INTERNATIONAL STANDARD

ISO 8528-3

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Reciprocating internal combustion engine driven alternating current generating sets —

Part 3:
Alternating current generators for generating sets

Groupes électrogènes à courant alternatif entraînés par moteurs alternatifs à combustion interne —
Partie 3: Alternateurs pour groupes électrogènes

Reference number
ISO 8528-3:1993(E)

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 8528-3 was prepared by Technical Committee ISO/TC 70, *Internal combustion engines*, Sub-Committee 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: Low-power general-purpose generating sets*

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

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— *Part 10: Measurement of airborne noise — Enveloping surface method*

— *Part 11: Security generating sets with uninterruptible power systems*

Parts 7, 8, 9 and 10 are in course of preparation. Part 11 is at an early stage of preparation and may be split into two parts.

Annex A forms an integral part of this part of ISO 8528.

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Reciprocating internal combustion engine driven alternating current generating sets —

Part 3:
Alternating current generators for generating sets

1 Scope

This part of ISO 8528 specifies the principal characteristics of alternating current (a.c.) generators under the control of their voltage regulators when used for generating set applications. It supplements the requirements of IEC 34-1.

NOTE 1 At present no International Standard is available for asynchronous generators. When such an International Standard is published, this part of ISO 8528 will be revised accordingly. See subclause 12.2.

This part of ISO 8528 applies to a.c. generators for a.c. generating sets driven by reciprocating internal combustion (RIC) engines for land and marine use, excluding generating sets used on aircraft or to propel land vehicles and locomotives.

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

For a.c. generating sets driven by other reciprocating-type prime movers (e.g. sewage gas engines, steam engines) the provisions of this part of ISO 8528 should be used as a basis.

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

IEC 34-1:1983, *Rotating electrical machines — Part 1: Rating and performance.*

CISPR 14:1985, *Limits and methods of measurement of radio interference characteristics of household electrical appliances, portable tools and similar electrical apparatus.*

CISPR 15:1985, *Limits and methods of measurement of radio interference characteristics of fluorescent lamps and luminaires.*

3 Symbols

NOTE 2 For indications of technical data for electrical equipment, IEC uses the term "rated" and the subscript "N". For indications of technical data for mechanical equipment, ISO uses the term "declared" and the subscript "r". Therefore, in this part of ISO 8528, the term "rated" is applied only to electrical items. Otherwise, the term "declared" is used throughout.

U_s	Set voltage
$U_{st,max}$	Maximum steady-state voltage deviation
$U_{st,min}$	Minimum steady-state voltage deviation
U_r	Rated voltage
U_{rec}	Recovery voltage
$U_{s,do}$	Downward adjustable voltage
$U_{s,up}$	Upward adjustable voltage
U_0	No-load voltage
$U_{dyn,max}$	Maximum upward transient voltage on load decrease
$U_{dyn,min}$	Minimum downward transient voltage on load increase
ΔU	Steady-state voltage tolerance band
ΔU_s	Range of voltage setting
$\Delta U_{s,do}$	Downward range of voltage setting
$\Delta U_{s,up}$	Upward range of voltage setting
δU_{dyn}	Transient voltage deviation
δU_{dyn}^-	Transient voltage deviation on load increase
δU_{dyn}^+	Transient voltage deviation on load decrease
δU_s	Related range of voltage setting
$\delta U_{s,do}$	Related downward range of voltage setting
$\delta U_{s,up}$	Related upward range of voltage setting
δU_{st}	Steady-state voltage deviation
$\hat{U}_{mod,max}$	Maximum peak of voltage modulation
$\hat{U}_{mod,min}$	Minimum peak of voltage modulation
$\hat{U}_{mod}$	Voltage modulation
$\delta U_{2,0}$	Voltage unbalance
δ_{QCC}	Grade of quadrature-current compensation voltage droop
$s_{r,G}$	Rated slip of asynchronous generator
f_r	Rated frequency
p	Number of pole pairs
$n_{r,G}$	Rated speed of rotation of generator
S_r	Rated output (rated apparent power)
P_r	Rated active power
$\cos \varphi_r$	Rated power factor
Q_r	Rated reactive power
t_U	Voltage recovery time
$t_{U,in}$	Voltage recovery time after load increase
$t_{U,de}$	Voltage recovery time after load decrease
I_L	Real current drawn by the load
T_L	Relative thermal life expectancy factor

4 Other regulations and additional requirements

4.1 For a.c. generators for generating sets used on board ships and offshore installations which have to comply with rules of a classification society, the additional requirements of the classification society shall be observed. The classification society shall be stated by the customer prior to placing of the order.

For a.c. generators operating in non-classed equipment, such additional requirements are in each case subject to agreement between the manufacturer and customer.

4.2 If special requirements from regulations of any other authority (e.g. inspecting and/or legislative authorities) have to be met, the authority shall be stated by the customer prior to placing of the order.

Any further additional requirements shall be subject to agreement between the manufacturer and customer.

5 Rating

The generator rating class shall be specified in accordance with IEC 34-1. In the case of generators for RIC engine driven generating sets, continuous rating (duty type S1) or rating with discrete constant loads (duty type S10) shall be specified.

For the purposes of this part of ISO 8528, the maximum continuous rating based on duty type S1 is called the basic continuous rating (BR). Additionally for duty type S10, there is a peak continuous rating (PR), where the permissible generator temperature rises are increased by a specific amount according to the thermal classification.

In the case of duty type S10, operation at the PR thermally ages the generator insulation systems at an increased rate. Factor T_L for the relative thermal life expectancy of the insulation system is therefore an important integral part of the rating class.

6 Limits of temperature and temperature rise

6.1 Basic continuous rating

The generator shall be capable of delivering its basic continuous rating (BR) over the whole range of operating conditions (e.g. minimum to maximum coolant temperatures) with total temperatures not exceeding 40 °C plus the temperature rises specified in IEC 34-1:1983, table I (see note 3).

6.2 Peak continuous rating

At the generator peak continuous rating (PR), the total temperatures may be increased by the following allowances (see notes 3 and 4):

Thermal classification	Rating < 5 MV·A	Rating $\geqslant 5$ MV·A
A or E	15 °C	10 °C
B or F	20 °C	15 °C
H	25 °C	20 °C

For ambient temperatures below 10 °C, the limit of the total temperature shall be reduced by 1 °C for each degree Celsius by which the ambient temperature is below 10 °C.

NOTES

3 The RIC engine output may vary with changes of ambient air temperature; the generator total temperature in operation will depend upon its primary coolant temperature, which is not necessarily related to the RIC engine inlet air temperature.

4 When the generator operates at these higher temperatures, the generator insulation systems will age thermally from two to six times faster (depending on the temperature increase and specific insulation system) than at the generator BR temperature rise values; i.e. operating 1 h at PR temperature rise values is approximately equal to operating 2 h to 6 h at BR temperature rise values. The exact value for the factor T_L is to be given by the manufacturer and marked on the rating plate (see also clause 14).

7 Rated power and speed characteristics

Terms, symbols and definitions for rated power and speed are given in 7.1 to 7.5.

No.	Term	Symbol	Definition
7.1	Rated output (rated apparent power)	S_r	Apparent electric power at the terminals, expressed in volt-amperes (V·A), or its decimal multiples together with the power factor.
7.2	Rated active power	P_r	Rated apparent power multiplied by the rated power factor, expressed in watts (W), or its decimal multiples: $P_r = S_r \cos \varphi_r$
7.3	Rated power factor	$\cos \varphi_r$	Ratio of the rated active power to the rated apparent power: $\cos \varphi_r = \frac{P_r}{S_r}$
7.4	Rated reactive power	Q_r	Geometrical difference between the rated apparent power and the rated active power, expressed in vars (var), or its decimal multiples: $Q_r = \sqrt{S_r^2 - P_r^2}$

No.	Term	Symbol	Definition
7.5	Rated speed of rotation of generator	$n_{r,G}$	Speed of rotation necessary for voltage generation at the rated frequency.
7.5.1	Rated speed of rotation for synchronous generator		Speed given by the following formula: $$n_{r,G} = \frac{f_r}{p}$$
7.5.2	Rated speed of rotation for asynchronous generator		Speed given by the following formula: $$n_{r,G} = \frac{f_r}{p}(1 - s_{r,G})$$

8 Voltage characteristics

Terms, symbols and definitions for voltages are given in 8.1 to 8.12.

No.	Term	Symbol	Definition
8.1	Rated voltage	U_r	Line-to-line voltage at the terminals of the generator at the rated frequency and rated output. NOTE — Rated voltage is the voltage assigned by the manufacturer for operating and performance characteristics.
8.2	Set voltage	U_s	Line-to-line voltage for defined operation selected by adjustment.
8.3	No-load voltage	U_0	Line-to-line voltage at the terminals of the generator at rated frequency and no-load.
8.4	Range of voltage setting	ΔU_s	Range of maximum possible upward and downward adjustment of voltage at the generator terminals at rated frequency, for all loads between no-load and rated output and within the agreed range of power factor: $$\Delta U_s = \Delta U_{s,up} + \Delta U_{s,do}$$
	Related range of voltage setting	δU_s	Range of voltage setting expressed as a percentage of the rated voltage: $$\delta U_s = \frac{\Delta U_{s,up} + \Delta U_{s,do}}{U_r} \times 100$$
8.4.1	Downward range of voltage setting	$\Delta U_{s,do}$	Range between the rated voltage and downward adjustment of voltage at the generator terminals at rated frequency, for all loads between no-load and rated output within the agreed range of power factor: $$\Delta U_{s,do} = U_r - U_{s,do}$$
	Related downward range of voltage setting	$\delta U_{s,do}$	Downward range of voltage setting expressed as a percentage of the rated voltage: $$\delta U_{s,do} = \frac{U_r - U_{s,do}}{U_r} \times 100$$

No.	Term	Symbol	Definition
8.4.2	Upward range of voltage setting	$\Delta U_{s,up}$	Range between the rated voltage and upward adjustment of voltage at the generator terminals at rated frequency, for all loads between no-load and rated output within the agreed range of power factor: $$\Delta U_{s,up} = U_{s,up} - U_r$$
	Related upward range of voltage setting	$\delta U_{s,up}$	Upward range of voltage setting, expressed as a percentage of the rated voltage: $$\delta U_{s,up} = \frac{U_{s,up} - U_r}{U_r} \times 100$$
8.5	Steady-state voltage deviation[1)]	δU_{st}	Change in steady-state voltage for all load changes between no-load and rated output, taking into account the influence of temperature, but not considering the effect of quadrature-current compensation droop. NOTE — The initial set voltage is usually the rated voltage, but may be anywhere within the range specified in accordance with 8.4. The steady-state voltage deviation is expressed as a percentage of the rated voltage: $$\delta U_{st} = \pm \frac{U_{st,max} - U_{st,min}}{2U_r} \times 100$$
8.6	Transient voltage deviation, on load increase (−) and on load decrease (+), respectively[1)]	δU_{dyn}^{-}	Transient voltage deviation on load increase is the voltage drop when the generator, driven at rated speed and at rated voltage under normal excitation control, is switched onto rated load, expressed as a percentage of rated voltage: $$\delta U_{dyn}^{-} = \frac{U_{dyn,min} - U_r}{U_r} \times 100$$
		δU_{dyn}^{+}	Transient voltage deviation on load decrease is the voltage rise when the generator, driven at rated speed and at rated voltage under normal excitation control, has a sudden rejection of rated load, expressed as a percentage of rated voltage: $$\delta U_{dyn}^{+} = \frac{U_{dyn,max} - U_r}{U_r} \times 100$$ If the load change differs from the above-defined values, then the specified values and the associated power factors shall be stated.
8.7	Recovery voltage	U_{rec}	Maximum obtainable steady-state voltage for a specified load condition. NOTE — Recovery voltage is normally expressed as a percentage of the rated voltage. It normally lies within the steady-state voltage tolerance band (ΔU). For loads in excess of the rated load, recovery voltage is limited by saturation and exciter-regulator field forcing capability (see figure A.1).
8.8	Steady-state voltage tolerance band	ΔU	Agreed voltage band about the steady-state voltage that the voltage reaches within a given regulating period after a specified sudden increase or decrease of load. Unless otherwise stated: $$\Delta U = 2\delta U_{st} \times \frac{U_r}{100}$$