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Reciprocating internal combustion engine driven alternating current generating sets —

Part 5:
Generating sets

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

Partie 5: Groupes électrogènes

Reference number
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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 70, *Internal combustion engines*.

This fifth edition cancels and replaces the fourth edition (ISO 8528-5:2018), which has been technically revised.

The main changes are as follows:

— Clause 3 has been revised;

— a list of symbols has been added in 3.2;

— mistakes have been corrected in Table 4;

— previous Figures 3, 7, 8, 14 and 16 have been modified and renumbered;

— previous Figures 1 and 17 have been deleted;

— Annex A has been deleted.

A list of all parts in the ISO 8528 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Reciprocating internal combustion engine driven alternating current generating sets —

Part 5: Generating sets

1 Scope

This document specifies design and performance criteria arising out of the combination of a reciprocating internal combustion (RIC) engine and an alternating current (AC) generator when operating as a unit. This unit can run in parallel to the grid or not.

This document applies to AC generating sets driven by 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 and high-rise buildings), supplementary requirements can apply. The provisions of this document are a basis for establishing any supplementary requirements.

For generating sets driven by other reciprocating-type prime movers (e.g. steam engines), the provisions of this document can be used as a basis for establishing these requirements.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 3046-5, *Reciprocating internal combustion engines — Performance — Part 5: Torsional vibrations*

ISO 8528-1:2018, *Reciprocating internal combustion engine driven alternating current generating sets — Part 1: Application, ratings and performance*

ISO 8528-3:2020, *Reciprocating internal combustion engine driven alternating current generating sets — Part 3: Alternating current generators for generating sets*

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

3 Terms, definitions and symbols

3.1 Terms and definitions

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

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1.1
frequency
f
reciprocal of the period

Note 1 to entry: The symbol f is mainly used when the period is a time.

3.1.2
no-load frequency
f_i
frequency at which the generating set is operating without load

3.1.3
rated no-load frequency
$f_{i,r}$
frequency at which the generating set is designed to operate without load

3.1.4
rated frequency
f_r
frequency at which the generating set is designed to operate

3.1.5
maximum safety frequency
f_{maxs}
maximum frequency which causes a stop to production

3.1.6
minimum safety frequency
f_{mins}
minimum frequency which causes a stop to production

3.1.7
frequency setting rate of change
v_f
rate of change of frequency setting under remote control

Note 1 to entry: $v_f = \frac{(f_{i,max} - f_{i,min}) / f_r}{t} \times 100$

where

$f_{i,max}$ is maximum no-load frequency;

$f_{i,min}$ is minimum no-load frequency;

f_r is *rated frequency* (3.1.4).

Note 2 to entry: Expressed as a percentage of related range of frequency setting per second.

3.1.8
voltage setting rate of change
v_U
rate of change of voltage setting under remote control

Note 1 to entry: $v_U = \frac{(U_{s,up} - U_{s,do}) / U_r}{t} \times 100$

where

U_r is *rated voltage* (3.1.11);

$U_{s,do}$ is *downward adjustment of voltage* (3.1.9);

$U_{s,up}$ is *upward adjustment of voltage* (3.1.10).

Note 2 to entry: Expressed as a percentage of the related range of voltage setting per second.

3.1.9
downward adjustment of voltage
$U_{s,do}$
lower limit of 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

3.1.10
upward adjustment of voltage
$U_{s,up}$
upper limit of 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

3.1.11
rated voltage
U_r
line-to-line voltage at the terminals of the generator at rated frequency and rated output

3.1.12
set voltage
U_s
maximum obtainable steady-state voltage for a specified load condition or line-to-line voltage for defined operation selected by adjustment

3.1.13
no-load voltage
U_0
line-to-line voltage at the terminals of the generator at rated frequency and no-load

3.1.14
voltage modulation
$\hat{U}_{mod,s}$
quasi-periodic voltage variation (peak-to-peak) about a steady-state voltage having typical frequencies below the fundamental generation frequency

Note 1 to entry: Expressed as a percentage of average peak voltage at rated frequency and constant speed.

Note 2 to entry: $\hat{U}_{mod,s} = 2 \times \frac{\hat{U}_{mod,s,max} - \hat{U}_{mod,s,min}}{\hat{U}_{mod,s,max} + \hat{U}_{mod,s,min}} \times 100$

where

$\hat{U}_{mod,s,max}$ is maximum peak of voltage modulation;

$\hat{U}_{mod,s,min}$ is minimum peak of voltage modulation.

Note 3 to entry: This is a cyclic or random disturbance which can be caused by regulators, cyclic irregularity or intermittent loads. Flickering lights are a special case of voltage modulation (see Figures 7 and 8).

3.1.15
steady-state frequency tolerance band
Δf
agreed frequency band about the steady-state frequency which the frequency reaches within a given governing period after increase or decrease of the load

3.1.16
related range of frequency setting

δf_s

range of frequency setting

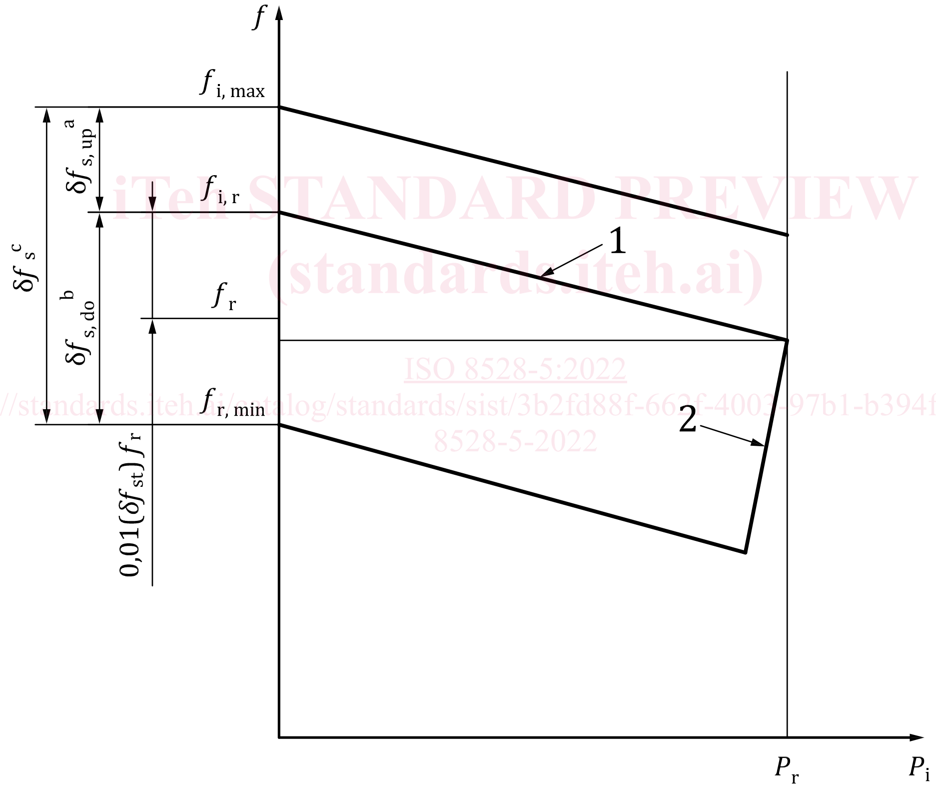
Note 1 to entry: See Figure 1.

Note 2 to entry: Expressed as a percentage of rated frequency.

Note 3 to entry: $\delta f_s = \frac{f_{i,max} - f_{i,min}}{f_r} \times 100$

where

$f_{i,max}$	is maximum no-load frequency;
$f_{i,min}$	is minimum no-load frequency;
f_r	is *rated frequency* (3.1.4).



Key

P	power
f	frequency
P_r	rated power
1	frequency/power characteristic curve
2	power limit [the power limit of the generating set depends upon the power limit of the RIC engine (e.g. fuel stop power) taking into account the efficiency of the AC generator]
[a]	Related upward range of frequency setting.
[b]	Related downward range of frequency setting.
[c]	Related range of frequency setting.

Figure 1 — Frequency/power characteristic, range of frequency setting

3.1.17
downward range of frequency setting
$\Delta f_{s,do}$
range between the declared no-load frequency and the lowest adjustable no-load

Note 1 to entry: See Figure 1.

Note 2 to entry: $\Delta f_{s,do} = f_{i,r} - f_{i,min}$

where

$f_{i,r}$	is *rated no-load frequency* (3.1.3);
$f_{i,min}$	is minimum no-load frequency.

3.1.18
upward range of frequency setting
$\Delta f_{s,up}$
range between the highest adjustable no-load frequency and the declared no-load frequency

Note 1 to entry: See Figure 1.

Note 2 to entry: $\Delta f_{s,up} = f_{i,max} - f_{i,r}$

where

$f_{i,max}$	is maximum no-load frequency;
$f_{i,r}$	is *rated no-load frequency* (3.1.3).

3.1.19
range of voltage setting
ΔU_s
range of maximum possible upward and downward adjustments 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

Note 1 to entry: $\Delta U_s = \Delta U_{s,up} + \Delta U_{s,do}$.

3.1.20
frequency/power characteristic deviation
$\Delta\delta f_{st}$
maximum deviation from a linear frequency/power characteristic curve in the power range between no-load and declared power

Note 1 to entry: Expressed as a percentage of rated frequency.

Note 2 to entry: See Figure 2.

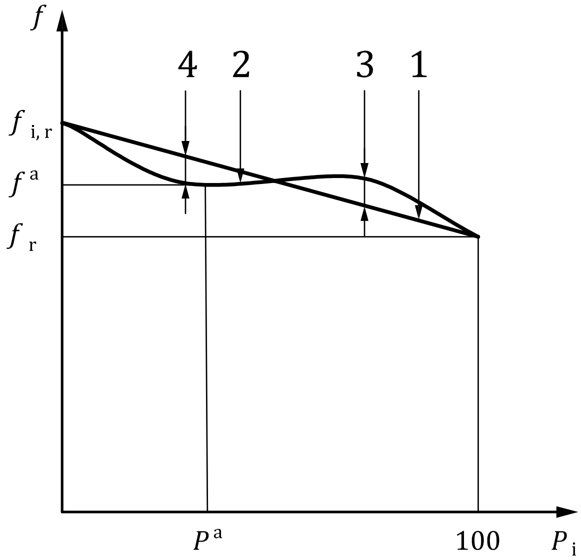
Note 3 to entry: $\Delta\delta f_{st} = \frac{\Delta f_c}{f_r} \times 100$

where

Δf_c	is maximum frequency deviation from a linear curve;
f_r	is *rated frequency* (3.1.4).

3.1.21
frequency/power characteristic curve
curve of steady-state frequencies in the power range between no-load and declared power, plotted against active power of the generating set

Note 1 to entry: See Figure 2.



Key

P power
f frequency
1 linear frequency/power characteristic curve
2 frequency/power characteristic curve
3 positive deviation from a linear curve, Δf_{pos}
4 negative deviation from a linear curve, Δf_{neg}
[a] Frequency/power characteristic deviation.

Figure 2 — Frequency/power characteristic, deviation from the linear curve

3.1.22
relative steady-state frequency tolerance band
α_f
ratio of the magnitude of frequency change to rated frequency

Note 1 to entry: $\alpha_f = \frac{\Delta f}{f_r} \times 100$

where

Δf is *steady-state frequency tolerance band* (3.1.15);

f_r is *rated frequency* (3.1.4).

3.1.23
steady-state frequency band
β_f
ratio of frequency oscillation envelope width frequency at constant power around a mean value of rated frequency at constant power

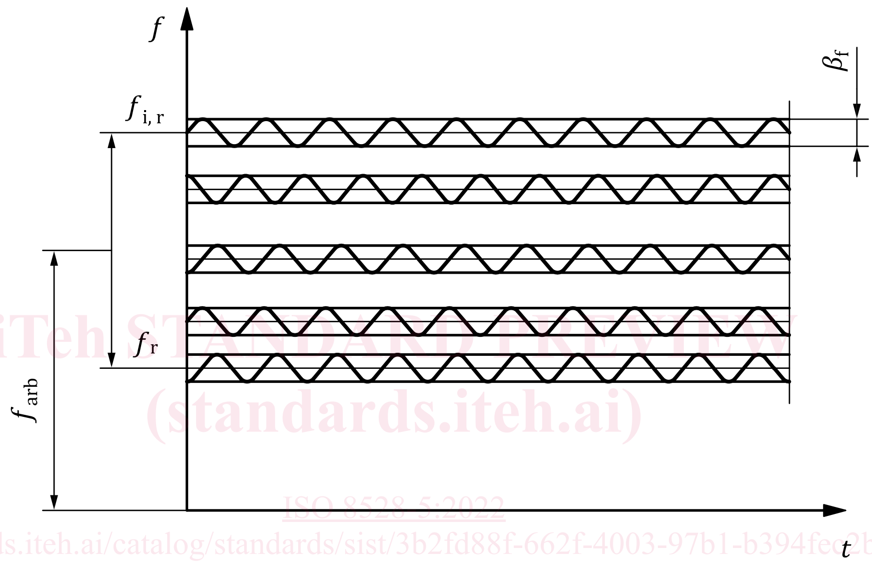
Note 1 to entry: Expressed as a percentage of rated frequency.

Note 2 to entry: See Figure 3.

Note 3 to entry: $\beta_f = \frac{\overset{\wedge}{\underset{\vee}{f}}}{f_r} \times 100$

where

$\overset{\wedge}{\underset{\vee}{f}}$	is envelope width oscillation of generating set;
f_r	is *rated frequency* (3.1.4).



Key

t time

f frequency

f_{arb} frequency at actual power

Figure 3 — Steady-state frequency band

3.1.24
related downward range of frequency setting
$\delta f_{s,do}$
range of downward frequency setting

Note 1 to entry: Expressed as a percentage of the rated frequency.

Note 2 to entry: $\delta f_{s,do} = \frac{f_{i,r} - f_{i,min}}{f_r} \times 100$

where

$f_{i,r}$	is *rated no-load frequency* (3.1.3);
$f_{i,min}$	is minimum no-load frequency;
f_r	is *rated frequency* (3.1.4).

3.1.25
related upward range of frequency setting
$\delta f_{s,up}$
range of upward frequency setting

Note 1 to entry: Expressed as a percentage of the rated frequency.

Note 2 to entry: $\delta f_{s,up} = \frac{f_{i,max} - f_{i,r}}{f_r} \times 100$

where

$f_{i,r}$ is *rated no-load frequency* (3.1.3);

$f_{i,max}$ is maximum no-load frequency;

f_r is *rated frequency* (3.1.4).

3.1.26
frequency droop
δf_{st}
frequency difference between rated no-load frequency and the rated frequency f_r at declared power

Note 1 to entry: See Figure 1.

Note 2 to entry: $\delta f_{st} = \frac{f_{i,r} - f_r}{f_r} \times 100$

where

$f_{i,r}$ is *rated no-load frequency* (3.1.3);

f_r is *rated frequency* (3.1.4).

Note 3 to entry: Expressed as a percentage of rated frequency at fixed frequency setting.

3.1.27
cyclic irregularity
δ_s
periodic fluctuation of speed caused by the rotational irregularity of the prime mover

3.1.28
steady-state voltage deviation
ΔU_{st}
change in steady-state voltage for all load changes between no-load and rated output, considering the influence of temperature but ignoring the effect of quadrature current compensation voltage droop

Note 1 to entry: $\Delta U_{st} = \pm \frac{U_{st,max} - U_{st,min}}{2 \cdot U_r} \times 100$

where

$U_{st,max}$ is maximum steady-state voltage;

$U_{st,min}$ is minimum steady-state voltage;

U_r is *rated voltage* (3.1.11).

Note 2 to entry: The initial set voltage is usually the rated voltage but can be anywhere within the range of voltage setting.

Note 3 to entry: ΔU_{st} is expressed as a percentage of the rated voltage.

3.1.29
voltage unbalance
$\Delta U_{2\cdot 0}$
ratio of the negative-sequence or the zero-sequence voltage components to the positive-sequence voltage components at no-load

Note 1 to entry: Voltage unbalance is expressed as a percentage of rated voltage.

3.2 Symbols

Symbol	Term	Meaning
$\overset{\wedge}{\underset{\vee}{f}}$	envelope width oscillation of generating set	oscillation frequency at constant power around rated frequency caused by the reciprocating internal combustion engine
$f_{i,max}$	maximum no-load frequency	maximum frequency at which the generating set is operating without load
$f_{i,min}$	minimum no-load frequency	minimum frequency at which the generating set is operating without load
f_r	rated frequency	frequency at which the generating set is designed to operate
f_{arb}	frequency at actual power	frequency at which the generating set is rated to operate
$t_{f,de}$	frequency recovery time after load decrease	time interval between the departure from the steady-state frequency band after a sudden specified load decrease and the permanent re-entry of the frequency into the specified steady-state frequency tolerance band
$t_{f,in}$	frequency recovery time after load increase	time interval between the departure from the steady-state frequency band after a sudden specified load increase and the permanent re-entry of the frequency into the specified steady-state frequency tolerance band
$t_{u,de}$	voltage recovery time after load decrease	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
$t_{u,in}$	voltage recovery time after load increase	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
ΔU	steady-state voltage tolerance band	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