

IEEE Standard Test Procedure for Polyphase Induction Motors Having Liquid in the Magnetic Gap

Sponsor
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of the
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Abstract: Instructions for conducting and reporting the more generally applicable and acceptable tests to determine the performance characteristics of polyphase induction motors having liquid in the magnetic gap are given. Constants in several equations and form apply to three-phase motors only and require modification for application to motors having another number of phases. It is not intended that the procedure cover all possible tests or tests of a research nature. The procedure shall not be interpreted as requiring the making of any or all of the tests described herein in any given transaction.

Keywords: liquid in the magnetic gap, polyphase induction motor, test procedures, three-phase motor

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Introduction

(This introduction is not part of IEEE Std 252-1995, IEEE Standard Test Procedure for Polyphase Induction Motors Having Liquid in the Magnetic Gap.)

In recent years, induction motors have found increasing usage in applications where the rotor operates in a liquid environment. Frequent applications include driving pumps in primary coolant loops in nuclear reactors, in boiler forced circulating systems, and in deep well pumping. From the viewpoint of testing and test procedures, motors designed for these applications differ from more conventional motors principally in having additional loss due to circulating currents in the metallic barriers in the air gap, in having higher friction loss, and in reduced accessibility to the windings and rotating parts. Because of these differences and the increasing usage of such motors, the Induction Machinery Subcommittee of the Rotating Machinery Committee undertook the preparation of this test procedure, which was derived from AIEE Std 500 (now IEEE Std 112-1991, IEEE Standard Test Procedure for Polyphase Induction Motors and Generators).

The Institute wishes to acknowledge its indebtedness to those who have so freely given of their time and knowledge, and have conducted experimental work on which many of the IEEE publications are based.

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IEEE Standard Test Procedure for Polyphase Induction Motors Having Liquid in the Magnetic Gap

1. Scope

This test procedure covers instructions for conducting and reporting the more generally applicable and acceptable tests to determine the performance characteristics of polyphase induction motors having liquid in the magnetic gap. Constants in several equations and forms apply to three-phase motors only and require modification for application to motors having another number of phases. It is not intended that the procedure cover all possible tests or tests of a research nature. The procedure shall not be interpreted as requiring the making of any or all of the tests described herein in any given transaction.

Test report forms are provided with this standard. For the convenience of the user, they are organized into a normative annex.

2. References

This standard shall be used in conjunction with the following references:

IEEE Std 4-1995, IEEE Standard Techniques for High-Voltage Testing (ANSI).¹

IEEE Std 43-1974 (Reaff 1991), IEEE Recommended Practice for Testing Insulation Resistance of Rotating Machinery (ANSI).

IEEE Std 85-1973 (Reaff 1986), IEEE Standard Test Procedure for Airborne Sound Measurements on Rotating Electric Machinery (ANSI).

IEEE Std 112-1991, IEEE Standard Test Procedure for Polyphase Induction Motors and Generators (ANSI).

IEEE Std 118-1978 (Reaff 1992), IEEE Standard Test Code for Resistance Measurements (ANSI).

IEEE Std 119-1974, IEEE Recommended Practice for General Principles of Temperature Measurement as Applied to Electrical Apparatus.²

IEEE Std 120-1989, IEEE Master Test Guide for Electrical Measurements in Power Circuits (ANSI).

¹IEEE publications are available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA.

²IEEE Std 119-1974 has been withdrawn; however, copies can be obtained from Global Engineering, 15 Inverness Way East, Englewood, CO 80112-5704, USA, tel. (303) 792-2181.

3. General

3.1 Kinds of tests

These motors are normally given either a routine test or a complete test.

3.1.1 Routine test

The routine test includes measurement of speed, power input, and current input at no load, rated voltage and frequency; power input and current input with locked rotor; and, winding resistance, insulation resistance, and dielectric test. The locked rotor test may also be performed with single-phase power applied to the motor. Form 1 may be used for reporting such data.

3.1.2 Complete test

The complete test includes a routine test plus additional tests necessary to determine efficiency, power factor, starting torque, breakdown torque, rated-load slip, and rated-load temperature rise.

Form 2 may be used for reporting such data. Additional tests, such as measurement of noise, vibration, and speed-torque characteristics that are described in this test procedure, and other tests, such as measurement of shaft currents that are not covered in this test procedure, may be used.

3.2 Choice of test

A complete list of tests covered by this procedure is given in the contents. Alternate methods are described for making many of the tests. In some cases the preferred method is indicated.

3.3 Cautions

Many IEEE and ANSI standards are referenced in this document. The standards referenced will be those in effect when this revision is approved. Users are cautioned to carefully review the history of old machines with respect to IEEE and ANSI standards in effect at the time when they were manufactured.

4. Electrical measurements

4.1 General

Electrical measurements shall be made in accordance with IEEE Std 120-1989.³

4.2 Power supply

The supply voltage shall closely approach sine-wave form and shall provide balanced phase voltages. The voltage waveform deviation shall not exceed 10%. The frequency shall be closely regulated and shall be measured within an accuracy of 0.1% of rated value.

4.3 Instrument selection

The instruments used in electrical measurements shall be selected to give indications well up on the scale, i.e., where a fraction of a division is easily estimated and where such a fraction is a small percentage of the value read. The indicating instruments shall bear record of calibration within 12 months of the test, indicating limits of error no greater than $\pm 0.5\%$ of full scale.

³Information about references can be found in clause 2.

4.4 Instrument transformers

When current and voltage instrument transformers are used, corrections shall be made for ratio errors in voltage and current measurements and for ratio and phase-angle errors in power measurements. The errors of the instrument transformers shall not be greater than 0.5%.

4.5 Voltage

The phase voltages shall be read at the motor terminals. The arithmetic average of the root-mean-square phase voltages shall be used in calculating machine characteristics.

4.6 Current

The line currents to each phase shall be measured. The arithmetic average of the root-mean-square line currents shall be used in calculating machine characteristics.

4.7 Power

The average power input to a three-phase machine shall be measured by three single-phase wattmeters connected in Y as in the three-wattmeter method, or by two single-phase wattmeters connected as in the two-wattmeter method, or by a single polyphase wattmeter. Correction shall be made for instrument losses.

5. Performance determination⁴

5.1 Temperature

Precautions shall be taken that the internal coolant approximates the design temperature. All performance determinations shall be corrected to a temperature corresponding to the rated temperature of the supplied coolant.

5.2 Pressure

Some designs may require pressurization of the internal coolant for safe operation. In these cases, safety measures appropriate to the design should be exercised.

5.3 Efficiency

Efficiency is the ratio of output power to input power. Unless otherwise specified, the efficiency shall be determined for rated voltage, frequency, and coolant temperature and flow.

5.3.1 Measurements

Readings of power input, current, voltage, frequency, slip, torque, temperature, coolant flow where applicable, and stator coil maximum winding surface temperature or stator winding resistance, shall be obtained for six load points approximately equally spaced from one-quarter (0.25) to one and one-half (1.5) times rated load.

⁴See Form 5 for nomenclature.

5.3.2 Mechanical-output measurement methods

In all mechanical-output measurement method tests, the electrical and mechanical power are measured directly. Performance of a machine may be calculated as shown on Form 3. The output power is calculated as follows:

$$W = K_1 \cdot n \cdot T$$

where

W is output power, in W
 T is torque
 K_1 is 0.142 if T is in lb·ft
 K_1 is 0.1047 if T is in N·m
 n is speed, in r/min

Torque corrections appropriate to the equipment used shall be made.

5.3.2.1 Brake

The *tare* (any locking beam or brake apparatus required for the test, but not part of the complete assembled motor), if present, shall be determined and compensated.

5.3.2.2 Dynamometer

The dynamometer rating should not exceed three (3) times the machine rating, and it should be sensitive to a change of torque of 0.25% of the rated torque.

5.3.3 Segregated-loss methods

The input shall be measured as indicated in 5.3.3.1 or calculated as described in 5.3.3.2. The output shall be determined by subtracting the losses from the input. An induction machine having liquid in the magnetic gap has, or may have, the losses shown in table 1.

Table 1—Losses in machines having liquid in the magnetic gap

Loss designation	Description
Friction and fluid loss	Mechanical loss due to rotation of rotor assembly in its normal environment
Iron core loss	Loss in iron at no load
Can loss ^a	Loss in cans at no load
Stator I^2R loss	Loss in stator windings
Rotor I^2R loss	Loss in rotor windings
Stray-load loss	Load-dependent loss in iron, rotor, and stator cans, and eddy current and high-frequency losses in conductors

^aThe term *can* in this standard refers to a protective cylinder at the stator inside diameter (ID) and/or the rotor outside diameter (OD) that may or may not be an electrically conductive material.