

Reciprocating internal combustion engine driven alternating current generating sets —

Part 11: Rotary uninterruptible power systems — Performance requirements and test methods

The European Standard EN 88528-11:2004 has the status of a
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National foreword

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The UK participation in its preparation was entrusted to Technical Committee PEL/2, Rotating electrical machinery, which has the responsibility to:

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Part 11: Rotary uninterruptible power systems -
Performance requirements and test methods
(IEC 88528-11:2004)**

Groupes électrogènes à courant alternatif
entraînés par moteurs alternatifs
à combustion interne
Partie 11: Alimentations sans interruption
à accumulation d'énergie cinétique -
Prescriptions de performances
et méthodes d'essai
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Stromerzeugungsaggregate
mit Hubkolben-Verbrennungsmotoren
Teil 11: Dynamische, unterbrechungsfreie
Stromversorgung -
Leistungsanforderungen
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(IEC 88528-11:2004)

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Foreword

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RECIPROCATING INTERNAL COMBUSTION ENGINE DRIVEN ALTERNATING CURRENT GENERATING SETS –

Part 11: Rotary uninterruptible power systems – Performance requirements and test methods

1 Scope

This International Standard, which forms part of the ISO 8528 series, specifies criteria, including performance and test methods, for rotary uninterruptible power systems (UPS) arising out of a combination of mechanical and electrical rotating machines. This standard applies to power supplies primarily designed for supplying uninterrupted a.c. power to the consumer. When operated without input mains feed, the power is provided by stored energy and/or reciprocating internal combustion (RIC) engine and the output power is provided by one or more rotating electrical machines.

This part 11 applies to a.c. power supplies primarily designed for supplying uninterruptible electrical power for stationary land and marine use, excluding supplies for aircraft, land vehicles or locomotives. It also excludes power supplies where the output power is generated by static converters. (See IEC 62040-3.)

The use of a rotary UPS installation to improve the quality of a.c. power supply, to provide voltage and/or frequency conversion, and to provide peak shaving is also described.

For some specific applications (for example, essential hospital supplies, offshore, non-stationary applications, high rise buildings, nuclear, etc.) supplementary requirements may be necessary. The provisions of this part of ISO 8528 should be used as a basis.

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 60034-1:2003, *Rotating Electrical Machines – Part 1: Rating and performance*

IEC 60034-22:1996, *Rotating Electrical Machines – Part 22: AC generators for reciprocating internal combustion (RIC) engine driven generating sets*

IEC 60417 (all parts), *Graphical symbols for use on equipment. Index, survey and compilation of the single sheets*

IEC 60529:1989, *Degrees of protection provided by enclosures (IP Code)*

IEC 61000, *Electromagnetic compatibility (EMC)*

ISO 3046-1:2003, *Reciprocating internal combustion engines*

ISO 7000, *Graphical symbols for use on equipment*

ISO 8178-1, *Reciprocating internal combustion engines – Exhaust emission measurement – Part 1: Test-bed measurement of gaseous and particulate exhaust emissions*

ISO 8528-1, *Reciprocating internal combustion engine driven alternating current generating sets – Part 1: Application, ratings and performance*

ISO 8528-6, *Reciprocating internal combustion engine driven alternating current generating sets – Part 6: Test methods*

ISO 8528-9, *Reciprocating internal combustion engine driven alternating current generating sets – Part 9: Measurement and evaluation of mechanical vibrations*

ISO 8528-10, *Reciprocating internal combustion engine driven alternating current generating sets – Part 10: Measurement of airborne noise by the enveloping surface method*

3 Terms and definitions

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

3.1 General

3.1.1

generating set

one or more RIC engines to produce mechanical energy and one or more generators to convert the mechanical energy into electrical energy together with components for transmitting the mechanical energy (for example, couplings, gearbox) and where applicable bearing and mounting components

3.1.2

uninterruptible power system (UPS)

power system for maintaining continuity of load power in the event of failure of the mains power

3.1.3

rotary UPS

UPS where one or more electrical rotating machines provide the output voltage

3.1.4

converter

set of equipment, static or rotating, to convert one type of electric current to another type, different in nature, voltage and/or frequency

3.1.5

power system reactor

regulated or non-regulated inductance in series with the input of some types of UPS

3.1.6

machine set

any combination of one or more electrical rotating machines

3.1.7

energy storage device

device to provide stored energy on failure of the normal power supply system. This energy shall be available either during the total failure time or until the take over of a power supply by the RIC engine

3.1.8

continuity of load power

availability of the power supplied to the load with voltage and frequency within steady-state and transient tolerance bands and with distortion and power interruptions within the limits specified for the load

3.2 Performance of systems and components

3.2.1

mains power

power normally continuously available which is supplied from the electrical power system or by independent electrical power generation

3.2.2

backfeed

condition where a portion of the voltage or energy available within the UPS is fed back to any of the input terminals, either directly or by a leakage path

3.2.3

linear load

load where the parameter Z (load impedance) is a constant when a variable sinusoidal voltage is applied to it and that a sinusoidal voltage causes a sinusoidal current

3.2.4

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

3.2.5

power failure

any variation in the input voltage or frequency of the mains power not within acceptable limits

3.2.6

redundant operation

any operation with the addition of parallel functional units or groups of functional units in a system to enhance the availability of load power

3.2.7

power conditioning mode

stable mode of operation that the UPS finally attains when operating under the following conditions:

- normal power is present and within its given tolerance;
- full (100 %) stored energy available within its given restored energy time;
- the operation is or may be continuous;
- the load is within its given range;
- the output voltage is within its given tolerance.

Where a bypass is used:

- the input voltage is available and within specified tolerances;
- the phase lock is active, if present.

3.2.8

independent mode

operation of the UPS when operating under the following conditions:

- normal power is disconnected or is out of given tolerance;
- energy is from storage device or RIC engine;
- load is within the given range;
- output voltage and frequency are within given tolerances.

3.2.9

bypass mode

state the UPS attains when operating and the load is supplied via the bypass

3.2.10

off mode

state that the rotary UPS attains when de-energized and at rest

3.2.11

synchronization

adjustment of an a.c. power source to match another a.c. source in frequency and phase angle

3.2.12

load power

power which is supplied to the load from the UPS

3.2.13

asynchronous transfer

switching of load power between two sources that are not synchronized. This transfer must happen with an interruption

3.3 Specified values

3.3.1

rated value

value of a quantity used for specification purposes, established for a specified set of operating conditions of a component, device, equipment, or system

[IEV 151-16-08]

3.3.2

tolerance band

range of values of a quantity within specified limits

3.3.3

deviation

difference between the desired value and the actual value of a variable at a given instant

NOTE This definition applies whether the desired value is constant or varies in time.

[IEV 351-12-15]

3.3.4

rated voltage

input or output supply voltage for which equipment is designed or specified

3.3.5

rated frequency

input or output frequency as declared by the manufacturer

3.3.6

phase angle

angle (usually expressed in electrical degrees) between reference points on one or more a.c. waveforms

3.3.7

crest factor

ratio of the peak value of a periodic waveform to its r.m.s. value

3.3.8**power**

time rate of transferring or transforming energy or of doing work. (also called active power)

[IEV 111-13-30]

3.3.9**apparent power**

product of the r.m.s. voltage U between the terminals of a two-terminal element or two-terminal circuit and the r.m.s. electric current I in the element or circuit:

$$S=UI$$

[IEV 131-11-41]

3.3.10**ambient temperature**

temperature of the air or other medium where the equipment is to be used

[IEV 826-01-04]

3.3.11**total harmonic distortion**

ratio of the r.m.s. value of the harmonic content as a percentage of the r.m.s. value of the fundamental component of the periodic function

3.3.12**recovery time**

time interval between the moment a stabilized voltage or frequency leaves the steady-state tolerance band until the instant when this quantity returns to and stays within the steady-state tolerance band

3.3.13**stored energy time**

minimum time during which the UPS will ensure conditions when the normal power fails starting with the energy storage means being charged

3.4 Input values

NOTE These definitions are only valid in the power conditioning mode (normal mode).

3.4.1**input voltage tolerance**

maximum continuous input voltage variation in normal operation

3.4.2**input power factor**

ratio of the input active power to the input apparent power with the UPS operating at rated input voltages at rated output power, and fully charged storage

3.4.3**high impedance mains failure**

mains failure where the mains impedance as presented to the UPS input terminals is infinite

3.4.4**low impedance mains failure**

mains failure where the mains impedance as presented to the UPS input terminals is negligible

3.5 Output values

3.5.1

output voltage

r.m.s. value (unless otherwise specified for a particular load) of the voltage between the output terminals

3.5.2

output current

r.m.s. value of the current (unless otherwise specified for a particular load) from the output terminals

3.5.3

rated load

load for which the system is defined

4 Symbols and abbreviations

$\cos \phi$	Fundamental portion of power factor
f	Rotary UPS output frequency in Hz
P	Active power
S	Apparent power
U_r	Rated output voltage of a rotary UPS
U_c	Rectified voltage
U_{ac}	Rotary UPS output voltage (r.m.s. line-line)
Z	Load impedance

5 Selection criteria

Complete application criteria should include the following features and shall be made available by the system supplier:

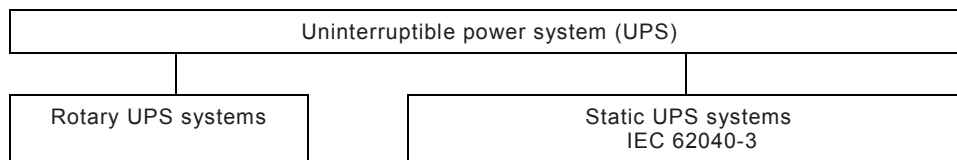
- rotary UPS load requirements;
- operating time required;
- starting capability of large electric motors in the load;
- fault clearing capability;
- input power quality;
- ambient temperature;
- reliability;
- maintainability;
- required floor space;
- parallel operation requirement;
- operating efficiency;
- reduction and/or isolation of voltage harmonics and other deviations from input to output;
- reduction and/or isolation of current harmonics and other deviations from output to input;
- environmental requirements (noise, vibration, dust, electromagnetic compatibility, etc.);
- degree of separation from the mains in power conditioning mode (harmonics, full galvanic isolation, etc.).

An input switching device shall be provided to isolate the rotary UPS from the incoming mains.

Means shall be provided to prevent reverse power flow, if required.

6 General description

Types of uninterruptible power systems are shown in Figure 1.



IEC 033/04

Figure 1 – Types of UPS systems

6.1 Rotary UPS

Rotary uninterruptible power supply as defined in this standard is achieved by a combination of electrical and when required RIC engines and generating sets.

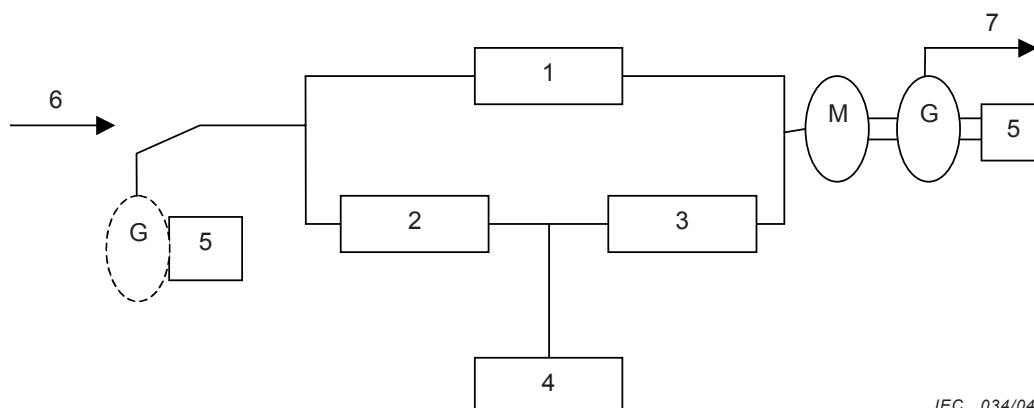
In order to achieve an uninterrupted supply of power during a short interruption period, a pneumatic, kinetic, electrochemical, or other such energy storage device is used. For extended periods of operation an RIC engine or generating set may be utilized to provide the energy supply. (See ISO 8528-1, subclause 6.5.)

6.2 Types of rotary UPS

Various configurations of rotary UPS systems are possible depending upon the application and performance requirements. It is important that the configuration shall be taken into account by the customer when agreeing upon the requirements with the manufacturer.

6.2.1 Series connected rotary UPS

Figure 2 illustrates a series connected rotary UPS.



IEC 034/04

Key

1 primary path	3 inverter	5 RIC engine	7 AC output	G generator
2 rectifier	4 energy storage	6 AC input	M motor	

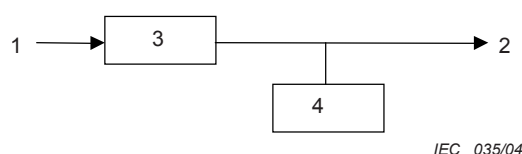
Figure 2 – Typical example series connected rotary UPS

In most series connected cases, two independent electrical machines (motor and generator) or a combination of both is used as the final output of the rotary UPS. In most cases the final output machine pair or combination machine is direct connected to the mains source with an alternate path to the mains through power converters allowing connection to a stored energy source. Direct connection provides higher efficiency and reduced input harmonics. Some series connected cases rely on the alternate path.

- Rotary UPS power supply to the electrical consumer is taken from the rotary UPS system, independent of whether the external power supply system is intact or has failed. In the event of a mains failure or if the power is outside the permissible tolerance limits of the input of the rotary UPS system, energy is provided from a short term stored energy source until a RIC engine can be started, if the installation is so equipped. When the installation is equipped with an engine, the required energy for continuity of the power supply to the electrical consumer is taken for a practically unlimited time from the engine (sufficient fuel supply assumed) (see also Clause 5). After restoration of the mains, supply power for the rotary UPS system is again taken from the mains system.
- The engine may be equipped with its own generator and transfer switch configured to supply power to the input of the series connected rotary UPS. The engine can also be directly connected by a clutch to the MG set of the series connected rotary UPS.
- Back feed to the mains during a short circuit of the mains or during rotary UPS transition modes must be prevented to maintain rotary UPS output power and prevent internal damage of the rotary UPS. In the series connected case with a single power path (i.e. rectifier to inverter to MG set) back feed prevention is provided by phase control of the rectifier. In series connected rotary UPS cases with a dual power path (i.e. static switch to MG set and rectifier to inverter to MG set) back feed is prevented by phase control of the sub-cycle static switch and the rectifier.
- In the series connected rotary UPS isolation protection of the consumer's load is provided by the electrical to mechanical and back to electrical power conversions of the final output MG set. The level of isolation protection depends on the MG set, insulation, air gaps, etc. The generator provides reactive power compensation and supplies the harmonics and unbalance as required by the load.
- In the event of mains failure or when exceeding the permissible tolerance limits of the electrical consumer, the power supply, practically without any interruption, will change over to short term stored energy and then to an engine when so equipped.
- Upon restoration of the stabilized mains, supply is effected synchronously and without interruption.

6.2.2 Line interactive rotary UPS

Figure 3 illustrates a line interactive rotary UPS.



Key

- | | |
|-------------|------------------------|
| 1 AC input | 3 power system reactor |
| 2 AC output | 4 machine set |

Figure 3 – Typical example of a line interactive rotary UPS

A machine set including a generator, energy storage means and an RIC engine if so equipped, is operated in parallel with the mains system.

The energy storage and RIC engine may all be coupled on the same shaft, or realized as separate units with an indirect coupling (electrical, hydraulic, mechanical, etc.).

- Power is taken from the mains system, provided the voltage and frequency lie within the tolerance range specified for the mains system or electrical consumers.
- The rotary UPS system is also supplied with energy from the mains system. A certain degree of isolation between the mains system and the electrical consumer is achieved by means of an impedance (reactor). This is installed in the incoming feeder so that voltage deviations can be compensated to suit system requirements by the synchronous machine (s) that are connected in parallel.
- The power system reactor limits back feed in case of low impedance mains failure and allows independent control of output voltage. The generator provides reactive power compensation and supplies the harmonics and unbalance as required by the load.
- In the event of mains system failure or when exceeding the permissible tolerance limits of the electrical consumer, the power supply will change over to the synchronous converter machine or to the synchronous generator of the twin machine set.

The energy required for driving the rotary UPS is taken for either a limited time from the energy storage device or a practically unlimited time from an RIC engine (sufficient fuel supply assumed) (see also Clause 5).

Continuation of energy supply from the restored and stabilized mains is effected synchronously and without interruption.

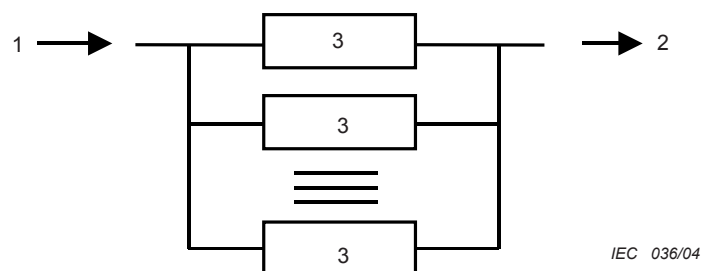
6.3 Parallel operation of a rotary UPS installation

6.3.1 General

Rotary UPS systems may be operated in parallel to increase power output, to increase availability, or to provide redundancy.

6.3.2 Parallel operation

Parallel operation of a rotary UPS system is illustrated in Figure 4. An arrangement of rotary UPS systems of identical rating is usual.



Key

1 AC input 2 AC output 3 UPS

Figure 4 – Parallel operation of a rotary UPS

6.3.3 Redundant operation

Increasing the number of active rotary UPS units by at least one active unit to ensure full supply of electrical consumers in cases of maintenance or failure of a single rotary UPS unit ($1 + n$ active redundancy).