BS ISO 8528-3:2005

Reciprocating internal combustion engine driven alternating current generating sets —

Part 3: Alternating current generators for generating sets

ICS 27.020; 29.160.20; 29.160.40

British Standards

National foreword

This British Standard reproduces verbatim ISO 8528-3:2005 and implements it as the UK national standard. It supersedes BS 7698-3:1993 which is withdrawn.

The UK participation in its preparation was entrusted by Technical Committee MCE/14, RIC engines, to Subcommittee MCE/14/-/8, RIC engines — generating sets, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this subcommittee can be obtained on request to its secretary.

Cross-references

The British Standards which implement international publications referred to in this document may be found in the *BSI Catalogue* under the section entitled "International Standards Correspondence Index", or by using the "Search" facility of the *BSI Electronic Catalogue* or of British Standards Online.

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Summary of pages

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INTERNATIONAL STANDARD

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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 8528-3:2005(E)

Contents

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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. 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.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 8528-3 was prepared by Technical Committee ISO/TC 70, *Internal combustion engines*.

This second edition cancels and replaces the first edition (ISO 8528-3:1993), which has been technically revised.

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*[1]*: Rotary uninterruptible power supply systems — Performance requirements and test methods*

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

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1) Part 11 will be published as ISO/IEC 88528-11.

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 in generating set applications. It supplements the requirements of IEC 60034-1.

NOTE 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.

This part of ISO 8528 applies to a.c. generators used in 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 (e.g. essential hospital supplies, high-rise buildings), supplementary requirements may be necessary. The provisions of this part of ISO 8528 should be regarded as the basis for establishing any supplementary requirements.

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

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.

ISO 8528-1[2)], *Reciprocating internal combustion engine driven alternating current generating sets — Part 1: Application, ratings and performance*

IEC 60034-1, *Rotating electrical machines — Part 1: Rating and performance*

CISPR 14-1, *Limits and methods of measurement of radio interference characteristics of household electrical appliances, portable tools and similar electrical apparatus*

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

2) To be published.

3 Symbols, terms and definitions

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 sub-script “r”. Therefore, in this part of ISO 8528, the term “rated” is applied only to electrical items. Otherwise, the term “declared” is used throughout.

An explanation of the symbols and abbreviations used in this International Standard are shown in Table 1.

Table 1 — Symbols, terms and definitions

Symbol	Term	Unit	Definition
U_s	Set voltage	V	Line-to-line voltage for defined operation selected by adjustment.
$U_{st,max}$	Maximum steady-state voltage deviation	V	
$U_{st,min}$	Minimum steady-state voltage deviation	V	
U_r	Rated voltage	V	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.
U_{rec}	Recovery voltage	V	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.2.1).
$U_{s,do}$	Downward adjustable voltage	V	
$U_{s,up}$	Upward adjustable voltage	V	
U_0	No-load voltage	V	Line-to-line voltage at the terminals of the generator at rated frequency and no-load.
$U_{dyn,max}$	Maximum upward transient voltage on load decrease	V	
$U_{dyn,min}$	Minimum downward transient voltage on load increase	V	
ΔU	Steady-state voltage tolerance band	V	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 given by: $\Delta U = 2\delta U_{st} \times \frac{U_r}{100}$

Table 1 (*continued*)

Symbol	Term	Unit	Definition
ΔU_s	Range of voltage setting	V	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 given by: $\Delta U_s = \Delta U_{s,up} + \Delta U_{s,do}$
$\Delta U_{s,do}$	Downward range of voltage setting	V	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 given by: $\Delta U_{s,do} = U_r - U_{s,do}$
$\Delta U_{s,up}$	Upward range of voltage setting	V	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 given by: $\Delta U_{s,up} = U_{s,up} - U_r$
δU_{dyn}	Transient voltage deviation	V	
δU_{dyn}^{-}	Transient voltage deviation on load increase[a]	%	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 given by: $\delta U_{dyn}^{-} = \frac{U_{dyn,min} - U_r}{U_r} \times 100$
δU_{dyn}^{+}	Transient voltage deviation on load decrease[a]	%	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 given by: $\delta U_{dyn}^{+} = \frac{U_{dyn,max} - U_r}{U_r} \times 100$ If the load change differs from the above-defined values, then the specified values and the associated power factors shall be stated.
δU_s	Related range of voltage setting	%	Range of voltage setting expressed as a percentage of the rated voltage given by: $\delta U_s = \frac{U_{s,up} + U_{s,do}}{U_r} \times 100$

Table 1 (*continued*)

Symbol	Term	Unit	Definition
$\delta U_{s,do}$	Related downward range of voltage setting	%	Downward range of voltage setting expressed as a percentage of the rated voltage given by: $$\delta U_{s,do} = \frac{U_r - U_{s,do}}{U_r} \times 100$$
$\delta U_{s,up}$	Related upward range of voltage setting	%	Upward range of voltage setting, expressed as a percentage of the rated voltage given by: $$\delta U_{s,up} = \frac{U_{s,up} - U_r}{U_r} \times 100$$
δU_{st}	Steady-state voltage deviation	%	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 specified range of ΔU_s. The steady-state voltage deviation is expressed as a percentage of the rated voltage given by: $$\delta U_{st} = \pm \frac{U_{st,max} - U_{st,min}}{2U_r} \times 100$$
$\hat{U}_{mod,max}$	Maximum peak of voltage modulation	%	Quasi-periodic maximum voltage variation (peak-to-peak) about a steady-state voltage
$\hat{U}_{mod,min}$	Minimum peak of voltage modulation	%	Quasi-periodic minimum voltage variation (peak-to-peak) about a steady-state voltage
$\hat{U}_{mod}$	Voltage modulation	%	Quasi-periodic voltage variation (peak-to-peak) about a steady-state voltage having typical frequencies below the fundamental generation frequency, expressed as a percentage of average peak voltage at rated frequency and constant speed given by: $$\hat{U}_{mod} = 2\frac{\hat{U}_{mod,max} - \hat{U}_{mod,min}}{\hat{U}_{mod,max} + \hat{U}_{mod,min}} \times 100$$
$\delta U_{2,0}$	Voltage unbalance	%	Ratio of the negative sequence or the zero sequence voltage components to the positive sequence voltage component at no-load. Voltage unbalance is expressed as a percentage of the rated voltage.
	Voltage regulation characteristics		Curves of terminal voltage as a function of load current at a given power factor under steady-state conditions at rated speed without any manual adjustment of the voltage regulating system.
δ_{QCC}	Grade of quadrature-current compensation voltage droop		

Table 1 (*continued*)

Symbol	Term	Unit	Definition
$s_{r,G}$	Rated slip of an asynchronous generator		The difference between the synchronous speed and the rated speed of the rotor referred to the synchronous speed, where the generating set is giving its rated active power and is given by: $s_{r,G} = \frac{(f_r / p) - n_{r,G}}{f_r / p}$
f_r	Rated frequency	Hz	
p	Number of pole pairs		
$n_{r,G}$	Rated speed of generator rotation	min^{-1}	Speed of rotation necessary for voltage generation at the rated frequency. NOTE For a synchronous generator, this rotational speed is given by: $n_{r,G} = \frac{f_r}{p}$ For an asynchronous generator, this speed is given by: $n_{r,G} = \frac{f_r}{p}(1 - s_{r,G})$
S_r	Rated output (rated apparent power)	V·A	Apparent electric power at the terminals or its decimal multiples together with the power factor.
P_r	Rated active power	W	Rated apparent power multiplied by the rated power factor or its decimal multiples given by: $P_r = S_r \cos \varphi_r$
$\cos \varphi_r$	Rated power factor		Ratio of the rated active power to the rated apparent power given by: $\cos \varphi_r = \frac{P_r}{S_r}$
Q_r	Rated reactive power	var	Geometrical difference between the rated apparent power and the rated active power or its decimal multiples given by: $Q_r = \sqrt{S_r^2 - P_r^2}$
$t_{U,in}$	Voltage recovery time after load increase[b]	s	Time interval from the point at which a load increase is initiated until the point when the voltage returns to and remains within the specified steady-state voltage tolerance band (see Figures A.2.1 and A.2.3). This time interval applies to constant speed and depends on the power factor. If the load change differs from the rated apparent power, the value of the power change and the power factor shall be stated.

Table 1 (*continued*)

Symbol	Term	Unit	Definition
$t_{U,de}$	Voltage recovery time after load decrease[b]	s	Time interval from the point at which a load decrease is initiated until the point when the voltage returns to and remains within the specified steady-state voltage tolerance band (see Figure A.2.2). This time interval applies to constant speed and depends on the power factor. If the load change differs from the rated apparent power, the value of the power change and the power factor shall be stated.
I_L	Real current drawn by the load	A	
T_L	Relative thermal life expectancy factor		

[a] Further details are given in Annex A.

[b] See Figure 5 of ISO 8528-5.

4 Other requirements and additional regulations

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 name shall be stated by the customer prior to placing the order.

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

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

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

5 Rating

5.1 General

The generator rating class shall be specified in accordance with the requirements of IEC 60034-1. In the case of generators for RIC engine driven generating sets, the continuous rating (duty type S1) or rating with discrete constant loads (duty type S10) shall be specified.

5.2 Basic continuous rating (BR)

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).

5.3 Peak continuous rating (PR)

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 and 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 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 Table 1 (see Note below) of IEC 60034-1.

6.2 Peak continuous rating

At the generator PR, the total temperatures may be increased by the amounts shown in Table 2 (see Note below):

Table 2 — Peak continuous rating temperatures

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 total temperature increase allowed shall be reduced by 1 °C for each degree Celsius by which the ambient temperature is below 10 °C.

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.

NOTE 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 the specific insulation system used) than at the generator BR temperature 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} shall be stated by the manufacturer and marked on the rating plate of the machine (see Clause 14).

7 Rated power and speed characteristics

Terms, symbols and definitions applicable to rated power and speed are given in Table 1.

8 Voltage characteristics

Terms, symbols and definitions applicable to voltages are given in Table 1.

9 Parallel operation

When a generator is running in parallel with other generator sets or with another source of electrical supply, means shall be provided to ensure stable operation and correct sharing of reactive power.

Stable operation is most often affected by influencing the automatic voltage regulator through a sensing circuit with an additional reactive current component. This causes a voltage droop characteristic to be present for reactive loads.

The grade of quadrature-current compensation voltage droop (δ_{QCC}) is the difference between the no-load voltage (U_0) and the voltage at the rated current at the power factor zero lagging ($U_{(Q = S_r)}$) expressed as a percentage of rated voltage (U_r) and is given by the following equation:

$$\delta_{QCC} = \frac{U_0 - U_{(Q = S_r)}}{U_r} \times 100$$

The value of δ_{QCC} should be < 8 %. Higher values have to be considered in the case of excessive system voltage variations.

NOTE 1 Unity power factor loads produce virtually no voltage droop.

NOTE 2 Identical a.c. generators with identical excitation systems may operate in parallel without voltage droop when their field windings are connected by equalizer links. Adequate reactive load sharing is achieved in the case of correct active load sharing and approximately the same load characteristics.

NOTE 3 When generating sets are operating in parallel with their star points directly connected together, circulating currents may occur, particularly third-harmonic currents.

10 Special load conditions

10.1 General

In the case of more severe load conditions than those given in IEC 60034-1, see 10.2 to 10.4 for assistance.

10.2 Unbalanced load current

Generators with ratings up to 1000 kV·A which are intended to be loaded between line and neutral shall be capable of operating continuously with a negative phase sequence current up to and including 10 % of the rated current or with a negative phase sequence current agreed between manufacturer and customer.

For all other generators the requirements of Clause 22 of IEC 60034-1 shall apply,

10.3 Sustained short-circuit current

Under short-circuit conditions on the generator, it is normally necessary to sustain a minimum value of current (after the transient disturbance has ceased) for a sufficient time to ensure operation of the system protective devices. Sustained short-circuit current is not necessary in cases where special relaying or other designs or means are used to achieve selective protection, or when no selective protection is required.

10.4 Occasional excess current capability

See 18.1 of IEC 60034-1.

10.5 Telephone Harmonic Factor (THF)

Limiting values of the line-to-line terminal voltage THF shall be in accordance with the requirements of Clause 28 of IEC 60034-1.

A 5 % THF shall also apply to generators from 62 kVA to 300 kVA, and a THF of 8 % shall apply for generators below 62,5 kVA.

10.6 Radio interference suppression (F)

Limiting values of continuous and clicking disturbance radio interference shall be in accordance with the requirements of CISPR 14-1 and CISPR 15.

The grade of radio interference suppression involves the interference voltage, power and field strength. This shall be decided by agreement between the customer and manufacturer.

11 Effect of electromechanical frequency of vibrations when sets operate in parallel

It is the responsibility of the generating set manufacturer to ensure that the set will operate stably in parallel with others. The generator manufacturer shall collaborate as necessary to meet this requirement.

If there is an engine torque irregularity at a frequency close to the electrical natural frequency, resonance will occur. The electrical natural frequency usually lies in the range 1 Hz to 3 Hz, and hence resonance is most likely to arise with low-speed (100 min^{-1} to 180 min^{-1}) RIC engine driven generator sets.

In such cases when resonance between sets does occur, the generating set manufacturer shall be prepared to give advice to the customer and assist in any investigation necessary to resolve the problem.

12 Asynchronous generators with excitation equipment

12.1 General

Asynchronous generators need reactive power for voltage generation.

When running in single operation, special excitation equipment is necessary. This equipment shall also supply the reactive power demand of the connected load.

All the terms defined in 12.2 to 12.4 are valid for asynchronous generators which are not connected to the power grid for supplying the required reactive power but are provided with specially incorporated excitation equipment.

12.2 Sustained short-circuit current

Asynchronous generators deliver a sustained short-circuit current only with a specially equipped excitation source (see 10.3).

12.3 Range of voltage setting

Controllable special excitation is required for reaching the range of voltage adjustment for asynchronous generators (see Table 1).

12.4 Parallel operation

Asynchronous generators with special excitation equipment running in parallel share the reactive power demand of the connected load according to their excitation output capability (see Clause 9).

Asynchronous generators share the active power demand of the connected load according to the speed of the RIC engine.

13 Operating limit values

Four performance classes are defined to describe the generator characteristics (see ISO 8528-1). The operating limit values are given in Table 3.

Table 3 — Generator operating limit values

Term	Symbol	Unit	Operating limit values Performance class			
			G1	G2	G3	G4
Related range of voltage setting	δU_s	%	⩽ ± 5[a]			AMC[b]
Steady-state voltage deviation	δU_{st}	%	± 5	± 2,5	± 1	AMC
Transient voltage[c,d,e] deviation on load increase	δU_{dyn}^{-}	%	− 30	− 24	− 18	AMC
Transient voltage[c,d,e] deviation on load decrease	δU_{dyn}^{+}	%	35	25	20	AMC
Voltage recovery time[c,d]	t_u	s	< 2,5	< 1,5	< 1,5	AMC
Voltage unbalance	$\delta U_{2,0}$	%	1[f]	1[f]	1[f]	1[f]

[a] Not necessary if no parallel operation or fixed voltage setting is required.

[b] AMC = by agreement between manufacturer and customer.

[c] Rated apparent power at rated voltage and rated frequency with constant impedance load. Other power factors and limit values may be by agreement between the manufacturer and customer.

[d] It should be appreciated that the choice of a grade of transient voltage deviation and/or recovery time lower than is actually necessary can result in a much larger generator. Since there is a fairly consistent relationship between transient voltage performance and transient reactance, the system fault level will also be increased.

[e] Higher values may be applied to generators with rated outputs higher than 5 MVA and speed of or below 600 min^{-1}.

[f] In the case of parallel operation, these values are reduced to 0,5.

The values given in Table 3 apply only to the generator, exciter and regulator operating at constant (rated) speed and starting from ambient temperature. The effect of the prime mover speed regulation may cause these values to differ from the values given in Table 3.

14 Rating plate

The generator rating plate shall be in accordance with the requirements of IEC 60034-1 and, in addition, the rated output and class of rating shall be combined as follows:

a) where a continuous rating based on duty type S1 is stated, the rated output shall be followed by the marking BR (e.g. S_r = 22 kV·A BR);

b) where a rating with discrete constant loads based on duty type S10 is stated, the basic continuous rating based on duty S1 shall be marked as in 14 a). In addition, the peak rated output shall be shown followed by:

- the marking PR;
- the maximum running time of 500 h or 200 h per year (see 13.3.3 and 13.3.4 of ISO 8528-1);
- the factor T_L, (e.g.: S_r = 24 kV·A PR 500 h/an, T_L = 0,9).

Upon request, the generator manufacturer shall provide the set manufacturer with a capability graph or set of values showing the permissible output of the generator set over the range of coolant temperature involved.

Annex A
(normative)

Transient voltage characteristic of an a.c. generator following a sudden change in load

A.1 General

When a generator is subjected to a sudden load change, there will be a resultant time-varying change in terminal voltage. One function of the exciter-regulator system is to detect this change in terminal voltage and to vary the field excitation as required to restore the terminal voltage. The maximum transient deviation in terminal voltage that occurs is a function of:

a) the magnitude, power factor and rate of change of the applied load;

b) the magnitude, power factor and current versus the voltage characteristic of any initial load;

c) the response time and voltage forcing capability of the exciter-regulator system; and

d) the RIC engine speed versus time following the sudden load change.

Transient voltage performance is therefore a system performance characteristic involving the generator, exciter, regulator and RIC engine and cannot be established from the generator data alone.

This annex covers only the generator and exciter-regulator system.

When selecting or installing generators, the maximum transient voltage deviation from rated voltage (voltage dip) following a sudden increase in load is often specified or requested. When requested by the customer, the generator manufacturer shall furnish the expected transient voltage deviation in either of the two following cases:

a) generator, exciter and regulator are supplied as a whole package by the a.c. generator manufacturer; or

b) complete data defining the transient performance of the regulator (and exciter, if applicable) are made available to the generator manufacturer.

When furnishing the expected transient voltage deviation, the following conditions shall be assumed unless otherwise specified:

a) constant speed (rated);

b) generator, exciter and regulator operate initially at no-load, rated voltage, starting from ambient temperature;

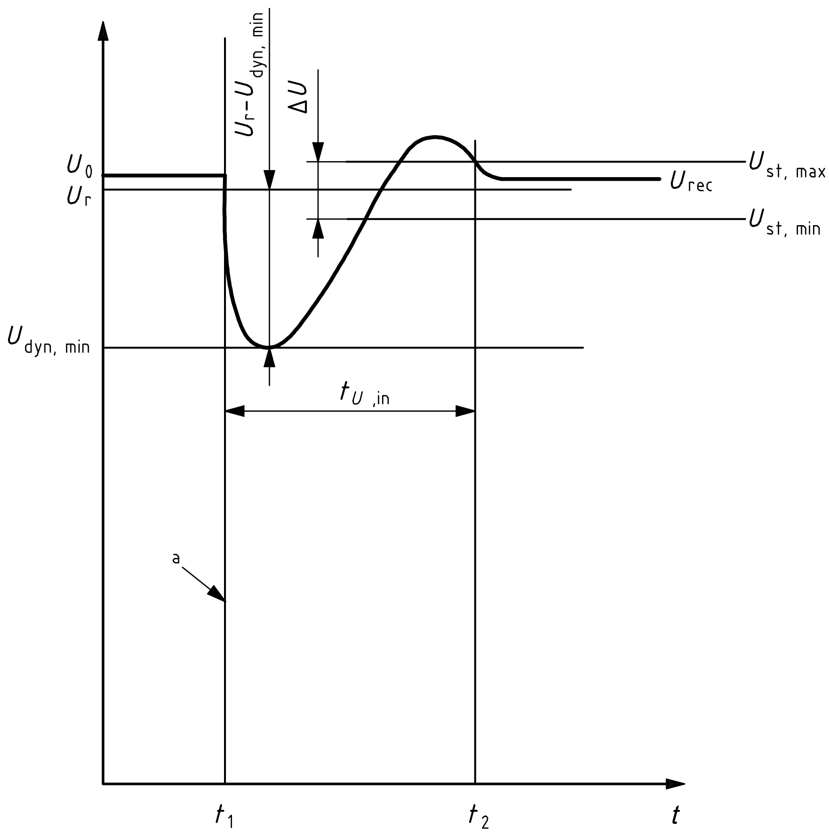
c) application of a constant load of linear impedance as specified.

NOTE The expected transient voltage deviation from rated voltage refers to the average voltage change of all phases at the generator terminals; i.e. it takes no account of asymmetry which is influenced by factors beyond the control of the generator manufacturer.

A.2 Examples

Strip charts of the output voltage as a function of time demonstrate the transient performance of the generator, exciter and regulator system to sudden changes in load. The entire voltage envelope should be recorded.

Strip charts representing two types of voltage recorder are illustrated in Figures A.1, A.2 and A.3. The labelled charts and sample calculations should be used as a guide to determine the generator-exciter-regulator performance when subjected to a sudden load change.



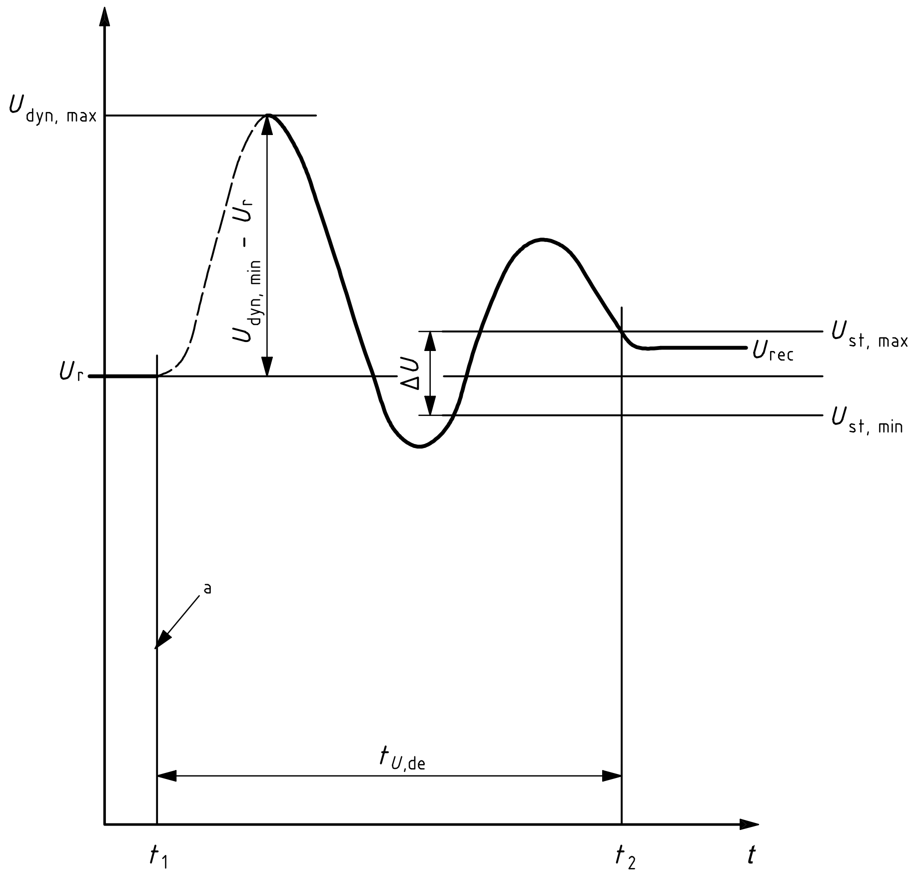
Key

t time

U voltage

a Time at which increased electrical load is applied.

Figure A.1 — Transient voltage characteristic (load increase)



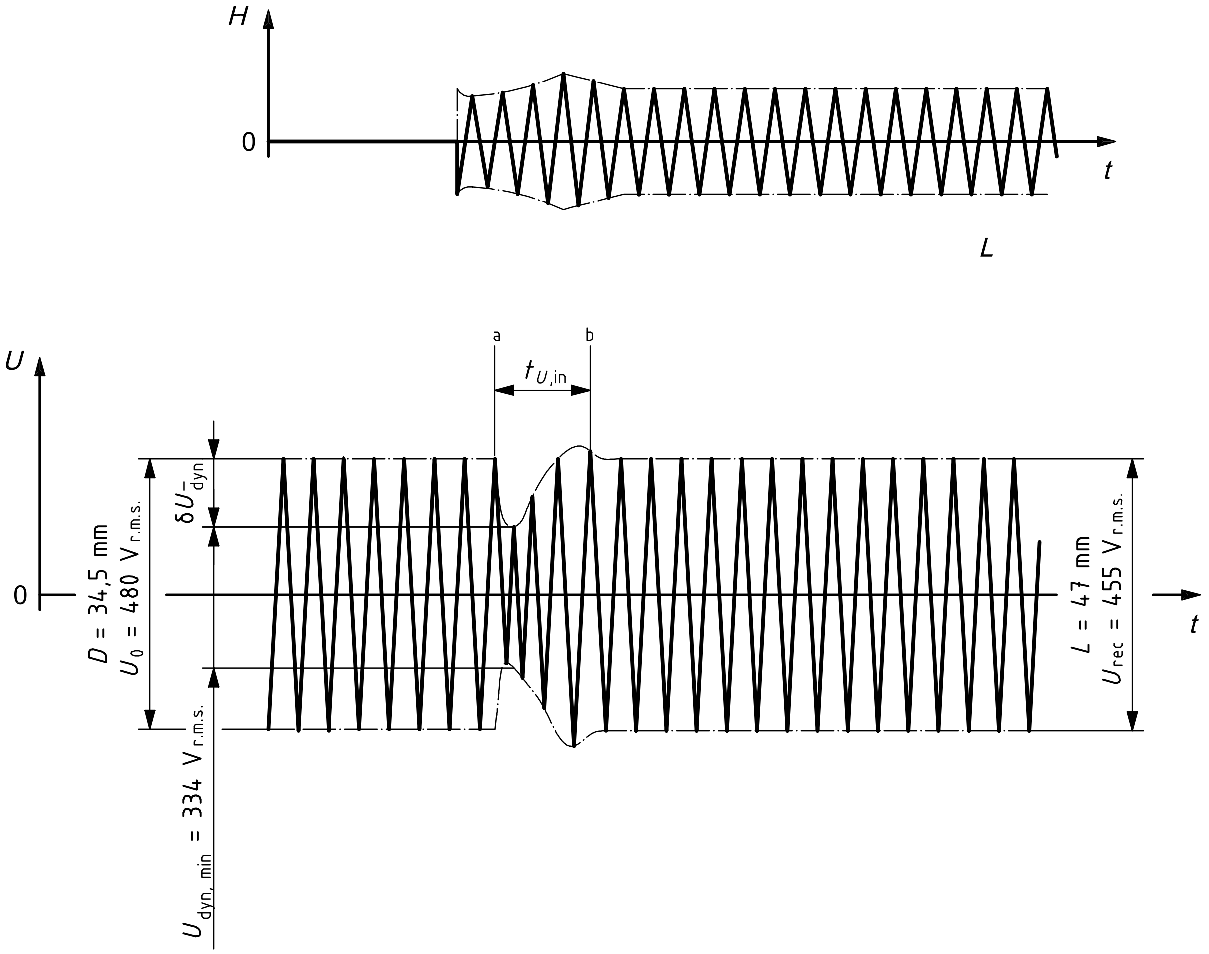
Key

t time

U voltage

a Time at which increased electrical load is applied.

Figure A.2 — Transient voltage characteristic (load decrease)



Key

t time

U voltage

L Measured peak-to-peak amplitude of recovery voltage (mm)

$I_L = I_L \frac{U_r}{U_{rec}}$ Current drawn by the load corrected to rated voltage (A)

D Measured peak-to-peak amplitude of minimum transient voltage (mm)

a Time at which load is applied.

b Time at which the specified regulation bend returns.

EXAMPLE $U_r = 480$ V $U_0 = 480$ V

$$U_{\text{dyn,min}} = \frac{D}{L} U_{\text{rec}} = \frac{34,5}{47} \times 455 = 334 \text{ V}$$

$$\delta U^{-}_{\text{dyn}} = \frac{U_{\text{dyn,min}} - U_r}{U_r} \times 100 = \frac{(334 - 480)}{480} \times 100 = 30,4\ \%$$

Figure A.3 — Generator transient voltage versus time curve for a sudden load increase

A.3 Motor starting loads

A.3.1 General

The following test conditions are recommended for demonstrating the motor starting performance of a synchronous generator, exciter and regulator system.

A.3.2 Load simulation

Test conditions for load simulation are as follows:

a) constant impedance (non-saturable reactive load);

b) power factor $\leqslant$ 0,4 lagging.

The current drawn by the simulated motor starting load should be corrected by using the ratio:

$$\frac{U_{\mathrm{r}}}{U_{\mathrm{rec}}}$$

whenever the generator terminal voltage fails to return to rated voltage. This corrected value of current and rated terminal voltage should be used to determine the actual kVA load applied.

A.3.3 Temperature

The test should be conducted with the generator and excitation system initially at ambient temperature.

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