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Reciprocating internal combustion engine driven alternating current generating sets —

Part 6: **Test methods**

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

Partie 6: Méthodes d'essai

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Contents

Page

Foreword

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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 third edition cancels and replaces the second edition (ISO 8528-6:2005), which has been technically revised.

The main changes are as follows:

— structure of testing completely modified (table updated);

— Clause 7 now includes a test procedure related to generating sets connected to the grid;

— Clause 8 introduced for accessing the performance of generating sets in isochronous mode and grid parallel mode.

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 6: **Test methods**

1 Scope

This document specifies the test methods to be used for characterizing an entire generating set. It applies to alternating current (AC) 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. This document also provides simulation methods as an alternative method for assessing the generating set capability to meet the requirements defined in ISO 8528-5.

For some specific applications (e.g., essential hospital supplies, high-rise buildings, operation in parallel with the grid), supplementary requirements could be necessary. The provisions of this document are intended as a basis for establishing any supplementary requirements.

For AC generating sets driven by other reciprocating-type prime movers (e.g., steam engines), this document is intended as a basis for establishing these requirements.

NOTE Existing test methods for the engine (ISO 3046-1 and ISO 3046-3) and generator (IEC 60034-2) are applicable for those components. The generating set manufacturer is responsible for specifying these characteristics and the tests to be performed to verify them.

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

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

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

ISO 8528-5:2022, *Reciprocating internal combustion engine driven alternating current generating sets — Part 5: Generating sets*

ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*

IEC 60034-5, *Rotating electrical machines — Part 5: Classification of degrees of protection provided by enclosures for rotating machines*

IEC 60947-1, *Low-voltage switchgear and control gear — Part 1: General rules*

IEC 60034-1:2017, *Rotating electrical machines — Part 1: Rating and performance*

IEC 61400-27-2:2020, *Wind energy generation systems – Part 27-1: Electrical simulation models — Model validation*

3 Terms, definitions and abbreviations

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
envelope width oscillation of generating set
$\hat{\check{f}}$
envelope width oscillation of the generating set frequency at constant power around a mean value

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
declared frequency
f_r
frequency at which the generating set is designed to operate

3.1.5
frequency at actual power
f_{arb}
frequency at which the generating set is actually operating

3.1.6
overshoot frequency
$f_{d,max}$
maximum transient frequency rise which occurs upon a sudden decrease from a higher to a lower power

Note 1 to entry: The symbol is different from that given in ISO 3046-4.

3.1.7
undershoot frequency
$f_{d,min}$
maximum transient frequency drop which occurs due to a sudden increase of load from a lower to a higher power

Note 1 to entry: The symbol is different from that given in ISO 3046-4.

3.1.8
total stopping time
t_a
time interval between the stop command being received by the generating set control system and the generating set completely stopping

Note 1 to entry: $t_a = t_i + t_c + t_d$.

where

t_i is time interval from a stop command being given until the load is disconnected;

t_c is the time interval from the removal of the load until the generating stop command is triggered, also known as the cooling run-on time;

t_d is the time from the generating set stop command is triggered (also known as cooling run-on time) to when the generating set has come to complete stop.

3.1.9
load pick-up readiness time
t_b
time interval between the start command and readiness for supplying an agreed power, taking into account a given frequency and voltage tolerance

Note 1 to entry: $t_b = t_p + t_g$.

where

t_p is time interval from the start command until the beginning of cranking;

t_g is time interval from the beginning of cranking until ready for supplying an agreed power, taking into account a given frequency and voltage tolerance.

3.1.10
block
functional block
mathematical representation of a system or element with one or more input variables and one or more output variables, in which the functional relationship between the input and output variables is given

Note 1 to entry: The functional relationship can be given by an arithmetic instruction, a transfer function, a differential or difference equation, a characteristic curve or a family of characteristic curves, or a switching function.

3.1.11
parameter accuracy
charatcteristic that reflects the product quality of component suppliers, and it is one of the key factors by which the simulation results are reliable

3.1.12
frequency recovery time after load decrease
$t_{f,de}$
time interval between the departure from the *steady-state frequency band* (3.1.27) after a sudden specified load decrease and the permanent re-entry of the frequency into the specified *steady-state frequency tolerance band* (3.1.25)

3.1.13
frequency recovery time after load increase
$t_{f,in}$
time interval between the departure from the *steady-state frequency band* (3.1.27) after a sudden specified load increase and the permanent re-entry of the frequency into the specified *steady-state frequency tolerance band* (3.1.25)

3.1.14
voltage recovery time after load decrease
$t_{u,de}$
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* (3.1.26)

3.1.15
voltage recovery time after load increase
$t_{u,in}$
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* (3.1.26)

3.1.16
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

3.1.17
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

3.1.18
maximum steady-state voltage
$U_{st,max}$
maximum voltage under steady-state conditions at the rated frequency, for all powers between no-load and rated output and at the specified power factor, taking into account the influence of temperature rise

3.1.19
minimum steady-state voltage
$U_{st,min}$
minimum voltage under steady-state conditions at the rated frequency, for all powers between no-load and rated output and at the specified power factor, taking into account the influence of temperature rise

3.1.20
no-load voltage
U_0
line-to-line voltage at the terminals of the generator at the rated no-load frequency and no-load

3.1.21
maximum upward transient voltage on load decrease
$U_{dyn,max}$
maximum voltage which results from a sudden decrease from a higher load to a lower load

3.1.22
minimum downward transient voltage on load increase
$U_{dyn,min}$
minimum voltage which results from a sudden increase from a lower load to a higher load

3.1.23
transient voltage drop
$\Delta U_{\mathrm{dyn}}^{-}$
maximum voltage drop when the AC generator, driven at the rated speed and at the rated voltage under normal excitation control, is switched onto a symmetrical load which absorbs a specified current at the rated voltage at a given power factor or range of power factors

[SOURCE: ISO 8528-3:2020, 3.12, modified — Notes to entry removed.]

3.1.24
transient voltage rise
$\Delta U_{\mathrm{dyn}}^{+}$
maximum voltage rise when the AC generator, driven at the rated speed and at the rated voltage under normal excitation control, has a sudden rejection of the rated output.

[SOURCE: ISO 8528-3:2020, 3.13, modified — Notes to entry removed.]

3.1.25
steady-state frequency tolerance band
Δf
agreed frequency band about the steady-state frequency which the frequency reaches within a given governing period after an increase or decrease of the load

3.1.26
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

Note 1 to entry: $"\ U = 2"\ U_{\mathrm{st}} \times \frac{U_{\mathrm{r}}}{100}$.

3.1.27
steady-state frequency band
β_{f}
envelope width osciallation of generating set (3.1.1) frequency at a constant power around a mean value

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

Note 2 to entry: $\beta_{\mathrm{f}} = \frac{\hat{f}\ \vee}{f_{\mathrm{r}}} \times 100$

3.1.28
transient frequency deviation (from initial frequency) on load increase (-) related to initial frequency
$\delta f_{\mathrm{d}}^{-}$
temporary frequency deviation between *undershoot frequency* (3.1.7) and initial frequency during the governing process following a sudden load increase, related to the initial frequency

3.1.29
transient frequency deviation (from initial frequency) on load decrease (+) related to initial frequency
$\delta f_{\mathrm{d}}^{+}$
temporary frequency deviation between *overshoot frequency* (3.1.6) and initial frequency during the governing process following a sudden load decrease, related to the initial frequency

3.1.30
transient frequency deviation (from initial frequency) on load increase (-) related to rated frequency
δf_{dyn}^{-}
temporary frequency deviation between undershoot frequency and initial frequency during the governing process following a sudden load increase, related to the rated frequency

Note 1 to entry: $\delta f_{dyn}^{-} = \frac{f_{d,min} - f_{arb}}{f_r} \times 100$.

3.1.31
transient frequency deviation (from initial frequency) on load decrease (+) related to rated frequency
δf_{dyn}^{+}
temporary frequency deviation between *overshoot frequency* (3.1.6) and initial frequency during the governing process following a sudden load change, related to the rated frequency

Note 1 to entry: $\delta f_{dyn}^{+} = \frac{f_{d,max} - f_{arb}}{f_r} \times 100$.

3.1.32
frequency droop
δf_{st}
frequency difference between *rated no-load frequency* (3.1.3) and the *rated frequency* (3.1.4) at declared power, expressed as a percentage of rated frequency at fixed frequency setting

Note 1 to entry: $\delta f_{st} = \frac{f_{I,r} - f_r}{f_r} \times 100$.

3.1.33
steady-state voltage deviation
ΔU_{st}
maximum deviation from the set voltage under steady-state conditions at rated frequency for all powers between no-load and rated output and at specified power factor, taking into account the influence of the temperature rise

Note 1 to entry: The steady-state voltage deviation is expressed as a percentage of the *rated voltage* (3.1.34).

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

3.1.34
rated voltage
U_r
rated value of the voltage assigned by the manufacturer to a component, device or equipment and to which operation and performance characteristics are referred

[SOURCE: IEV 442-09-10.]

3.1.35
generating set family
group of generating sets with similar behaviour, the same technology and the same structure of components, but with different rated output and/or different voltage levels

3.1.36
component
individual physical building elements of the generating set

EXAMPLE Engine, AC generator, controller.

Note 1 to entry: This definition does not apply when used in reference to negative or positive sequence components in Clause 8.

3.1.37
rated load
P_n
real power that the generating set is capable of producing at the *rated voltage* (3.1.34) and frequency as recommended by the manufacturer

3.1.38
load angle
internal angle between the vectors of terminal voltage and e.m.f., the latter indicating the quadrature axis direction

[SOURCE: IEC 60034-4-1:2018; 6.9]

3.1.39
national grid code
details of technical requirement for connecting to and using the national electricity transmission and distribution system (also known as grid paralleling) in different regions or nations

3.2 Abbreviated terms

AC	alternating current
AVR	automatic voltage regulator
AGM	absorbant glass material used for making batteries
AMC	Agreement between manufacturer and customer
CSV	comma separated value files
ECU	electronic control unit
e.m.f	electro magnatic force
ESP	emergency standby power
FRT	fault ride through
UVRT	under-voltage ride through
OVRT	over-voltage ride through
LFSM-O	limited frequency sensitive mode at over frequency
LFSM-U	limited frequency sensitive mode at under frequency
PQ curve	active power – reactive power curve
PRP	prime power
p.u	per unit
RoCoF	rate of change of frequency

4 Other regulations and additional requirements

For AC generating sets used on board ships and offshore installations which are subject to the rules of a classification society, it is presupposed that the additional requirements of the classification society are observed. The classification society name shall be stated by the customer prior to placing the order.

For AC generating sets operating in non-classified equipment, any additional requirements are subject to agreement between the manufacturer and customer.

If special requirements from regulations of any other authority (e.g. inspecting and/or legislative authorities) apply, the authority name shall be stated by the customer prior to placing the order. If it is agreed to use any other authority, then the testing shall be performed in accordance with ISO/IEC 17025 testing and measurement standards.

NOTE 1 Attention is drawn to the need to take note of additional regulations or requirements imposed by various regulatory bodies.

NOTE 2 Examples of regulatory authorities include:

— classification societies, for generating sets used on ships and offshore installations;

— government agencies;

— inspection agencies, local utilities.

5 General test requirements

5.1 General

Generating sets shall be tested in accordance with the following tests:

a) Functional test:

This test procedure is intended for use with the generating set installed on the manufacturer's test bed.

As a minimum, the manufacturer shall perform the functional testing in accordance with the correct rating and performance class of the generating set.

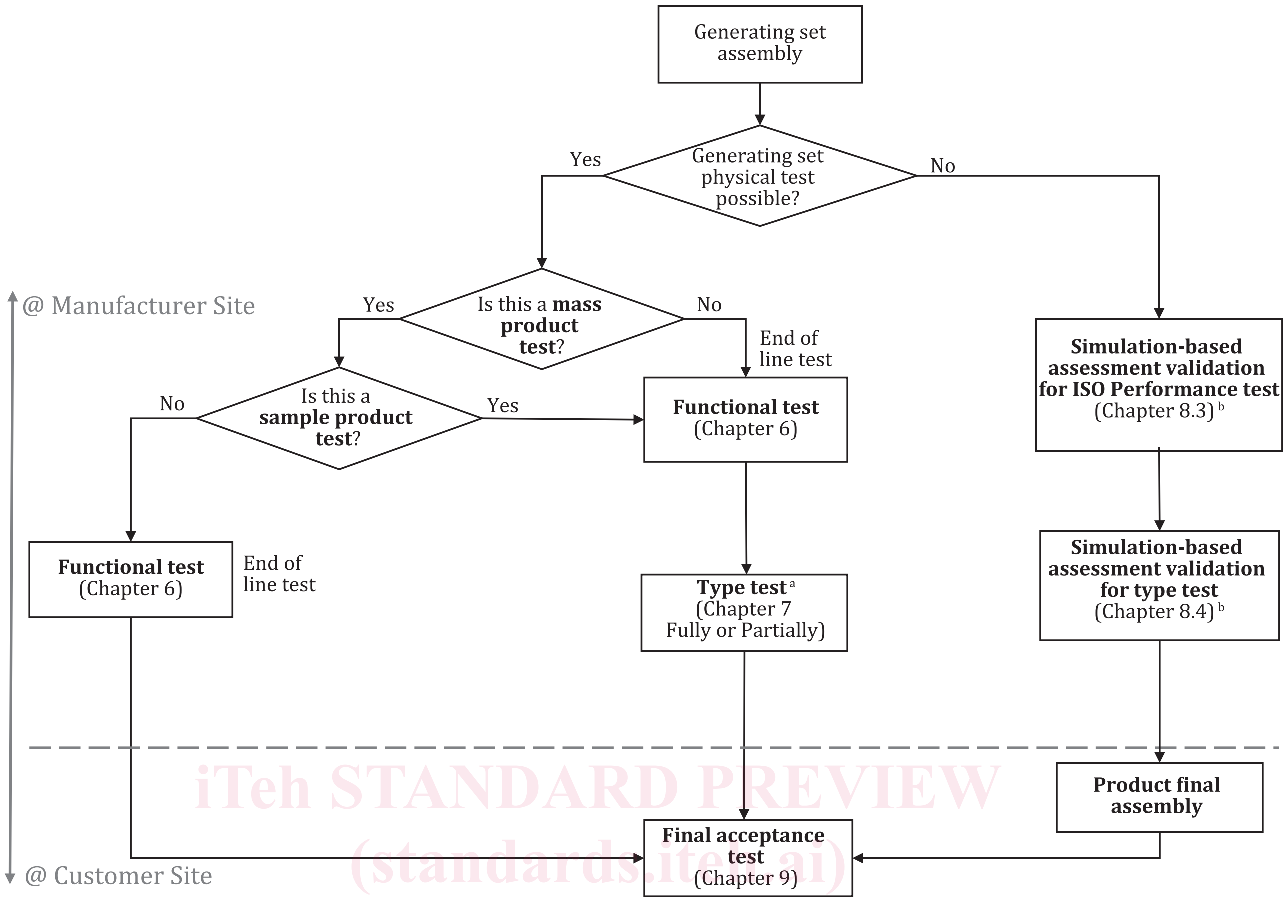
b) Type test for sample product:

This test is applicable only for a sample product that represents generating sets in a family. All these tests can be performed or selected tests can be performed, depending on the application of the generating set and any additional requirements are to be fulfilled.

c) Acceptance test (if required by the customer):

Subject to contractual agreement between the generating set manufacturer and the customer, any or all of the functional tests can be combined with the acceptance test.

Figure 1 can be used as guidance on how the tests can be applied for mass produced products or sample products, generating sets that can only be assembled at customer sites.



a Requirements in ISO 8528-1, ISO 8528-2, ISO 8528-3, and ISO 8528-5 to be verified.

b For validated models, see the assessments in 8.3 and 8.4.

Figure 1 — Flowchart for testing procedure

5.2 Measurement equipment accuracy

The accuracy of the instrumentation used in the test shall be as shown in Table 1. The measurement of time series data shall be carried out with a sampling rate of at least twice the frequency of the measured signal, i.e., 10 ms for 50 Hz frequency operation or 8,3 ms for 60 Hz frequency operation to prevent any aliasing of data. The measured time series data shall be reported in accordance with how the data shall be analysed.

Signal processing in measured time series data shall be done according to IEC 61400-27-2:2020, 6.4. Measuring transformers and transducers should be of a corresponding accuracy class.