# GB

NATIONAL STANDARD OF THE

PEOPLE'S REPUBLIC OF CHINA

ICS 29.160.01

CCS K 22

# GB/T 1032-2023

Replacing GB/T 1032-2012

# Test Methods for Three-Phase Asynchronous Motors

# 三相异步电动机试验方法

**Issued on: September 7, 2023** **Implemented on: April 1, 2024**

**Issued by: State Administration for Market Regulation;**

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

# Table of Contents

# Test Methods for Three-Phase Asynchronous Motors

## 1 Scope

This Document describes the test requirements and test methods for three-phase asynchronous motors. Test methods include measurement of insulation resistance, measurement of DC resistance, thermal test, load test, no-load test, locked-rotor test, determination of loss and efficiency, torque speed characteristic test, moment of inertia test, short-time over-torque test, Inter-turn insulation impulse voltage test, power frequency withstand voltage test, rotor open circuit voltage measurement, overspeed test, vibration and noise measurement, shaft voltage and bearing current measurement.

This Document applies to three-phase asynchronous motors.

## 2 Normative References

The provisions in following documents become the essential provisions of this Document through reference in this Document. For the dated documents, only the versions with the dates indicated are applicable to this Document; for the undated documents, only the latest version (including all the amendments) is applicable to this Document.

GB/T 755-2019 Rotating electrical machines - Rating and performance

GB/T 10068-2020 Mechanical vibration of certain machines with shaft heights 56 mm and higher - Measurement, evaluation and limits of vibration severity

GB/T 10069.1-2006 Measurement of airborne noise emitted by rotating electrical machines and the noise limits - Part 1: Method for the measurement of airborne noise emitted by rotating electrical machines

GB/T 21211-2017 Rotating electrical machines - Equivalent loading and super-position techniques - Indirect testing to determine temperature rise

GB/T 22715-2016 Impulse voltage withstand levels of form-wound stator coils for rotating A.C. machines

GB/T 22719.1-2008 Interturn insulation of random-wound winding for AC low-voltage electrical machines - Part 1: Test methods

#### 5.2.2 Frequency

During the test and measurement process, the average change in power frequency shall be within ±0.1% of the frequency required for the test (see 5.4.2 in GB/T 25442-2018).

This requirement is not applicable to equivalent circuit method (see 12.6).

### 5.3 Measuring instruments and requirements

#### 5.3.1 General description

Environmental conditions shall be within the specified range given by the instrument manufacturer. If possible, temperature correction should be made according to the instrument manufacturer's instructions.

Digital instruments should be used wherever possible.

The accuracy of analog instruments is usually expressed as a percentage of the full scale. Therefore, the smallest range shall be selected according to the actual situation, and the observed reading should be more than 2/3 of the full scale.

The full-scale range of the instrument (especially the current sensor) shall match the relevant parameters of the motor under test.

#### 5.3.2 Electrical measurement

##### 5.3.2.1 Effective value

Unless otherwise stated, all measurement value of voltage and current are effective value (r.m.s.).

##### 5.3.2.2 Current measuring instruments

Generally, the accuracy of current meters shall be no less than grade 0.5 of their full ranges (megameter excluded). To ensure the accuracy and repeatability of the test results when measuring the motor efficiency using Method A or B (see 12.1.4), it is required that the accuracy of the measuring instruments be no lower than grade 0.2 of the full range.

NOTE: For the inspection test described in 9.1 of GB/T 755-2019, the accuracy level only needs to be 0.5.

Digital instruments have a very large input impedance compared to passive instruments (non-electronic), so there is no need to correct the reading due to the instrument's own losses. But high input impedance instruments are more sensitive to interference. Measures to reduce interference shall be taken based on practical experience.

##### 5.3.2.3 Instrument transformers (or transducer)

The accuracy level of the instrument transformer (or transducer) used for measurement shall be no lower than 0.2. When using method B to determine motor efficiency, if the transformer or transducer and the instrument measuring voltage, current or power are calibrated as a system, the error of the system shall not exceed ±0.2% of the full scale.

**5.3.2.4 Voltage measurement**

The signal wire used to measure the terminal voltage shall be connected with the motor terminal. If this is not allowed on the site, it is required to calculate the corresponding error and correct the readings. Arithmetic mean of the three phase voltages ($U_{uv}$, $U_{vw}$, $U_{wu}$) shall be used to obtain the motor performance.

**5.3.2.5 Current measurement**

Each of the three line-currents of electric motors shall be measured concurrently. Arithmetic mean of the three phase currents shall be used to obtain the motor performance.

When using current transformer (or transducer), the total impedance of the instruments connected with secondary circuit (including connecting wires) shall be no larger than the rated values.

For electric motors with $I_N < 5$ A, current transformer (or transducer) shall not be used except for the locked rotor test and overload test.

**5.3.2.6 Power measurement**

Two-meter method (2 single-phase power meters) shall be used to measure the input power of 3-phase motors. Alternatively, 1 set of 3-phase power meter or 3 sets of single-phase power meters could be used to measure the input power. The voltage signal line of the power meter shall be connected to the winding lead terminal.

If the instrumental loss may affect the accuracy of test data, please correct the instrumental loss and the error thereof in accordance with Annex A.

**5.3.3 Resistance measurement**

The winding D.C. resistance shall be measured using electric bridge or digital micro-ohmmeter, of which the accuracy shall be no less than grade 0.2.

**5.3.4 Frequency measurement**

Accuracy of frequency meter shall be no less than grade 0.1.

**5.3.5 Measurement of rotating speed or slip**

**5.3.5.1 Rotation speed measurement**

temperature (measured with a thermal meter or embedded temperature detector) and the temperature of cooling agent shall not exceed 2K. For large- and medium-scale motors, the keeping time of thermal meters shall be no less than 15 min.

For motors practicing a short working system (S2 working shift), the difference between the winding temperature and the temperature of cooling agent, at the beginning of testing, shall be within 5K.

**6.2.2 Measurement of Winding D.C. end resistance**

**6.2.2.1 General**

D.C. resistance between winding terminals U and V, V and W, W and U is named as end-resistance, which can be separately marked as $R_{UV}$, $R_{VW}$ and $R_{WU}$. Winding DC end-resistance can be measured by bridge method, micro-ohmmeter method, DC voltmeter-ammeter method, etc.

**6.2.2.2 Bridge Method**

Each resistance shall be measured for 3 times, each of which shall be measured and read for number after rebalance of electric bridge when using electric bridge for measuring. Difference between each reading and the arithmetic mean value of 3 times of reading shall be no larger than ±0.5% of the mean value, and the mean value shall be taken as the actual value of the resistance.

If end-resistance of winding is lower than 1 Ω, Kelvin [double-arm] bridge shall be adopted for measuring.

**6.2.2.3 Micro-ohmmeter Method**

When the winding end-resistance is measured with instruments such as automatic monitoring device or digital micro-ohmmeter, the test current of measured winding shall be no more than 10% of the current during its normal operation, and the conduction time shall be within 1 min. In case that the resistance is less than 0.01 Ω, it is not suitable that the current of winding measured is too low.

**6.2.2.4 DC Voltmeter-Ammeter Method**

The principle wiring diagram of the voltmeter-ammeter method is shown in Figure 2. Among them, $R_b$ is the adjusting current limiting resistance, $R$ is the measured winding end resistance, V is the voltmeter, and A is the ammeter. Figure 2a) is applicable to the situation where the ratio of the internal resistance of the voltmeter to the resistance being measured is greater than 200; Figure 2b) is applicable to the situation where the ratio of the internal resistance of the ammeter to the resistance being measured is less than 1/200.

During measurement, the applied current shall be no more than 10% of the rated winding

At the beginning of the thermal test, all temperature measuring devices shall be checked to ensure that they do not increase the temperature measurement error due to the influence of stray magnetic fields.

The temperature of the fully enclosed motor rotor and other parts can be quickly measured with a temperature measuring device after the power is shut down.

### 7.3 Measurement method of temperature

#### 7.3.1 General

There are three methods of temperature measurement:

--- Resistance method;

--- Embedded thermometer method;

---Thermometer method.

Different methods shall not be used for cross-checking.

The indirect measurement method is in accordance with the provisions of GB/T 21211-2017.

#### 7.3.2 Resistance method

The temperature of the winding is determined based on the increase in winding resistance.

The measurement methods are as follows:

--- Use a bridge or micro-ohmmeter of appropriate range and measure directly at the beginning and end of the test, see 6.2.2.2 and 6.2.2.3;

--- Measured with a D.C. ammeter-voltmeter, see 6.2.2.4;

--- Live measurement method, without interrupting the A.C. load current, superimposes a weak D.C. measurement current on the load current, see 8.6.2.1 in GB/T 755-2019.

Small errors in the winding resistance will cause large errors when determining the temperature. Therefore, special attention shall be paid to this measurement to ensure that the accurate resistance value is measured.

#### 7.3.3 Embedded thermometer method

Use a thermometer embedded inside the motor (such as a resistance thermometer, thermocouple or semiconductor negative temperature coefficient thermometer) to measure the temperature. The thermometer is embedded in an out-of-reach part of the motor during the manufacturing process.

#### 7.3.4 Thermometer method

Measure the temperature by attaching a thermometer to an accessible surface of the motor. The term "thermometer" includes not only expansion thermometers, but also non-embedded thermocouples and resistance thermometers. When the expansion thermometer is used to measure the temperature of a location with a strong alternating or moving magnetic field, an alcohol thermometer shall be used instead of a mercury thermometer.

### 7.4 Measurement of cooling agent temperature

#### 7.4.1 Reference cooling medium

The determination of reference cooling medium of the motor shall be as specified in Table 5 of GB/T 755-2019.

#### 7.4.2 Air-cooled motor

For motors cooled by ambient air, multi-point measurements (2 to 3 points) shall be made on the path where the cooling air enters the motor. The measuring point is placed about 1m~2m away from the motor, at half the height of the motor, and shall be protected from the influence of external heat radiation and air flow.

#### 7.4.3 External cooler motor

For motors that use external coolers and pipe ventilation cooling, the temperature of the cooling medium shall be measured at the entrance of the cooling medium into the motor.

#### 7.4.4 Internal cooler motor

For motors cooled that use an internal cooler, the temperature of the cooling medium shall be measured at the outlet of the cooler; for motors with a liquid (usually water) cooler, the temperature of the coolant shall be measured at the inlet of the cooler.

#### 7.4.5 Determination of the cooling medium temperature at the end of the test

##### 7.4.5.1 Continuous working system (S1) and intermittent periodic working system (S3) motors

For continuous working system (S1) and intermittent periodic working system (S3) motors, the cooling medium temperature at the end of the test shall take the average value of the thermometer reading measured at the same time interval during the last 1/4 of the entire test process.

##### 7.4.5.2 Short-time working system (S2) motor

For the cooling medium temperature at the end of the short-time working system (S2) motor test, if the rating is 30min and below, take the average value of the thermometer readings at the

temperature readings shall be regarded as the ring temperature.

### 7.6 Thermal test methods

#### 7.6.1 General

Thermal test methods consist of direct method and indirect method, and the former method is generally preferred, indirect method for continuous rating motor only.

Indirect method includes reduced voltage load method, reduced current load method, and stator frequency method as well as other indirect methods specified in GB/T 21211-2017.

#### 7.6.2 Direct method

##### 7.6.2.1 General

Thermal test by direct method shall be conducted at the rated frequency, rated voltage, and rated load or nominal current.

##### 7.6.2.2 Continuous rating motors (S1)

The thermal test of continuous operating (S1) motors shall be continued under rated load until the temperature of each part reaches stability.

During the test, record the following data once at a time interval of 30 min: three-phase end-voltage $U$, three-phase line-current $I_1$, input power $P_1$, frequency $f$, rotating speed $n$ or slip $s_t$, torque $T_d$ (if any), winding temperature $\theta_{wt}$ (measured by embedded temperature detector or thermal couple thermometer) stator iron core temperature, bearing temperature, cooling agent temperature at the entrance and exit to air channel, and ambient cooling agent temperature $\theta_b$. If the live temperature measurement shall be used, the winding resistance shall also be measured at a time interval of 30 min and before the termination of the test.

If the extrapolation method is used to determine the temperature rise of the winding, the resistance of the winding of the motor under test shall be measured immediately after the power is cut off and stopped, and the resistance $R_N$ shall be determined according to 7.6.5.5 after the rated load thermal test is. For motor with an external cooler and pipe air ventilation cooling, when cutting off the power supply, the supply of cooling medium shall be stopped at the same time.

If the nameplate current is used for testing, the winding temperature rise $\Delta\theta_N$ (K) corresponding to the rated output power is converted as follows:

If $\frac{I_1 - I_N}{I_N}$ exceeds ±5% but within ±10% range, it shall be calculated as per Formula (13):

#### 7.6.4 Multiple rated motors

Motors with multiple ratings (such as multi-speed or oil well motors) shall be thermally tested under the rating state where the highest temperature rise occurs. If it cannot be predicted in advance, the test shall be carried out in each rated state separately. Dual-frequency motors can be tested at any convenient frequency, but the load must be adjusted to be equivalent to the load operating at one frequency, and the maximum temperature rise shall occur when the motor is operated at that frequency.

Motors with a service factor greater than 1.0 shall undergo a thermal test under the service coefficient load condition to determine their temperature rise value. When calculating motor performance, the thermal test value when the service factor is 1.0 (rated power) shall be used.

#### 7.6.5 Test procedure

##### 7.6.5.1 Initial state

If the resistance method is used to determine the winding temperature, the difference between the initial winding temperature and the cooling medium temperature should be no greater than 2K.

For motors tested according to the short-time working quota (S2 working system), the difference between the temperature at the beginning of the thermal test and the cooling medium temperature shall be within 5K.

The test can be carried out at any suitable cooling medium temperature.

##### 7.6.5.2 Permissible overload

It will take a rather long time for motors with a continuous rating to reach a stable temperature. To shorten the test time, it is allowable to have a proper overload (25% to 35%) when preheating the motor.

##### 7.6.5.3 Temperature Measurement

Use appropriate temperature measurement methods (see 7.3) to measure the temperatures of the windings, stator iron core, inlet cooling medium and discharged cooling medium after heating of the motor under test. Each measurement method has its own characteristics and is suitable for measuring the temperature of specific parts of the motor under test.

During the thermal test, the temperature of the following components can be measured with a thermometer. If specified, measurements can be made after shutdown:

a) Stator winding, at least in two locations;

b) Stator iron core, for medium and large motors, at least in two locations;

c) Ambient temperature;

d) The air discharged from the machine base or exhaust ventilation duct or the internal cooling medium discharged from the motor with a circulating cooling system to the cooler inlet;

e) Machine base;

f) Bearings (if they are parts of a motor).

The temperature sensitive element shall be placed where the highest temperature can be measured. For the temperature of air in the incoming and outgoing airflow or other cooling media, the sensitive element shall be placed where the average temperature can be measured.

During the thermal test, a local temperature detector can be used to measure the temperature of each component of the motor. When several local temperature detectors are used to measure the winding temperature, the temperature readings of all temperature detectors shall be recorded, and the maximum value shall be taken as the winding temperature measured by the local temperature detector. There is usually no need to take temperature detector readings after shutdown.

When the motor is equipped with several embedded temperature detectors, the readings of all temperature detectors shall be recorded during the thermal test, and the maximum value shall be taken as the winding temperature measured by the embedded temperature detector.

The temperature of the stator winding of the motor and the rotor winding of the wound motor shall be determined by the resistance measured after the power is turned off (see 7.5.1). The resistance between any two wire ends shall be measured directly at the outlet end, and the initial value and initial temperature of this resistance have been measured. If there is equipment capable of measuring winding resistance during the test, and the accuracy is sufficient, it can also be used.

The temperature of temperature measuring components such as bearings, lubricating oil, etc. equipped on the motor should also be noted and recorded.

**7.6.5.4 Duration of thermal test**

For continuous duty (S1) rated motors, the thermal test shall be continued until thermal stability, that is, until the temperature rise change between two consecutive readings 30 min apart is within 1K. However, for motors whose temperature rise is not easy to stabilize, the thermal test shall be carried out until the temperature rise change between two consecutive readings 60 min apart is within 2K.

For short-time working system (S2) rated motors, the thermal test shall be based on the time specified in the rating.

reduce the impact of motor temperature changes on the test results during the test.

The frequency variation of the power supply shall not exceed ±0.1% at all load points.

At each loading point, measure U, $I_1$, $P_1$, $T_d$ (if any), $n$ (or $s_t$), $f$, $\theta_t$ or $R_t$ (if any), and $\theta_a$.

It should use a temperature sensor (embedded at the end of stator winding) to measure the winding temperature.

When the motor efficiency is measured with Methods B or A, $\theta_t$ and $R_t$ at each point shall be measured in the following a) of this subclause. When the motor efficiency is measured with Methods C, E or E1, it is allowable to determine the resistance at each loading point in accordance with the procedures described in the following b). If the motor efficiency is determined with other methods specified in this Document, it is allowable to determine the resistance at each point in accordance with the procedures described in the following c).

There are 3 methods to measure the resistance at each load point.

a) Preset a temperature sensor on the stator winding, and determine its resistance value by measuring the temperature $\theta_t$ of the stator winding. That is, according to the proportional relationship between temperature and resistance, the resistance value of each load point can be determined by using the initial resistance and initial temperature of the winding measured before the start of the test and the temperature of each point measured.

b) The resistance value greater than and equal to 100% of the rated load point is the resistance value before the maximum load point reading. The resistance value at each point less than 100% rated load is determined in a linear relationship with the load. The starting point is the resistance value at 100% rated load, and the end point is the resistance value after the minimum load reading.

c) After the load test is completed and the power is turned off, the stator winding resistance is immediately measured and used as the resistance value of each load point.

**8.3 Correction of the torque reading**

**8.3.1 General**

When there is a bearing between the torque measuring equipment and the output shaft of the motor under test, there shall be friction loss in the bearing. The torque correction value $T_c$ (N·m) can be obtained based on the friction loss and the torque reading can be corrected.

**8.3.2 The motor under test is tested by coupling the torque measuring equipment to the load motor**

If the load motor is a D.C. motor, its armature winding is open circuit and is not excited. If the load motor is a three-phase asynchronous motor, it is not connected to the power supply.

**This is an excerpt of the PDF (Some pages are marked off intentionally)**



**------ The End ------**