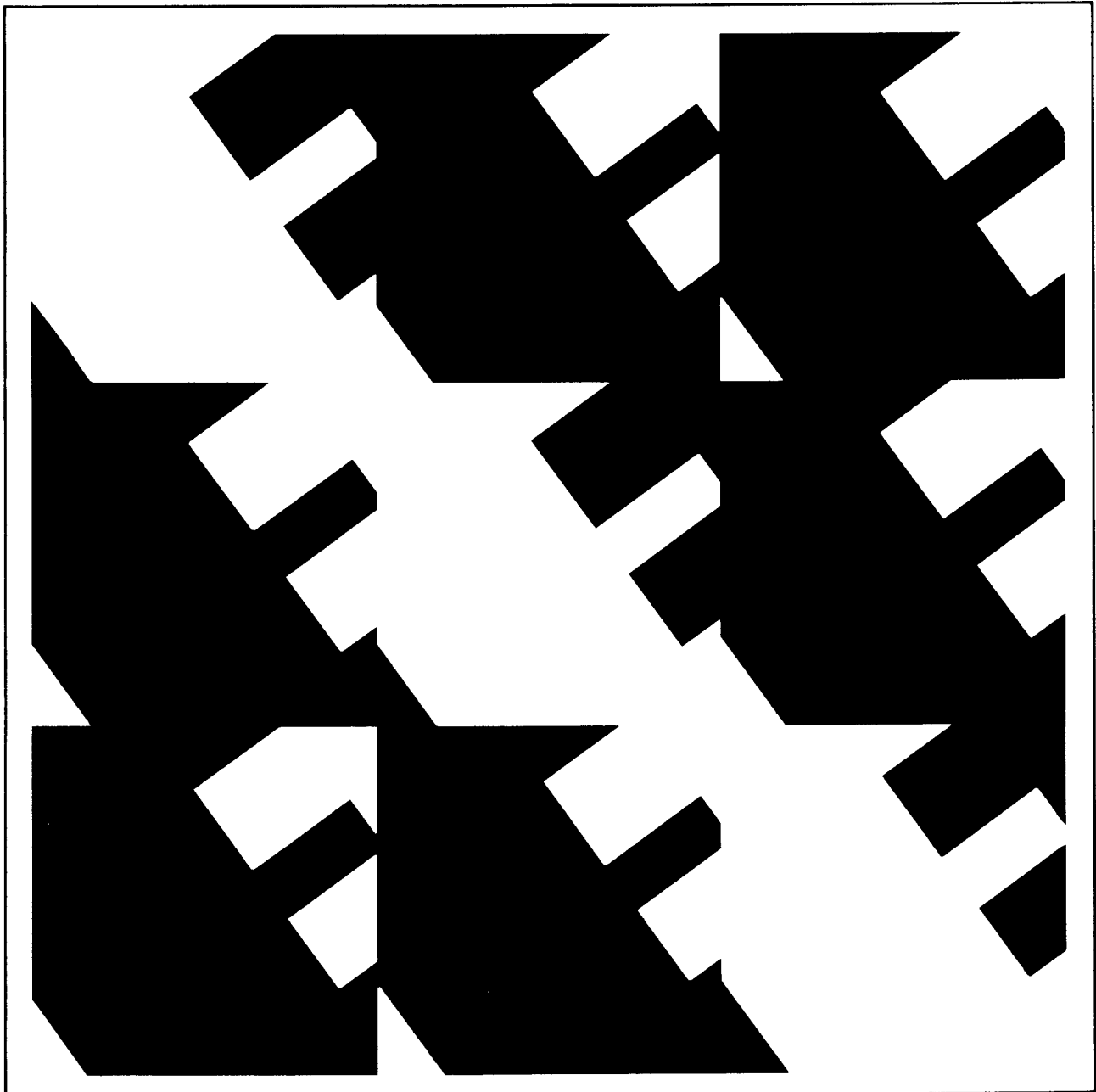


IEEE Guide: Procedures for Testing Single-Phase and Polyphase Induction Motors for Use in Hermetic Compressors



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1. Scope and References

1.1 Scope. This guide specifies test procedures to determine the efficiency and other performance characteristics of hermetic motors. Hermetic motors are electric motors designed to operate as integral parts of compressor units in refrigerators, air conditioners, and heat-pump systems. Such motors are normally manufactured for sale as component parts (that is, rotors and stators) intended for assembly by the compressor manufacturer. For this reason, the procedures set forth here are designed to determine the characteristics of a given rotor and stator under a standardized set of ambient conditions. Because of the wide variety of environmental conditions possible within a compressor, no attempt is made to simulate such operation. This guide deals with both single-phase and polyphase hermetic induction motors. Where test equipment or methods are critical to the accurate determination of motor performance, one or more suggested approaches are described.

1.2 References. This guide is to be used in conjunction with the following publications:

- [1] ANSI/IEEE Std 100-1984, IEEE Standard Dictionary of Electrical and Electronics Terms.¹
- [2] IEEE Std 1-1969, IEEE General Principles for Temperature Limits in the Rating of Electrical Equipment.²
- [3] IEEE Std 118-1978, IEEE Standard Test Code for Resistance Measurement.

¹ This publication is available from the Sales Department, IEEE Service Center, 445 Hoes Lane, Piscataway, NJ 08854. Copies are also available from the Sales Department, American National Standards Institute, 1430 Broadway, New York, NY 10018.

² IEEE publications are available from the Sales Department, IEEE Service Center, 445 Hoes Lane, Piscataway, NJ 08854.

[4] IEEE Std 119-1974, IEEE Recommended Practice for General Principles of Temperature Measurement As Applied to Electrical Apparatus.

[5] IEEE Std 120-1955 (R 1972), Master Test Code for Electrical Measurements in Power Circuits.

2. Tests—General

2.1 Types of Tests. The standard test report on a hermetic motor should include data on starting (or locked-rotor) torque, low-speed torque, *maximum running torque*, breakdown torque, and also efficiency, line current, power factor, and speed at rated-load torque. The rated torque is usually full-load torque, but can be any other specified torque. Additional tests to determine temperature rate of rise at locked-rotor conditions (for the motor windings and rotor end rings), speed-torque characteristics and curves for relay application may also be conducted. The tests are summarized as follows:

- (1) Locked-rotor torque (LRT)
- (2) Locked-rotor amperes (LRA)
- (3) Maximum running torque (MRT)—Torque at 83.3% synchronous speed
- (4) Breakdown torque (BDT)
- (5) Low-speed torque (LST)—Torque at 8.33% synchronous speed
- (6) The following data at rated voltage and torque:
 - (a) Torque
 - (b) Speed
 - (c) Output power
 - (d) Input power
 - (e) Efficiency
 - (f) Power factor
 - (g) Line current
 - (h) Capacitor voltage (if applicable)
- (7) Plots of the following data as functions of torque:

- (a) Speed
- (b) Input power
- (c) Efficiency
- (d) Power factor
- (e) Line current
- (f) Capacitor voltage (if applicable)
- (8) Temperature rate of rise at locked-rotor conditions
- (9) Tests necessary for application of starting devices (if used)

2.2 Test Conditions. Unless otherwise requested, all tests should be taken at rated voltage and frequency, beginning with the motor at 25 °C (77 °F) in air. Additional details are noted in Section 4 with descriptions of the individual test methods.

3. Measurements

3.1 RMS Quantities. All electrical quantities are root-mean-square values unless otherwise indicated.

3.2 Power Supply. Inasmuch as the performance of an induction motor is dependent, not only upon the values of the voltage and frequency, but also upon the wave shape of the voltage, correct data can be obtained only by careful measurement and the use of a suitable source of power for the tests.

The supply voltage shall closely approach a sinusoidal waveform, and its waveform deviation factor shall not exceed 5% (see ANSI/IEEE Std 100-1984 [1]).³ In this reference, the *equiv-*

³The numbers in brackets correspond to the numbers of the references in 1.2.

alent sine wave is one having the same frequency and root-mean-square value as the one used for testing. The frequency shall be maintained within an accuracy of 0.1%.

Means should be provided whereby the voltage can be adjusted to the desired value. This control can be effected by the use of a continuously variable transformer or autotransformer, by an induction regulator, or by a controlled motor-generator set. Electronic voltage control systems may tend to produce nonsinusoidal voltages, and may be used if all voltage spikes have been eliminated from the voltage waveform, and the waveform deviation factor is 5% or less. The voltage source used in testing polyphase motors should be essentially balanced. During the test the negative sequence voltage should not exceed 0.1% of the positive sequence voltage.

3.3 Preferred Arrangement of Electrical Measuring Instruments

3.3.1 Single-Phase Motor Tests. The circuit diagram of Fig 1 shows the preferred connection of instruments for tests of single-phase hermetic motors.

3.3.2 Three-Phase Motor Tests. The circuit diagram of Fig 2 shows the preferred connection of instruments for tests of three-phase hermetic

Fig 1
Preferred Instrument Arrangement for Single-Phase Motor Tests

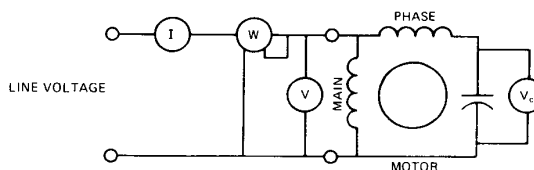
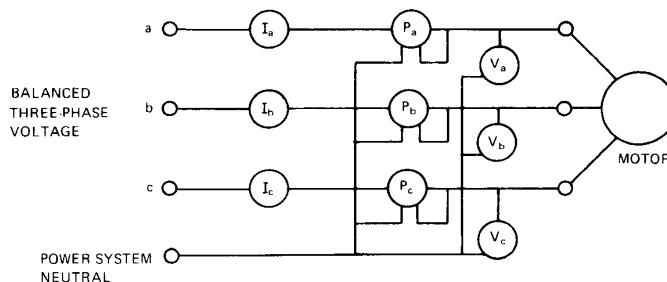


Fig 2
Instrument Arrangement for Three-Phase Motor Tests



motors. Note the preference of measurement of power by the *three-wattmeter* method. The accuracy of this method is superior to that of the two-wattmeter method, particularly at low power factor. However, the two-wattmeter method may be considered as an option. See IEEE Std 120-1955 (R 1972) [5] for instrument connections.

3.4 Instrument Selection. Measurements of voltage, current, and power are likely to be made under one of the following conditions:

- (1) Self-contained meters may be used to take steady-state readings
- (2) Electronic meters may be connected to voltage, current, and power transducers to take steady-state readings
- (3) Transducers may be connected to a plotter to take continuous graphical readings during dynamic tests
- (4) Analog outputs of transducers may be connected to analog-to-digital converters (ADC) to facilitate digital data acquisition by a computer
- (5) Voltage and current waveforms may be sampled at close intervals in their cycles, and a computer used to calculate instantaneous power, average power, and root-mean-square values of voltages and current

Regardless of the method used in data acquisition, instruments should be selected with accuracies of $\pm 0.25\%$ of full scale or better and ranges chosen so that indications are well up on the scale. Additional restrictions on accuracy are given in 3.5, 3.6, and 3.7. Further information regarding the use of instruments will be found in IEEE Std 120-1955 (R 1972) [5].

When multimeters or other steady-state read-out devices are used with transducers to measure electrical quantities, the overall accuracy should be $\pm 0.25\%$ of full scale or better. Compensation should be made for any zero offset in the transducer output. Transducers used for continuous data acquisition should be chosen to coordinate well with the data acquisition system. Full scale on the transducer should correspond as closely as possible to full scale on the recording device. Time constants of all of the transducers selected should be adequate and compatible to the data acquisition system and to the characteristics of the test signals being measured. The internal losses of transducers should be shown to be negligible when compared to the magnitudes being measured.

If an analog-to-digital converter (ADC) is used

between a measurement transducer and a computer, the accuracy of the stored value of the quantity being measured should be within $\pm 0.25\%$ of full scale of the transducer to which it is connected. Word size of any microprocessor used in data acquisition should be sufficient to maintain this accuracy. If dynamic tests are involved, care should be taken to compensate for the differing response times of the transducers. Data from the various transducers should be delayed or time shifted in such a way that the stored data represent simultaneous conditions at a given instant during the test or at a given motor speed.

When computer sampling of voltage and current waveform is used as a technique for obtaining data, samples of all waveforms should be taken simultaneously, or, if taken sequentially, the sampling frequency should be sufficiently high as to maintain an accuracy of measurement of $\pm 0.25\%$ of full scale in the calculation of average power.

3.5 Voltage Measurements. Voltage should be read at the motor terminals and at the terminals of the capacitor, if any. In testing polyphase motors, the voltage may be read between any two motor terminals, if it has been determined that the line voltages at the motor terminals are balanced within 0.1%. However, the use of three voltmeters or voltage sensors connected in wye (Y) to the power system neutral is recommended. For the purpose of correcting current readings, as in 3.6.1.2, the voltmeter circuit neutral should be connected to the neutral of the wattmeter (or watt transducer) potential leads (see Fig 2). Voltage meters or transducers should provide true root-mean-square readings. They should have sufficiently high impedance so that their effects on current and power readings are negligible. Voltage instruments should be chosen so that their readings are accurate to within $\pm 0.25\%$.

Line Voltage Determination in Three-Phase Tests. It is assumed that the line-to-line voltages of the source used in testing three-phase motors are balanced, as specified in 3.2. If the line-to-system neutral voltages are balanced, the three voltage readings should be equal within the specified accuracy of $\pm 0.25\%$ of full scale. If this condition exists, the line voltage is taken to be

$$V_L = \sqrt{3} \left(\frac{V_a + V_b + V_c}{3} \right) = \frac{(V_a + V_b + V_c)}{\sqrt{3}} \quad (\text{Eq 1})$$