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**Replacing GB/T 20140-2006**

# Measurement Method and Evaluation criteria of Dynamic Characteristic and Vibration on Stator End Windings of Cylindrical Synchronous Generators

隐极同步发电机定子绕组端部动态特性和振动测量方法及评定



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**Standardization Administration of the People's Republic of China.**

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# Foreword

This Standard was drafted in accordance with the rules given in GB/T 1.1-2009.

This Standard replaces GB/T 20140-2006, *Dynamic Characteristic and Vibration Measurement Method of Turbo-generators on Stator Windings and Evaluation Criteria*. Compared with GB/T 20140-2006, the main differences of this Standard are as follows:

-- it modifies the standard name (see the cover page; the cover page of edition 2006);

-- it modifies the application scope of the standard (see Chapter 1; Chapter 1 of edition 2006);

-- it adds the evaluation criteria of 4-pole generators of rotational speed 1 500 r/min and 1 800 r/min (see 6.1);

-- it adds the measurement method for response ratio and the evaluation criteria of dynamic characteristics with response ratio (see 6.1);

-- it adds the vibration limits and evaluation criteria of pass frequency (frequency range greater than or equal to rotational frequency) (see 6.2);

-- it increases the content of Annex A (see A.3, A.4 and A.5).

This Standard was proposed by China Electrical Equipment Industry Association.

This Standard shall be under the jurisdiction of China National Standardization Technical Committee on Large Generators (SAC/TC 511).

The drafting organizations of this Standard: Harbin Institute of Large Electrical Machinery, Dongfang Electric Corporation Dongfang Electric Machinery Co., Ltd., Shanghai Electric Power Station Equipment Co., Ltd., Huadian Electric Power Research Institute Co., Ltd., State Grid Liaoning Province Electric Power Co., Ltd. Electric Power Research Institute, State Grid Hubei Province Electric Power Co., Ltd. Electric Power Research Institute, Beijing Sifang Automation Co., Ltd., China Nuclear Power Engineering Co., Ltd., Beijing Beizhong Steam Turbine Generator Co., Ltd. and State Grid Shandong Province Electric Power Co., Ltd. Electric Power Research Institute.

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The edition of the standard replaced by this Standard is as follows:

-- GB/T 20140-2006.

# Measurement Method and Evaluation criteria of Dynamic Characteristic and Vibration on Stator End Windings of Cylindrical Synchronous Generators

## 1 Application Scope

This Standard specifies the measurement method and evaluation criteria of dynamic characteristic and vibration on stator end windings of cylindrical synchronous generators.

This Standard applies to 4-pole cylindrical synchronous generators of rated rotational speed 1 500 r/min and 1 800 r/min and 2-pole cylindrical synchronous generators of rated rotational speed 3 000 r/min and 3 600 r/min, with a rated power 200 MW and above.

The dynamic characteristic on stator end windings shall be measured for cylindrical synchronous generators before delivery and during new-machine handover, abnormal occurrences during operation (e.g. circuit abrasion or loosening) and overhaul inspection.

When stator end windings are loosened significantly and end windings has unqualified modes such as elliptical or 4-lobe mode shape, during the type test of cylindrical synchronous generators, the vibration should be measured at the end of stator windings.

Refer to this Standard for cylindrical synchronous generators with a rated power below 200 MW.

## 2 Normative References

The following referenced documents are indispensable for the application 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.

GB/T 2298, *Mechanical Vibration, Shock and Condition Monitoring – Vocabulary*

## 3 Terms and Definitions

For the purposes of this Standard, those defined in GB/T 2298 and the following terms

and definitions apply. For the convenience of use, some terms and definitions in GB/T 2298 are also listed as follows.

**3.1**

**natural frequency**

frequency of free vibration of linear systems

**3.2**

**frequency response function**

frequency response function is defined as follows:

a) ratio of steady state output vector to input vector during harmonic excitation;

b) ratio of output Fourier transform to input Fourier transform during instantaneous excitation;

c) ration of output or input cross spectrum to input auto spectrum during stationary random excitation.

**3.3**

**modal test analysis**

vibration test analysis carried out for the determination of system modal parameters. Under normal conditions, frequency response matrix is obtained through the relationship between excitation and response; then modal parameters are identified with the methods such as curve fitting

**3.4**

**modal parameter**

characteristic parameter of a mode, i.e. natural frequency, vibration mode, modal mass, modal stiffness and modal damping of each order of a vibration system

**3.5**

**mode shape**

model of vibration of some given vibration mode of a mechanical system, i.e. the graph described by the maximum displacement of point on neutral plane (or neutral axis) deviating from its equilibrium position. The mode shape values of all points shall usually be normalized in accordance with the deviation values of selected points.

**3.6**

Use an appropriate modal analyzer to do further analysis and fitting for the frequency function obtained, before obtaining modal parameters.

**4.1.2** Measured parameters

The measured parameters are as follows:

a) natural frequency of phase connection and main connection of stator end windings, in Hz;

b) elliptical or 4-lobe mode shape of integral stator end windings;

c) response ratio value corresponding to natural frequency of frequency response function of stator end windings and connection original point, in $(m/s^2)/N$.

**4.1.3** Measuring environment

Modal test analysis for stator end windings shall be carried out at room temperature.

**4.1.4** Measuring position and requirement

The measuring points for connection natural frequency test are mainly located on the axial and tangential line of phase connection and main connection of exciter end windings (radial natural frequency can also be measured). For some units, when exciter end phase connection and end are connected tightly, becoming an entirety which is hard to differentiate, the measurement of natural frequency of connection can be omitted. The manufacturer usually only measure phase connection; the manufacturer measures main connection during type test; the power plant can measure natural frequency of main connection.

The measuring positions for integral end mode shape test are located on the cross sections of end windings on the steam side and exciter side. Take three circles respectively as shown in Figure 1; distribute the measuring points evenly along the circles, with at least 16 measuring points for 2-pole generators and at least 32 measuring points for 4-pole generators. It is recommended that the measurement shall be carried out in the order from circle 1 to circle 3 (see Figure 1). Usually, the data of circle 2 and circle 3 can be measured as required by the analysis, when the mode of circle 1 is measured.

Use viscous material or other methods to fix acceleration sensor temporarily on corresponding measuring positions.

parameters of generator: rotational speed, stator voltage, stator current, active power and reactive power.

#### 4.2.2 Measured parameters

Absolute vibration displacement amplitudes of stator end windings, mainly including peak to peak values of pass frequency (frequency range greater than or equal to rotational frequency) and double frequency vibration displacement, expressed in μm.

#### 4.2.3 Measuring conditions

The measuring conditions are as follows:

a) generators' rated idling;

b) generators' rated no-load;

c) generators' rated short circuit;

d) generators' rated load (on site).

#### 4.2.4 Arrangement of measuring points and mounting

Arrange measuring points on stator windings nose joint, stator windings outgoing line and stator end windings fastener or arrange measuring points at other positions of winding bar as required. Arrange measuring points at the positions having significant abrasion or vibration in accordance with the modal test results of stator end windings. Sensor and signal line shall be mounted securely without influencing the operation and overhaul of generators. When they are used on hydrogen cooling generators, signal line shall be led out of generator stand, which shall meet the requirements for air tight test for generators.

## 5 Measuring Apparatus

### 5.1 Measuring apparatus for dynamic characteristic

#### 5.1.1 Force hammer

Force hammer shall be equipped with a force sensor. The hammer body shall have sufficient mass in order to excite stator end windings. Force hammer of body weight about 1.4 kg is recommended; hammer cover shall be made of materials such as rubber or soft plastic.

#### 5.1.2 Acceleration sensor

Use piezoelectric type acceleration sensor to measure vibration response. ICP type acceleration sensor and signal acquisition and analysis equipment directly matched and connected with it are recommended. The acceleration sensor having a sensibility

**6.2** Evaluation criteria of vibration on stator end windings of cylindrical synchronous generators

**6.2.1** During the rated no-load or rated short-circuit operation of generators, the peak to peak values of pass frequency (frequency range greater or equal to rotational frequency) and double frequency vibration displacement are less than 100 μm.

**6.2.2** During the normal operation of generators, if the peak to peak value of pass frequency (frequency range greater or equal to rotational frequency) and double frequency vibration displacement of stator end windings are less than 250 μm, it is generally acknowledged that they are suitable for long-term operation without limit.

**6.2.3** During the normal operation of generators, if the peak to peak values of pass frequency (frequency range greater or equal to rotational frequency) and double frequency vibration displacement of stator end windings are greater than 250 μm and less than 400 μm, an alarm signal shall be given. Generally, the units can continue to operate for a certain time under such circumstances; during such periods, the reasons for the vibration shall be found out by research and it shall be observed whether vibration can be stabilized within a certain range.

**6.2.4** During the normal operation of generators, if the peak to peak values of pass frequency (frequency range greater or equal to rotational frequency) and double frequency vibration displacement of stator end windings are greater than 400 μm, a halt signal shall be given. Generally, it is inappropriate to continue operation under such circumstances; stop the machine as soon as possible for inspection and treatment, or take corresponding measures to lower the vibration to below the limits in accordance with actual conditions.

**6.2.5** During the normal operation of generators, if the variation of the peak to peak values of pass frequency (frequency range greater or equal to rotational frequency) and double frequency vibration displacement of stator end windings is greater than 100 μm, an alarm signal shall be given and the monitoring shall be enhanced. Generally, if the variation of vibration amplitude reaches a certain quantity, the reasons for the variation shall be found out, no matter whether the vibration amplitude increases or decreases. Such variation can be instantaneous or developed along with time; it may indicate that a damage has occurred, or a fault is to occur, or some abnormal conditions exist.

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