



BSI Standards Publication

Rotating electrical machines

Part 33: Synchronous hydrogenerators including motor-generators — Specific requirements (IEC 60034-33:2022)

National foreword

This British Standard is the UK implementation of EN IEC 60034-33:2022. It is identical to IEC 60034-33:2022.

The UK participation in its preparation was entrusted to Technical Committee PEL/2, Rotating electrical machinery.

A list of organizations represented on this committee can be obtained on request to its committee manager.

Contractual and legal considerations

This publication has been prepared in good faith, however no representation, warranty, assurance or undertaking (express or implied) is or will be made, and no responsibility or liability is or will be accepted by BSI in relation to the adequacy, accuracy, completeness or reasonableness of this publication. All and any such responsibility and liability is expressly disclaimed to the full extent permitted by the law.

This publication is provided as is, and is to be used at the recipient's own risk.

The recipient is advised to consider seeking professional guidance with respect to its use of this publication.

This publication is not intended to constitute a contract. Users are responsible for its correct application.

© The British Standards Institution 2022
Published by BSI Standards Limited 2022

ISBN 978 0 580 96581 4

ICS 29.160.01; 29.160.20

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 May 2022.

Amendments/corrigenda issued since publication

Date	Text affected
------	---------------

EUROPEAN STANDARD

EN IEC 60034-33

NORME EUROPÉENNE

EUROPÄISCHE NORM

March 2022

ICS 29.160.01; 29.160.20

English Version

**Rotating electrical machines - Part 33: Synchronous
hydrogenerators including motor-generators - Specific
requirements
(IEC 60034-33:2022)**

Machines électriques tournantes - Partie 33 : Hydro-
génératrices synchrones y compris les groupes moteur-
générateurs - Exigences spécifiques
(IEC 60034-33:2022)

Drehende elektrische Maschinen - Teil 33: Besondere
Anforderungen an Synchrongeneratoren, angetrieben durch
hydraulische Turbinen, einschließlich Motor-Generatoren
(IEC 60034-33:2022)

This European Standard was approved by CENELEC on 2022-03-04. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.



European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

European foreword

The text of document 2/2081/FDIS, future edition 1 of IEC 60034-33, prepared by IEC/TC 2 "Rotating machinery" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN IEC 60034-33:2022.

The following dates are fixed:

- latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2022-12-04
- latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2025-03-04

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

Any feedback and questions on this document should be directed to the users' national committee. A complete listing of these bodies can be found on the CENELEC website.

Endorsement notice

The text of the International Standard IEC 60034-33:2022 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC/TS 60034-32 NOTE Harmonized as CLC IEC/TS 60034-32

ISO 5801 NOTE Harmonized as EN ISO 5801

CONTENTS

FOREWORD.....	6
1 Scope.....	8
2 Normative references	8
3 Terms and definitions	9
4 Site operation conditions	11
5 Ratings and parameters.....	11
5.1 Output.....	11
5.1.1 Output rating of a hydrogenerator	11
5.1.2 Output ratings of a motor-generator	11
5.1.3 Increase in active power	11
5.1.4 Under-excited operation	11
5.2 Rated voltage	12
5.3 Rated power factor.....	12
5.4 Rated speed	12
5.5 P-Q capability diagram.....	12
5.6 Voltage and frequency variations during operation	13
5.7 Efficiency and losses	15
5.7.1 Weighted average efficiency.....	15
5.7.2 Losses.....	15
5.7.3 Determination of winding losses	16
5.7.4 Windage Losses	16
5.7.5 Determination of thrust bearing losses for vertical machines.....	16
5.7.6 Tolerance of the total losses.....	17
5.8 Electrical parameters and time constants.....	17
5.8.1 Short-circuit ratio	17
5.8.2 Direct axis transient and subtransient reactances	17
5.8.3 General case	18
5.9 Tolerances on reactance.....	18
5.10 Total harmonic distortion (THD)	18
5.11 Torques	18
6 Temperature.....	18
6.1 Temperature rise	18
6.2 Measurements for the stator winding.....	19
6.3 Measurements for the stator core.....	20
6.4 Correction due to deviation from reference operation	20
6.5 Bearing temperature	21
7 Operating performances and electrical connections	21
7.1 Special operational requirements	21
7.1.1 Stator overload current	21
7.1.2 Rotor overload current.....	21
7.1.3 Continuous unbalanced load.....	21
7.1.4 Short time unbalanced load	22
7.1.5 Mechanical output overload	22
7.1.6 Sudden short circuit.....	22
7.2 Connection to grid.....	23
7.2.1 Synchronization.....	23

7.2.2	Application of load	23
7.3	Starting of motor-generator	23
7.4	System earthing	24
7.5	Neutral point leads	25
7.6	Rotating direction and phase sequence	25
7.7	Stator winding	25
8	Winding insulation	25
8.1	Winding insulation performance	25
8.1.1	General	25
8.1.2	Winding insulation resistance	25
8.1.3	Dielectric dissipation factor measurements on new stator bars or coils	26
8.1.4	Partial discharge measurements for stator winding	27
8.1.5	Voltage withstand test for turn insulation of multi-turn coil for stator	27
8.2	Voltage withstand tests	27
8.2.1	Stator bars/coils	27
8.2.2	Inserted stator bars/coils	27
8.2.3	Stator winding completed before rotor inserted	27
8.2.4	Field winding before delivery	27
8.2.5	Field winding completed	28
8.2.6	Stator winding for completed machine	28
8.2.7	Field winding for completed machine	28
8.2.8	DC alternative tests	28
8.2.9	Global VPI stators	28
8.3	Breakdown test for insulation	28
8.4	Voltage endurance test for insulation	29
8.5	Thermal cycle test	30
8.6	Stator winding terminals	30
9	Mechanical performances and design	30
9.1	Rotating part mass moment of inertia	30
9.2	Maximum speed	30
9.3	Structural strength	30
9.4	Critical bending speed	31
9.5	Start and stop of motor-generators	31
9.6	Start and stop of hydrogenerators	31
9.7	Over speed	31
9.8	Fatigue verification	32
10	Core vibration	32
11	Noise	32
12	Basic structural requirements	34
12.1	General layout	34
12.1.1	Structure and general layout of the machines	34
12.1.2	Machine components	34
12.1.3	Hydraulic or pneumatic braking system	34
12.1.4	Hydraulic jacking system	34
12.1.5	Dynamical (electrical) braking	34
12.2	Stator	34
12.2.1	Frame and core structure	34
12.2.2	Stator frame connecting structure	35

12.2.3	Stator end winding	35
12.3	Rotor	35
12.3.1	Damper winding	35
12.3.2	Structure with one shaft or segmented shafts	35
12.4	Structure tolerance	35
12.5	Bearings	35
12.5.1	Bearing alloy	35
12.5.2	Bearing lubricant	35
12.5.3	Shaft currents	35
12.5.4	Bearing insulation resistance	36
13	Ventilation and cooling system	36
13.1	Cooling scheme	36
13.1.1	General	36
13.1.2	Air cooling system	36
13.1.3	Evaporative cooling system	36
13.1.4	Water cooling system	36
13.2	Redundancy on the design of coolers and motor fans	37
13.3	Cooling structure	37
13.3.1	Materials	37
13.3.2	Water supply and drainage	37
13.3.3	Cooling water pressure	37
14	Instrumentation required for protection and control	37
14.1	General	37
14.2	Stator and bearing temperature	37
14.3	Bearing vibration and shaft displacement	38
15	Condition monitoring of machines	38
15.1	General	38
15.2	Instrumentation required for condition monitoring	39
16	Marking	39
16.1	Information to be marked on machine nameplate:	39
16.2	Repaired or refurbished machines	40
17	Factory and site tests	40
Annex A (informative)	Special tools	41
Annex B (informative)	Correction of measured windage losses on the machines	42
Annex C (informative)	Correction of measured bearing losses for different oil bath temperatures	45
Annex D (informative)	Scope of supply	47
Annex E (informative)	Test run and guaranteed period	48
E.1	72 h test run	48
E.2	15~30-day examination test run for motor-generators	48
E.3	Handover and guarantee period	48
Annex F (informative)	Test items	49
F.1	Inspection test for hydrogenerator and motor-generator in factory	49
F.2	Site routine test of hydrogenerator and motor-generator	49
F.3	Startup test run of hydrogenerator and motor-generator	50
F.4	Performance test of hydrogenerator	50
Annex G (informative)	Condition monitoring	51
G.1	Air gap distance	51

G.2	Core and frame vibration.....	51
G.3	Stator end winding vibration.....	51
G.4	Partial discharge.....	51
G.5	Air gap magnetic flux.....	52
G.6	Others.....	52
	Bibliography.....	53
	Figure 1 – P-Q capability in p.u.....	13
	Figure 2 – Voltage and frequency limits for hydro machines.....	14
	Figure 3 – Location of measuring points in the horizontal plane.....	33
	Table 1 – Preferred speed for 50 Hz machines.....	12
	Table 2 – Preferred speed for 60 Hz machines.....	12
	Table 3 – Reference temperature.....	16
	Table 4 – Temperature rise limits.....	19
	Table 5 – Permitted overload current multiple vs. time duration.....	21
	Table 6 – Permitted negative phase sequence current for the machines.....	22
	Table 7 – Permitted negative phase sequence current for the machines.....	22
	Table 8 – Material properties for grounding connectors.....	24
	Table 9 – Test voltage for insulating resistance measurement.....	26
	Table 10 – Dielectric dissipation factor.....	26
	Table 11 – Testing values for voltage withstand test of field winding.....	28
	Table 12 – Test voltage and time limits.....	29
	Table 13 – Limits for vibration in the core.....	32
	Table 14 – Temperature sensor locations.....	38
	Table A.1 – Special tools.....	41

INTERNATIONAL ELECTROTECHNICAL COMMISSION

ROTATING ELECTRICAL MACHINES –

**Part 33: Synchronous hydrogenerators including motor-generators –
Specific requirements**

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

IEC 60034-33 has been prepared by IEC technical committee 2: Rotating machinery. It is an International Standard.

The text of this International Standard is based on the following documents:

Draft	Report on voting
2/2081/FDIS	2/2088/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

A list of all parts in the IEC 60034 series, published under the general title *Rotating electrical machines*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

ROTATING ELECTRICAL MACHINES –

Part 33: Synchronous hydrogenerators including motor-generators – Specific requirements

1 Scope

This part of IEC 60034 applies to three-phase salient-pole synchronous generators and synchronous motor-generators for hydraulic turbine and pump-turbine applications, that have rated frequency of 50 Hz or 60 Hz, rated output of 10 MVA and above, pole pair number 3 and above, and rated voltage of 6 kV and above.

This document supplements basic requirements for rotating machines given in IEC 60034-1.

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.

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

IEC 60034-2-1, *Rotating electrical machines – Part 2-1: Standard methods for determining losses and efficiency from tests (excluding machines for traction vehicles)*

IEC 60034-2-2, *Rotating electrical machines – Part 2-2: Specific methods for determining separate losses of large machines from tests – Supplement to IEC 60034-2-1*

IEC 60034-4-1, *Rotating electrical machines – Part 4-1: Methods for determining electrically excited synchronous machine quantities from tests*

IEC 60034-15, *Rotating electrical machines – Part 15: Impulse voltage withstand levels of form-wound stator coils for rotating a.c. machines*

IEC 60034-18-1, *Rotating electrical machines – Part 18-1: Functional evaluation of insulation systems – General guidelines*

IEC 60034-18-32, *Rotating electrical machines – Part 18-32: Functional evaluation of insulation systems – Test procedures for form-wound windings – Evaluation by electrical endurance*

IEC TS 60034-18-33, *Rotating electrical machines – Part 18-33: Functional evaluation of insulation systems – Test procedures for form-wound windings – Multifactor evaluation by endurance under simultaneous thermal and electrical stresses*

IEC 60034-27-1, *Rotating electrical machines – Part 27-1: Off-line partial discharge measurements on the winding insulation*

IEC 60034-27-3, *Rotating electrical machines – Part 27-3: Dielectric dissipation factor measurement on stator winding insulation of rotating electrical machines*