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Reciprocating internal combustion engine driven alternating current generating sets —

Part 8:
Requirements and tests for low-power generating sets

Groupes électrogènes à courant alternatif entraînés par moteurs alternatifs à combustion interne —

Partie 8: Prescriptions et essais pour groupes électrogènes de faible puissance

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Contents

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 8528-8 was prepared by Technical Committee ISO/TC 70, *Internal combustion engines*, Subcommittee SC 2, *Performance and tests*.

ISO 8528 consists of the following parts, 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*

— *Part 9: Measurement and evaluation of mechanical vibrations*

— *Part 10: Measurement of airborne noise by the enveloping surface method*

— *Part 11: Dynamic uninterruptible power supply systems*

— *Part 12: Emergency power supply to safety services*

Annex A of this part of ISO 8528 is for information only.

Reciprocating internal combustion engine driven alternating current generating sets —

Part 8:
Requirements and tests for low-power generating sets

1 Scope

This part of ISO 8528 defines requirements, minimum performances and type tests for low-power generating sets driven by reciprocating internal combustion engines for land and marine use (domestic, recreational and industrial application), excluding generating sets used on aircraft.

It concerns mainly low-power generating sets driven by reciprocating internal combustion engines for the generation of single or multiphase alternating current or direct current up to 500 V. The generating sets are standard manufactured sets that can be selected from a commercial catalogue or leaflet.

In this part of ISO 8528, "low power" is taken to mean power of a magnitude up to approximately 10 kW.

NOTE 1 An exact determination of a power limit is not possible.

Low-power generating sets for the purpose of this standard are determined by the following special features:

— the users normally are laymen (for further details see 3.1);

— the complete generating set is usually transportable, or mobile;

— the electrical output is connected by plugs and sockets (except for extra low voltages; see 6.6.3);

— the generating set is ready for use without any additional installation work by the user.

Generating sets for special applications or of higher rated power conforming to the above special features may, by agreement between manufacturer and customer, be tested in accordance with this part of ISO 8528. If supplementary stipulations are required for certain applications this should be done taking this part of ISO 8528 as a basis.

This part of ISO 8528 deals with the special requirements of test and safety design which should be observed in addition to the definitions and requirements laid down in ISO 8528 parts 1 to 6, where applicable.

Furthermore it lays down safety requirements in order to protect the user from danger.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 8528. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 8528 are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 3046-1:1995, *Reciprocating internal combustion engines — Performance — Part 1: Standard reference conditions, declarations of power, fuel and lubricating oil consumptions, and test methods.*

ISO 8528-1:1993, *Reciprocating internal combustion engine driven alternating current generating sets — Part 1: Application, ratings and performance.*

ISO 8528-2:1993, *Reciprocating internal combustion engine driven alternating current generating sets — Part 2: Engines.*

ISO 8528-3:1993, *Reciprocating internal combustion engine driven alternating current generating sets — Part 3: Alternating current generators for generating sets.*

ISO 8528-4:1993, *Reciprocating internal combustion engine driven alternating current generating sets — Part 4: Controlgear and switchgear.*

ISO 8528-5:1993, *Reciprocating internal combustion engine driven alternating current generating sets — Part 5: Generating sets.*

ISO 8528-6:1993, *Reciprocating internal combustion engine driven alternating current generating sets — Part 6: Test methods.*

ISO 7000:1989, *Graphical symbols for use on equipment — Index and synopsis.*

IEC 34-1:1994, *Rotating electrical machines — Part 1: Rating and performance.*

IEC 34-5:1991, *Rotating electrical machines — Part 5: Classification of degrees of protection provided by enclosures for rotating electrical machines.*

IEC 68-2-63:1991, *Environmental testing — Part 2: Tests — Test Eg.: Impact, spring hammer.*

IEC 83:1975, *Plugs and socket-outlets for domestic and similar general use — Standards.*

IEC 245-4:1980, *Rubber insulated cables of rated voltages up to and including 450/750 V — Part 4: Cords and flexible cables.*

IEC 309-1:1988, *Plugs, socket-outlets and couplers for industrial purposes — Part 1: General requirements.*

IEC 309-2:1989, *Plugs, socket-outlets and couplers for industrial purposes — Part 2: Dimensional interchangeability requirements for pin and contact-tube accessories.*

IEC 335-1:1991, *Safety of household and similar electrical appliances — Part 1: General requirements.*

IEC 364-4-41:1992, *Electrical installations of buildings — Part 4: Protection for safety — Chapter 41: Protection against electric shock.*

IEC 417:1973, *Graphic symbols for use on equipment — Index, survey and compilation of the single sheets.*

IEC 529:1989, *Degrees of protection provided by enclosures (IP Code).*

CISPR 12:1990, *Limits and methods of measurement of radio interference characteristics of vehicles, motor boats, and spark ignited engine-driven devices.*

CISPR 14:1993, *Limits and methods of measurement of radio disturbance characteristics of electrical motor-operated and thermal appliances for household and similar purposes, electric tools and electric apparatus.*

3 Definitions

For the purposes of this part of ISO 8528 the following definitions and those of ISO 8528-1 shall apply.

3.1 layman: A person who does not necessarily recognize potential danger resulting from electricity, moving parts or hot parts (see also clause 6). The layman has a lack of training, knowledge and experience, and has insufficient knowledge of the relevant regulations.

3.2 close proximity: The 30 mm space immediately around the operating and adjusting controls and carrying handles, including their whole movement range.

3.3 power rating: The electric power available at the outlets or sockets of the generator, expressed in kilowatts (kW) at the rated frequency and the rated power factor.

3.4 rated power: The prime power according to ISO 8528-1:1993, 13.3.2 as assigned by the generating set manufacturer.

NOTE 2 Due to the variable power sequence for this kind of low-power generating set the average permissible power is 90 % of the rated power.

3.5 thermal steady-state condition: State reached when the temperature rise of the generator does not vary by more than 2 K over a period of 1 h. For electrical parts see IEC 34-1:1994, 2.11; for RIC engines see ISO 3046-3, 4.2.

NOTE 3 Under normal test conditions the RIC engine has first reached a steady-state condition before a set of

measurements is taken. If not, the permissible deviations for the steady-state conditions of the RIC engine according to ISO 3046-3 apply.

3.6 uncontrolled generator: Where there is no load- and speed-dependent adjustment of excitation by an automatic voltage regulator for control of terminal voltage.

NOTE 4 This includes generators with directly acting load current-dependent excitation devices (compounding).

3.7 automatic voltage regulator-controlled generator: Where the terminal voltage is controlled by changing the excitation by means of an automatic voltage regulator as a function of load and speed.

4 Regulations and additional requirements

For low-power generating sets additional regulations depending on the location of its operation may exist.

These may refer to environmental and safety requirements defined in the laws and regulations of the legal authorities in the different countries where generating sets are used. They are mainly in the fields of

— noise emission limitation;

— exhaust gas emission limitation;

— electrical safety;

— fuel systems.

5 General notes on tests

Tests according to this part of ISO 8528 are type tests; unless otherwise specified, the tests are made on a single sample as delivered, which shall withstand all the relevant tests.

During the tests the temperature of the ambient air shall be kept between 15 °C and 30 °C.

Generating sets built for more than one type of rated voltage, rated frequency or current shall be tested for all relevant operating parameters.

6 Safety requirements and tests

The requirements and tests cover mechanical and electrical performance and safety.

Acceptability of the component parts of the generating set shall be judged on the mechanical and electrical strength and resistance to ignition and distorsion.

6.1 Mechanical strength

6.1.1 Generating sets shall be designed in such a way as to be able to withstand robust handling within the framework of normal operation. All parts, damage to which may impair safety, shall have sufficient mechanical strength.

The generating set shall satisfy the tests defined below.

a) Subjected to impact using an impact tester

Blows are applied to the generating set by means of the spring-operated impact tester according to IEC 68-2-63.

The spring is adjusted in such a way as to cause the hammer to strike with an impact energy of 1,0 J ± 0,05 J.

The release mechanism springs are adjusted in such a way as to exert just sufficient pressure to keep the release jaws in the engaged position.

The apparatus is cocked by pulling the cocking knob until the release jaws engage with the groove in the hammer shaft.

Blows are applied by pushing the release cone against the sample in a direction perpendicular to the surface of the sample at the point to be tested.

Pressure is slowly increased so that the cone moves back until it is in contact with the release bars, which then move to operate the release mechanism and allow the hammer to strike.

The entire sample, under no-running conditions, is rigidly held and three blows are applied to every point of the enclosure which is likely to be weak.

Blows are also applied to protective devices, handles, levers, knobs, etc.

b) Free-fall test

Before testing the generating set shall be in the ususal carrying/transporting position. It is dropped from a height of 20 cm on to a concrete floor. This test is performed once.

After testing, the sample shall exhibit no damage which would impair mechanical or electric safety.

6.1.2 For handles, knobs, grips, levers and similar devices, requirements and tests shall be in accordance with IEC 335-1:1991, 22.12.

The generating set shall satisfy the tests defined below.

6.2 Mechanical stability

6.2.1 Generating sets shall exhibit proof of suitable stability when not in operation.

Compliance is checked by placing the unit on a surface which is tilted 15° in all directions. The unit shall neither overturn nor spill fuel.

Units with flaps and doors are tested both with the flaps and doors closed and then with them open. The unit shall satisfy requirements under the worst of conditions.

6.2.2 Generating sets shall be suitable for operation on mounting surfaces inclined up to 4°.

Compliance is checked by operating the unit in four positions set at 90° intervals around the vertical axis on a rough concrete surface inclined up to 4°. The unit shall not change its position by more than 10 mm even after 30 min of operation at no-load and at rated power.

6.3 Mechanical safety

Generating sets shall be so designed that sufficient protection is afforded against damage during transport, storage and normal use.

6.3.1 The units and accessories shall have no sharp corners, burrs or the like which may injure the user during normal use.

Compliance is checked by visual inspection.

6.3.2 Moving parts shall be so arranged or enclosed as to provide sufficient protection against injury during normal use. Protective enclosures, screens and the like shall be sufficiently rigid. It shall only be possible for them to be removed using tools.

Compliance is checked by inspection and by the test according to 6.1.1.

6.3.3 The reciprocating internal combustion engine shall be provided with a starting facility which allows start-up with sufficient protection for the operator, when used in accordance with operating instructions:

— permanently installed rope-pull starters shall be provided with automatic rewinding facilities;

— starting handles shall have sufficient safety clearance, in the pulling or rotation directions, from other parts of the set, as well as from the mounting surfaces. The handles shall meet the requirements specified in International Standards yet to be published[1)];

— diesel engines with a manual starter shall have a decompression facility which does not require to be hand-held during cranking.

Compliance is checked by visual inspection and several starting attempts which shall lead to an actual start-up.

6.4 Protection against hot parts

The generating set shall be fitted with protection against hot parts in order to eliminate the risk of burns to personnel during the normal operation of generating sets.

6.4.1 All operating controls on the generating set and any parts in close proximity shall not attain higher temperature rises (related to the ambient test temperature given in clause 5) than

35 °C (35 K) for metallic surfaces;

60 °C (60 K) for low thermal conductivity surfaces.

Carrying handles of generating sets and any parts in close proximity shall not attain higher temperature rises than

30 °C (30 K) for metallic surfaces;

50 °C (50 K) for low thermal conductivity surfaces.

6.4.2 Parts of the protective frame (except parts in accordance with 6.4.1) shall not attain temperatures exceeding 90 °C. This does not apply to parts located within the frame contour (e.g. protective cover).

Compliance is checked by temperature measurement immediately after the test run described in 7.3.2.

6.4.3 Parts which can reach temperatures above 150 °C (e.g. exhaust systems), shall not project beyond the contour of the protective frame into the working area.

1) ISO 11102-1 and ISO 11102-2.

6.4.4 Parts which may cause burns shall be correspondingly marked by a sign or be protected.

Compliance is checked by visual inspection.

6.5 Fire protection

Under operating conditions in accordance with the instruction manual (see clause 9) and when the generating set is in a well-maintained condition it should not catch fire by itself (see also ISO 6826).

6.5.1 Fuel tanks shall be so designed as to ensure that no leaks develop under normal operating conditions.

Compliance shall be checked by shock and impact tests in accordance with 6.1.1.

Leaking fuel from the vent holes of the tanks, as well as during operating processes for the start-up of reciprocating internal combustion engines, is permissible as long as it has been ensured that there be no subsequent danger of fire.

6.5.2 Filler necks in fuel tanks shall be arranged and designed in such a way as to ensure that during fuelling using fuel cans with spouts, no fuel come into contact with hot parts.

6.5.3 Any parts of the generating set which are in direct contact with the flat supporting surface shall not exceed a temperature of 90 °C.

6.6 Electrical equipment

Electrical enclosures, wiring insulation and functional parts shall be made of materials suitable for normal temperature conditions.

6.6.1 Protection against external influences

During generating set operation and non-operation, in accordance with the instruction manual (see clause 9), external influences in the form of water, moisture and foreign bodies shall not have any effects detrimental to the safety of the user.

6.6.1.1 Protection against solid foreign bodies

Protection against the ingress of solid foreign bodies in the case of the electrical equipment of the generating set shall be at least IP2X in accordance with IEC 529.

Compliance shall be checked under non-operating conditions in the usual operating position according to IEC 529:1989, clause 13.

6.6.1.2 Protection against ingress of water

Protection against the ingress of water in the case of the electrical equipment of the generating set shall be at least IPX3 according to IEC 529.

Compliance shall be checked according to IEC 529 under non-operating conditions in the usual operating position; inspection after test according to IEC 529.

After testing, the electrical equipment shall be inspected for ingress of water and subjected to the following verifications and tests:

— the amount of water which has entered shall not interfere with satisfactory operation;

— no water shall reach windings and live parts not designed to operate when wet;

NOTE 5 Socket covers are not necessarily required.

— test of dielectric strength according to IEC 335-1:1991, 16.3 and for the generator according to IEC 34-5:1989, 9.2.

6.6.1.3 Protection against moisture

The sets shall be able to withstand humid conditions which may occur during normal use.

Compliance shall be checked via moisture treatment according to IEC 335-1:1991, 15.3. Immediately after the treatment: test of current leakage and dielectric strength according to IEC 335-1:1991, clause 16.

6.6.2 Generator

6.6.2.1 Rating and performance

The generator shall meet the requirements of IEC 34-1 concerning duty type S2, covering rated values, irregularities of waveform, symmetry of voltages, capability of unbalanced load, temperature rise, dielectric properties and short circuit strength.

Compliance shall be checked by testing according to IEC 34-1.

6.6.2.2 Irregularities of waveform of a.c. generators

The voltage waveform depends on the design of the generator. For definitions and test conditions see IEC 34-1, clause 28.

For low-power generating sets there are two classes:

Class 1: THF < 8 % (see ISO 8528-3:1993, 10.4)

Class 2: THF < 20 %

NOTE 6 Definition of class 3 for non-sinusoidal waveform is under consideration.

Compliance shall be checked by testing according to IEC 34-1:1994, 28.2.

6.6.2.3 Low-voltage windings

In generators equipped with safety extra low-voltage windings for battery charging or extra low-voltage windings for control circuits, these shall be electrically isolated from other windings.

The voltage test according to IEC 34-1:1994, clause 17, shall be performed between the main and/or excitation windings at

$2U_N$ + 2 000 V for safety extra low voltage;

$2U_N$ + 1 000 V for extra low voltage.

6.6.2.4 Connection to stator or field

Access to brushes shall not be possible without tools. Screw caps of brush holders shall be screwed against a shoulder or a similar stop and grip with at least three full threads. Brush holders in which the brush is held in position by a locking facility shall be made in such a way as to ensure that locking is not dependent on brush spring pressure if loosening of the locking facility could give access to live parts.

Screw caps of brush holders accessible from the outside surface of the generator shall be made of insulating material or be covered by insulating material of suitable mechanical and electrical strength. They shall not project beyond the surrounding surface of the unit.

Compliance shall be checked by visual inspection, mechanical test according to 6.1.1 a) and dielectric strength according to 6.9.

6.6.3 Connection of electrical loads

For rated alternating current voltages up to 25 V and by means of rated direct current voltages up to 60 V connection may be via terminals with insulated screw connection or by means of plug and socket. For higher rated voltages plug-and-socket connections according to IEC 83 (single phase) and IEC 309 (multiphase), or relevant national standards, shall be applied.

It shall not be possible to confuse plugs and socket outlets for low voltage circuits with those plugs and socket outlets for rated voltages in excess of 50 V.

6.6.4 Switch gear and terminal boxes

Where vibration-sensitive devices (e.g. measuring instruments or current-operated earth-leakage circuit-breakers) are located in the switch boxes, sufficient protection against vibration is required.

Compliance shall be checked by checking of manufacturer's certificate and measurements over the whole operating range for the prescribed use of the set.

6.6.5 External components

Components located outside the alternator and/or the switch gear (especially interference suppressors or excitation capacitors and connecting leads) shall be sufficiently protected against external influences and mechanical damage.

Compliance shall be checked by visual inspection.

6.6.6 Corrosion resistance

Electrically conductive parts and other metal parts shall be sufficiently resistant to corrosion under normal conditions of use.

NOTE 7 Stainless steel and similar corrosion resistant alloys, copper, brass and steel with protective coatings are considered as being suitable for this purpose.

6.6.7 Screws and connections

Screws and connections shall be designed in accordance with IEC 335-1:1991, clause 28.

Compliance shall be checked in accordance with IEC 335-1:1991, clause 28.

6.7 Protection against electric shock

6.7.1 Protection against direct contact shall comply with requirements laid down in IEC 364-4-41:1992, 411.1, 412.1 and 412.2.

6.7.2 Protection against indirect contact shall be provided in accordance with requirements of IEC 364-4-41:1992, 413, taking into consideration the points given in 6.7.2.1 to 6.7.2.3.

6.7.2.1 Safety extra-low voltage according to IEC 364-4-41:1992, 411.1.

6.7.2.2 Protection by automatic disconnection of supply according to IEC 364-4-41:1992, 413.1, with the following exceptions:

— in TN systems and TT systems only residual-current protective devices having a tripping level not exceeding 30 mA may be used as protective devices (see e.g. IEC 947-2 and IEC 364-3);

— in IT systems all exposed conductive parts shall be interconnected through a protective conductor and earthed collectively. An earthing resistance equal to or less than 100 Ω will in all cases be sufficient;

— in IT systems an insulation-monitoring device and automatic disconnection of supply can be dispensed with in the event of two faults, provided that, in the case of a double dead short circuit to an exposed conducting part at any point, the voltage applied between the generator terminals drop to ⩽ 50 V.

NOTE 8 For definition of IT-, TN- and TT-systems, see IEC 364-3.

6.7.2.3 Protection by electrical separation in accordance with IEC 364-4-41:1992, 413.5, with the deviations given in 6.7.2.3.1 and 6.7.2.3.2.

6.7.2.3.1 Where the generating set is not of Class II construction, its exposed conductive part shall be connected to the equipotential bonding conductor.

6.7.2.3.2 If several items of apparatus are connected to a generating set, one of the following requirements must be fulfilled:

— when the insulation resistance between live parts and the equipotential bonding conductor drops below 100 Ω/V, the items of apparatus shall be automatically isolated from the generator within 1 s. Neither restriction of the range of the system, nor compliance with the conditions of automatic disconnection on the occurence of two simulatneous faults is necessary;

— the total length of cables, wires or cords shall be so limited that the product of voltage by total length is not greater than 100 000 V·m, as the total length of cables, wires or cords, must not exceed 500 m. One of the following requirements shall be fulfilled on the occurence of two faults affecting exposed conducting parts fed by conductors of different polarity

  an automatic disconnection shall be effected according to IEC 364-4-41:1992, 413.5.3.4

  or

  the output voltage applied between the generator terminals shall drop to ⩽ 50 V within the time laid down in IEC 364-4-41:1992, 413.5.3.4.

NOTE 9 In the case of a faulty circuit caused by defective insulation on each of two different, connected load items of the installation, the maximum sum of the resistances of the conductors between the generator and the items is relevant.

6.7.3 Generating sets within the scope of this part of ISO 8528 shall comply with the protection against indirect contact as defined in 6.7.2.3 without any action on the part of the user.

With due regard to general field service conditions, the requirements mentioned apply:

— automatic reduction of the generator voltage to ⩽ 50 V or the actuation of an overcurrent protective device according to 6.7.2.3 shall be achieved up to a loop resistance of 1,5 Ω behind the socket. For multiphase generators, the conditions in the event of a short circuit between two phase conductors and between a phase conductor and a possibly existing neutral conductor shall be checked;

— as a result of the rapidly decaying peak short-circuit current of the generators, only protective circuit breakers especially matched to the generator shall be used for shutdown. Fuse-elements are not acceptable for this application;

— with regard to the application of additional protective features, an earth terminal with appropriate marking in accordance with IEC 417 shall be affixed to the generating set. The housing of the generator and, if provided, the terminal box shall be connected to the earthing contacts of the socket outlets and the earth terminal;

— if a neutral conductor is fitted, it shall not be connected to either the protective earth (PE) connection or to the housings.

Appropriate information with regard to the protective features including the lead length and cross-sectional areas permitted as a result of the above mentioned resistance limit value shall be included in the operating instructions.

Compliance shall be checked by visual inspection and attempts at shorting with 1,5 Ω loop resistance behind the socket.

6.7.4 Where generating sets are fitted with current-operated, earth-leakage circuit breakers for use in TT or TN systems, the required earthing with the maximum permitted earth resistance dependent on the protective measure selected according to IEC 364-4-41:1992, 413.1.3.5, 413.1.4.2 shall be stated in the operating instructions.

The current-operated, earth-leakage circuit-breaker shall be installed at a suitable point, and shall be protected against moisture, excessive temperature and mechanical vibration.

Compliance shall be checked by visual inspection, trial run and checking of the operating instructions.

6.7.5 Generating sets for supplying current to existing distribution networks or secondary distribution systems shall be adapted to the requirements of the protective measures used in each case.

For assessing the conventional tripping current available in the generating set for the excess current circuit-breaker, as a rule the earth-fault loop limit resistance of 1,5 Ω behind the socket, specified in 6.7.3, shall also be applied.

Where the short-circuit currents required for the secondary distribution system concerned are not supplied by the generating set or if the overall resistance in the network behind the socket is greater than 1,5 Ω, a protective measure shall be provided which is independent of the conventional tripping current and length of leads (e.g. current-operated earth-fault circuit-breaker).

The selective tripping of overcurrent devices connected on the load side is only possible in exceptional cases; in the performance category concerned fuses are not permitted in generating sets as an automatic disconnection system of protection.

Compliance shall be checked by visual inspection and attempts at shorting with 1,5 Ω loop resistance behind the socket.

6.8 Temperature rise

During the operating of a generating set with given ratings, the permitted temperature limits shall not be exceeded.

This requirement is met if at average permitted power and for a minimum run of 60 min, the permitted values according to 6.8.1 and 6.8.2 are not exceeded.

6.8.1 Generator

The permitted temperature limits are given in IEC 34-1:1994, section 5.

Compliance shall be checked by the generator being operated at ambient conditions as defined in clause 5 of this part of ISO 8528. Temperature rise test and method of measurement shall be in accordance with IEC 34-1:1994, section 5.

During the test the average permitted power for the generating set shall be maintained at a constant level.

According to IEC 34-1:1994, clause 15 the temperature rise shall be determined immediately after the temperature rise test.

To measure the temperature of the windings the resistance method shall be used.

NOTE 10 In the case of an asynchronous generator, higher temperatures may occur when the generator is running at no-load or in the part-load range than when at rated power. If necessary, a further temperature rise test is required at part-load conditions.

6.8.2 RIC engine and other components

The temperatures are measured at thermal steady-state conditions. They shall not exceed the maximum temperatures specified by the component manufacturers.

Compliance is checked by temperature measurement.

6.9 Leakage current and dielectric strength at operating temperatures

The insulating capacity of all live parts and any interference suppressors required shall be designed in such a way that the permitted leakage currents are not exceeded at rated operating conditions.

The dielectric strength of the electrical equipment shall be adequate.

Compliance shall be checked by tests according to IEC 335-1:1991, 13.1 and 13.2.

6.10 Overload conditions

Overload is likely to occur in normal use. Generating sets which are tested in accordance with this part of ISO 8528 shall not suffer any damage as a result of an overload which could impair safety.

6.10.1 Uncontrolled generator

For generating sets with uncontrolled generators, load limitation is provided by means of the speed and voltage reduction which occurs with increasing load.

This mode of operation shall be checked at ambient conditions in accordance with clause 5 and at rated power in accordance with 7.1; the generating set shall be loaded with active or apparent power to above its rated power until maximum power occurs or until the voltage drops to 0,8 rated voltage.

A temperature rise test is then performed at the determined working point for a maximum of 30 minutes or until the protective device provides trips. During this test, the temperature rise of the generator windings shall not exceed the limits laid down in IEC 34-1:1994, 16.1.3, by more than 20 K (i.e. for S2 a total of 30 K).

6.10.2 Controlled generator

In the case of generating sets with controlled generators, the voltage also remains within set limits with increasing load. The power supplied by the generator increases in proportion to the load. The power of the generating set is generally limited by the reciprocating internal combustion engine.

It is necessary to protect the a.c. generator against thermal overloading if underspeed occurs. Where a shutdown function is used for this purpose, this may not switch back again automatically.

This mode of operation shall be checked by loading the generating set above its rated power up to the maximum available power before voltage collapse. This is then followed by a temperature rise test and assessment in accordance with 6.10.1.

6.11 Improper operation

6.11.1 Generating sets may only be loaded up to rated power under the specified cooling and temperature conditions. If operating conditions do not conform to the reference conditions as stipulated in this part of ISO 8528, and if the cooling of the engine or the generator is impaired (e.g. as a result of operation in restricted areas) a reduction in power is necessary. This fact shall be stipulated in the operating instructions.

Compliance shall be checked via a check of operating instructions.

6.11.2 Short circuits on any of the electrical outputs of the generating set shall not cause mechanical or electrical damage that could impair safety. This also applies to electrical charging rectifiers, even in the event of reversal of polarity when connected to a charged battery.

Where different rated voltages are possible, incorrect voltage selection shall not cause any consequential damage to the generating set.

Compliance shall be checked by operating the generating set until stable conditions are established, whilst short-circuiting output terminals or terminations and fuses which are accessible without the aid of a tool. Each check on incorrect running conditions shall be performed separately.

After each test, any protection device that has operated shall be replaced or reset.

For generating sets with a battery charger output a fully charged battery is connected in reverse to the output terminals or terminations until stable conditions are established.

During these tests, the generating set shall not emit flames or molten metal, or, in hazardous amounts, poisonous or ignitable gas and enclosures shall not deform to such an extent as to impair compliance with this part of ISO 8528.

The battery used for this test is a lead acid battery having a rated DC output voltage equal to the rated DC output voltage of the battery-charging circuit of the generating set and a capacity of at least 70 A·h. These conditions are valid unless the marking on the battery charger indicates that it is intended to charge a different type of battery in which case the test is made with a battery of that type and whose maximum capacity is in accordance with the marking on the generating set or in the owner's manual.

6.11.3 Controls which determine the specified engine speed shall be factory safeguarded by the manufacturer of the generating set against misuse by the user. Where sealing is not possible or if the connecting linkage between the speed governor and the actuator is accessible from the exterior, short-term overspeed to 1,2 times the rated speed shall not cause damage to the generating sets.

Compliance shall be checked by visual inspection and one minute operation at 1,2 times rated speed.

6.12 Creepage distances, clearances and distances through insulation

Creepage distances and clearances shall not be less than the values, in mm, laid down in IEC 335-1:1991, clause 29.

Compliance shall be checked by measurement of the clearances and verification on the basis of manufacturing documents.

6.13 Individual components of electrical equipment

Electrical components important to safety shall comply with the safety requirements stipulated in the applicable ISO, IEC or national standards.

Where these individual parts are marked with their operating data, the conditions under which they are used in the generator set shall comply with this information.

The testing of individual parts which must comply with specifications other than this part of ISO 8528 is, as a rule, performed separately in accordance with the applicable standard as follows.

Where an individual part is marked and is used in accordance with such marking, it is tested in accordance with such marking. In this case, the number of test specimens shall be as required in the applicable standard.

If no ISO, IEC, or national standards are available for the component concerned or where the component is not used in accordance with its marking, it is tested in accordance with the conditions which prevail in the apparatus. In this case, the number of specimens is, as a rule, taken to be as specified in similar regulations.

Compliance shall be checked by visual inspection or verification in accordance with the relevant ISO, IEC or national standards or applicable individual specifications.

7 Operating characteristics, power output, quality class and fuel consumption

7.1 Standard reference conditions

The standard reference conditions (see ISO 3046-1) are as follows:

— ambient air temperature: 25 °C;

— ambient air pressure: 100 kPa;

— relative humidity: 30 %.

7.2 Start-up and operating conditions

Generating sets in accordance with this part of ISO 8528 shall be able to start-up and to operate at ambient temperatures between – 15 °C and 40 °C.

7.3 Determination of power output, quality class and voltage tolerances

7.3.1 Generating sets shall be prepared and started in accordance with the operating instructions. After approximately 5 min warming-up time for the reciprocating internal combustion engine, the upper limit values for voltage and frequency shall be measured with the generator on no-load.

7.3.2 The generating set shall be run for a minimum of 60 min at average permitted power and at the stated power factor. The power test is performed by gradually increasing the load from generator no-load operation to rated power output or up to the power output limit.

A check shall be completed to ascertain whether, during the loading sequence, voltage and frequency parameters comply with class G1 of ISO 8528-5:1993, 16.1, 16.6, 16.7 and 16.10.

The active power is measured directly using an active-power meter and the apparent power is calculated by taking the product of current and voltage.

Where pressure and/or ambient temperature at the test location deviate during measurement from the standard reference conditions specified in this part of ISO 8528 (see 7.1) the relevant measured values of the RIC engine shall be corrected according to ISO 3046-1.

The performance power value calculated to standard reference conditions shall not be more than 5 % below the rated power for quality class A and 10 % for quality class B.

7.3.3 The specific fuel consumption of low-power generating sets is calculated at 75 % of rated power output (terminal output). The data shall be given in grams per kilowatt hour complying with the stipulations in ISO 3046-1 or alternatively in litres per hour.

7.4 Radio interference suppression

The generating set shall be designed in such a way that the limit of radio interference for the electrical parts according to CISPR Publication 14, and for the spark ignition internal combustion engine according to CISPR Publication 12 are met.

The installation of components for the suppression of radio interference voltages shall not have a detrimental effect on the electrical and mechanical safety of the generating set.

Compliance shall be checked in accordance with CISPR Publications 12 and 14.

8 Marking

Plates and labels on the generating set shall be permanent and easily legible.

8.1 Rating plate

The rated power output of the generating set and its quality class shall be marked as power in kilowatts stating the power factor.

The performance data of the generating set always refer to the standard reference conditions in accordance with ISO 3046-1. It is therefore not necessary to state the installation elevation and ambient temperature on the rating plate. Rating plate information is according to ISO 8528-5:1993, clause 14.

Compliance shall be checked by visual inspection.

8.2 Safety and information labels

The symbols shall be labelled according to ISO 7000.

Any generating set built in accordance with this part of ISO 8528 must have a permanently attached label which instructs the user

a) to read the operator's instruction manual;

b) that exhaust gas is poisonous; do not operate in an unventilated room;

c) to not refuel when operating.

Parts which may cause burns shall be correspondingly marked by a sign or be protected.

Control functions should be clearly marked. Additional labels may be required depending on the model of the generating set and the local authorities' requirements.

9 Instruction manual — Safety guide

A generating set may cause hazards that are not recognized by the layman and especially not recognized by children. Safe operation is possible with sufficient knowledge of the function of the generating set.

In the operation manual for RIC engine-driven generating sets in accordance with this part of ISO 8528 the following information on safety, operation and maintenance requirements should be considered as minimum practice.

a) **General safety information**

This shall include identification and explanation of warning labels that appear on the generating set.

The following directives shall be mentioned:

1) Protect children by keeping them at a safe distance from the generating set.

2) Fuel is combustible and easily ignited. Do not refuel during operation. Do not refuel while smoking or near naked flames. Do not spill fuel.

3) Some parts of the internal combustion engine are hot and may cause burns. Pay attention to the warnings on the generating set.

4) Engine exhaust gases are toxic. Do not operate the generating set in unventilated rooms. When installed in ventilated rooms, additional requirements for fire and explosion protection shall be observed.

b) **Electrical safety**

The following directives shall be mentioned:

1) Electrical equipment (including lines and plug connections) should not be defective.

2) The generating set must not be connected to other power sources, such as the power company supply mains. In special cases where stand-by connection to existing electrical systems is intended, it shall only be performed by a qualified electrician who has to consider the differences between operating equipment using the public electrical supply network and operating the generating set. In accordance with this part of ISO 8528 the differences shall be stated in the instruction manual.

3) Protection against electrical shock depends on circuit breakers specially matched to the generating set. If the circuit breakers require replacement they must be replaced with a circuit breaker having identical ratings and performance characteristics.

4) Due to high mechanical stresses only tough rubber-sheathed flexible cable (in accordance with IEC 245-4) or the equivalent should be used.

If the generating set complies with the protection feature "protection by electrical separation" in accordance with 6.7.2.3 of this part of ISO 8528, the following notes are to be taken into consideration:

5) Earthing of the generator is not required.

6) When using extension lines or mobile distribution networks the total length of lines for a cross section of 1,5 mm^2 should not exceed 60 m; for a cross section of 2,5 mm^2 this should not exceed 100 m.

c) **Before start-up**

Safe operation requires sufficient operator knowledge of the functions and positions of the controls and indicators or meters.

1) A description of the location, functions and positions of controls, indicators and meters shall be supplied.

2) A pictorial representation of the labels on the generating set and further explanation of their meaning if necessary should be supplied.

3) Notes about any necessary pre-operation checks, including the positioning of the generating set, shall be supplied.

d) **Starting the RIC engine**

1) Special guidance should be given regarding the use of readily evaporating fuels as starting aids if their use is appropriate.

2) Engines with manual starting equipment (e.g. handle starting equipment, recoil starter) should have notices warning against the dangers of injury caused by the sudden change of rotation direction of the engine.

e) **Using the generating set**

Generating sets may only be loaded up to their rated power under the rated ambient conditions. If generating set use is under conditions which do not conform to the reference conditions as stipulated in this part of ISO 8528 and if cooling of the engine or alternator is impaired, e.g. as a result of operation in restricted areas, a reduction in power is necessary. Information should be provided to inform the user of the necessary reduction in power due to use in higher temperatures, altitudes and humidity than those given in the reference conditions.

f) **Maintenance**

Prior to commencing maintenance work it must be ensured that untimely start-up is not possible.

A schedule for routine and extended maintenance should be provided. The schedule should indicate which items can be performed by the layman and which items require the expertise of professional service personnel. Specifications should be given for the material necessary to perform maintenance that can be carried out by the layman.

g) **Instructions for transporting and storage**