

INTERNATIONAL STANDARD

NORME INTERNATIONALE

**Uninterruptible power systems (UPS) –
Part 1: General and safety requirements for UPS**

**Alimentations sans interruption (ASI) –
Partie 1: Exigences générales et règles de sécurité pour les ASI**



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INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

PRICE CODE
CODE PRIX

XB

ICS 29.200

ISBN 2-8318-9791-2

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Withdrawn

INTERNATIONAL ELECTROTECHNICAL COMMISSION

UNINTERRUPTIBLE POWER SYSTEMS (UPS) –**Part 1: General and safety requirements for UPS**

FOREWORD

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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 standard cancels and replaces the first edition of IEC 62040-1-1, published in 2004 and IEC 62040-1-2, published in 2004 and constitutes a technical revision. This standard merges all requirements of previous IEC 62040-1-1 and IEC 62040-1-2, with the addition of the following:

- update of normative references including IEC 60950-1 as Reference Document (RD);
- harmonization and alignment with current world recognized best practices;
- enhancement of backfeed protection, definition of ground-fault, revision of temperature rise tables and of hydrogen concentration in battery compartments.

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

FDIS	Report on voting
22H/104/FDIS	22H/106/RVD

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

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

It is to be used with IEC 60950-1, Edition 2.0, which is referred to in this standard as "RD".

In this standard, the following print types are used:

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

A list of all parts of the IEC 62040 series, under the general title: *Uninterruptible power systems (UPS)*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result 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.

The contents of the corrigendum of September 2008 have been included in this copy.

UNINTERRUPTIBLE POWER SYSTEMS (UPS) –

Part 1: General and safety requirements for UPS

1 Scope and specific applications

1.1 Scope

This part of IEC 62040 applies to **uninterruptible power systems (UPS)** with an electrical energy storage device in the d.c. link. It is used with IEC 60950-1, which is referred to in this standard as "RD" (reference document).

NOTE **UPS** applications generally make use of a chemical battery as the energy storage device. Alternative devices may be suitable, and as such, where "battery" appears in the text of this standard, where applicable, this may be understood as "energy storage device".

When a clause is referred to by the phrase "The definitions or the provisions of item/RD apply", this phrase is intended to mean that the definitions or provisions in that clause of IEC 60950-1 apply, except any which are clearly inapplicable to **uninterruptible power systems**. National requirements additional to those in IEC 60950-1 apply and are found as notes under relevant clauses of the RD.

The primary function of the **UPS** covered by this standard is to ensure continuity of an alternating power source. The **UPS** may also serve to improve the quality of the power source by keeping it within specified characteristics.

This standard is applicable to **UPS** which are movable, stationary, fixed or for building-in, for use in low-voltage distribution systems and intended to be installed in any **operator** accessible area or in **restricted access locations** as applicable. It specifies requirements to ensure safety for the **operator** and layman who may come into contact with the equipment and, where specifically stated, for the **service person**.

This standard is intended to ensure the safety of installed **UPS**, both as a single **UPS** unit or as a system of interconnected **UPS** units, subject to installing, operating and maintaining the **UPS** in the manner prescribed by the manufacturer.

This standard does not cover **UPS** based on rotating machines.

Electromagnetic compatibility (EMC) requirements and definitions are given in IEC 62040-2.

1.2 Specific applications

Even if this standard does not cover all types of **UPS**, it may be taken as a guide for such equipment. Requirements additional to those specified in this standard may be necessary for specific applications, e.g. related to **UPS** that operate:

- while exposed to extremes of temperature; to excessive dust, moisture, or vibration; to flammable gases; to corrosive or to explosive atmospheres;
- where ingress of water and foreign objects are possible;

NOTE 1 Annex H provides guidance on such requirements and on relevant testing.

- in vehicles, on board ships or aircraft, in tropical countries, or at elevations greater than 1 000 m;

NOTE 2 Guidance for performance of **UPS** operating at elevations greater than 1 000 m is provided in 4.1.1 of IEC 62040-3.

- with trapezoidal output waveforms and long run times (greater than 30 min);

NOTE 3 In addition to complying with 5.3.1.2 of IEC 62040-3, voltage distortion tests for the purpose of load compatibility should also be performed.

- subject to transient overvoltages exceeding those of overvoltage category II according to IEC 60664;

NOTE 4 Subclause G.2.1/RD provides guidance for additional protection against transient overvoltages at the mains supply to the **UPS**. Where such additional protection is an integral part of the equipment insulation requirements, creepage distances and clearance distances from the mains through to the load side of the additional protection may be judged as category III or IV as required. All further downstream insulation requirements, creepage distances, and clearance distances on the load side of the additional protection may be judged as category I or II as required.

- in electromedical applications with the **UPS** located within 1,5 m of the patient contact area;
- in systems classified as emergency power systems by an authority having jurisdiction.

NOTE 5 Additional requirements may also apply in accordance with local regulations.

2 Normative references

The following referenced documents are indispensable for the application 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.

IEC 60364-4-42, *Electrical installations of buildings – Part 4-42: Protection for safety – Protection against thermal effects*

IEC 60417, *Graphical symbols for use on equipment*

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

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

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

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

IEC 61000-2-2, *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*

IEC 62040-3:1999, *Uninterruptible power systems (UPS) – Part 3: Method of specifying the performance and test requirements*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1 General definitions

NOTE 1 Where the terms "voltage" and "current" are used, they imply the r.m.s. values, unless otherwise specified.

NOTE 2 Care should be taken that measuring instruments give a true r.m.s. reading in the presence of non-sinusoidal signals.

3.1.1

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 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 load. 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**.

3.1.2

bypass

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

3.1.3

primary power

power supplied by an electrical utility company or by a **user's** generator

3.1.4

active power

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

$$P = \frac{1}{T} \int_0^T p \, dt$$

NOTE 1 Under sinusoidal conditions, the **active power** is the real part of the complex power.

NOTE 2 The SI unit for **active power** is the watt.

[IEV 131-11-42]

NOTE 3 DC, fundamental and harmonic voltages contribute directly 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.

3.1.5

apparent power

product of the r.m.s. voltage and r.m.s. current

3.1.6

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

3.1.7

backfeed protection

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

3.1.8

stored energy mode

operation of the **UPS** when supplied by the following conditions:

- **primary power** is disconnected or is out of a given tolerance;
- battery is being discharged;
- load is within the given range;
- output voltage is within the given tolerance

3.2 **UPS electrical ratings**

3.2.1

rated voltage

input or output voltage (for three-phase supply, the phase-to-phase voltage) as declared by the manufacturer

3.2.2

rated voltage range

input or output voltage range as declared by the manufacturer, expressed by its lower and upper **rated voltages**

3.2.3

rated current

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

NOTE See 4.7.2.

3.3 **Load types**

3.3.1

normal load

mode of operation which approximates as closely as possible the most severe conditions of normal use in accordance with the manufacturer's operating instructions

NOTE 1 However, when the conditions of actual use can obviously be more severe than the maximum load conditions recommended by the manufacturer, a load should be used that is representative of the maximum that can be applied

NOTE 2 For examples of reference **normal load** conditions for **UPS**, see Annex L.

3.3.2

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 load impedance

3.3.3

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 (see Annex L)

3.4 Connection to the supply

The definitions of 1.2.5/RD apply together with the following.

3.4.1

power cord

flexible cord or cable for interconnection purposes

3.5 Circuits and circuit characteristics

The definitions of 1.2.8/RD (e.g. hazardous voltage 1.2.8.6/RD) apply.

3.6 Insulation

The definitions of 1.2.9/RD apply.

3.7 Equipment mobility

The definitions of 1.2.3/RD apply.

3.8 Insulation classes of UPS

The definitions of 1.2.4/RD apply.

3.9 Earth fault

Occurrence of an accidental conductive path between a live conductor and the earth

[IEV 195-04-14]

3.10 Enclosures

The definitions of 1.2.6/RD apply.

3.11 Accessibility

The definitions of 1.2.7/RD apply.

3.12 Components

The definitions of 1.2.11/RD apply.

3.13 Power distribution

The definitions of 1.2.8.1/RD and 1.2.8.2/RD apply.

3.14 Flammability

The definitions of 1.2.12/RD apply.

3.15 Miscellaneous

The definitions of 1.2.13/RD (e.g. type test definition 1.2.13.1/RD) apply.

3.16 Clearances and creepage distances

The definitions of 1.2.10/RD apply.

3.17 Telecommunication networks

The following definitions apply: 1.2.8.11/RD, 1.2.8.12/RD, 1.2.8.13/RD, 1.2.8.14/RD.

4 General conditions for tests

4.1 Introduction

The provisions of 1.4.1/RD, 1.4.3/RD, 1.4.6/RD, 1.4.7/RD, 1.4.8/RD, 1.4.10/RD, 1.4.11/RD, 1.4.12/RD, 1.4.13/RD, 1.4.14/RD apply together with the following.

Only the leakage current and heating tests shall be performed at input voltage tolerances (see 1.4.5/RD). All tests shall be run at nominal input voltages, unless specifically prescribed otherwise.

4.2 Type test

The provisions of 1.4.2/RD apply together with the following addition.

Where in this standard compliance of materials, components or subassemblies is checked by inspection or by testing of properties, it is permitted to confirm compliance by reviewing any relevant data or previous test results that are available instead of carrying out the specified **type tests**.

NOTE For physically large units and/or power ratings, adequate test facilities to demonstrate some of the **type tests** may not exist.

This situation also applies to some electrical tests for which no commercial test simulation equipment is available or requires specialized test facilities beyond the scope of the manufacturer's premises.

4.3 Operating parameters for tests

Except where specific test conditions are stated elsewhere in the standard, and where it is clear that there is a significant impact on the results of the test, the tests shall be carried out at **rated voltage** and under the most unfavorable combination of the following parameters, within the manufacturer's operating specifications:

- absence of supply voltage;
- supply frequency;
- charge condition of the battery;
- physical location of **UPS** and position of movable parts;
- operating mode.

The following does not apply to **UPS** installed in **restricted access locations**:

- adjustments of **thermostats**, regulating devices or similar controls in **operator access areas**, which are
 - a) adjustable without the use of a **tool**, or
 - b) adjustable using a means, such as a key or a **tool**, deliberately provided for the **operator**.

4.4 UPS loading during tests

Where test results could reasonably be expected to vary upon **UPS** loading, adjustments shall be made to provide the most unfavorable results. This is achieved by considering loading

- that could be connected to any standard supply outlet or terminal on the equipment, up to the value indicated in the marking required by 4.7.2;
- due to recharge of the stored energy source (batteries or similar);
- due to optional features, offered or provided for by the manufacturer for inclusion in or with the equipment under test;
- due to other units of equipment intended by the manufacturer to draw power from the equipment under test.

NOTE 1 Artificial loads may be used to simulate such loading while testing.

NOTE 2 See also 4.6.

4.5 Components

Where safety is involved, components shall comply either with the requirements of this standard or with the safety aspects of the relevant IEC component standards.

NOTE 1 An IEC component standard is considered relevant only if the component in question clearly falls within its scope.

Further, the provisions of 1.5.2/RD, 1.5.3/RD, 1.5.4/RD, 1.5.5/RD, 1.5.6/RD, 1.5.7/RD and 1.5.8/RD apply.

NOTE 2 The requirements of this standard include abnormal tests to ensure safe failure mode of components; see 8.3.

4.6 Power interfaces

The provisions of 1.6.1/RD, 1.6.2/RD, 1.6.4/RD apply together with the following.

NOTE While supplying rated output under each of the conditions described in a) to d) below, the relevant a.c. or d.c. steady state input current should not exceed 110 % of the **rated current**.

- a) **Recharging mode** – Applicable to the **primary power** received by the **UPS** while also charging the battery.
- b) **Stored energy mode** – Applicable to the d.c. current from, for example, a remote battery while simulating **primary power** outage. The inverter portion of the **UPS** should receive power from either a fully charged battery bank or an external d.c. source of supply.
- c) **Bypass mode** – The transfer switch should be positioned to allow the **primary power** for the output load to bypass the rectifier/charger and inverter sections of the **UPS** and be delivered directly to the load.
- d) **Normal mode** – With a fully charged battery, the **UPS** should receive power from the **primary power** source.

The neutral conductors, if any, shall be insulated from earth and the body throughout the equipment, as if they were phase conductors. Components connected between neutral and earth shall be rated for a **working voltage** equal to the phase-to-neutral voltage. In the case of the output neutral conductor being isolated from the input neutral conductor, the **service person** responsible for the installation shall connect this output neutral conductor as required by local wiring rules and as detailed in the installation instructions.

Compliance is checked by inspection.

4.7 Markings and instructions

4.7.1 General

Where a marking is required as detailed below, provision shall be allowed for equivalent wording. The marking shall be readily visible either in an **operator access area** or shall be located on an outside surface of the equipment. If located on an outside surface of fixed equipment, the marking shall be visible after the equipment has been installed as in normal use.

For equipment intended to be installed by a **service person** or located in a **restricted access location**, the marking may be located behind a door or cover that it is not operator accessible. In this case, a readily visible marker shall be attached to the equipment to clearly indicate the location of such marking. It is allowed to use a temporary marker.

4.7.2 Power rating

Equipment shall be provided with adequate markings in order to specify

- input supply requirements;
- output supply ratings.

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.

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

The markings of input and output shall include those in the RD, in addition to the following:

- output **rated voltage**;
- output rated power factor, if less than unity, or **active power** and **rated current**;
- number of output phases and neutral (refer to 1.7.1/RD);
- output rated **active power**, in watts or kilowatts according to Annex L/RD;
- output rated **apparent power** in volt-amperes or kilovoltamperes according to Annex L/RD;
- ambient operating temperature range (if other than 0 °C to 40 °C).

NOTE For example for indoor office ambient, the temperature range specified by the manufacturer may be 10 °C to 35 °C.

For units designed with additional separate automatic **bypass/maintenance bypass**, additional input a.c. supply, or external batteries, it shall be allowed for relevant supply ratings to be specified in the accompanying installation instructions. Where this is done, the following instruction shall appear on or near the point of connection:

**SEE INSTALLATION INSTRUCTIONS BEFORE
CONNECTING TO THE SUPPLY**

4.7.3 Safety instructions

4.7.3.1 General

The manufacturer shall make safety instructions available as required to avoid introduction of hazards when operating, installing, maintaining, transporting or storing the **UPS**.

For example, special precaution for the protective earth conductor may be required when installing a pluggable **UPS** comprising separate enclosures. The protective conductor should remain interconnected between enclosures also when the mains plug of the **UPS** is disconnected. Such enclosures may house power electronics, battery strings, **bypass** switch, terminals and/or outlets.

4.7.3.2 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 location** only
The installation instructions shall clearly state that the **UPS** may only be installed in accordance with the requirements of IEC 60364-4-42. Such **UPS** may not meet the requirements for a fire enclosure as specified in 1.2.6.2/RD.
- **UPS** designed for permanent connection by fixed wiring to the a.c. supply or to the load or to a separate energy storage device, e.g. batteries that are not installed when delivered to the **user**. The installation instructions shall clearly state that only a qualified professional (e.g. **service person**) may install the **UPS** and that, when the disconnect device for isolation of mains power is not incorporated in the equipment (see 3.4.2/RD), 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, e.g. a battery, already installed by the supplier. The installation instructions for **UPS** intended for **user** installation shall be made available to the **user**, e.g. in the **user** manual. When the disconnect device for isolation of mains power is not incorporated in the equipment (see 3.4.2/RD) or when the plug on the power supply 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 power cord** must 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 **power cords** are normally 2 m in length or less.

4.7.3.3 Operation

The manufacturer shall, except when the **UPS** is intended for operation by a layperson, provide guidance on the level of competence necessary to operate the equipment. This may include reference for operators to undergo training or to be qualified and authorized to enter **restricted access locations**.

4.7.3.4 Maintenance

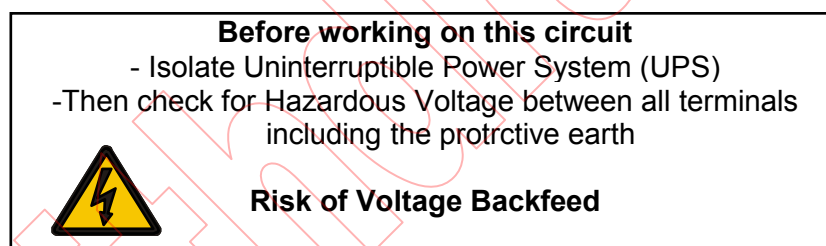
Except for minor routine maintenance that may be performed by the operator, safety instructions to be used during maintenance of the **UPS** are normally made available only to **service persons**.

4.7.3.5 Distribution related backfeed

For the purpose of warning the electrical **service person** against backfeed situations not caused by the **UPS** but that may 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, e.g. an impedance grounded IT system, the installation instructions for permanently connected **UPS** shall require the fitting of a warning label

- by the **UPS** supplier, at the **UPS** input terminals
- and
- by the **user**, 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 5.1.4) 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 1.6.1/RD).

The warning label shall carry the following wording or equivalent.



NOTE **Backfeed protection** against faults occurring in the **UPS** is described in 5.1.4.

4.7.4 Main voltage adjustment

The provisions of 1.7.4/RD apply.

4.7.5 Power outlets

The provisions of 1.7.5/RD apply.

4.7.6 Fuses

The provisions of 1.7.6/RD apply.

4.7.7 Wiring terminals

The provisions of 1.7.7/RD apply.

4.7.8 Battery terminals

Terminals intended for connection to batteries shall indicate the polarity according to IEC 60417 or be so constructed as to reduce the likelihood of improper connection.

4.7.9 Controls and indicators

The provisions of 1.7.8/RD apply.

4.7.10 Isolation of multiple power sources

The provisions of 1.7.9/RD apply.

4.7.11 IT power systems

The provisions of 1.7.2.4/RD apply.

4.7.12 Protection in 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 (see 5.5.2).

If the protection against electric shock of the **UPS** (see 5.1) 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 d.c. component is possible, the installation instructions shall define the building residual current devices as type B (see IEC 60755) for three-phase **UPS** and as type A (IEC 61008-1 or IEC 61009-1) for single-phase **UPS**.

NOTE Consideration should be given to national wiring rules, if any, regarding requirements for public networks protection.

4.7.13 High leakage current

The provisions of 5.1/RD apply in addition with the following.

For **UPS** systems intended for use as **pluggable equipment type B** or fixed installations, where the earth leakage currents of the **UPS** and connected loads sum in the primary **UPS** protective earth conductor exceeds or is likely to exceed the limits of 5.1/RD under any mode of operation, the unit shall carry a warning label as required by 5.1/RD, and the installation manual shall define the connection method to the **primary power** source.

4.7.14 Thermostats and other regulating devices

The provisions of 1.7.10/RD apply.

4.7.15 Language

Instructions and equipment marking related to safety shall be in a language which is acceptable in the country in which the equipment is to be installed.

The provisions of 1.7.2.1/RD and 1.7.8.1/RD apply.

4.7.16 Durability of markings

The provisions of 1.7.11/RD apply.

4.7.17 Removable parts

The provisions of 1.7.12/RD apply.

4.7.18 Replaceable batteries

The provisions of 1.7.13/RD apply.

4.7.19 Operator access with a tool

The provisions of 1.7.2.5/RD apply.

4.7.20 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 **service person** when servicing the **UPS**, in accordance with the requirements of 1.7.1/RD:

- 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 following instructions.

Exception: **Pluggable equipment type A UPS**, supplied with integral batteries or with separate battery cabinets, intended for location either under or over or alongside the **UPS**, connected by plugs and sockets for **operator** installation, need only be fitted with the warning label (see item d) above) on the outside of the unit.

All other information shall be given in the **user's instructions**.

Instructions:

- 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 **service person** shall be stated in the installation/service handbook;
 - if batteries are to be installed by a **service person**, instructions for interconnections including terminal torques shall be provided.

The operator 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.

CAUTION: Do not dispose of batteries in a fire. The batteries may explode.

CAUTION: Do not open or mutilate batteries. Released electrolyte is harmful to the skin and eyes. It may be toxic.

- 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 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 2.1.1.5/RD.

NOTE 1 Bare parts that involve an energy hazard should be located, enclosed, guarded or provided with a barrier to take into account the unintentional bridging by conductive materials that might be present during service operations.

NOTE 2 Bare parts operating at a hazardous voltage level should be located or guarded such that unintentional contact with such parts is unlikely during servicing operations involving other parts of the equipment.

4.7.21 Installation instructions

Adequate information shall be provided in the installation instructions as to the purpose and connection of any signaling circuits, relay contacts, emergency power off (EPO) circuits, etc. Attention should be drawn as to the necessity of maintaining characteristics of any **TNV**, **SELV** or **ELV circuits** when connected to other equipment.

Installation instructions shall carry sufficient information, including the basic internal circuit configuration of the **UPS**, to emphasize its compatibility to power distribution systems.

Special attention shall be given to the compatibility with the relevant wiring rules and to **bypass** circuits.

Where a **UPS** output neutral relies on the input supply/supplies neutral reference, adequate installation instructions shall be provided to prevent loss of this neutral reference, if a hazard should result due to external isolation/changeover of supply sources, etc.

Only **UPS** complying with the marking instruction of 1.7.2.4/RD are suitable for use on IT power systems, as defined in Annex V/RD. Where additional external components are required to meet this requirement, these shall be referenced in the installation instructions.

5 Fundamental design requirements

5.1 Protection against electric shock and energy hazards

5.1.1 Protection for UPS intended to be used in operator access areas

The requirements and restrictions of 2.1.1/RD apply.

The requirements for protection against electric shock from energized parts are based on the principle that the **operator** is permitted to have access to:

- bare parts of **SELV circuits**; and
- bare parts of **limited current circuits**; and
- **TNV circuits** under specified conditions.

NOTE **TNV circuits** are generally not part of the **UPS** design, but some **UPS** support interconnection with external **TNV circuits**, e.g. with a communication line to the PSTN.

The requirements for protection against energy hazards are based on the principle that there shall be no risk of injury where a hazardous energy level exists.

UPS intended for building-in and/or rack mounting or for incorporation in larger equipment is tested with access to **UPS** limited according to the method of mounting detailed by the manufacturer.

5.1.2 Protection for UPS intended to be used in service access areas

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 **SELV circuits** or to **TNV circuits** (for example, by **tools** or test probes used by a **service person**) is unlikely.

No requirement is specified regarding access to **ELV circuits** or to **TNV circuits**. However, 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 during service operations involving other parts of the equipment.

Any guards required for compliance with 5.1.2 shall be easily removable and replaceable if removal is necessary for servicing. Compliance is checked by inspection and measurement. In deciding whether or not unintentional contact is likely, account is taken of the way a **service person** needs to gain access past, or near to, the bare parts in order to service other parts. For determination of a **hazardous energy level**, see 2.1.1.5 c) /RD.

5.1.3 Protection for UPS intended to be used in restricted access areas

For equipment to be installed in a **restricted access location**, the requirements for **operator access areas** apply, except as permitted in the following three paragraphs.

Contact with bare parts of a **secondary circuit** at **hazardous voltage** with the test finger, Figure 2A/RD (see 2.1.1.1/RD) is permitted. 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 **TNV-1**, **TNV-2** and **TNV-3 circuits**.

Compliance is checked by inspection and measurement.

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 2.1.1.5 c) /RD.

5.1.4 Backfeed protection

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

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

For permanently connected **UPS**, the requirement may be implemented with the use of an a.c. input line isolation device external to the **UPS**, in which case:

- the requirement applies to the input terminals of the isolation device,
- the **UPS** supplier shall provide or specify a suitable isolating device,
- additional labeling applies (4.7.3).

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

When an air gap is employed for **backfeed protection**, the provision of 2.10.3.3/RD 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 secondary circuit of overvoltage category I (for this purpose identify the overvoltage category I value in Table 2J/RD by using the appropriate **UPS** r.m.s. output voltage).
- b) The creepage and clearance distances shall meet the basic insulation requirements for pollution degree 2 (see Tables 2M/RD and 2N/RD).

NOTE Reinforced or equivalent insulation may apply if any output conductor including the neutral does not meet basic insulation to earth while the **UPS** operates in **stored energy mode**. In all other cases, basic insulation is acceptable.

Compliance is checked by inspection.

5.1.5 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 wiring rules.

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.

5.2 Requirements for auxiliary circuits

5.2.1 Safety extra low voltage circuits – SELV

The provisions of 2.2/RD apply for any **SELV circuits** provided by the **UPS**.

5.2.2 Telephone network voltage circuits – TNV

The provisions of 2.3/RD apply for any incoming **TNV circuits** supported by the **UPS**.

NOTE Most **UPS** would not provide **TNV circuits** themselves, but due consideration should apply to any incoming **TNV circuit** that may be supported by the **UPS**, e.g. connection to the PSTN.

5.2.3 Limited current circuits

The provisions of 2.4/RD apply for any limited current circuits provided by the **UPS**.

5.2.4 External signalling circuits

The provisions of 3.5/RD applies.

5.2.5 Limited power source

The provisions of 2.5/RD apply.

5.3 Protective earthing and bonding

5.3.1 General

The provisions of 2.6/RD apply together with the following.

5.3.2 Protective earthing

Accessible conductive parts of **Class I equipment**, which might assume a **hazardous voltage** in the event of a single insulation fault, shall be reliably connected to a protective earthing terminal within the equipment.

NOTE In **service access areas**, conductive parts such as motor frames, electronic chassis, etc., which might assume a **hazardous voltage** in the event of a single insulation fault, either should be connected to the protective earthing terminal or, if this is impossible or impracticable, a suitable warning label should indicate to a **service person** that such parts are not earthed and should be checked for **hazardous voltages** before being touched.

This requirement does not apply to accessible conductive parts that are separated from parts at **hazardous voltage** by

- earthed metal parts, or
- solid insulation or an air gap, or a combination of the two, meeting the requirements for **double insulation** or **reinforced insulation**. In this case, the parts involved shall be so fixed and so rigid that the minimum distances are maintained during the application of force as required by the relevant tests of 2.10/RD and 4.2/RD.

Compliance is checked by inspection and by the applicable requirements of 2.6.1/RD and 5.2/RD.

5.3.3 Protective bonding

The **UPS** output a.c. circuit shall be referenced to the protective earth of the equipment as required by the AC power distribution system in which the **UPS** is intended to operate.

The bonding of the protective earth and neutral conductors applies to all modes of operation of the unit. The physical bonding point may be external to the **UPS**.

The output a.c. circuit of a **pluggable type A** or **pluggable type B UPS** that is not a separately derived source during the normal mode of operation is not required to be bonded in the **stored energy mode** of operation. Refer to Annex V/RD for grounding supplied from separately derived a.c. sources.

NOTE Annex V/RD classifies a.c. power distribution systems as TNS, TNC, TT or IT depending on:

- the bonding condition between the protective earth and the neutral conductor (or, where no neutral conductor applies, a phase conductor),
- the separation, if any, between the neutral conductor and the earth,
- the earthing of the equipment structure.

For **Class I pluggable equipment type A**, the **UPS** shall provide sufficient terminals, earthed socket-outlets or other means to permit, in the final installed system configuration, equipotential protective bonding to the **UPS** from other **Class I equipments**, including external **UPS** battery cabinets, irrespective of whether the **UPS** primary protective conductor is disconnected from its source. Any special bonding instructions shall be stated in the **user's instructions**.

Compliance is checked by inspection and earth resistance tests between respective connection points.

5.4 AC and d.c. power isolation

5.4.1 General

The provisions of 3.4/RD apply together with the following.

5.4.2 Disconnect devices

Means shall be provided to disconnect the **UPS** from the a.c. and d.c. supplies for service and testing by qualified personnel.

NOTE 1 Unless required for functional use, the means of isolation may be located either in the **service access area** or external to the equipment.

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 required by other means, e.g. by using a static transfer switch.

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

If operation of a disconnect device causes the reference from the **UPS** output voltage to the protective earth to differ from requirements of 5.3.3, 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 situation may arise 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.

5.5 Overcurrent and earth fault protection

5.5.1 General

The provisions of 2.7.3/RD, 2.7.4/RD, 2.7.5/RD, 2.7.6/RD apply together with the following.

5.5.2 Basic requirements

Protection against excess currents, short circuits and earth faults in input and output circuits shall be provided, either as an integral part of the equipment or as part of the building installation.

NOTE 1 Earth-faults in this context are not to be understood as residual or leakage currents which are covered by 4.7.12 and 4.7.13.

Protective devices in the building installations shall provide short-circuit and earth-fault protection for **UPS** components in series with the mains input. Such components include the supply cord, appliance coupler, RFI filter, **bypass** and isolation switches. Otherwise, protective devices necessary to comply with the requirements for abnormal operating and fault conditions detailed in 8.3 shall be included as an integral part of the equipment.

Where reliance is placed on protection in the building installation, the installation instructions shall comply with the requirements for protection in building installation (see 4.7.12). For **pluggable equipment type A**, the building's installation shall be regarded as providing protection in accordance with the rating of the socket and 4.7.12 does not apply.

The manufacturer shall specify the r.m.s. value of the available fault current under the most unfavourable conditions to allow the correct dimensioning and protection of the neutral and phase conductors for permanently connected output circuits. The fault current need not be provided if the manufacturer provides output circuit protection or for **pluggable equipment type A** outputs.

When the inverter output current is controlled solely by a current limiting circuit, the available short-circuit current or overload current shall not produce a hazard within the meaning of this standard.

The protection from short circuits shall operate within 5 s.

NOTE 2 The purpose of the above requirement is to reduce the risk of electric shock or fire hazard during the period of an output short-circuit. Providing an automatic circuit-breaker at the output, rated the same as the output circuit, or current limiting, at the same rating, is considered sufficient to meet this requirement.

Compliance is checked by inspection and functional test.

5.5.3 Battery circuit protection

5.5.3.1 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 5.5.3.2 and 5.5.3.3.

NOTE Earth-fault in this context is not to be understood as residual or leakage current which are covered by 4.7.12 and 4.7.13.

5.5.3.2 Location of protective devices

Where the batteries are installed inside the **UPS**, the battery supply circuit shall be provided with a protective device.

NOTE Where the batteries are installed outside the **UPS**, the overcurrent-protective device should be located in close proximity to the battery in accordance with local installation regulations.

Compliance is checked by inspection.

5.5.3.3 Rating of protective devices

The rating of the overcurrent protective device located internally shall be such as to protect against conditions described in 5.3.1/RD.

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 determined from the requirements given in 6.2.

NOTE Where the battery bank terminals are not directly grounded, the device should protect both terminals.

Compliance is checked by inspection.

5.6 Protection of personnel – Safety interlocks

5.6.1 Operator protection

To areas where **operators** have access, the provisions and compliance requirements of 2.8/RD **safety interlocks** apply.

5.6.2 Service person protection

5.6.2.1 Introduction

In addition to the requirements of 2.8/RD, the following subclauses apply to **service persons** who find it necessary to reach over, under, across and around an uninsulated electrical part or moving part to make adjustments or measurements while the **UPS** is energized.

5.6.2.2 Covers

Parts at **hazardous voltage** or energy level shall be so arranged and covers so located as to reduce the risk of electric shock or high current levels while covers are being removed and replaced.

5.6.2.3 Location and guarding of parts

Parts at **hazardous voltage** or energy level and moving parts that involve a risk of injury to persons shall be located, guarded or enclosed so as to reduce the likelihood of unintentional contact by a **service person** adjusting or resetting controls, or the like, or performing mechanical functions that may be performed with the **UPS** energized, such as lubricating a motor, adjusting the setting of a control with or without marked dial settings, resetting a trip mechanism or operating a manual switch.

5.6.2.4 Parts on doors

Parts at **hazardous voltage** or energy level located on the rear side of a door shall be guarded or insulated to reduce the likelihood of unintentional contact of the live parts by a **service person**.

Compliance with 5.6.1 to 5.6.2.4 is checked by inspection, measurement and use of the test finger (Figure 2A/RD).

5.6.2.5 Component access

A component that requires inspection, resetting, adjustment, servicing or maintenance while energized shall be so located and mounted with respect to other components and with respect to grounded metal parts that it is accessible for electrical service functions without subjecting the **service person** to the risk of electric shock, **hazardous energy level**, high current or injury to person by adjacent moving parts. Access to a component shall not be impeded by other components or wiring.

For an adjustment that is to be made with a screwdriver or similar **tool** when the **UPS** is energized, the requirement in 2.8.3/RD necessitates that protection be provided so that inadvertent contact with adjacent uninsulated hazardous live parts involving a risk of electric shock or **hazardous energy level** is unlikely, taking into consideration that misalignment of the **tool** with the adjustment can result when an adjustment is attempted.

This protection shall be provided by

- location of the adjustment means away from uninsulated hazardous live parts, or
- a guard to reduce the likelihood of the **tool** from contacting uninsulated live parts.

Compliance is checked by inspection and, where necessary, by fault simulation.

5.6.2.6 Moving parts

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

5.6.2.7 Capacitor banks

Capacitor banks shall be fitted with a means of discharge for protection of **service persons**. A warning label shall be added if discharge time exceeds 1,0 s, stating the time taken to reduce the hazard to a safe level (not greater than 5 min) (see 1.2.8.5/RD and 1.2.8.8/RD).

5.6.2.8 Internal batteries

Internal batteries 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's** or service manual, as applicable, shall include the following instructions or similar warning:

"CAUTION: A battery can present a risk of electrical shock and high short circuit current. The following precautions should be observed when working on batteries.

- a) Remove watches, rings or other metal objects.
- b) Use tools with insulated handles.
- c) Wear rubber gloves and boots.
- d) Do not lay tools or metal parts on top of batteries.
- e) Disconnect the charging source prior to connecting or disconnecting battery terminals.
- f) Determine if battery is inadvertently grounded. If inadvertently grounded, remove source from ground. Contact with any part of a grounded battery can result in electrical shock. The likelihood of such shock can be reduced if such grounds are removed during installation and maintenance (applicable to equipment and remote battery supplies not having a grounded supply circuit)."

Compliance with 5.6.2.6 to 5.6.2.8 is checked by inspection.

5.7 Clearances, creepage distances and distances through insulation

The provisions of 2.10/RD apply.

6 Wiring, connections and supply

6.1 General

6.1.1 Introduction

The provisions and compliance requirements of 3.1/RD apply together with the following.

Supply leads to apparatus and measuring instruments in covers or doors shall be so installed that no mechanical damage can occur to conductors as a result of movement of these covers or doors.

Neutral conductors in three-phase **UPS** shall be rated to take account of harmonic currents summing in this conductor as a result of single-phase loads.

Generally, only one conductor shall be connected to a terminal, the connection of two or more conductors being allowed only in those cases where terminals are designed for this purpose.

6.1.2 Dimensions and ratings of busbars and insulated conductors

The choice of cross-sections of conductors inside the **UPS** is the responsibility of the manufacturer. In addition to the current which must be carried, the choice is governed by the mechanical stresses to which the **UPS** is subjected, by the way the conductors are laid, by type of insulation and, if applicable, by the kind of elements connected (for example, electronics).

Compliance is checked by inspection and test.

6.2 Connection to power

6.2.1 General provisions for connection to power

The provisions of 3.2.2/RD, 3.2.3/RD, 3.2.4/RD, 3.2.5/RD, 3.2.6/RD, 3.2.7/RD, 3.2.8/RD apply together with the following.

6.2.2 Means of connection

For safe and reliable connection to the **primary power** supply, **UPSs** are classified and connected as follows (see 1.2.5.2/RD):

- **UPS** for permanent connection: terminals for permanent connection to the supply;
- **pluggable UPS type B: non-detachable power supply cord** or a **type B** appliance coupler meeting the requirements of 3.2.5/RD;
- **pluggable UPS type A: an appliance inlet for connection of a detachable power supply cord** or a **non-detachable power supply cord** meeting the requirements of 3.2.5/RD.

Where equipment is provided with more than one supply connection (for example, with different voltages/frequencies or as a redundant 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 result from incorrect attachment;
- the **operator** is prevented from touching bare parts at ELV or **hazardous voltages**, such as plug contacts, when one or more connectors have been disconnected.

Compliance is checked by inspection.

6.3 Wiring terminals for external power conductors

The provisions of 3.3/RD apply, together with the following.

Provisions shall be made for the securement of external power cable glands and accessories, for example, metal/wire sheaths to prevent movement of the cable in its installed condition.

The manufacturer shall indicate if 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 and the short-circuit strength of the apparatus and the circuit is maintained.

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

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 N.

7 Physical requirements

7.1 Enclosure

The frame or chassis of a unit shall not be used to carry current during intended operation.

NOTE The frames or chassis connected to earth ground can carry leakage currents or current during an electric malfunction.

A part, such as a dial or nameplate that serves as a functional part of the **enclosure** shall comply with the **enclosure** requirements.

Individual modules of a modular unit may be of open construction – either no **enclosure** or partial **enclosure** is supplied – provided that when the modules are assembled in the field as intended, the unit **enclosure** complies with the requirements in 2.1/RD. For identification of the modules, see 1.7.2/RD and for electrical connections, see 6.2.1 and 1.7.7/RD.

The **enclosure** shall protect the various parts of the unit. The parts of an **enclosure** that are required to be in place to comply with the requirements for risk of fire, electric shock, injury to persons and **hazardous energy level** shall comply with the applicable **enclosure** requirements specified in this standard.

Compliance is checked by inspection.

7.2 Stability

The provisions of 4.1/RD apply together with the following.

Under conditions of normal use, units and equipment shall not become physically unstable to the degree that they may become a hazard to **operators** and **service persons**.

If a reliable stabilizing means is used to improve stability when drawers, doors, etc., are opened, it shall be automatic in operation when associated with **operator** use. Where it is not automatic, suitable and conspicuous markings shall be provided to caution **service persons**.

Compliance is checked by the following tests, where relevant. Each test is carried out separately. During the tests, containers shall contain the amount of substance within their rated capacity producing the most disadvantageous condition. Castors, if used in the normal operation of the unit, shall be in their most unfavourable position.

A unit shall not tip over, with or without batteries installed, in whatever represents the most severe conditions outlined in the RD.

7.3 Mechanical strength

The provisions of 4.2/RD apply.

7.4 Construction details

7.4.1 Introduction

The provisions of 4.3.1/RD, 4.3.2/RD, 4.3.3/RD, 4.3.4/RD, 4.3.5/RD, 4.3.7/RD, 4.3.11/RD, 4.4/RD and 4.5/RD apply together with the following.

The minimum protection degree IP20 shall be provided for **enclosures** when installed in accordance with manufacturer's instructions unless a greater level of protection is stated by the manufacturer.

Compliance is checked by inspection and with the test finger, except where a greater level of protection is declared and the test finger replaced by the appropriate test method in IEC 60529.

7.4.2 Openings

Openings vertically above bare parts at **hazardous voltages** in the top of a **fire enclosure** or an **electrical enclosure** shall not exceed 5 mm in any dimension unless the construction prevents vertical access to such parts, for example, by means of a trap or similar restriction (see Figure 4B/RD). This requirement does not apply to equipment having openings in the top of an **enclosure** with a height exceeding 1,8 m.

Compliance is checked by inspection.

7.4.3 Gas concentration

Equipment that, in normal use, contains batteries shall incorporate adequate safeguards against the risk of explosive gas concentration and internal or external spillage (see also 7.6 and Annex M).

Compliance is checked by inspection.

7.4.4 Equipment movement

Equipment provided with castors to temporarily enable easy movement to installed position and intended to have rigid fixed wiring shall have an additional method to ensure the equipment does not move when installed. For a unit having mass of 25 kg or more, a force equal to 20 % of the weight of the unit but not more than 250 N is applied to verify that the unit does not move.

Compliance is checked by inspection and test.

7.5 Resistance to fire

The provisions of 4.7/RD apply with the following.

UPS intended to be used in **operator access areas** (see 5.1.1) shall meet the minimum requirements of 4.7.2/RD.

Batteries shall have a **flammability class HB** or better (see 1.2.12/RD).

7.6 Battery location

7.6.1 Battery location and installation

Batteries for use with **UPS** shall be installed taking into account the requirements prescribed in 7.6.2 through 7.6.8.

Batteries shall be installed in:

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

Exception: Valve-regulated and other sealed-cell battery types do not require a separate location or compartment.

7.6.2 Accessibility and maintainability

When deemed necessary, battery poles and battery connectors shall be accessible so that their fixings can be tightened with the correct **tools**. Batteries with liquid electrolyte must be so located that the battery cell caps are accessible for electrolyte tests and readjusting of electrolyte levels.

*Compliance is checked by inspection and application of the **tools** and measuring equipment supplied or recommended by the battery manufacturer's conditions.*

7.6.3 Distance

Battery cells shall be mounted with a distance to each other for the purpose of complying with ventilation, battery temperature and insulation requirements.

The batterie shall be so located and mounted that the terminals of cells will be 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.

NOTE This distance between battery blocks or cells may be zero, when applicable.

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

7.6.4 Case insulation

Cells in conductive casings shall have adequate insulation between each other and to cabinets or compartments. Such insulation shall meet the requirements of 5.2/RD.

Compliance is checked by test.

7.6.5 Wiring

Contacts, connections and wiring shall be protected against effects of ambient temperature, moisture, gas, vapor and mechanical stress according to Clause 6.

Compliance is checked by inspection and test.

7.6.6 Electrolyte spillage

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

NOTE This requirement does not apply to VRLA type batteries.

Compliance is checked by inspection.

7.6.7 Ventilation

Proper ventilation shall be provided so that any potential explosive mixtures of hydrogen and oxygen are dispersed safely below hazardous levels.

For battery compartments (separate or combined), the determination method of the necessary airflow to ensure adequate dissolution levels is given in Annex M.

In combined apparatus of battery and electrical components, attention shall be given to prevent ignition of local concentrations of hydrogen and oxygen by adjacent operational arcing parts, such as contactors and switches close to battery vents/valves.

This shall be achieved by the use of fully enclosed components or separation of battery compartments or adequate ventilation dependent upon the technical construction of the **UPS** and battery.

The sufficiency of the distance between battery vents/valves and any open arcing component shall be demonstrated by the manufacturer with technical data for the construction of the equipment under test (see Clause M.2 for guidance).

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.

7.6.8 Charging voltages

Batteries shall be protected against excessive voltages, including under a single fault condition, for example due to a charger failure, by switching off the charger or interrupting the charging current. The charging voltage limits shall be as declared by the manufacturer.

Compliance is checked by circuit evaluation and test.

7.7 Temperature rise

The provisions of 4.5/RD apply with the following.

NOTE 1 Table 1 is a partial extract from Table 4B/RD and values are applicable for rise of resistance or embedded thermocouple methods.

NOTE 2 Table 2 provides additional temperature limits for infrequent and occasional occurrences.

Table 1 – Temperature limits

Insulation class	Maximum temperature °C
Insulation, including winding insulation, of	
– Class A material 105	100
– Class E material 120	115
– Class B material 130	120
– Class F material 155	140
– Class H material 180	165
– Class C material 200	180
– Class N material 220	200
– Class P material 250	225

**Table 2 – Permitted temperature limits for magnetic windings
at the end of stored energy mode of operation**

Insulation class °C	Temperature by average resistance method °C	Temperature by thermocouple method °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

8 Electrical requirements and simulated abnormal conditions

8.1 General provisions for earth leakage

The provisions of 5.1.1/RD apply together with the following.

Where the circuit configuration is such that in any mode of operation the **UPS** protective earth conductor will carry the sum of the **UPS** and connected load earth leakage currents, the **UPS** shall meet the following requirements.

Systems of interconnected equipment with individual connections to the **a.c. mains supply** shall have each piece of equipment tested separately. Systems of interconnected equipment with one common connection to the **a.c. mains supply** shall be treated as a single piece of equipment. See also 1.4.10/RD regarding the inclusion of optional features.

NOTE Systems of interconnected equipment are specified in more detail in IEC 60990, Annex A.

Equipment which is designed for connection to multiple **mains supplies**, only one of which is required at a time (for example, for backup) shall be tested with only one **mains supply** connected. Equipment requiring power simultaneously from two or more **mains supplies** shall be tested with all **mains supplies** connected.

Where the earth leakage current exceeds 3,5 mA, the requirements of 5.1.7/RD shall apply.

See 6.2.2 for means of connection to the **primary power** supply.

Compliance is checked by inspection and by the relevant tests performed at most unfavourable input voltage.

8.2 Electric strength

The provisions of 5.2/RD apply.

8.3 Abnormal operating and fault conditions

8.3.1 General

The provisions of 5.3.1/RD, 5.3.2/RD, 5.3.3/RD, 5.3.4/RD, 5.3.5/RD, 5.3.9/RD apply together with the following.

8.3.2 Simulation of faults

For components and circuits other than those covered by 5.3.2/RD, 5.3.3/RD and 5.3.5/RD, compliance is checked by simulating the following conditions:

- faults in any components in **primary circuits**;
- faults in any components where failure could adversely affect **supplementary insulation** or **reinforced insulation**;
- additionally, for equipment that does not comply with the requirements of 4.7.1/RD and 4.7.2/RD, faults in all components;
- faults arising from connection of the most unfavourable load impedance to terminals and connectors that deliver power or signal outputs from the equipment, other than main power outlets.

A **UPS** having forced ventilation shall be operated in the normal mode with the rotor of a blower motor or fan locked. For a **UPS** having more than one blower motor or fan, the test shall be conducted with the rotor of each blower motor or fan locked, one at a time. A **UPS** having filters over ventilation openings shall be operated with the openings blocked to represent clogged filters. The test shall be conducted initially with the ventilation openings blocked approximately 50 %, and then repeated under a fully blocked condition.

Exception 1: A single blower or fan with a filter need not be tested under the fully blocked condition.

Exception 2: All blower or fan motors in a unit having more than one blower or fan motor may be locked simultaneously.

Where there are multiple outlets having the same internal circuitry, the test needs to be made only to one sample outlet.

For components in **primary circuits** associated with the mains input and output, such as the supply cord, appliance couplers, RFI filtering components, **bypass**, switches and their inter-connecting wiring, no fault is simulated, provided that the component complies with 5.3.4 a)/RD.

The equipment, circuit diagrams and component specifications shall be examined to determine those fault conditions that might reasonably be expected to occur.

NOTE Examples are short circuits and open circuits of transistors, diodes and capacitors (particularly the electrolytic capacitors), faults causing continuous dissipation in resistors designed for intermittent dissipation, and internal faults in integrated circuits causing excessive dissipation.

The tests are applied one at a time with the equipment operating at **rated voltage** or at the upper limit of the **rated voltage range**.

It is permitted to test circuits within the equipment, or to test simulated circuits, separate components or sub-assemblies outside the equipment.

In addition to the compliance criteria given in 5.3.3/RD, temperatures in the transformer supplying the component under test shall not exceed those specified in Annex C/RD and account shall be taken of the exception detailed in such annex.

8.3.3 Conditions for tests

Equipment shall be tested by applying any condition that may be expected in normal use and foreseeable misuse, with the **UPS** operating at **rated voltage** or at the upper limit of the **rated voltage range**.

NOTE Examples of normal use or foreseeable misuse conditions are:

- any operation of accessible operating devices, such as knobs, levers, keys and bars, that is not in accordance with the manufacturer's instructions;
- covering of groups of ventilating openings that are likely to be covered simultaneously, for example, groups of openings situated on one side or on the top of the equipment; such groups to be covered in turn;
- operation under any output overload conditions, including a short circuit.

In addition, equipment that is provided with a protective covering shall be tested with the covering in place.

9 Connection to telecommunication networks

The provisions of Clause 6/RD and 3.5/RD apply together with the following: 2.1.3/RD, 2.3.1/RD, 2.3.2/RD, 2.3.3/RD, 2.3.4/RD, 2.3.5/RD, 2.6.5.8/RD, 2.10.3.3/RD, 2.10.3.4/RD, 2.10.4/RD, Annex M/RD.

NOTE Clause 6/RD refers the **user** to take into account the provisions of 5.1.8/RD.

Withdrawn

Annex A
(normative)

Tests for resistance to heat and fire

Annex A/RD applies.

Withdrawn

Annex B
(normative)

Motor tests under abnormal conditions

Annex B/RD applies.

Withdrawn