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First edition
2004-03

**Reciprocating internal combustion engine driven
alternating current generating sets –**

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

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CONTENTS

FOREWORD.....	5
1 Scope.....	7
2 Normative references	7
3 Terms and definitions	8
3.1 General	8
3.2 Performance of systems and components	9
3.3 Specified values	10
3.4 Input values.....	11
3.5 Output values	12
4 Symbols and abbreviations.....	12
5 Selection criteria	12
6 General description	13
6.1 Rotary UPS	13
6.2 Types of rotary UPS	13
6.2.1 Series connected rotary UPS.....	13
6.2.2 Line interactive rotary UPS.....	14
6.3 Parallel operation of a rotary UPS installation.....	15
6.3.1 General	15
6.3.2 Parallel operation	15
6.3.3 Redundant operation	15
6.4 Power system changeover with rotary UPS installations (bypass).....	16
6.5 Enclosure protection.....	16
7 Modes of operation.....	16
7.1 Power conditioning mode	17
7.2 Independent mode.....	17
7.3 Bypass mode	18
7.4 Off mode	18
7.5 Transitions	18
7.5.1 Transition 1, starting the system with mains voltage present.....	18
7.5.2 Transition 2, start-up without mains voltage (black start)	18
7.5.3 Transition 3, disconnect from grid.....	19
7.5.4 Transition 4, connect to grid	19
7.5.5 Transition 6, transfer	19
7.5.6 Transition 7, 8, retransfer	19
8 Service conditions	19
8.1 Normal service conditions	19
8.2 Operation at extended ambient.....	19
8.2.1 Ambient service temperature	19
8.2.2 Ambient storage and transportation conditions	19
8.3 Engines.....	20
8.4 Rotating electrical machines.....	20
8.5 Control logic.....	20

9	Electrical service conditions and performance	20
9.1	General – all rotary UPS.....	20
9.2	Performance.....	21
10	Manufacturer technical declarations	22
10.1	General.....	22
10.2	Purchaser specification guidelines.....	22
10.2.1	Type of rotary UPS, additional features, and system requirements	23
10.2.2	Rotary UPS input.....	23
10.2.3	Load to be supplied from a rotary UPS	23
10.2.4	Rotary UPS output.....	24
10.2.5	Battery (where applicable).....	24
10.2.6	General application requirements and special service conditions.....	25
10.2.7	Multi-module system configurations	25
10.2.8	Electromagnetic compatibility	26
11	Testing	27
11.1	Static output voltage and frequency deviations.....	27
11.2	Dynamic output voltage and frequency deviations	28
11.3	Input current characteristics	28
11.4	Measurement of filter properties	28
11.4.1	From mains to output.....	28
11.4.2	From output to mains.....	30
11.5	System performance	30
11.5.1	Efficiency.....	30
11.5.2	Stored energy times	30
11.5.3	Multi-module rotary UPS performance	30
11.6	Black start test	31
11.7	Environmental tests.....	31
11.8	Audible noise	31
11.9	Testing.....	31
12	Maintenance and product marking	33
12.1	Nameplate markings.....	33
12.2	Label requirements.....	34
12.3	Name plate marker.....	34
12.4	Decals – labelling	35
12.4.1	Safety instructions and documentation	35
12.5	Maintenance.....	35
	Annex A (informative) Typical energy storage devices	36
	Annex B (normative) Reference non-linear load – Single-phase.....	40
	Annex C (normative) Reference non-linear load – Three-phase	42
	Annex D (normative) Input mains failure – Test method	43
	Annex E (informative) Types of uninterruptible power systems (UPS) configurations	44
	Figure 1 – Types of UPS systems	13
	Figure 2 – Typical example series connected rotary UPS.....	13
	Figure 3 – Typical example of a line interactive rotary UPS.....	14
	Figure 4 – Parallel operation of a rotary UPS	15

Figure 5 – Bypass operation	16
Figure 6 – Illustration of rotary UPS operation	17
Figure 7 – Operating modes.....	18
Figure 8 – Surge test	29
Figure 9 – Warning label.....	34
Figure A.1 – Dual conversion – direct-coupled flywheel	37
Figure A.2 – Line interactive – direct-coupled flywheel.....	37
Figure A.3 – Dual conversion – indirect coupled flywheel.....	37
Figure A.4 – Line interactive – indirect coupled flywheel.....	38
Figure A.5 – Double fed a.c. machine	38
Figure A.6 – Dual conversion with battery.....	38
Figure A.7 – Line interactive with battery	39
Figure B.1 – Single-phase non-linear load	40
Figure C.1 – Three-phase non-linear load.....	42
Figure D.1 – Input mains failure test method.....	43
Figure E.1 – Series connected type 1	44
Figure E.2 – Series connected type 2	45
Figure E.3 – Line interactive.....	45
Figure E.4 – Typical UPS.....	46
Figure E.5 – Typical switchless dual feed UPS.....	47
Table 1 – Compatibility levels for individual harmonic voltages in mains power	21
Table 2 – Operating steady-state limit values for performance classes	21
Table 3 – Operating dynamic limit values for performance classes (note 1).....	22
Table 4 – Technical data sheets – Manufacturers declaration	26
Table 5 – Test methods for rotary UPS performance characteristics	32

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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**RECIPROCATING INTERNAL COMBUSTION ENGINE DRIVEN
ALTERNATING CURRENT GENERATING SETS –**
**Part 11: Rotary uninterruptible power systems –
Performance requirements and test methods**

FOREWORD

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International Standard IEC 88528-11 has been prepared jointly by IEC technical committee 2: Rotating machinery, and ISO technical committee 70: Internal combustion engines.

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

FDIS	Report on voting
2/1275/FDIS	2/1280/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.

The committee has decided that the contents of this publication will remain unchanged until 2007. At this date, the publication will be

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

IEC 88528-11 is integrated into the ISO 8528 series listed below, under the general title *Reciprocating internal combustion engine driven alternating current generating sets*:

- Part 1: Application, ratings and performance
- Part 2: Engines
- Part 3: Alternating current generators for generating sets
- Part 4: Controlgear and switchgear
- Part 5: Generating sets
- Part 6: Test methods
- Part 7: Technical declarations for specification and design
- Part 8: Requirements and tests for low-power generating sets (available in English only)
- Part 9: Measurement and evaluation of mechanical vibrations (available in English only)
- Part 10: Measurement of airborne noise by the enveloping surface method
- Part 12: Emergency power supply to safety services

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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

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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

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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:

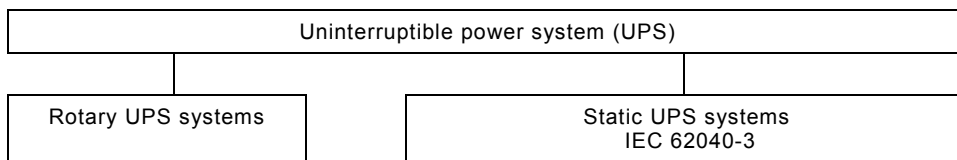
- rotary UPS load requirements;
- operating time required;
- starting capability of large electric motors in the load;
- fault clearing capability;
- input power quality;
- ambient temperature;
- reliability;
- maintainability;
- required floor space;
- parallel operation requirement;
- operating efficiency;
- 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)

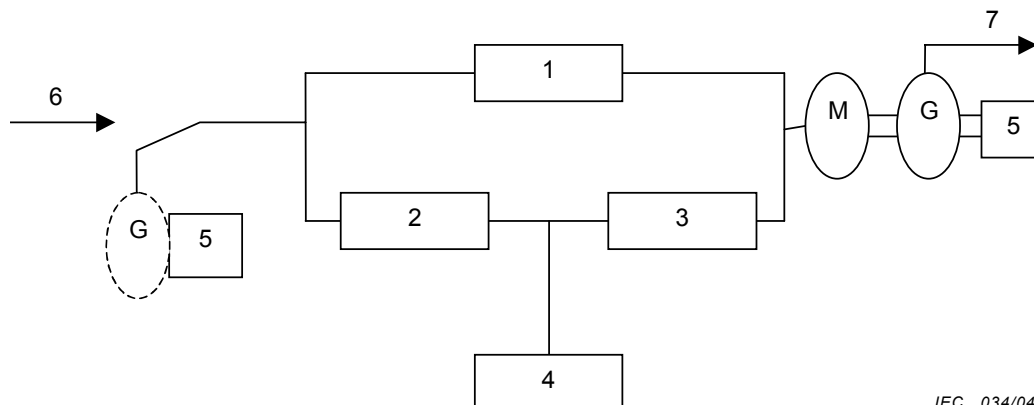
6.2 Types of rotary UPS

IEC 88528-11:2004

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