
UPS
combination of convertors, switches and energy storage devices (such as batteries), constituting a power system for maintaining continuity of load power in case of input power failure

Note 1 to entry: Continuity of load power occurs when voltage and frequency are within rated steady-state and transient tolerance bands, and with distortion and interruptions within the limits specified for the output port. Input power failure occurs when voltage and frequency are outside rated steady-state and transient tolerance bands, or with distortion or interruptions outside the limits specified for the **UPS**.

3.102
skilled person
person with relevant education and experience to enable him or her to perceive risks and to avoid hazards which the equipment can create

Note 1 to entry: Such person has access to restricted access areas.

[SOURCE: IEC 60050-195:1998, 195-04-01, modified – The word "(electrically)" has been deleted from the term, and "electricity" has been replaced by "the equipment" in the definition. The note has been added.]

3.103
instructed person
person adequately advised or supervised by **skilled persons** to enable him or her to perceive risks and to avoid hazards which the equipment can create

Note 1 to entry: Such person has access to restricted access areas.

Note 2 to entry: Examples of activities performed by an **instructed person** can be found in IEC 61140:2001, Clause 8.

[SOURCE: IEC 60050-195:1998, 195-04-02, modified – The word "(electrically)" has been deleted from the term, and the notes have been added.]

3.104
ordinary person
person who is neither a **skilled person** nor an **instructed person**

Note 1 to entry: Such person does not have access to a restricted access area and is not trained to identify hazards. Such person may otherwise have access to the equipment or may be in the vicinity of the equipment. An ordinary person will not intentionally create hazards nor have access to hazardous parts under normal and **single fault conditions**.

[SOURCE: IEC 60050-195:1998, 195-04-03, modified – The note has been added.]

3.105
service access area
area accessible by **skilled person**s by the use of a tool, where it is necessary for **skilled person** to have access regardless of the equipment being energized

3.106
hazardous voltage
voltage exceeding 42,4 V peak, or 60 V DC, existing in a circuit that does not meet the requirements for either a limited current circuit or a TNV-1 circuit

Note 1 to entry: A limited current circuit is understood in the context of "protection by means of protective impedance" as described in IEC 62477-1:2012, 4.4.5.4.

[SOURCE: IEC 60950-1:2005, 1.2.8.6 modified – TNV has been replaced by TNV-1.]

3.107
hazardous energy
available power level of 240 VA or more, having a duration of 60 s or more, or a stored energy level of 20 J or more (for example, from one or more capacitors), at a potential of 2 V or more

Note 1 to entry: See IEC 62477-1:2012, 4.5.1.2.

3.108
primary power
power supplied by an electrical utility company or by a local generator

3.109
cord
flexible cable with a limited number of conductors of small cross-sectional area

[SOURCE: IEC 60050-461:2008, 461-06-15.]

3.110
bypass
alternative power path, either internal or external to the **UPS**

3.111
active power
under periodic conditions, mean value, taken over one period T, of the instantaneous power p

$$P = \frac{1}{T}\int_0^T p\,\mathrm{d}t$$

Note 1 to entry: Under sinusoidal conditions, the **active power** is the real part of the complex power $\underline{S}$, thus $\underline{P}$ = Re $\underline{S}$

Note 2 to entry: The coherent SI unit for **active power** is watt, W.

Note 3 to entry: DC, fundamental and harmonic voltages and currents contribute to the magnitude of the **active power**. Where applicable, instruments used to measure **active power** should therefore present sufficient bandwidth and be capable of measuring any significant non-symmetrical and harmonic power components.

[SOURCE: IEC 60050-131: 2013, 131-11-42, modified – A third note to entry has been added.]

3.112
apparent power
product of the RMS voltage and RMS current

3.113
rating
set of **rated values** and operating conditions of a machine, a device or equipment

[SOURCE: IEC 60050-151:2001, 151-16-11, modified – The words "of a machine, a device or equipment" have been added.]

3.114
rated value
value of a quantity used for specification purposes, generally established by a manufacturer for a specified set of operating conditions of a component, device, equipment, or system

[SOURCE: IEC 60050-151:2001, 151-16-08, modified – The word "established" has been expanded to read "generally established by a manufacturer".]

3.115
rated load
load or condition in which the output of the **UPS** delivers the power for which the **UPS** is rated

Note 1 to entry: The **rated load** is expressed in **apparent power** (VA) and **active power** (W) resulting in a (rated) power factor that includes the effect of any applicable combination of **linear** and of **non-linear load** as prescribed in Annex BB.

Note 2 to entry: **Rated load** is a value of load used for specification purposes, generally established by a manufacturer for a specified set of operating conditions of a component, device, equipment, or system

3.116
rated voltage
input or output voltage as declared by the manufacturer

Note 1 to entry: For a three-phase supply, the rated voltage corresponds to the phase-to-phase voltage.

3.117
rated current
input or output current of the **UPS** as declared by the manufacturer

3.118
rated peak withstand current
I_{pk}
value of peak short-circuit current, declared by the **UPS** manufacturer, that can be withstood under specified conditions

Note 1 to entry: For the purpose of this document, I_{pk} refers to the initial asymmetric peak value of the prospective test current listed in Table 104.

3.119
rated short-time withstand current
I_{cw}
RMS value of short-time current, declared by the **UPS** manufacturer, that can be carried under specified conditions, defined in terms of current and time

[SOURCE: IEC 61439-1:2011, 3.8.10.3, modified – The definition has been rephrased and the word "assembly" has been replaced by "**UPS**".]

3.120
rated conditional short-circuit current
I_{cc}
RMS value of **prospective short-circuit current**, declared by the **UPS** manufacturer, that can be withstood for the total operating time (clearing time) of the **short-circuit protective device** (**SCPD**) under specified conditions

Note 1 to entry: The **short-circuit protective device** does not necessarily form an integral part of the **UPS**.

[SOURCE: IEC 61439-1:2011, 3.8.10.4, modified – The word "RMS" has been added to "value", the word "assembly" has been replaced by "**UPS**", and the note has been rephrased.]

3.121
low impedance path
path containing devices that for **UPS** load purposes present negligible impedance, such as cabling, switching devices, protecting devices and filtering devices

Note 1 to entry: The devices in a **low impedance path** generally present current limiting characteristics under short-circuit conditions.

Note 2 to entry: Examples include current limiting fuses, current limiting circuit-breakers, transformers and inductors.

3.122
prospective short-circuit current
I_{cp}
RMS value of the current which would flow if the supply conductors to the circuit are short-circuited by a conductor of negligible impedance located as near as practicable to the supply terminals of the **UPS**

[SOURCE: IEC 61439-1:2011, 3.8.7, modified – The word "assembly" has been replaced by "**UPS**".]

3.123
linear load
load where the current drawn from the supply is defined by the relationship:

$$I = U/Z$$

where

I is the load current;

U is the supply voltage;

Z is the constant load impedance

Note 1 to entry: Application of a **linear load** to a sinusoidal voltage results in a sinusoidal current.

[SOURCE: IEC 62040-3:2011, 3.2.4]

3.124
non-linear load
load where the parameter Z (load impedance) is no longer a constant but is a variable dependent on other parameters, such as voltage or time

[SOURCE: IEC 62040-3:2011, 3.2.5]

3.125
reference test load
load or condition in which the output of the **UPS** delivers the **active power** (W) for which the **UPS** is rated

Note 1 to entry: This definition permits, when in test mode and subject to local regulations, the **UPS** output to be injected into the input AC supply.

[SOURCE: IEC 62040-3:2011, 3.3.5]

3.126
reference non-linear load
non-linear load that when connected to a **UPS**, consumes the **apparent power** at which the **UPS** shall be tested

Note 1 to entry: Refer to Clause BB.5 for test details.

[SOURCE: IEC 62040-3:2011, 3.3.6, modified – The expression "the apparent and active power for which the UPS is rated in accordance with Annex E" has been replaced by "the apparent power at which the **UPS** shall be tested", and the note has been added.]

3.127
backfeed
condition in which a voltage or energy available within the **UPS** is fed back to any of the input terminals, either directly or by a leakage path while operating in the **stored energy mode** and with **primary power** not available

[SOURCE: IEC 62040-3:2011, 3.2.3, modified – The words "while AC input power is" have been replaced by "with **primary power**".]

3.128
backfeed protection
control scheme that reduces the risk of electric shock due to **backfeed**

3.129
stored energy mode
stable mode of operation that the **UPS** attains under the following conditions:

a) AC input power is disconnected or is out of required tolerance;

b) all power is derived from the energy storage device;

c) the load is within the specified **rating** of the **UPS**

[SOURCE: IEC 62040-3:2011, 3.2.10, modified – The words "of UPS operation" have been deleted in the term, and the word "system" has been replaced by "device" in b).]

3.130
short-circuit protective device
SCPD
device intended to protect a circuit or parts of a circuit against short-circuit currents by interrupting them

[SOURCE: IEC 60947-1:2007, 2.2.21]

3.131
earth fault
occurrence of an accidental conductive path between a live conductor and the earth

[SOURCE: IEC 60050-826:2004, 826-04-14, modified – The second preferred term "ground fault" has been deleted, as well as the notes.]

4 Protection against hazards

Clause 4 of IEC 62477-1:2012 applies, except as follows:

4.2 Fault and abnormal conditions

Subclause 4.2 in IEC 62477-1:2012 applies, except as follows:

Replace the fourth paragraph of IEC 62477-1:2012, 4.2 by the following:

Compliance is checked by analysis or by test according to 5.2.4.6 of IEC 62477-1:2012.

Compliance through analysis only is permitted when such analysis conclusively shows that no hazard will result from failure of the component.

4.3 Short-circuit and overload protection

Subclause 4.3 in IEC 62477-1:2012 applies except as follows:

Add the following:

4.3.101 AC input current

The input current to the **UPS** shall not exceed that declared by the **UPS** manufacturer – see 6.2 a).

In determining the steady state input current, the consumption due to optional features offered or provided by the manufacturer for inclusion in or with the **UPS** shall be considered and adjusted to give the most unfavourable result.

NOTE Transient input current arising from dynamic occurences, for example inrush or overload current, is not considered.

Compliance is checked when highest current measured or calculated (as applicable) when performing the test described in 5.2.3.102 does not exceed the input current declared by the manufacturer (see 6.2).

4.3.102 Transformer protection

Transformers shall be protected against overtemperature.

NOTE Means of protection include:

- overcurrent protection,
- internal thermal cut-outs,
- use of current limiting devices.

Compliance is checked by the applicable tests of 5.2.3.104.

4.3.103 AC input short-circuit current

The **UPS** manufacturer shall specify the **rated conditional short-circuit current** (I_{cc}) or the **rated short-time withstand current** (I_{cw}) at each AC input port of the **UPS**. The UPS manufacturer may specify both. Individual AC input ports of a **UPS** may have individual **ratings**.

A **UPS** with AC input ports that may be configured with jumpers or busbars to present a single AC input port or multiple AC input ports shall be tested as having multiple AC input ports. Testing with installed jumpers or busbars that combine multiple AC input ports into a single

AC input port is not required when the construction of the jumpers or busbars is at least as robust as that of the phase conductors in terms of cross-sectional area, mechanical support and clearance.

A **UPS** with multiple AC input ports and different **ratings** for each port shall indicate, when configured as a single AC input port, a **rating** equal to the lowest **rating** of any port (see table 101).

Table 101 – UPS input port configuration

UPS input port configuration	AC input port(s)	I_{cc}/I_{cw} rating
Single input port	Port 1 e.g. combined rectifier and **bypass** input	I_{cc}/I_{cw}
Multiple input ports	Port 1 e.g. rectifier input	I_{cc1}/I_{cw1}
	Port 2 e.g. **bypass** input	I_{cc2}/I_{cw2}
	Combined ports 1 and 2	Lesser of I_{cc1}/I_{cw1} or I_{cc2}/I_{cw2}

Except where exempted in 5.2.3.103.4, conditional short-circuit **ratings** and withstand current **ratings** shall be verified by application of a short-circuit across the AC output port only in modes of operation wherein the output power is delivered by the AC input through a low impedance path. Refer to 5.2.3.103.1 for general procedure, and to Figures EE.1 to EE.3 for a typical circuit for implementation of the test of Clause EE.4.

The effects of faults that originate within the **UPS** are addressed in 4.2, except as follows.

Where a **UPS** has an AC input port with no **low impedance path** to the AC output port, compliance is checked by applying the short-circuit immediately before the point where the input path no longer presents negligible impedance. The point of application of the short-circuit may be internal to the **UPS**.

*Compliance shall be verified in the modes of operation wherein the output power is or, as a result of the short-circuit, becomes delivered, by the AC input through a **low impedance path**. Verification in **stored energy mode** is not required.*

NOTE 1 Examples of such modes of operation include:

– input voltage and frequency dependent (VFD) **UPS** operating in normal and/or **bypass** modes;
– input voltage independent (VI) **UPS** operating in normal and/or **bypass** modes;
– input voltage and frequency independent (VFI) **UPS** operating in **bypass** mode;
– **UPS** with built-in maintenance **bypass** switch when operating in maintenance **bypass** mode.

NOTE 2 **UPS** performance classifications VFD, VI and VFI are detailed in IEC 62040-3:2011.

4.3.104 Protection of the energy storage device

The energy storage device whether internal (integral) or external to the **UPS** unit shall be protected against fault current and against overcurrent.

An overcurrent protective device providing the functions of a disconnect device as stated in 4.101.2 shall be located in close proximity to the energy storage device, and the following requirements apply:

a) for the purpose of interrupting a fault current supplied by the energy storage device, the overcurrent protective device shall:
   – not require a current greater than the fault current available,
   – be rated to interrupt the maximum fault current available.

b) the cables interconnecting the energy storage device, the overcurrent protective device and the **UPS** unit shall be rated to support:

– the maximum current required by the **UPS** when operating in **stored energy mode,**

– the maximum fault current available.

The maximum fault current available shall be determined at the output of the fully charged energy storage device.

Compliance with requirements a) and b) above is verified by investigation of the characteristics of the protective device(s) and of the cables as supplied (or as specified for installation) while considering the energy storage device (or range of energy storage devices) to be supported.

NOTE Guidance for current **rating** of cables is found in IEC 60287-1-1.

4.3.105 Unsynchronised load transfer

This abnormal condition is to be simulated on a **UPS** which employs either a solid state or manual switch that connects the bypass source of supply to the **UPS** output.

Compliance is determined by conducting the test in 5.2.3.105.

NOTE This test is to simulate the effects of foreseeable wiring connection misplacements in the sources of supply to the **UPS**.

4.4 Protection against electric shock

Subclause 4.4 in IEC 62477-1:2012 applies, except as follows:

4.4.2.2.2 Selection tables for contact area and skin humidity condition

Subclause 4.4.2.2.2 in IEC 62477-1:2012 applies, except as follows:

Add the following text:

UPS within the scope of this document are by default specified for indoor dry environmental service conditions and for access by an **ordinary person**. For such default application, select the following area and condition:

a) body contact area: "Hand" (Table 3)

b) skin humidity condition: "Dry" (Table 4)

NOTE The area and condition above determine the decisive voltage category of the **UPS** to be DVC A, thus limiting the voltage on touchable parts to equal or less than 30 V RMS, 42,4 V peak or 60 V DC.

Different body contact area and/or skin humidity condition shall be applied where different environmental service conditions and/or operator access restrictions apply.

For equipment to be installed in a **restricted access area,** the following exceptions are permitted.

- Contact with bare parts of a circuit at **hazardous voltage** with the test finger is permitted (see Figure M.101). However, such parts shall be so located or guarded that unintentional contact is unlikely.
- Bare parts that present a **hazardous energy** level shall be located or guarded so that unintentional bridging by conductive materials that might be present is unlikely.
- No requirement is specified regarding contact with bare parts of circuits complying with the limits of decisive voltage classifications DVC A1, A2, A3, A or B (see Table A.101).

In deciding whether or not unintentional contact is likely, account is taken of the need to gain access past, or near to, the bare parts. For determination of a **hazardous energy** level, see 4.5.1.2 in IEC 62477-1: 2012.

Compliance is checked by inspection and measurement.

4.4.3.3 Protection by means of enclosures or barriers

Replace the existing title and text of 4.4.3.3 in IEC 62477-1: 2012 by the following:

4.4.3.3 Openings

Accessible openings in enclosures shall comply with minimum protection degree IP2X in accordance with IEC 60529 when installed in accordance with manufacturer's instructions unless a greater level of protection is stated by the manufacturer.

Openings shall not exceed 5 mm in any dimension when such openings are located in the top of an enclosure not exceeding a height of 1,8 m and when located above bare parts presenting a **hazardous voltage**, unless the construction prevents vertical access to such parts, for example, by means of design (see Figure 101).

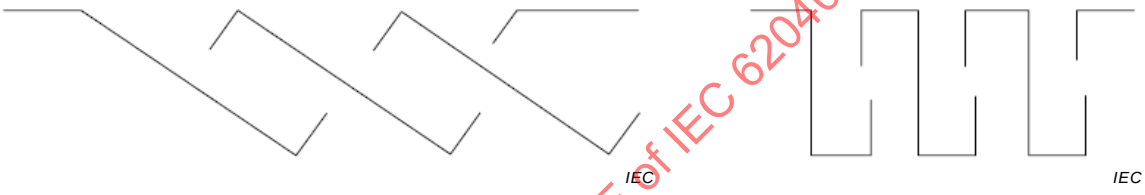

Figure 101 – Examples of design of openings preventing vertical access

Compliance is checked by inspection as per 5.2.2.2 in this document.

4.4.7.1.1 Influencing factors

Subclause 4.4.7.1.1 in IEC 62477-1:2012 applies, except as follows:

Add the following text:

The working voltage can also be measured in accordance with Annex A.

4.4.7.1.2 Pollution degree

Subclause 4.4.7.1.2 in IEC 62477-1:2012 applies, except as follows:

Add the following text:

Unless otherwise specified by the **UPS** manufacturer, the **UPS** shall be suitable for installation in environments in which the pollution degree is 2 (PD2), see IEC 62477-1: 2012, Table 8.

4.4.7.1.3 Overvoltage category (OVC)

Subclause 4.4.7.1.3 in IEC 62477-1:2012 applies, except as follows:

Add the following text:

As a minimum, the **UPS** shall be suitable for installation in environments presenting overvoltage categories listed in Table 102.

For **UPS** units designed to be part of a parallel configuration, the current to be considered in Table 102 is that provided by the parallel configuration.

Table 102 – Overvoltage categories

Rated UPS output current I (RMS) A	**Overvoltage category** **OVC**[a]
$I \leq 16$	II
$16 < I \leq 75$	II
$75 < I \leq 400$	II
$400 < I \leq 500$	III
$500 < I$	III
NOTE In general and depending on the mode of operation, the OVC to which the critical load is subjected is that of the **UPS** input. This can be reduced through overvoltage reduction techniques (see Annex I of IEC 62477-1:2012). [a] The OVC specified represent those of typical installations in accordance with 4.4.7.1.3. Different OVC can apply under special conditions (see Annex I of IEC 62477-1:2012).	

If measures are provided to reduce impulses of overvoltage category III to values of category II, or values of category II to values of category I, appropriate insulation may be designed to the reduced values, provided that following a single failure, e.g. of the reduction measure, at least the basic insulation requirements for the original overvoltage category shall be fulfilled.

NOTE For guidance on overvoltage category reduction, see Annex I of IEC 62477-1:2012.

4.4.7.1.7 Components bridging insulation

Subclause 4.4.7.1.7 in IEC 62477-1:2012 applies, except as follows:

Add the following text:

A capacitor connected between two line conductors in a primary circuit, or between one line conductor and the neutral conductor or between the primary circuit and protective earth shall comply with one of the subclasses of IEC 60384-14 or with the requirement of 4.4.7.1.7 of IEC 62477-1: 2012 and shall be used in accordance with its rating for voltage and current.

For equipment to be connected to IT power distribution systems components connected between line and earth shall be rated for the line-to-line voltage. However, capacitors rated for the applicable line-to-neutral voltage are permitted in such applications if they comply with subclass Y1, Y2 or Y4 of IEC 60384-14.

4.4.7.2.2 Circuits connected to mains supply

Subclause 4.4.7.2.2 in IEC 62477-1:2012 applies, except as follows:

Add the following text:

A preventive maintenance plan is an alternative to monitoring, as long as the continuity of the overvoltage reduction remains the same.

4.4.7.7 PWB spacings for functional insulation

Subclause 4.4.7.7 in IEC 62477-1:2012 applies, except as follows:

Replace, in the second paragraph, the first sentence by the following text:

Decreased spacing for components mounted on PWB or decreased spacing on PWB are permitted when all the following are satisfied:

4.4.9 Capacitor discharge

Clause 4.4.9 of IEC 62477-1: 2012 applies except as follows:

Replace, in the first paragraph, the two bullet points by the following text:

- for pluggable **UPS** type A, the discharge time shall not exceed 1 s or the hazardous live parts shall be protected against direct contact by at least IPXXB (see 4.4.3.3);
- for pluggable **UPS** type B, the discharge time shall not exceed 5 s or the hazardous *live parts* shall be protected against direct contact by at least IPXXB (see 4.4.3.3);
- for permanently connected **UPS**, the discharge time shall not exceed 15 s.

4.5 Protection against electrical energy hazards

4.5.2 Service access areas

Subclause 4.5.2 in IEC 62477-1:2012 applies except as follows:

Add, after the second paragraph, the following text:

This requirement does not apply to terminals covered by 4.4.9.

In a **service access area**, the following requirements apply.

Bare parts at **hazardous voltage** shall be located or guarded so that unintentional contact with such parts is unlikely during service operations involving other parts of the equipment. Bare parts at **hazardous voltage** shall be located or guarded so that accidental shorting to parts at non-hazardous potentials (for example, by **tools** or test probes used by a **service person**) is unlikely.

Compliance is checked by inspection.

4.6 Protection against fire and thermal hazards

Subclause 4.6 in IEC 62477-1:2012 applies, except as follows:

4.6.2.2 Components within a circuit representing a fire hazard

Subclause 4.6.2.2 in IEC 62477-1:2012 applies, except as follows:

Add the following text:

Batteries shall have a flammability class HB or better.

4.6.3.1 General

Subclause 4.6.3.1 in IEC 62477-1:2012 applies, except as follows:

*Replace "PECS" by "**UPS**".*

Replace, in the second paragraph, the first bullet point by the following text:

- circuits inside of an enclosure are within the limits of limited power sources in 4.6.5 of this document.

4.6.3.2 Flammability of enclosure materials

Subclause 4.6.3.2 in IEC 62477-1:2012 applies, except as follows:

Replace the second paragraph with the following new paragraph:

Materials are considered to comply without test if, in the minimum thickness used, the materials are of flammability class 5VB or better, according to IEC 60695-11-20.

Add, after the second paragraph, the following new paragraph:

For movable **UPS** having a total mass not exceeding 18 kg, materials are considered to comply without test if, in the minimum thickness used, the materials are of flammability class of V-1 or better, according to IEC 60695-11-10.

4.6.3.3.2 Openings in the top and side of fire enclosures

Subclause 4.6.3.3.2 in IEC 62477-1:2012 applies, except as follows:

Replace the third paragraph by the following text:

The test requirements are found in 5.2.2.2 of this document.

Replace, in the fourth paragraph, "IP3X" by "IP2X".

4.6.4 Temperature limits

4.6.4.1 Internal parts

Subclause 4.6.4.1 in IEC 62477-1:2012 applies, except as follows:

*Replace, in the first paragraph, the words "*when tested in accordance with*" by "*when tested in normal mode in accordance with*".*

Add, after the first paragraph, the following text:

Magnetic components shall not attain temperatures in excess of those in Table 103 when tested in stored energy mode in accordance with the ratings of the equipment.

NOTE Table 103 provides additional temperature limits for infrequent and occasional occurrences.

Table 103 – Maximum temperature limits for magnetic components during stored energy mode of operation

Insulation class °C	Temperature by average resistance method °C	Temperature by thermocouple methods °C
105	127	117
120	142	132
130	152	142
155	171	161
180	195	185
200	209	199
220	216	206
250	234	224

4.6.5 Limited power sources

Subclause 4.6.5 in IEC 62477-1:2012 applies, except as follows:

Add, at the end of the first paragraph, the following text:

Compliance to both the maximum allowed current and maximum **apparent power** available from the power source is required.

Replace, in the second paragraph, letter b) by the following text:

b) a linear or non-linear impedance limits the output in compliance with Table 16. If a positive temperature coefficient device (PTC) is used, it shall pass the tests specified in IEC 60730-1, Clauses 15, 17, J.15 and J.17; or

4.7 Protection against mechanical hazards

Subclause 4.7 in IEC 62477-1:2012 applies, except as follows:

Add the following subclause:

4.7.101 Protection in service access area

Moving parts that can cause injury to persons during service operations shall be located, or protection shall be provided, such that unintentional contact with the moving parts is not likely.

Compliance is checked by inspection.

4.8 Equipment with multiple sources of supply

Replace the existing text of 4.8 in IEC 62477-1:2012 by the following:

4.8.101 General

If equipment is provided with more than one supply connection (for example, with different voltages or frequencies or as backup power), the design shall be such that all of the following conditions are met:

- separate means of connection are provided for different circuits;

- supply plug connections, if any, are not interchangeable if a hazard could be created by incorrect plugging;
- hazards, within the meaning of this document, shall not be present under normal or **single fault condition**s due to the presence of multiple sources of supply. Actions such as disconnection or de-energizing of a supply are considered a normal condition.

Compliance is checked by evaluation in accordance with IEC 62477-1:2012, 4.2.

Information is to be provided with the equipment indicating the presence of multiple sources of supply and disconnection procedures (see IEC 62477-1:2012, 6.5.5).

NOTE Examples of the types of hazards considered are:

a) **Backfeed**;

b) Unintentional islanding;

c) Higher touch current levels with multiple sources connected simultaneously (if that is a normal condition for the equipment);

d) Hazard resulting from damage to one or more connected sources due to energy from another source, such as from the mains to a generator;

e) Damage to wiring due to currents higher than the wiring is designed for flowing from another source.

4.8.102 Backfeed protection

A **UPS** shall prevent **hazardous voltage** or **hazardous energy** from being present on the **UPS** input AC terminals after interruption of the input AC power.

No shock hazard shall exist at AC input terminals when measured 1 s after de-energization of AC input for pluggable **UPS**, or 15 s for permanently connected **UPS**.

For permanently connected **UPS**, **backfeed protection** may be implemented external to the **UPS** with the use of an AC input line isolation device.

In this case, the **backfeed protection** requirement applies to the input terminals of the isolation device. The **UPS** supplier shall provide or specify a suitable isolating device which shall include additional labelling and instructions in accordance with 6.4.3.101.

Compliance is checked by inspection of the equipment and relevant circuit diagram, and by simulating fault conditions in accordance with 5.2.3.101.

When an air gap is employed for **backfeed protection**, the provision of IEC 62477-1:2012, Table 10 and Table 11 for creepage and clearance distances applies in addition to the following.

a) Subject to confirmation from the manufacturer, the **UPS** output, in **stored energy mode**, may be considered a transient free circuit of overvoltage category I (for this purpose identify the overvoltage category I value in IEC 62477-1:2012, Table 9, by using the appropriate **UPS** RMS system output voltage). An impulse voltage withstand test is not required since there is no transient overvoltage present when the AC main input supply is not available. Therefore, the overvoltage category values apply without an impulse test.

b) The creepage and clearance distances shall meet the requirements for pollution degree 2 (see IEC 62477-1:2012, Table 10 and Table 11).

c) Reinforced or equivalent insulation of the **UPS** output to the **UPS** input applies if during **stored energy mode** of operation not all input poles are isolated by the **backfeed protection** device. In all other cases, basic insulation is acceptable. Impulse withstand voltage is not required since there is no impulse when the AC main input supply is not available. Therefore, the pollution degree values apply without an impulse test.

NOTE 1 A contactor is an example of an isolation device presenting an air gap.

NOTE 2 One method of obtaining insulation equivalent to reinforced insulation is to combine an air gap meeting the basic insulation requirements and a solid-state power isolation device(s) as described in 5.2.3.101.5.

Compliance is checked by inspection

4.9 Protection against environmental stresses

Subclause 4.9 in IEC 62477-1:2012 applies, except as follows:

Add the following text:

The **UPS**, as a minimum, shall comply with the following indoor conditions: climatic, pollution degree, and humidity condition of the skin as part of the environmental service condition 3K2 of Table 18 of IEC 62477-1:2012. The manufacturer may elect to comply with environmental service conditions more onerous than 3K2 subject to the **UPS** being marked accordingly (see 6.2).

4.10 Protection against sonic pressure hazards

Replace the existing text of 4.10 in IEC 62477-1:2012 by the following:

The requirements for protection against sonic pressure hazards are considered to be beyond the scope of this document because such requirements are dependent on local regulations.

4.11 Wiring and connections

Subclause 4.11 in IEC 62477-1:2012 applies, except as follows:

4.11.8.2 Connecting capacity

Subclause 4.11.8.2 in IEC 62477-1:2012 applies, except as follows:

Add the following text:

The **UPS** manufacturer shall indicate whether the terminals are suitable for connection of copper or aluminium conductors, or both. The terminals shall be such that the external conductors may be connected by a means (screws, connectors, etc.) which ensures that the necessary contact pressure corresponding to the current **rating**, the short-circuit strength of the apparatus and the circuit are maintained.

In the absence of a special agreement between the **UPS** manufacturer and the purchaser, terminals shall be capable of accommodating copper conductors from the smallest to the largest cross-sectional areas corresponding to the appropriate **rated current** (see Annex AA).

Compliance is checked by inspection, by measurement and by fitting at least the smallest and largest cross-sectional areas of the appropriate range in Annex AA.

Add the following subclauses:

4.11.101 Non-detachable cords

4.11.101.1 Cord guard

A **cord** guard shall be provided at the **cord** inlet opening of equipment that has a non detachable **cord** and is intended to be moved while in operation. Alternatively, the inlet or bushing shall be provided with a smoothly rounded bell-mouthed opening having a radius of curvature equal to at least 150 % of the overall diameter of the **cord** with the largest cross-sectional area to be connected.

Cord guards shall:

- be so designed as to protect the **cord** against excessive bending where it enters the equipment,
- be of insulating material,
- be fixed in a reliable manner, and project outside the equipment beyond the inlet opening for a distance of at least five times the overall diameter or, for flat **cords**, at least five times the major overall cross-sectional dimension of the **cord.**

4.11.101.2 Cord anchorages and strain relief

For equipment with a non-detachable **cord**, a cord anchorage shall be supplied such that:

- the connecting points of the **cord** conductors are relieved from strain, and
- the outer covering of the **cord** is protected from abrasion.

It shall not be possible to push the **cord** back into the equipment to such an extent that the **cord** or its conductors, or both, could be damaged or internal parts of the equipment could be displaced.

For non-detachable **cords** containing a protective earthing conductor, the construction shall be such that, if the **cord** should slip its anchorage, placing a strain on conductors, the protective earthing conductor shall be the last to take the strain.

The cord anchorage shall either be made of insulating material or have a lining of insulating material complying with the requirements for supplementary insulation. However, where the cord anchorage is a bushing that includes the electrical connection to the screen of a screened **cord,** this requirement shall not apply.

The construction of the cord anchorage shall be such that:

- **cord** replacement does not impair the safety of the equipment,
- for replacement **cords**, it is clear how relief from strain is to be obtained,
- the **cord** is not clamped by a screw that bears directly on the cord, unless the cord anchorage, including the screw, is made of insulating material and the screw is of comparable size to the diameter of the **cord** being clamped,
- methods such as tying the **cord** into a knot or tying the cord with string are not used, and
- the **cord** cannot rotate in relation to the body of the equipment to such an extent that mechanical strain is imposed on the electrical connections.

*Compliance is checked by inspection and by applying the following tests that are made with the type of **cord** supplied with the equipment.*

*The **cord** is subjected to a steady pull of the following value, applied in the most unfavourable direction:*

a) *30 N for **UPS** of mass up and to including 1 kg;*

b) *60 N for **UPS** over 1 kg and including 4 kg;*

c) *100 N for **UPS** over 4 kg.*

*The test is conducted 25 times, each time for duration of 1 s. During the tests, the **cord** shall not be damaged. This is checked by visual inspection, and by AC or DC voltage test (dielectric strength test) between the **cord** conductors and accessible conductive parts, at the test voltage appropriate for reinforced insulation.*

*After the tests, the **cord** shall not have been longitudinally displaced by more than 2 mm nor shall there be appreciable strain at the connections, and clearances and creepage distances shall not be reduced below the values specified in IEC 62477-1:2012, 4.4.7.4. and 4.4.7.5.*

Add the following subclauses:

4.101 UPS isolation and disconnect devices

4.101.1 Emergency switching (disconnect) device

A **UPS** shall be provided with an integral single emergency switching device (or terminals for the connection of the remote emergency switching device), which prevents further supply to the load by the **UPS** in any mode of operation. If reliance is placed on additional disconnection of supplies in the building wiring installation, the installation instructions shall so state. The requirement is not mandatory for pluggable **UPS** if permitted by national regulations.

NOTE In some countries, an emergency switching device is called "EPO" (emergency power off).

Compliance is checked by inspection and analysis of relevant circuit diagrams.

4.101.2 Normal disconnect devices

Means shall be provided to disconnect the **UPS** from the AC and DC supplies for service and testing by **skilled person**.

Means of isolation and disconnect devices for internal and external DC supplies, for example a battery bank, shall open all ungrounded conductors connected to the DC supply.

Means of isolation and disconnect devices for external AC supplies shall open all ungrounded conductors connected to the AC supply.

NOTE 1 Unless applicable for functional use, the means of disconnection are generally located either in the **service access area** or external to the equipment, and specified in the installation instructions. For further guidance about selection of disconnect devices, refer to IEC 60947-3:2008, Table 2.

NOTE 2 Disconnect devices for service and test purposes are generally designed for operation under no-load, provided that the critical load can be transferred as applicable by other means, for example by using a static transfer switch.

If operation of a disconnect device alters the **UPS** output voltage with respect to the protective earth potential, then operation of that device shall be alarmed. Alternatively, an appropriate warning label shall be located adjacent to that disconnect device or to its command.

NOTE 3 Such a situation arises upon opening of a 4-pole input isolator that provides neutral reference to the **UPS**.

If the operating means of the disconnection device is operated vertically rather than rotationally or horizontally, the "UP" position of the operating means shall be the "ON" position.

Where a permanently connected **UPS** receives power from more than one external source, there shall be a prominent marking at each disconnect device giving adequate instructions for the removal of all power from the unit.

4.102 Stored energy source

4.102.1 General

Batteries, when selected as the stored energy source for use with **UPS**, shall be installed taking into account the requirements prescribed in 4.102.

Batteries can be installed in:

- separate battery rooms or buildings, or
- separate cabinets or compartments, indoor or outdoor, or
- battery bays or compartments within the **UPS** enclosure.

NOTE Requirements for installation of valve regulated batteries in a separate room, cabinet or compartment are subject to local regulation.

4.102.2 Accessibility and maintainability

When deemed necessary, access to battery poles and battery connectors shall be provided so that their fittings can be tested for correct tightening (torque) and be readjusted if required. Batteries with liquid electrolyte shall be so located that the battery cell caps are accessible for electrolyte tests and readjustment of electrolyte levels.

Compliance is checked by inspection and application of the tools and measuring equipment supplied or recommended by the battery manufacturer for the prevailing conditions.

4.102.3 Distance between battery cells

Battery cells or blocks, as applicable, shall be mounted for the purpose of complying with ventilation, battery temperature and insulation requirements in accordance with the requirements from the battery manufacturer.

The batteries shall be so located and mounted that the terminals of cells are prevented from coming into undesirable contact with terminals of adjacent cells, or with metal parts of the battery compartment, as the result of shifting of the battery.

Compliance is checked by inspection and by analysis of the battery manufacturer data-sheet.

4.102.4 Case insulation

Cells in conductive casings shall have adequate insulation between each other and to cabinets or compartments. The insulation shall meet the AC or DC voltage test (dielectric strength test) requirements of IEC 62477-1:2012, 5.2.3.4.

Compliance is checked by test.

4.102.5 Electrolyte spillage

To prevent effects of electrolyte spillage from the battery, adequate protection such as an electrolyte-resistive coating on the battery trays and cabinets shall be provided.

This requirement does not apply to valve regulated lead-acid batteries.

Compliance is checked by inspection.

4.102.6 Ventilation and hydrogen concentration

A **UPS** enclosure or compartment housing a vented battery

- shall comply with the ventilation requirements of Annex CC,
- may contain arc-producing elements such as open fuse links and the contacts of circuit breakers, relays, switches, disconnectors, switch-disconnectors and fuse-combination units, only if any such parts are mounted at least 100 mm below the lowest battery vent, and
- shall not vent into other closed spaces where arc-producing elements are located.

For the purpose of 4.102.6, the following components are not considered arc-producing elements: connectors, monitoring sensors (such as thermistors) and sand enclosed fuses. For battery rooms, proper information on the required flow of air shall be provided in the installation instructions where the battery installation is supplied with the **UPS**.

Compliance is checked by inspection, calculation or measurement.

4.102.7 Charging voltages

The **UPS** shall protect the batteries against excessive voltages, including under a single fault condition within the charger. Protection may be accomplished by turning off the charger or by interrupting the charging current.

Compliance is checked by circuit evaluation or test.

4.102.8 Battery circuit protection

4.102.8.1 Overcurrent and earth fault protection

A battery supply circuit shall be provided with overcurrent and **earth fault** protection, and shall comply with the requirements described in 4.102.8.

NOTE Earth-fault in the context of 4.102.8 differs from residual, leakage or touch current, covered in IEC 62477-1:2012, 4.4.8.

4.102.8.2 Location of protective devices

The protective device shall be constructed and positioned so that arc-producing elements in this device, if any, are not subject to operation where hazardous levels of hydrogen mixture with air may be present. Where the batteries are installed in a separate room or cabinet, the overcurrent protective device shall be located in close proximity to the battery in accordance with the installation regulation applying.

NOTE Examples of locations where hazardous levels of hydrogen mixture with air can be present include those on top of battery vents and enclosed spaces where hydrogen can be trapped ("air-pockets").

Compliance is checked by inspection.

4.102.8.3 Rating of protective devices

The **rating** of the overcurrent protective device shall be such as to avoid hazards due to internal faults of the **UPS**, and circuit analysis shall be carried out for the battery circuit in accordance with IEC 62477-1:2012, 4.2.

For a **UPS** to be used with a separate battery supply, the **rating** of the overcurrent protective device shall be indicated in the instruction manual and shall take into account the current **rating** of the conductors to be connected between the **UPS** and battery supply, as well as the fault current capability of the battery supply.

Where the battery terminals are not directly grounded, the device shall protect all terminals.

Compliance is checked by analysis and inspection.

4.103 UPS connection to telecommunication lines

Terminals in the **UPS** that are intended for connection to telecommunication lines shall comply with the relevant telecommunication network voltage (TNV) classification. Refer to Table A.101 for a TNV classification comparison with decisive voltage classification (DVC).

Compliance is checked by analysis.

5 Test requirements

Clause 5 of IEC 62477-1 applies, except as follows:

5.1.5.3 Operating parameters for tests

Subclause 5.1.5.3 in IEC 62477-1:2012 applies, except as follows:

Replace the last bullet point by the following text:

- adjustments of thermostats, regulating devices or similar controls available to an **ordinary person**:
  - without the use of a tool,
  - with the use of a tool deliberately provided.

For **UPS** with external controls intended to be installed in a **restricted access area**, these controls shall be set to manufacturer's settings.

5.1.7 Test overview

Replace the existing text of 5.1.7 in IEC 62477-1:2012, including Table 22, by the following:

Table 22 provides an overview of the type, routine and sample testing.

5.1.7.101 UPS test overview

Table 22 – Test overview

Test	Type	Routine	Sample	Requirement(s)		Specification(s)	
				IEC 62040-1	IEC 62477-1	IEC 62040-1	IEC 62477-1
Visual inspection	X	X					5.2.1
Mechanical tests							
Clearance and creepage distances test	X				4.4.7.1, 4.4.7.5		5.2.2.1
Non-accessibility test, including energy hazard test after disconnection	X			4.4.3.3	4.5.1.1		5.2.2.2
Ingress protection test (IP **rating**)	X				4.12.1		5.2.2.3
Enclosure integrity test	X				4.12.1		5.2.2.4
Deflection test	X				4.12.1		5.2.2.4.2
Steady force test, 30 N	X				4.12.1		5.2.2.4.2.2
Steady force test, 250 N	X				4.12.1		5.2.2.4.2.3
Impact test	X				4.12.1		5.2.2.4.3
Drop test	X				4.12.1		5.2.2.4.4
Stress relief test	X				4.12.1		5.2.2.4.5
Stability test	X				4.12.1		5.2.2.5
Wall or ceiling mounted equipment test	X				4.12.1		5.2.2.6

Test	Type	Routine	Sample	Requirement(s)		Specification(s)	
				IEC 62040-1	IEC 62477-1	IEC 62040-1	IEC 62477-1
Rack mounted equipment test	X			Annex GG		5.2.2.6.102	
Handles and manual control securement test	X				4.12.1		5.2.2.7
Cord guard test	X			4.11.101		5.2.2.101	
Electrical tests							
Impulse voltage test	X[a,c,f]		X[b]		4.4.3.2, 4.4.5.4, 4.4.7.1, 4.4.7.10.1, 4.4.7.10.2, 4.4.7.8.3		5.2.3.2
AC or DC voltage test (dielectric strength test)	X[f]	X[e]			4.4.3.2, 4.4.5.4, 4.4.7.1, 4.4.7.10.1, 4.4.7.10.2, 4.4.7.8.4.2		5.2.3.4
Partial discharge test	X[a,f]		X[b]		4.4.7.1, 4.4.7.10.2, 4.4.7.8.3		5.2.3.5
Protective impedance test	X	X			4.4.5.4		5.2.3.6
Touch current measurement test	X				4.4.4.3.3		5.2.3.7
Capacitor discharge test	X				4.4.9		5.2.3.8
Limited power source, test including energy hazards test	X				4.5.1.2, 4.6.5		5.2.3.9
Temperature rise test	X				4.6.4		5.2.3.10
Backfeed protection test	X			4.8.102		5.2.3.101	
Protective equipotential bonding	X	X			4.4.4.2.2		5.2.3.11, 5.2.4.3
Input current	X			4.3.101		5.2.3.102	
Transformer protection	X			4.3.102		5.2.3.104	
Stored energy source tests							
Case insulation test	X	X		4.102.4			5.2.3.4
Ventilation and hydrogen concentration	X			4.102.6		Annex CC	
Charging voltages	X			4.102.7		Annex CC	
Wiring test	X			4.11.101	4.11		5.2.3.10
Abnormal operation tests							
Output short-circuit test	X				4.3.2.3		5.2.4.4
Short-time withstand current	X			4.3.103		5.2.3.103	
Unsynchronised load transfer test	X			4.3.105		5.2.3.105	

Test	Type	Routine	Sample	Requirement(s)		Specification(s)	
				IEC 62040-1	IEC 62477-1	IEC 62040-1	IEC 62477-1
Output overload test	X				4.3		5.2.4.5
Breakdown of components test	X				4.2		5.2.4.6
PWB short-circuit test	X				4.4.7.7		5.2.4.7
Loss of phase test	X				4.2		5.2.4.8
Cooling failure tests	X				4.2, 4.7.2.3.6		5.2.4.9
Inoperative blower test	X				4.2		5.2.4.9.2
Clogged filter test	X				4.2		5.2.4.9.3
Loss of coolant test	X				4.7.2.3.6		5.2.4.9.4
Material tests							
High current arcing ignition test	X[a]				4.4.7.8.2		5.2.5.2
Glow-wire test	X[a]				4.4.7.8.2		5.2.5.3
Hot wire ignition test	X[a]				4.4.7.8.2		5.2.5.4
Flammability test	X[a]				4.6.3		5.2.5.5
Flaming oil test	X				4.6.3.3.3		5.2.5.6
Cemented joints test	X				4.4.7.9		5.2.5.7
Environmental tests							
Dry heat test	X[d]				4.9		5.2.6.3.1
Damp heat test	X[d]				4.9		5.2.6.3.2
Hydrostatic pressure test	X	X			4.7.2.3.3		5.2.7

[a] Type testing of a component is not required when such type testing is performed by the supplier of the relevant component (see IEC 62477-1:2012, 5.1.5.2).

[b] Sample testing of a component only applies when required by the relevant component standard or where a component standard does not exist.

Sample testing is not required when such sample testing is performed by the supplier of the relevant component.

[c] Compliance with impulse voltage type test requirements may be satisfied in conjunction with IEC 62040-2:2005 immunity type tests (provided that the relevant safety criteria are observed).

[d] Compliance with dry and damp heat type test requirements is also satisfied in conjunction with IEC 62040-3:2011 dry and damp heat type tests (provided that the relevant safety criteria are observed).

[e] Preconditioning as described in IEC 62477-1:2012, 5.2.3.1, is not required.

[f] Multiple test are permitted following one single preconditioning as described in IEC 62477-1:2012, 5.2.3.1.

5.2 Test specification

Subclause 5.2 in IEC 62477-1:2012 applies, except as follows:

5.2.2.2 Non-accessibility test (type test)

Replace the existing text of 5.2.2.2 in IEC 62477-1:2012 by the following:

This test is intended to show that live parts protected by means of enclosures or barriers in compliance with 4.4.3.3 are not accessible.

This test shall be performed as a type test of the enclosure of a **UPS** as specified in IEC 60529 for the enclosure classification for protection against access to hazardous parts.

Except for openings preventing vertical access as noted below:

– A test probe for IP2X (12,5 mm Ø) shall not penetrate the top surface of the enclosure when probed from the vertical direction ±5° only.

Further, for **UPS** with a height not exceeding 1,8 m, such openings shall not exceed 5 mm in any direction as per 4.4.3.3.

Compliance is checked by inspection and test as above.

5.2.2.4.4 Drop test

Replace the existing text of 5.2.2.4.4 in IEC 62477-1:2012 by the following:

UPS with mass of 18 kg or less is subjected to the following test.

A sample of the complete equipment is subjected to three impacts that result from being dropped onto a horizontal surface in positions likely to produce the most adverse results.

The horizontal surface shall consist of hardwood at least 13 mm thick, mounted on two layers of plywood each 19 mm to 20 mm thick, all supported on a concrete or equivalent non-resilient floor.

The height of the drop shall be 750 mm.

Compliance is verified in accordance with the requirements in 5.2.2.4.1 of IEC 62477-1:2012.

5.2.2.6 Wall or ceiling mounted equipment test

Replace the existing title and text of 5.2.2.6 in IEC 62477-1:2012 by the following:

5.2.2.6 Wall, ceiling or rack mounted equipment test

5.2.2.6.101 Wall and ceiling mounted equipment test

The equipment is mounted in accordance with the manufacturer's instructions. A force in addition to the weight of the equipment is applied downwards through the geometric centre of the equipment, for 1 min. The additional force shall be equal to three times the weight of the equipment but not less than 50 N. The equipment and its associated mounting means shall remain secure during the test.

5.2.2.6.102 Rack mounted equipment test

Requirements for rack-mounted equipment are listed in Annex GG.

Add the following subclause:

5.2.2.101 Cord guard test

The equipment is so placed that the axis of the **cord** guard, where the **cord** leaves it, projects at an angle of 45° when the **cord** is free from stress. A mass equal to 10 D^2 g is then attached to the free end of the cord, where D is the overall diameter of, or for flat cords, the minor overall dimension of the cord, in millimeters. If the cord guard is of temperature-sensitive material, the test is made at 23 °C ± 2 °C. Flat cords are bent in the plane of least resistance. Immediately after the mass has been attached, the radius of curvature of the **cord** shall nowhere be less than 1,5 D.

*Compliance is checked by inspection, by measurement and, where necessary, by the test above with the **cord** as delivered with the equipment.*

5.2.3 Electrical tests

5.2.3.9 Limited power source test (type test)

Replace the existing text of 5.2.3.9 in IEC 62477-1:2012 by the following:

When required by 4.6.5, a limited power circuit shall be tested as below, with the equipment operating under normal operating conditions.

In case the limited power source requirement depends on overcurrent protective device(s) in Table 17, the device(s) shall be short-circuited.

With the limited power source in normal operating condition, and with a variable resistive load being the only load connected to the limited power source, the restive load shall be adjusted to obtain the maximum **apparent power**. Further adjustment is made, if necessary, to maintain the maximum **apparent power** for the time period indicated in Table 16 or Table 17, as applicable.

With the limited power source in normal operating condition, and with a variable resistive load being the only load connected to the limited power source, the restive load shall be adjusted to obtain the maximum current. Further adjustment is made, if necessary, to maintain the maximum current for the time period indicated in Table 16 or Table 17, as applicable.

Simulated faults in a regulating network, required according to 4.6.5, c), are applied under the above maximum measured values.

The test is passed, if after the test period the maximum available **apparent power** and maximum available current do not exceed the limits indicated in Table 16 or Table 17, as applicable.

5.2.3.10 Temperature rise test (type test)

Replace the existing ninth paragraph of 5.2.3.10 in IEC 62477-1: 2012 by the following:

No corrected temperature of the material or component shall exceed the temperature in Table 14 in IEC 62477-1: 2012 or Table 103 as applicable.

Add the following subclauses:

5.2.3.101 Backfeed protection test (type test)

5.2.3.101.1 General

A **UPS** shall not allow excessive touch currents to be available between any pairs of input supply terminals of the **UPS** during its **stored energy mode** of operation. Where the measured open-circuit voltage does not exceed 30 V RMS (42,4 V peak, 60 V DC), the touch current measurement need not be taken.

*Compliance is checked by tests as described in 5.2.3.101.2, 5.2.3.101.3 and 5.2.3.101.5, if applicable. The single-fault condition shall be determined by applying a short-circuit across any components where failure could adversely affect the **backfeed protection**, or by disconnecting such components.*

5.2.3.101.2 Test for pluggable UPS

The **UPS** shall initially operate in normal mode. The AC input terminals or plug(s) shall then be disconnected. This shall cause the **UPS** to operate in **stored energy mode**. When tested under no-load, under full-load and under load-induced change of reference potential conditions as described in 5.2.3.101.4, the following complying performance shall be verified:

a) the current shall not exceed 3,5 mA when measured between any two input terminals or parts accessible by an **ordinary person**, using the measurement instruments shown in Annex L;

b) the protection shall operate within 1 s for pluggable type A and within 5 s for pluggable type B **UPS** of the disconnection of the input terminals.

A single-fault condition shall then be applied. The test above shall be repeated and the compliance shall again be verified.

5.2.3.101.3 Test for permanently connected UPS

The **UPS** shall initially operate in normal mode. The AC input terminals, except for the protective earth conductor, shall then be disconnected from the AC supply. This shall cause the **UPS** to operate in **stored energy mode**. When tested under no-load and under full-load conditions, the following complying performance shall be verified:

a) the current shall not exceed 3,5 mA when measured between any two input terminals, using the measurement instruments shown in Annex L;

b) the protection shall operate within 15 s of the disconnection of the input terminals.

A single-fault condition shall then be applied. The test above shall be repeated and the compliance shall again be verified.

Where a **backfeed protection** isolation device is provided externally, compliance shall be determined by relevant circuit diagram inspection and by demonstrating that the means required to operate the external **backfeed** isolating device is within the **UPS** manufacturer's specifications for such circuit to operate.

5.2.3.101.4 Method to simulate the load-induced change of reference potential for pluggable UPS

The method detailed in 5.2.3.101.4 is used to create the change of reference potential required in 5.2.3.101.2. Change of reference potential can be caused by summation of otherwise complying load-induced earth currents and may arise when a **UPS** operate in **stored energy mode**. This condition is simulated by applying the test circuits of Figures 102 or 103. Figure 103 applies for 3-phase systems and simulates also the effect of asymmetrical single-phase loads.

NOTE 1 Some countries require the input neutral to be opened together with the phases either in the building installation or in the transmission system. In this case, the **UPS** voltage potential of neutral input is of concern unless it is clearly stated in the installation guide that the **UPS** is for use with symmetrical 3-phase loads only.

NOTE 2 5.2.3.101.4 applies to pluggable **UPS** (see 5.2.3.101.2).

NOTE 3 C simulates the capacitance of concern. The value of C is fixed as shown in Figures 102 and 103.

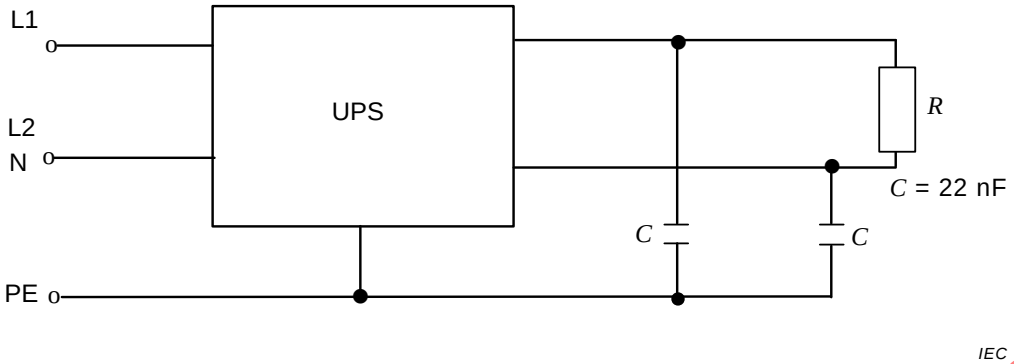

Figure 102 – Test circuit for load-induced change of reference potential – Single-phase output

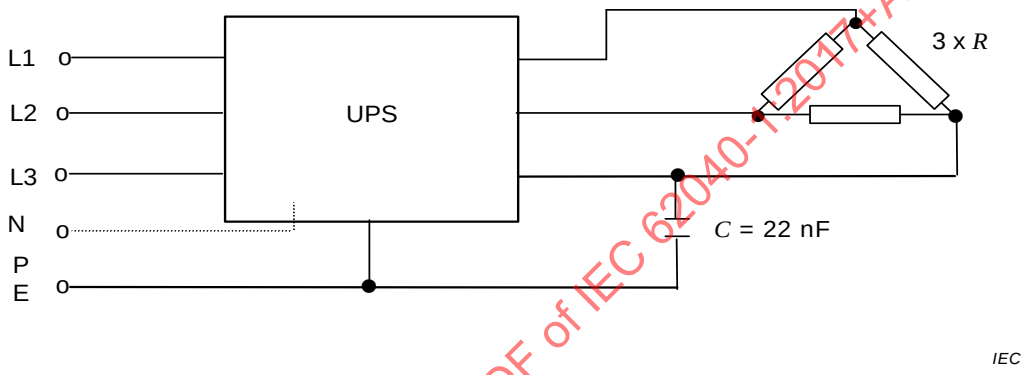

Figure 103 – Test circuit for load-induced change of reference potential – Three-phase output

The value of resistive load R shall be equal to that specified as the maximum load at unity power factor by the manufacturer.

5.2.3.101.5 Solid-state backfeed protection

In addition to 5.2.3.101.2 and 5.2.3.101.3 requirements, when **backfeed protection** relies on solid-state power isolation device(s), and if the isolation devices are not redundant, the components necessary to ensure **backfeed protection** shall withstand the effects of immunity requirements of IEC 62040-2:2005, Clause 7, and of environmental testing in IEC 62477-1:2012, 5.2.6.

5.2.3.102 Input current test

At rated input voltage in accordance with 6.2 a) and with the energy storage device disconnected (or fully charged), measure the steady state input current of the **UPS** when supplying its **rated load**.

Under the same rated load and input voltage conditions, measure or alternatively extrapolate the rated input current due to the combined effects resulting from battery recharge current at rated input voltage(s)

a) For **UPS** with separate **bypass** input, the **bypass** rated input current shall be evaluated.

b) For **UPS** with other inputs, the other rated input current shall be evaluated by test.

NOTE the manufacturer is alerted to the possible influence of input voltage tolerance on the input current being drawn.

Where the **UPS** has more than one rated input voltage, the input current is measured at each rated input voltage.

5.2.3.103 Short-time withstand current test (type test)

5.2.3.103.1 General procedure

The **UPS** AC input shall be connected to a supply capable of delivering the prospective test current in accordance with Table 104. The **UPS** shall be in the appropriate mode of operation (see 4.3.103.2) and otherwise operating without load and at rated input voltage and frequency. A short-circuit shall then be applied across the output terminals of the **UPS**. A **UPS** rated for multiple inputs may be tested at any of its rated input voltages, provided that applicable interrupting components have been certified or tested to interrupt the prospective test current at the highest rated input voltage. Each **UPS** AC input port shall be tested individually.

NOTE 1 The manufacturer can opt to perform additional tests at other **rated voltages** and currents.

NOTE 2 For consideration in a future edition of this document, the making capability of the short-circuit current into the **low impedance path** can be verified for safety purposes. Such verification could involve tests or analysis of component documentation. Examples include a **UPS** that, in normal mode of operation, does not supply the output terminals through a **low impedance path**, but that, upon application of a short-circuit across the output terminals, automatically transfers into a **low impedance path**.

NOTE 3 For consideration in a future edition of this document it will be evaluated whether tests would be permitted at voltages lower than rated and, subject to the phase current flowing throughout the minimum duration listed in Table 104, whether the manufacturer could then declare the I_{cw} to be the phase current recorded during the test.

UPS that provide single phase output shall be tested by applying a short-circuit across the output phase to neutral conductors.

UPS that provide multi-phase output shall be tested by applying a short-circuit across all output phase conductors. A single test with all phase conductors shorted together is an acceptable means of conducting the test.

UPS that provide multi-phase and a neutral output shall also be tested by placing a short-circuit across the neutral conductor and the phase conductor closest to the neutral terminal when the latter is provided. However, the phase-to-neutral test is not required when the neutral construction is at least as robust as that of the phase conductors in terms of cross-sectional area, mechanical support and clearance.

In the case where a **UPS** AC input port does not have a **low impedance path** between the input port and output port, the short-circuit shall be applied by means of a shorting cable or busbar of cross sectional area not less than the cross sectional area of the manufacturers recommended input wiring for one phase conductor. The length and installation of the shorting cable or busbar shall be selected so as to present negligible impedance.

The **UPS** shall be in the appropriate modes of operation (see 4.3.101.2) and otherwise operating without load and at rated input voltage and frequency.

A new **UPS** sample or a repaired **UPS** may be used for each short-circuit test.

Exception: It is acceptable to perform the test on an un-energized **UPS** if it can be shown by analysis that test results will not be affected.

NOTE 4 Examples of this exemption include testing of:

– a maintenance **bypass** path, and

– a **UPS** design that requires application of an internal short-circuit.

If the manufacturer declares a **rated short-time withstand current** higher than shown in Table 104, the declared value applies for test purposes.

The test setup is considered suitable when the prospective test current has been made available for the minimum duration listed in Table 104.

Table 104 – Short-time withstand current

Rated UPS output current I (RMS) A	**Prospective test current** [a]		**Initial asymmetric peak current ratio** [e] (I_{pk} / I_{cw})	**Minimum duration of prospective test current** [f] (cycles 50/60 Hz)
	I_{cp} (RMS) A [b]	**Typical power factor** [e]		
$I \leq 16$	1 000 [c d]	0,95	1,42	1,5
	3 000	0,9		
$16 < I \leq 75$	6 000	0,7	1,53	1,5
$75 < I \leq 400$	10 000	0,5	1,70	1,5
$400 < I \leq 500$	10 000	0,5	1,70	3,0
$500 < I$	$20 \times I$ or 50 kA whichever is the lower	0,5–0,3 × (I_{cp} / 20 – 500)/2000 or 0,2, whichever is the higher	(0,5 I_{cp}/20 + 3150) / 2000 or 2,2, whichever is the lower	3,0

NOTE 1 Depending on the characteristics of the **UPS**, the actual values observed during the test can be different from those listed in this table.

NOTE 2 Refer to 6.4.3.102 for conditions applying if the I_{cp} value declared is higher than that specified in this table.

NOTE 3 The minimum duration of prospective test current can be increased when required by national deviation.

[a] Prospective test current, in the context of this document, shall be understood as **prospective short-circuit current** (I_{cp}), see 3.122.

[b] Values compatible with IEC 60947-6-1: 2005/IEC 60947-6-1: 2005/AMD1:2013, Table 4.

[c] Pluggable **UPS** only.

[d] The typical fault current of public supply networks rated 75 A and below and intended to supply equipment with a **rated current** of 16 A or below can be calculated from the reference impedances in IEC TR 60725:2005: phase conductor 0,24 + j0,15 Ω and neutral conductor 0,16 + j0,10 Ω. For 230 V/400 V supplies, this results in typical fault currents of 0,5 kA (230 V) and 0,7 kA (400 V).

[e] From IEC 60947-1:2007, Table 16.

[f] From IEC 60947-6-1: 2005/IEC 60947-6-1:2005/AMD1:2013, 5.3.6.1.

Where a **UPS** has an AC input with no **low impedance path** between the AC input and the AC output, a short-circuit shall be applied immediately before the point where the input path no longer presents negligible impedance.

Compliance is checked when, at the conclusion of the test, the following criteria are satisfied.

a) *The UPS shall not have emitted flames, molten metal or burning particles, other than, for example, metal particles normally emitted from a circuit breaker when it clears a fault.*

NOTE 5 Further guidance, if applicable, is found in 4.6.

b) *There shall have been no arcing from live parts to the **UPS** chassis or enclosure.*

An intact enclosure test fuse as described in Annex EE indicates compliance.

*The use of an enclosure test fuse is not applicable for **UPS** with non conductive chassis or enclosure (e.g. plastic case).*

c) *Components, for example busbar supports, used for the mounting of live parts shall not break away from their initial position.*

d) *Any enclosure door shall not open rapidly (so as to cause injury) when protected only by its normal latch.*

e) *No conductor shall get pulled out of its terminal connector and there shall be no damage to the conductor or conductor insulation.*

f) *The **UPS** shall successfully pass the AC or DC voltage test (dielectric strength test) as specified in IEC 62477-1:2012, 5.2.3.4.*

5.2.3.103.2 Input port rated conditional short-circuit current

If the manufacturer declares a rated **conditional short-circuit current**, the **prospective short-circuit test current** (I_{cp}) shall be determined in accordance with Table 104.

If the manufacturer declares a rated **conditional short-circuit current rating** higher than shown in Table 104, the declared value shall be used as the **prospective short-circuit test current** (I_{cp}).

All **short-circuit protective device**s shall be installed within the **UPS** and, if applicable, external to the **UPS** in accordance with the manufacturers' instructions. If internal or external alternate **short-circuit protective device**s are specified by the manufacturer, testing shall be performed with each alternate **short-circuit protective device**.

NOTE 1 Multiple manufacturers or part numbers of molded case circuit breakers are examples of alternate **short-circuit protective devices**.

After the short-circuit test current is made available at the **UPS** input port, the test is considered complete when the minimum duration of the prospective test current listed in Table 104 has elapsed. This is irrespective of whether the current has ceased to flow upon opening of an internal or external protective device or mechanism, or due to the occurrence of a component failure.

The shorting switch SW or any installed shorting cables or busbars shall remain closed until the minimum duration of the prospective test current listed in Table 104 has elapsed.

Compliance is checked when, at the completion of the test, the following criteria are satisfied.

a) *The **UPS** shall not have emitted flames, molten metal or burning particles, other than, for example, metal particles normally emitted from a circuit breaker when it clears a fault.*

NOTE 2 Further guidance, if applicable, is found in 4.6.

b) *There shall have been no arcing from live parts to the **UPS** chassis or enclosure.*

An intact enclosure test fuse as described in Annex EE indicates compliance.

*The use of an enclosure test fuse is not applicable for **UPS** with non conductive chassis or enclosure (e.g. plastic case).*

c) *Components, for example busbar supports, used for the mounting of live parts shall not break away from their initial position.*

d) *Any enclosure door shall not open rapidly (so as to cause injury) when protected only by its normal latch.*

e) *No conductor shall get pulled out of its terminal connector and there shall be no damage to the conductor or conductor insulation.*

f) *The **UPS** shall successfully pass the AC or DC voltage test (dielectric strength test) as specified in IEC 62477-1:2012, 5.2.3.4.*

After testing the **UPS** is not required to be operational.

5.2.3.103.3 Input port short-time withstand current rating

If the manufacturer declares a short-time withstand current **rating**, the prospective short-circuit test current (I_{cp}) shall be determined in accordance with Table 104.

If the manufacturer declares a short-time withstand current **rating** higher than shown in Table 104, the declared value shall be used as the prospective short-circuit test current (I_{cp}).

The test is considered complete when the prospective test current has been made available for the minimum duration of the prospective test current listed in Table 104. Although the actual current flowing may be different from the prospective short-circuit test current (I_{cp}), the prospective short-circuit test current shall be the declared short-time withstand current **rating**.

Compliance is checked when, at the completion of the test, the following criteria are satisfied.

a) *The **UPS** shall not have emitted flames, molten metal or burning particles, other than, for example, metal particles normally emitted from a circuit breaker when it clears a fault;*

NOTE 1 Further guidance, if applicable, is found in 4.6.

b) *There shall have been no arcing from live parts to the **UPS** chassis or enclosure;*

An intact enclosure test fuse as described in Annex EE indicates compliance.

*The use of an enclosure test fuse is not applicable for **UPS** with non conductive chassis or enclosure (e.g. plastic case)*

c) *Components, e.g. busbar supports, used for the mounting of live parts shall not break away from their initial position;*

d) *Any enclosure door shall not open rapidly (so as to cause injury) when protected only by its normal latch;*

e) *No conductor shall get pulled out of its terminal connector and there shall be no damage to the conductor or conductor insulation;*

f) *The **UPS** shall successfully pass the AC or DC voltage test (dielectric strength test) as specified in IEC 62477-1:2012, 5.2.3.4.*

After testing the **UPS** is not required to be operational.

5.2.3.103.4 Exemption from testing

Exemption from short-time withstand current testing applies to:

a) **UPS** with declared $\boldsymbol{I_{cw}}$ and/or $\boldsymbol{I_{cc}}$ neither of which exceeding 10 kA;

b) **UPS** protected by current-limiting devices having a cut-off current not exceeding 17 kA with the maximum allowable **prospective short-circuit current** at the terminals of the incoming circuit of the **UPS**;

c) **UPS** intended to be supplied from transformers whose rated power does not exceed 10 kVA per phase for a rated secondary voltage of not less than 110 V, or 1,6 kVA per phase for a rated secondary voltage less than 110 V, and whose short-circuit impedance is not less than 4 %;

d) **UPS** variants of a reference design **UPS** tested compliant with the test requirements prescribed in 5.2.3.103.1.

For guidance on how to determine when a **UPS** is a variant of a reference design **UPS**, refer to IEC 61439-1:2011, 10.11.3 and Table 13, or 10.11.4.

NOTE The exemption conditions above align this document with IEC 61439-1:2011, 10.11.2.

Compliance is checked by satisfying at least one of the exemption conditions.

5.2.3.104 Transformer protection test

Transformers shall be tested in the **UPS** for overload, and abnormal tests.

The following conditions apply:

If the tests in 5.2.3.104 are conducted under simulated conditions on the bench, these conditions shall include any protective device that would protect the transformer in the complete equipment. Transformers for switch mode power supply units are tested in the complete power supply unit or in the complete equipment. Test loads are applied to the output of the power supply unit. A linear transformer or a ferro-resonant transformer has each secondary winding loaded in turn, with any other secondaries loaded between zero and their specified maxima to result in the maximum heating effect. The output of a switch mode power supply unit is loaded to result in the maximum heating effect in the transformer.

NOTE For examples of loading to give the maximum heating effect, see Annex FF.

Table 105 – Temperature limits for transformer windings

Maximum temperature°C

Method of protection	Thermal class [a]							
	105 (A)	120 (E)	130 (B)	155 (F)	180 (H)	200 (N)	220 (R)	250 (-)
Protection by inherent or external impedance	150	165	175	200	225	245	265	295
Protection by protective device that operates during the first hour	200	215	225	250	275	295	315	345
Protection by any protective device:								
– maximum after first hour	175	190	200	225	250	270	290	320
– arithmetic average during the 2nd hour and during the 72nd hour	150	165	175	200	225	245	265	295

[a] The designations A to R, formely assigned in IEC 60085 to thermal classes 105 to 220, are given in parentheses.

The test is limited to transformers that bridge basic, supplementary or reinforced insulation; or that provide power external to the product.

The text in 5.2.3.104 referencing transformer also applies to magnetic components in general.

Compliance is verified when the maximum temperature of the transformer does not exceed the values in Table 105 and determined as specified below:

– *with external overcurrent protection: at the moment of operation, for determination of the time until the overcurrent protection operates, it is permitted to refer to a data sheet of the overcurrent protective device showing the trip time versus the current characteristics;*

– *with an automatic reset thermal cut-out and after a test duration of 400 h.*

– *with a manual reset thermal cut-out: at the moment of operation or after temperature has stabilized;*

– *for current-limiting transformers: after temperature has stabilized.*

5.2.3.105 Unsynchronised load transfer test

5.2.3.105.1 General

The unsynchronised load transfer requirement specified in 4.3.105 shall be simulated with the UPS operating in normal mode and in stored energy mode while supplying its rated reference load.

The test in **normal mode** is waived for **UPS** wherein the load is normally supplied from the bypass source, for example for stand-by topology **UPS**.

The bypass source shall be set to its most unfavorable level of **rated voltage** if this creates a more onerous condition.

5.2.3.105.2 Phase displacement

The bypass source is to be displaced 120 electrical degrees with respect to the normal phase rotation for a 3-phase supply or 180 electrical degrees for a single phase supply. The solid state or manual switch is to be subjected to one operation of switching the load from the output of the **UPS** to the bypass source.

Compliance is determined by 5.2.4.2 of IEC 62477-1: 2012.

5.2.4 Abnormal operation and simulated faults tests

5.2.4.1 General

Subclause 5.2.4.1 in IEC 62477-1:2012 applies except, as follows:

*Replace, in the ninth paragraph of IEC 62477-1:2012, 5.2.4.1, "*PECS*" by "*UPS*".*

Add, after the ninth paragraph of IEC 62477-1:2012, 5.2.4.1, the following text:

Examples in which the lesser **prospective short-circuit current** available from the test supply may be used include situations wherein:

- the fault path of concern is not a **low impedance path**; or
- the resulting let-through current from the supply is equal or less than 10 kA; or
- the result is independent of the prospective short-circuit current available from the supply

5.2.6.4 Vibration test (type test)

Replace the existing text of 5.2.6.4 in IEC 62477-1: 2012 by the following:

The default environmental conditions applying to **UPS** within the scope of this document do not require compliance with vibration tests.

A vibration test is nevertheless to be considered if a different environmental service condition applies.

5.2.6.5 Salt mist test (type test)

Replace the existing text of 5.2.6.5 in IEC 62477-1:2012 by the following:

The default environmental conditions applying to **UPS** within the scope of this document do not require compliance with salt-mist tests.

A salt mist test is nevertheless to be considered if a different environmental service condition applies.

5.2.6.6 Dust and sand test (type test)

Replace the existing text of 5.2.6.6 in IEC 62477-1:2012 by the following:

The default environmental conditions applying to **UPS** within the scope of this document do not require compliance with dust and sand tests.

A dust and sand test is nevertheless to be considered if a different environmental service condition applies.

6 Information and marking requirements

Clause 6 of IEC 62477-1:2012 applies, except as follows:

6.1 General

Replace the existing text of 6.1 in IEC 62477-1:2012 by the following:

6.1.101 Durability

Any marking required by this document shall be durable and legible. In considering the durability of the marking, the effect of normal use shall be taken into account.

Compliance is checked by inspection and by rubbing the marking by hand for 15 s with a piece of cloth soaked with water and again either for 15 s with a piece of cloth soaked with petroleum spirit or for 30 s with a piece of cloth soaked with 70 % isopropyl alcohol. After this test, the marking shall be legible; it shall not be possible to remove marking plates easily and they shall show no curling.

The petroleum spirit to be used for the test is aliphatic solvent hexane having a maximum aromatics content of 0,1 % by volume, a kauributenol value of 29, an initial boiling point of approximately 65 °C, a dry point of approximately 69 °C and a mass per unit volume of approximately 0,7 kg/l.

As an alternative, it is permitted to use a reagent grade hexane with a minimum of 85 % as n-hexane.

NOTE The designation "n-hexane" is chemical nomenclature for a "normal" or straight chain hydrocarbon. This petroleum spirit is further identified as a certified ACS (American Chemical Society) reagent grade hexane (CAS No. 110-54-3).

6.1.102 Removable parts

Marking required by this document shall not be placed on removable parts that can be replaced in such a way that the marking would become misleading.

6.2 Information for selection

Replace the existing text of 6.2 in IEC 62477-1:2012 by the following:

Each **UPS** that is supplied as a separate product shall be provided with information relating to its function, electrical characteristics, and intended environment, so that its fitness for purpose and compatibility with other parts of the system can be determined.

This information includes, but is not limited to:

a) on the **rating** plate:

- the name or trademark of the manufacturer, supplier or importer;
- catalogue number or equivalent;
- electrical **rated values** for each power port, as applicable:
  - input voltage(s) or input voltage range(s);
  - input current(s) or input current range(s) (see 5.2.3.102);
  - output voltage(s);
  - output current(s);
  - output **apparent power**:
  - output **active power** or output power factor;
  - frequency(ies) or frequency range(s);
  - I_{cc} and/or I_{cw} (see 6.4.3.102).
- number of phases and neutral (e.g. 3 Ph + N);
- protective class, for class II UPS only (see 6.3.7.3.3);

b) on the **rating** plate or in the user manual:

- the type of electrical supply system (e.g. TN, IT,) to which the **UPS** may be connected;
- the type of electrical supply system (e.g. TN, IT) supplied to the load;
- the type of electrical supply system (e.g. TN, IT) supplied to the stored energy device;
- output short-circuit current in accordance with IEC 62477-1:2012, 4.3.2.3 and 5.2.4.4;
- protective device characteristics, in accordance with IEC 62477-1:2012, 4.3.2 and 5.2.4.4;
- liquid coolant type and design pressure for liquid cooled **UPS**;
- IP **rating** for enclosure;
- operating and storage environment;
- ambient operating temperature range (if other than 15 °C to 30 °C);
- reference(s) to relevant standard(s) for manufacture, test, or use;
- reference to instructions for installation, use and maintenance.

The range shall have a hyphen (-) between the minimum and maximum rated values and when multiple values or ranges are given, they shall be separated by a solidus (/);

Equipment with a **rated voltage** range shall be marked with either the maximum **rated current** or with the current range.

EXAMPLE

100-240 V; 2,8 A

or

100-240 V; 2,8-1,2 A

For equipment with multiple **rated voltages,** the corresponding **rated currents** shall be marked such that the different current ratings are separated by a solidus (/) and the relation between **rated voltage** and associated **rated current** appears distinctly.

EXAMPLE

100-120 V; 2,8 A / 200-240 V; 1,4 A

or

100-120 V; 2,8-2,4 A / 200-240 V; 1,4-1,2 A

6.3 Information for installation and commissioning

Subclause 6.3 in IEC 62477-1:2012 applies, except as follows:

Replace the existing text of 6.3.7.3.3 of IEC 62477-1:2012 by the following:

Equipment of protective class II shall be marked on the rating plate with symbol IEC 60417-5172 (2011-01) (see Annex C). Where such equipment has provision for the connection of an earthing conductor for functional reasons (see 4.4.6.3) this provision shall be marked with symbol IEC 60417-5018 (2011-01) (see Annex C).

Add the following subclause:

6.3.101 Guidance on UPS installation

The manufacturer shall provide guidance on the level of competence necessary for installation. Where appropriate, installation instructions should include reference to national wiring rules. Distinct instructions apply for:

- **UPS** designed for location in a **restricted access area** only: the installation instructions shall clearly state that the **UPS** may only be installed in accordance with the applicable requirements including those in IEC 60364-4-42. Such **UPS** may not meet the requirements for a fire enclosure as specified in IEC 62477-1:2012, 4.6.3.
- **UPS** designed for permanent connection by fixed wiring to the AC supply or to the load or to a separate energy storage device, for example batteries that are not installed when delivered: the installation instructions shall clearly state that only a **skilled person** may install the **UPS** and that, when the disconnect device for isolation of mains power is not incorporated in the equipment (see 4.101.2), an appropriate and readily accessible disconnect device shall be incorporated in the fixed wiring.
- pluggable type A or pluggable type B **UPS** with energy storage device, for example a battery, already installed by the supplier: the installation instructions shall be made available, for example in the user manual that shall state whether a **skilled person** is required for installation. When the disconnect device for isolation of mains power is not incorporated in the equipment (see 4.101.2), or when the plug on the **cord** is intended to serve as the disconnect device, the installation instructions shall state that the mains socket outlet that supplies the **UPS** shall be installed near the **UPS** and shall be easily accessible. When the **UPS cord** shall be connected to an earthed mains socket outlet for safety reasons, the **UPS** marking or installation instructions shall so state. The same requirement for marking applies to any special equipotential earth bonding to other connected **UPS** equipment or to class I loads.

NOTE Pluggable **cords** are normally 2 m in length or less.

6.4 Information for use

Subclause 6.4 in IEC 62477-1:2012 applies, except as follows:

6.4.3 Labels, signs and signals

Subclause 6.4.3 in IEC 62477-1:2012 applies, except as follows:

Add the following subclauses:

6.4.3.101 Distribution-related backfeed

A label shall be required for the purpose of warning the electrical service person, which shall be a **skilled person**, against **backfeed** situations not caused by the **UPS**. A **backfeed** situation can arise when a particular load fault is present while the **UPS** operates in **stored**