

ISO/FDIS ~~8528-6:2022~~2023(E)

ISO/TC ~~70~~

Secretariat: SAC

Date: ~~2023-03-29~~06-14

Reciprocating internal combustion engine driven alternating current  
generating sets — Part 6: Test methods

iTeh STANDARD PREVIEW  
(standards.iteh.ai)

ISO 8528-6

<https://standards.iteh.ai/catalog/standards/sist/674bcd61-b3ec-4b38-a0e6-a3736a888b79/iso-8528-6>

Edited DIS - MUST BE USED FOR FINAL DRAFT

© ISO 2023

All rights reserved. Unless otherwise specified, or required in the context of its implementation, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office

CP 401 • Ch. de Blandonnet 8

CH-1214 Vernier, Geneva

Phone: +41 22 749 01 11

Email: [copyright@iso.org](mailto:copyright@iso.org)

Website: [www.iso.org](http://www.iso.org)

Published in Switzerland

#### Copyright notice

This ISO document is a working draft or committee draft and is copyright-protected by ISO. While the reproduction of working drafts or committee drafts in any form for use by participants in the ISO standards development process is permitted without prior permission from ISO, neither this document nor any extract from it may be reproduced, stored or transmitted in any form for any other purpose without prior written permission from ISO.

Requests for permission to reproduce this document for the purpose of selling it should be addressed as shown below or to ISO's member body in the country of the requester:

[Indicate the full address, telephone number, fax number, telex number, and electronic mail address, as appropriate, of the Copyright Manager of the ISO member body responsible for the secretariat of the TC or SC within the framework of which the working document has been prepared.]

Reproduction for sales purposes may be subject to royalty payments or a licensing agreement.

Violators may be prosecuted.

<b>Contents</b>	<b>Page</b>
<b>Foreword</b> .....	xii
<b>1</b> — <b>Scope</b> .....	1
<b>2</b> — <b>Normative references</b> .....	1
<b>2.1</b> — <b>Terms and definitions</b> .....	2
<b>2.2</b> — <b>Abbreviated terms</b> .....	8
<b>3</b> — <b>Other regulations and additional requirements</b> .....	9
<b>4</b> — <b>General test requirements</b> .....	10
<b>4.1</b> — <b>General</b> .....	10
<b>4.2</b> — <b>Measurement equipment accuracy</b> .....	12
<b>5</b> — <b>Functional test</b> .....	13
<b>5.1</b> — <b>General</b> .....	13
<b>5.1.1</b> — <b>General</b> .....	13
<b>5.1.2</b> — <b>Physical functional test</b> .....	13
<b>5.1.3</b> — <b>Functional test by simulation</b> .....	13
<b>5.2</b> — <b>General inspection</b> .....	13
<b>5.3</b> — <b>Measurements</b> .....	14
<b>5.4</b> — <b>Functional test report</b> .....	14
<b>6</b> — <b>Type test</b> .....	15
<b>6.1</b> — <b>General</b> .....	15
<b>6.2</b> — <b>Testing conditions</b> .....	16
<b>6.3</b> — <b>Characterisation of performance class</b> .....	16
<b>6.3.1</b> — <b>Steady state verification at constant power</b> .....	16
<b>6.3.2</b> — <b>Verification of power sharing capability</b> .....	17
<b>6.3.3</b> — <b>Step load test</b> .....	18
<b>6.3.4</b> — <b>Start and stop time characteristics</b> .....	20
<b>6.4</b> — <b>Reactive power capability</b> .....	21
<b>6.4.1</b> — <b>General</b> .....	21
<b>6.4.2</b> — <b>Verification of reactive power capability</b> .....	21
<b>6.4.3</b> — <b>Test method for verification of reactive power capability control methods</b> .....	24
<b>6.5</b> — <b>Verification of grid synchronization limits</b> .....	29

6.5.1	General	29
6.5.2	Testing method for verification of grid synchronisation limits	29
6.6	Test method for verification of FRT capability	30
6.6.1	General	30
6.6.2	Aim of the test	30
6.6.3	Documents to be provided before test	31
6.6.4	Test method	31
6.6.5	Acceptance criteria	32
6.7	Test method for verification of active power response to frequency variation	32
6.7.1	General	32
6.7.2	Aim of the test	33
6.7.3	Documents to be provided before test	33
6.7.4	Test method	34
6.7.5	Acceptance criteria	34
6.8	Test method for verification of generating set protections	35
6.8.1	General	35
6.8.2	Verification of generating set disconnection time from the grid	35
6.8.3	Verification of protection limits	35
7	Simulation method-based assessment	37
7.1	General	37
7.2	Specification of model blocks	39
7.2.1	General	39
7.2.2	Engine and engine controller or governor block	39
7.2.3	AC generator block	39
7.2.4	Generating set controller block	39
7.2.5	Excitation controller (AVR) block	39
7.2.6	Exciter block	40
7.2.7	Protective devices block	40
7.2.8	Measurement transformer (if applicable)	40
7.3	Simulation for ISO performance class in standalone island operation	40
7.3.1	General	40
7.3.2	Model validation for standalone island mode	40
7.4	Simulation for generating sets used in grid connected applications	43
7.4.1	General	43

7.4.2	Requirements and methodologies for model validation	43
7.4.3	Model validation for different grid requirements	44
7.5	Assessment for generating set family	48
7.5.1	Methodology	48
7.5.2	Assessment for ISO performance class for family	48
7.5.3	Assessment for type test for family in grid parallel application	49
8	Acceptance test	49
8.1	General	49
8.2	Responsibility	50
8.3	Preparation	50
8.3.1	Provision of auxiliary personnel, test equipment and operating materials	50
	50	
8.3.2	Acceptance test preparation at the installation site	50
8.3.3	Acceptance test preparation at the manufacturer's site or facility	50
8.3.4	Preliminary safety checks on generating set prior to testing	50
8.4	Further details	51
8.5	Extent of acceptance test	51
8.5.1	General	51
8.5.2	Checks (C)	51
8.5.3	Measurements (M)	52
8.6	Accuracy of measurement equipment and acceptance test procedure	54
8.6.1	Measurement equipment accuracy	54
8.6.2	Warm-up time	54
8.6.3	Generating set load test duration	54
8.6.4	Performing acceptance tests at the manufacturer's works	54
8.6.5	Installation site acceptance test	55
8.7	Acceptance test report	56
8.7.1	General	56
8.7.2	General data	56
8.7.3	Additional measured data for acceptance test	58
Annex A (informative) Test method using OVRT/UVRT test equipment		59
Annex B (informative) Test method for frequency ride through requirements		68
Annex C (informative) Example load step test report		74

<b>Bibliography</b> .....	76
<b>Foreword</b> .....	xii
<b>1 Scope</b> .....	1
<b>2 Normative references</b> .....	1
<b>3 Terms, definitions and abbreviations</b> .....	2
<b>3.1 Terms and definitions</b> .....	2
<b>3.2 Abbreviated terms</b> .....	8
<b>4 Other regulations and additional requirements</b> .....	9
<b>5 General test requirements</b> .....	10
<b>5.1 General</b> .....	10
<b>Figure 1 — Flowchart for testing procedure</b> .....	12
<b>5.2 Measurement equipment accuracy</b> .....	12
<b>Table 1 — Measurement equipment accuracy</b> .....	12
<b>6 Functional test</b> .....	13
<b>6.1 General</b> .....	13
<b>6.1.1 General</b> .....	13
<b>6.1.2 Physical functional test</b> .....	13
<b>6.1.3 Functional test by simulation</b> .....	13
<b>6.2 General inspection</b> .....	13
<b>6.3 Measurements</b> .....	14
<b>6.4 Functional test report</b> .....	14
<b>7 Type test</b> .....	15
<b>7.1 General</b> .....	15
<b>7.2 Testing conditions</b> .....	16
<b>7.3 Characterisation of performance class</b> .....	16
<b>7.3.1 Steady state verification at constant power</b> .....	16
<b>Table 2 — Parameters to be obtained before the test</b> .....	16
<b>Table 3 — Parameters to be measured during load test</b> .....	16
<b>Table 4 — Post-treatments to be performed after load test</b> .....	17

7.3.2	Verification of power-sharing capability .....	17
7.3.3	Step load test .....	18
	<b>Table 5 — Parameters to be measured during step load test.....</b>	<b>18</b>
	<b>Table 6 — Example of load steps declared to validate performance class.....</b>	<b>19</b>
	<b>Table 7 — Post treatment to be performed after step load test.....</b>	<b>19</b>
7.3.4	Start and stop time characteristics .....	20
	<b>Table 8 — Parameters to be measured during the test.....</b>	<b>20</b>
	<b>Table 9 — Post-treatment to be performed after the test.....</b>	<b>21</b>
7.4	Reactive power capability .....	21
7.4.1	General .....	21
7.4.2	Verification of reactive power capability.....	21
	<b>Table 10 — Example test steps for reactive power capability assessment.....</b>	<b>22</b>
	<b>Figure 2 — Example of generating set manufacturer PQ diagram.....</b>	<b>24</b>
7.4.3	Test method for verification of reactive power capability control methods .....	24
	<b>Table 11 — Example steps for VAR/power factor verification .....</b>	<b>25</b>
	<b>Figure 3 — Example Q(P) diagram.....</b>	<b>27</b>
	<b>Table 12 — Example verification steps of Q/P- U characteristics.....</b>	<b>27</b>
	<b>Figure 4 — Example verification for Q/P -U curve.....</b>	<b>28</b>
7.5	Verification of grid synchronization limits .....	29
7.5.1	General .....	29
7.5.2	Testing method for verification of grid synchronisation limits.....	29
	<b>Table 13 — Example steps for synchronisation limit verification.....</b>	<b>29</b>
7.6	Test method for verification of FRT capability .....	30
7.6.1	General .....	30
7.6.2	Aim of the test .....	30
7.6.3	Documents to be provided before test.....	31
7.6.4	Test method .....	31
	<b>Table 14 — Recommended voltage step profile test combination .....</b>	<b>32</b>

<b>7.6.5</b>	<b>Acceptance criteria</b> .....	<b>32</b>
<b>7.7</b>	<b>Test method for verification of active power response to frequency variation</b> .....	<b>32</b>
<b>7.7.1</b>	<b>General</b> .....	<b>32</b>
<b>7.7.2</b>	<b>Aim of the test</b> .....	<b>33</b>
<b>7.7.3</b>	<b>Documents to be provided before test</b> .....	<b>33</b>
<b>7.7.4</b>	<b>Test method</b> .....	<b>34</b>
<b>7.7.5</b>	<b>Acceptance criteria</b> .....	<b>34</b>
<b>7.8</b>	<b>Test method for verification of generating set protections</b> .....	<b>35</b>
<b>7.8.1</b>	<b>General</b> .....	<b>35</b>
<b>7.8.2</b>	<b>Verification of generating set disconnection time from the grid</b> .....	<b>35</b>
<b>7.8.3</b>	<b>Verification of protection limits</b> .....	<b>35</b>
	<b>Table 15 — Example steps for protection limit verification</b> .....	<b>36</b>
<b>8</b>	<b>Simulation-method-based assessment</b> .....	<b>37</b>
<b>8.1</b>	<b>General</b> .....	<b>37</b>
	<b>Figure 5 — Example of simulation model structure for simulation-based assessment</b> .....	<b>38</b>
<b>8.2</b>	<b>Specification of model blocks</b> .....	<b>39</b>
<b>8.2.1</b>	<b>General</b> .....	<b>39</b>
<b>8.2.2</b>	<b>Engine and engine controller or governor block</b> .....	<b>39</b>
<b>8.2.3</b>	<b>AC generator block</b> .....	<b>39</b>
<b>8.2.4</b>	<b>Generating set controller block</b> .....	<b>39</b>
<b>8.2.5</b>	<b>Excitation controller (AVR) block</b> .....	<b>39</b>
<b>8.2.6</b>	<b>Exciter block</b> .....	<b>40</b>
<b>8.2.7</b>	<b>Protective devices block</b> .....	<b>40</b>
<b>8.2.8</b>	<b>Measurement transformer (if applicable)</b> .....	<b>40</b>
<b>8.3</b>	<b>Simulation for ISO performance class in standalone island operation</b> .....	<b>40</b>
<b>8.3.1</b>	<b>General</b> .....	<b>40</b>
<b>8.3.2</b>	<b>Model validation for standalone island mode</b> .....	<b>40</b>
	<b>Table 16 — Performance class operating limit for simulation-based assessment</b> ...	<b>42</b>
<b>8.4</b>	<b>Simulation for generating sets used in grid connected applications</b> .....	<b>43</b>
<b>8.4.1</b>	<b>General</b> .....	<b>43</b>
<b>8.4.2</b>	<b>Requirements and methodologies for model validation</b> .....	<b>43</b>



8.4.3	Model validation for different grid requirements .....	44
8.5	Assessment for generating set family .....	48
8.5.1	Methodology .....	48
8.5.2	Assessment for ISO performance class for family .....	48
8.5.3	Assessment for type test for family in grid parallel application .....	49
9	Acceptance test .....	49
9.1	General .....	49
9.2	Responsibility .....	50
9.3	Preparation .....	50
9.3.1	Provision of auxiliary personnel, test equipment and operating materials	
	50	
9.3.2	Acceptance test preparation at the installation site .....	50
9.3.3	Acceptance test preparation at the manufacturer's site or facility .....	50
9.3.4	Preliminary safety checks on generating set prior to testing .....	50
9.4	Further details .....	51
9.5	Extent of acceptance test .....	51
9.5.1	General .....	51
9.5.2	Checks (C) .....	51
9.5.3	Measurements (M) .....	52
9.6	Accuracy of measurement equipment and acceptance test procedure .....	54
9.6.1	Measurement equipment accuracy .....	54
9.6.2	Warm-up time .....	54
9.6.3	Generating set load test duration .....	54
9.6.4	Performing acceptance tests at the manufacturer's works .....	54
9.6.5	Installation site acceptance test .....	55
	Table 17 — Checks and measurements groups .....	55
9.7	Acceptance test report .....	56
9.7.1	General .....	56
9.7.2	General data .....	56
9.7.3	Additional measured data for acceptance test .....	58
	Annex A (informative) Test method using OVRT/UVRT test equipment .....	59
	Figure A.1 — Fault ride-through test illustration using impedance .....	60
	Figure A.2 — Example tolerance of the voltage-time profile for a no-load dip .....	62

**Figure A.3 — Example tolerance of the voltage-time profile for OVRT tests .....63**

**Figure A.4 — Example under-voltage-time capability profile to be verified by testing .....65**

**Table A.1 — Example under-voltage steps to verify under-voltage-time profile similar to Figure A.4 .....65**

**Figure A.5 — Example over-voltage-time capability profile to be verified by testing .....66**

**Table A.2 — Example over-voltage tests for verification of the voltage-time capability profile in Figure A.5 .....66**

**Annex B (informative) Test method for frequency ride through requirements .....68**

**B.1 Verification of active power response to under-frequency (LFSM-U) .....68**

**Figure B.1 — Example of active power response to under-frequency .....69**

**Table B.1 — Example of parameters of response to under-frequency .....69**

**B.2 Testing method .....69**

**B.2.1 General .....69**

**Table B.2 — Parameters to be measured during active power response to under-frequency test .....70**

**Table B.3 — Example of measurement records for active power under frequency response test .....70**

**B.2.2 Grid simulator testing method .....70**

**B.2.3 Creating a frequency measurement offset .....70**

**B.2.4 Assessment of measurement and post-treatment .....71**

**B.2.5 Criteria of acceptance .....71**

**B.3 Verification of active power response to over-frequency (LFSM-O) .....71**

**B.3.1 General .....71**

**Figure B.2 — Example of active power response to over-frequency .....72**

**Table B.4 — Example of parameters of response to over-frequency .....72**

**B.3.2 Testing method .....72**

<b>Table B.5 — Parameters to be measured during active power response to over-frequency test.....</b>	<b>73</b>
<b>Table B.6 — Example of measurement records for active power over frequency response test.....</b>	<b>73</b>
<b>B.3.3 Documentation of measurement results.....</b>	<b>73</b>
<b>B.3.4 Criteria of acceptance.....</b>	<b>73</b>
<b>Annex C (informative) Example load step test report .....</b>	<b>74</b>
<b>Bibliography.....</b>	<b>76</b>

iTeh STANDARD PREVIEW  
(standards.iteh.ai)

ISO 8528-6

<https://standards.iteh.ai/catalog/standards/sist/674bcd61-b3ec-4b38-a0e6-a3736a888b79/iso-8528-6>

## 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](http://www.iso.org/directives)).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see [www.iso.org/patents](http://www.iso.org/patents)).

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](http://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 67 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](http://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*

**ISO/FDIS 8528-6:2023(E)**

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*

~~IEC/TS 62786-1<sup>1</sup>, *Distributed energy resources connection with the grid — general requirements*~~

**3 ~~Under preparation. Stage at the time of publication: IEC TS/CDTS 62786-1:2023~~  
Terms, definitions and ~~abbreviated terms~~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**

^  
~~f~~  
v  
^  
f  
v

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 ~~declared~~rated frequency**  
~~rated~~declared frequency

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

ITeH STANDARD PREVIEW  
(standards.iteh.ai)

ISO 8528-6  
<https://standards.iteh.ai/catalog/standards/sist/674bcd61-b3ec-4b38-a0e6-a3736a888b79/iso-8528-6>

Field Code Changed

### 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,

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,

where

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