IEC 60034-33

Edition 1.0 2022-01

INTERNATIONAL STANDARD

NORME INTERNATIONALE

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

Machines électriques tournantes –
Partie 33: Hydro-génératrices synchrones y compris les groupes moteur-générateurs – Exigences spécifiques

IEC 60034-33:2022-01(en-fr)

IEC Secretariat
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

About the IEC
The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications
The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigendum or an amendment might have been published.

IEC publications search - webstore.iec.ch/advsearchform
The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee, …). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished
Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and once a month by email.

IEC Customer Service Centre - webstore.iec.ch/csc
If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: sales@iec.ch.

IEC Products & Services Portal - products.iec.ch
Discover our powerful search engine and read freely all the publications previews. With a subscription you will always have access to up to date content tailored to your needs.

Electropedia - www.electropedia.org
The world's leading online dictionary on electrotechnology, containing more than 22 300 terminological entries in English and French, with equivalent terms in 19 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

A propos de l'IEC
La Commission Electrotechnique Internationale (IEC) est la première organisation mondiale qui élabore et publie des Normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

A propos des publications IEC
Le contenu technique des publications IEC est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

Recherche de publications IEC - webstore.iec.ch/advsearchform
La recherche avancée permet de trouver des publications IEC en utilisant différents critères (numéro de référence, texte, comité d'études, …). Elle donne aussi des informations sur les projets et les publications remplacées ou retirées.

IEC Just Published - webstore.iec.ch/justpublished
Restez informé sur les nouvelles publications IEC. Just Published détaille les nouvelles publications parues. Disponible en ligne et une fois par mois par email.

Service Clients - webstore.iec.ch/csc
Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions contactez-nous: sales@iec.ch.

IEC Products & Services Portal - products.iec.ch
Découvrez notre puissant moteur de recherche et consultez gratuitement tous les aperçus des publications. Avec un abonnement, vous aurez toujours accès à un contenu à jour adapté à vos besoins.

Electropedia - www.electropedia.org
Le premier dictionnaire d'électrotechnologie en ligne au monde, avec plus de 22 300 articles terminologiques en anglais et en français, ainsi que les termes équivalents dans 19 langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (IEV) en ligne.

IEC 60034-33

Edition 1.0 2022-01

INTERNATIONAL STANDARD

NORME INTERNATIONALE

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

Machines électriques tournantes –
Partie 33: Hydro-génératrices synchrones y compris les groupes moteur-générateurs – Exigences spécifiques

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

ICS 29.160.01; 29.160.20

ISBN 978-2-8322-1071-2

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*

IEC 60034-27-4, *Rotating electrical machines – Part 27-4: Measurement of insulation resistance and polarization index of winding insulation of rotating electrical machines*

IEC 60050-411, *International Electrotechnical Vocabulary (IEV) – Part 411: Rotating machinery*

IEC 60060-1, *High-voltage test techniques – Part 1: General definitions and test requirements*

IEC 60085, *Electrical insulation – Thermal evaluation and designation*

IEC 60287-3-1, *Electric cables – Calculation of the current rating – Part 3-1: Operating conditions – Site reference conditions*

IEC 60417:2002, *Graphical symbols for use on equipment – 12-month subscription to regularly updated online database comprising all graphical symbols published in IEC 60417*

IEC 60445, *Basic and safety principles for man-machine interface, marking and identification – Identification of equipment terminals, conductor terminations and conductors*

IEC 63132-1, *Guidance for installation procedures and tolerances of hydroelectric machines – Part 1: General aspects*

IEC 63132-2, *Guidance for installation procedures and tolerances of hydroelectric machines – Part 2: Vertical generators*

ISO 20816-1, *Mechanical vibration – Measurement and evaluation of machine vibration – Part 1: General guidelines*

ISO 20816-5, *Mechanical vibration – Measurement and evaluation of machine vibration – Part 5: Machine sets in hydraulic power generating and pump-storage plants*

EN 50522:2010, *Earthing of power installations exceeding 1 kV a.c.*

IEEE Std 1043™:1996, *IEEE Recommended practice for voltage-endurance testing of form-wound bars and coils*

IEEE Std 1310™:2012, *IEEE Recommended practice for thermal cycle for voltage-endurance testing of form-wound bars and coils for large rotating machines*

IEEE Std 1553™:2002, *IEEE Trial-use standard for voltage-endurance testing of form-wound coils and bars for hydrogenerators*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60034-1, IEC 60034-2-1, IEC 60034-2-2, IEC 60050-411 and IEC 63132-1, as well as the following apply.

3.1
hydrogenerator
synchronous machine operated as generator and driven by a hydraulic turbine

3.2
motor-generator
synchronous machine which can operate in motor mode and generator mode, generally used in pumped-storage power plant

3.3
stator concentricity
radial distance from the reference centre to the best centre of stator bore

3.4
rotor concentricity
radial distance from the reference centre to the best centre of rotor outer circle

3.5
stator circularity
difference between the maximum and minimum radii, measured from the best centre of stator bore

3.6
rotor circularity
difference between the maximum and minimum radii, measured from the best centre of rotor outer circle

3.7
Air gap

3.7.1
nominal air gap
design air gap value between stator inner surface and rotor at the centre of poleshoe at rated conditions

3.7.2
static air gap
air gap at standstill and in cold condition after full load rejection

Note 1 to entry: This value is used for the purposes of IEC 63132-1 and IEC 63132-2.

3.8
stress control coating
paint or tape on the surface of the main insulation that extends beyond the conductive slot portion coating in high-voltage stator bars and coils

3.9
condenser
heat exchanger device by which cooling medium is changed to liquid phase from vapour in evaporative cooling circulation system

3.10
grid
public electrical network or a local (e.g. industrial) network which is connected to the machine either directly or through a transformer

3.11
SFC starting
operating mode in which synchronous machine is started in motor mode by the method of regulating power frequency, using static frequency converter (SFC) as variable-frequency power supply

3.12
back to back starting
synchronous starting method in which one machine is started in motor mode, driven by the other electric connected machine that is started in generator mode

4 Site operation conditions

The machines shall be able to operate continuously at rated conditions (MVA, MW, voltage, frequency and power factor) at the following site operation conditions:

a) The altitude does not exceed 1 000 m above sea level (based on coupling elevation for vertical machine, centre line of shaft for horizontal machine);
b) The cooling air temperature (primary coolant) does not exceed 40 °C;
c) The inlet water temperature (secondary coolant) of air coolers, oil coolers and heat exchangers (e.g. of direct water cooled stator windings) is not higher than 25 °C and not less than 5 °C;
d) The inlet water temperature (primary coolant) of direct water cooled stator windings shall be 30 °C to 40 °C, the water conductivity is in the range of 0,4 μS/cm to 2,0 μS/cm, the pH value is 6,5 to 9,0, and the hardness is less than 2 μmol/l, at 25 °C of water temperature;
e) Relative humidity in powerhouse (generator floor) does not exceed 85 %;
f) Installed in covered powerhouse on proper foundation;
g) Structural strength of machine shall meet the requirement of seismic accelerations at the location. Appropriate design measures shall be taken to prevent harmful damage to the machine. The acceleration value may be different for different regions due to the local geographical condition. The acceleration values in horizontal direction and vertical direction shall be defined as a technical condition according to the seismic grade at the location by the purchaser.

Site conditions different from the above shall be agreed between purchaser and manufacturer.

5 Ratings and parameters

5.1 Output

5.1.1 Output rating of a hydrogenerator

The output rating of a hydrogenerator is the apparent power (in MVA) or the active power (in MW), available continuously at the stator terminals (main leads) at rated frequency, voltage and power factor.

5.1.2 Output ratings of a motor-generator

The output ratings of a motor-generator include two parts:

a) The apparent power (in MVA) or the active power (in MW), available continuously at the stator terminals (main leads) at rated frequency, voltage and power factor during generator mode;
b) Mechanical output power (in MW) available continuously at the shaft during motor mode.

5.1.3 Increase in active power

By agreement between purchaser and manufacturer, it is allowed to increase active power of hydrogenerators to rated output (apparent power) by increasing power factor up to 1,0.

5.1.4 Under-excited operation

Hydrogenerators and motor-generators when operating in generator mode shall be able to operate continuously in under-excited mode at power factor 0,9 with rated active power at rated voltage.

5.2 Rated voltage

The rated voltage (line to line voltage U_N at stator terminals) of the machine shall be defined by purchaser and manufacturer according to rated output, rated speed of machine, as well as other conditions in the system.

5.3 Rated power factor

The power factor shall be agreed upon between purchaser and manufacturer. Preferred rated power factors at generator terminals are 0,85; 0,875; 0,9; 0,925 or 0,95 overexcited.

Rated power factor of motor-generators in motor mode shall be defined as a design condition by purchaser.

5.4 Rated speed

The rated speed (1/min) shall be:

$3000/p$ for 50 Hz machines;

$3600/p$ for 60 Hz machines.

where p is the number of pole pairs.

NOTE The preferred speeds in Table 1 and Table 2 are convenient to design electrical symmetric and balanced windings for the machines.

Table 1 – Preferred speed for 50 Hz machines

								Unit: 1/min
1 000	750	600	500	428,6	375	333,3	300	250
214,3	200	187,5	166,7	150	142,9	136,4	125	115,4
107,1	100	93,8	88,2	83,3	75	71,4	68,2	62,5
60								

Table 2 – Preferred speed for 60 Hz machines

								Unit: 1/min
1 200	900	720	600	514,3	450	400	360	300
257,1	240	225	200	180	171,5	163,7	150	138,5
128,5	120	112,6	105,8	100	90	85,7	81,8	75
72								

5.5 P-Q capability diagram

The manufacturer shall supply a P-Q capability diagram indicating the limits of operation as shown in Figure 1, where:

– Curve A represents operation limits with rated stator current and constant apparent power output, which is restricted by temperature rise of the stator winding;

– Curve B represents operation limits with rated field current, which is restricted by temperature rise of the field winding;

– Curve C1 and C2 indicate the theoretical and practical limits set by the effects of end region heating, steady-state stability, etc.

– Curve D indicates the limits of minimum excitation current to prevent instability issues (usually defined by a minimum excitation current of 10 % of the no-load excitation current);
– Curve E indicates the reluctance circle. Although possible, the operation within the reluctance circle needs special care and a special design of the excitation and control systems.

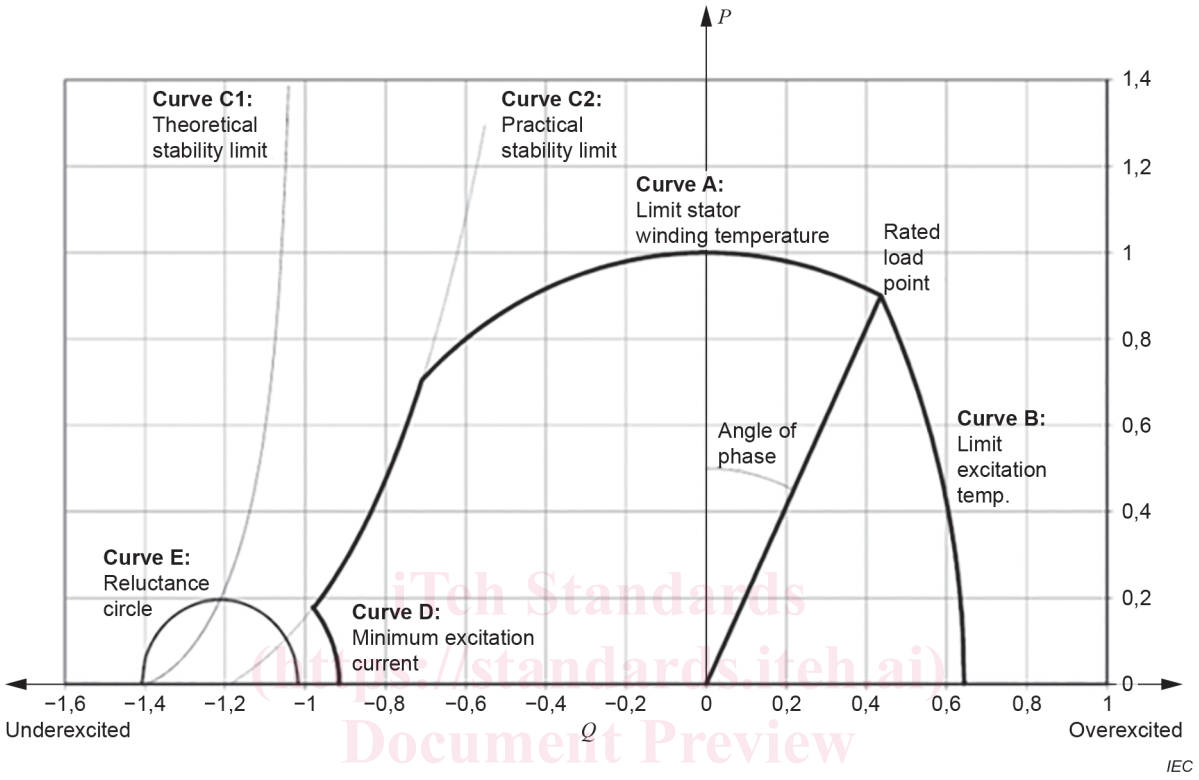

Figure 1 – P-Q capability in p.u.

NOTE Figure 1 shows the limitation of the electrical machine only and does not consider operational limitation of the hydraulic machine.

5.6 Voltage and frequency variations during operation

For generators and motor-generators, combinations of steady state voltage variation and frequency variation are classified as being either zone A or zone B (maximum case outside of zone A), in accordance with Figure 2.

Synchronous hydrogenerators and synchronous motor-generators shall be capable of delivering continuous rated output at the rated power factor, over the ranges of ±5 % in voltage and ±2 % in frequency, as defined by the shaded area of Figure 2 (zone A), but need not fully comply with its performance at rated voltage and frequency (see rated point in Figure 2), and may exhibit some deviations. Temperature rises may be higher than the condition for rated voltage and frequency.

The temperature rise or temperature limits in accordance with this document, such as Table 4, apply at the rated point only and may progressively be exceeded as the operating point moves away from the rated point. For conditions at the extreme boundaries of zone A, the temperature rises and temperature typically exceed the limits specified in this document.

A machine shall be capable of operation within zone B, and reaching the rated output, but will exhibit greater deviations from its performance at rated voltage and frequency than in zone A. Temperature rises will be higher than at rated voltage and frequency and most likely will be higher than those in zone A. Temperature limits for insulation systems may be exceeded. Extended operation at the perimeter of zone B is not recommended at all.