FM Approvals®

Member of the FM Global Group

Examination Standard for Electric Fire Pump Motors

Class Number 1320

June 2024

Foreword

This standard is intended to verify that the products and services described will meet stated conditions of performance, safety and quality useful to the ends of property conservation. The purpose of this standard is to present the criteria for examination of various types of products and services.

Examination in accordance with this standard shall demonstrate compliance and verify that quality control in manufacturing shall ensure a consistent and reliable product.

TABLE OF CONTENTS

1 INTRODUCTION

1.1 Purposes

1.1.1 This standard states testing and certification criteria for electric motors used to drive fire pumps that supply water to fire protection systems. These electric motors must have an extended service life, throughout which they must be capable of operating reliably at rated power and speeds during emergency fire incidents, despite being idle for extended periods.

1.1.2 Testing and certification criteria may include performance requirements, marking requirements, examination of manufacturing facility(ies), audit of quality assurance procedures, and a surveillance program.

1.2 Scope

1.2.1 This standard contains the electric motor requirements specific to the fire pump application including inverter duty rated motors for variable speed fire pump applications. This standard covers only motors rated less than 500hp (373kW) and 600V.

1.2.2 This standard is intended to supplement one or more of the following standards for electric motor construction:

- ANSI/NEMA MG 1- Motors and Generators
- ANSI/UL 1004-1 - Rotating Electric Machines – General Requirements
- IEC 60034 - Rotating Electric Machines

1.2.3 The installation of motors covered in this standard should be in accordance with local jurisdictional requirements.

1.3 Basis for Requirements

1.3.1 The requirements of this standard are based on experience, research and testing, and/or the standards of other organizations. The advice of manufacturers, users, trade associations, jurisdictions and/or loss control specialists was also considered.

1.3.2 The requirements of this standard reflect tests and practices used to examine characteristics of electric motors for the purpose of obtaining certification.

1.4 Basis for Certification

Certification is based upon satisfactory evaluation of the product and the manufacturer in the following major areas:

1.4.1 Examination and tests on production samples shall be performed to evaluate:

- the suitability of the product,
- the performance of the product as specified by the manufacturer and required for certification,
- the durability and reliability of the product.

1.4.2 An examination of the manufacturing facilities and audit of quality control procedures may be conducted to evaluate the manufacturer's ability to consistently produce the product which is examined and tested, and the marking procedures used to identify the product. Subsequent surveillance may be

required by the certification agency in accordance with the certification scheme to ensure ongoing compliance.

1.5 Basis for Continued Certification

The basis for continual certification may include the following based upon the certification scheme and requirements of the certification agency:

- production or availability of the product as currently certified;
- the continued use of acceptable quality assurance procedures;
- compliance with the terms stipulated by the certification;
- satisfactory re-examination of production samples for continued conformity to requirements; and
- satisfactory surveillance audits conducted as part of the certification agencies product surveillance program.

1.6 Effective Date

The effective date of this examination standard mandates that all products tested for certification after the effective date shall satisfy the requirements of this standard.

The effective date of this standard is the date of publication.

1.7 System of Units

Units of measurement used in this Standard are United States (U.S.) customary units. These are followed by their arithmetic equivalents in International System (SI) units, enclosed in parentheses. The first value stated shall be regarded as the requirement. The converted equivalent value may be approximate. Conversion of U.S. customary units is in accordance with ANSI/IEEE/ASTM SI 10.

1.8 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 cited edition applies.

ANSI/IEEE/ASTM SI 10, *American National Standard for Metric Practice*

ANSI/ASTM E230, *Standard Specification and Temperature-Electromotive Force (EMF) Tables for Standardized Thermocouples*

ANSI/NEMA MG1, *Motors and Generators*

ANSI/UL 1004-1, *Rotating Electric Machines – General Requirements*

IEC 60034*, Rotating Electric Machines*

1.9 Terms and Definitions

For purposes of this standard, the following terms apply:

Anti-friction Bearings – Bearings that contain moving elements to provide low friction support surfaces for rotating or sliding surfaces – commonly made with hardened rolling elements and races.

Electric Fire Pump Motor – An electric motor specifically designed to drive fire pumps.

Electric Motor Efficiency – The ratio between power output (mechanical) and power input (electrical).

Electric Motor Power Factor – The phase angle between voltage and current (cos ϕ), used to calculate the power consumption of a motor.

Fire Pump – A pump used in water-based fire protection systems to increase the pressure of a water source when that source is not adequate for the system it's supplying.

Flexible Drive Coupling – A motor-to-pump shaft connection designed to accommodate some degree of misalignment between the shafts and provide a smooth transmission of torque and power while absorbing shock, vibration, and noise. They are suitable for application with moderate misalignment and variable load conditions.

Insulation Class – An electrical insulation system used in electric motors and other wire-wound electrical components, which is divided into different classes by temperature and temperature rise.

Inverter Duty Rated Motor – A motor whose speed is controlled by an inverter or VFD (variable frequency drive).

IP (Ingress Protection) – An international standard (IEC 60529) used to rate the degree of protection or sealing effectiveness in electrical enclosures against the intrusion of object, water, dust or accidental contact.

Locked Rotor – A condition which occurs when a motor's rotor is prevented from turning, usually due to a mechanical obstruction or excessive load.

Service Factor – The capacity of a motor to operate efficiently beyond its rated capacity for short periods. A multiplier which, when applied to rated power, indicates a permissible power loading that may be carried under the conditions specified for the service factor.

Thermocouple – a thermoelectric device for measuring temperature, consisting of two wires of different metals connected at two points, a voltage being developed between the two junctions in proportion to the temperature difference.

Variable Frequency Drive – a type of motor controller that drives an electric motor by varying the frequency and voltage of its power supply.

2 GENERAL INFORMATION

2.1 Product Information

Electric fire pump motors are single- or multi-phase electric motors used to drive fire pumps as defined by NFPA 20. Electric fire pump motors are expected to start and perform reliably for the purpose of supplying water to fire protection systems.

Variable frequency installations that use inverter duty rated motors are included in this standard.

2.2 Certification Application Requirements

The manufacturer shall provide the following preliminary information with any request for certification consideration:

- a complete list of all models, types, sizes, and options for the products or services being submitted for certification consideration;
- general assembly drawings, complete set of manufacturing drawings, materials list, anticipated marking and nameplate format, brochures, sales literature, spec. sheets, installation, operation and maintenance procedures; and
- the number and location of manufacturing facilities.

All documents shall identify the manufacturer's name, document number or other form of reference, title, date of last revision, and revision level. All documents shall be provided with English translation.

2.3 Requirements for Samples for Examination

2.3.1 Following authorization of a certification examination, the manufacturer shall prepare samples for examination and testing based on the following:

- sample requirements to be determined by the certification agency.

2.3.2 Requirements for samples may vary depending on design features, results of prior or similar testing, and results of any foregoing tests.

2.3.3 The manufacturer shall submit samples representative of production.

2.3.4 It is the manufacturer's responsibility to provide any necessary test fixtures, such as those which may be required to evaluate the electric motor fire pump drivers.

3 GENERAL REQUIREMENTS

3.1 Review of Documentation

3.1.1 During the initial evaluation and prior to physical testing, the manufacturer's specifications and details shall be reviewed to assess the ease and practicality of installation and use. The certification examination results may further define the limits of the final certification.

3.2 Physical or Structural Features

3.2.1 Electric motors shall conform to the motor construction requirements in one or more of the standards listed in section 1.2.2.

3.2.2 The shaft shall be of adequate size and strength to successfully transmit the torques encountered in starting and during operation.

Calculations shall be provided to verify the maximum torsional shearing stress, as calculated by the formula below, shall not exceed 30 percent of the elastic limit in tension and 18 percent of the ultimate tensile strength of the shaft material. For shafts with keyways, a further 25 percent reduction is required.

Maximum Torsional Shearing Stress:

English

$$S_s = \frac{3.21 \times 10^5 \times P}{n \times d^3}$$

Metric

$$S_s = \frac{4.86 \times 10^{10} \times P}{n \times d^3}$$

Where: S_s - Torsional shear stress, psi (kPa)
P - Maximum input power demand, hp (kW)
n - Rated speed, r/min
d - Shaft diameter, in. (mm)

3.2.3 The electric fire pump driver output shaft shall be arranged to allow the working space required to service a fire pump when a fire pump is connected directly to the motor. If a flexible drive coupling is used, it shall not have a center element that is elastomeric or polymeric without having metal-to-metal contact of components to drive the pump in case of center element failure. The coupling assembly shall permit minor angular and parallel misalignment as restricted by both the pump and coupling manufacturers.

3.2.4 Suitable bearings shall be provided to ensure smooth, low friction rotation of the drive shaft. When anti-friction bearings are used, they shall be designed to withstand the maximum radial and thrust loads encountered during maximum load conditions.

To provide adequate durability, anti-friction bearings shall have the following features:

- a minimum calculated life rating of not less than 5000 hours at maximum load;
- arrangement to float axially on one or both ends;
- grease lubrication, with a grease fitting and relief hole if lubrication is necessary.

Calculations shall be provided to verify the bearing life exceeds the 5000-hour requirements.

3.3 Markings

3.3.1 A permanently marked, legible, corrosion-resistant nameplate shall be securely attached to the exterior of the electric motor where it shall be easily visible. The nameplate shall include the minimum following information:

- name and address of the manufacturer or marking traceable to the manufacturer;
- date of manufacture or code traceable to date of manufacture or lot identification;
- model number, rated voltage, full-load amperes, service factor amperes. locked rotor amperes, rated speed, rated power, service factor, insulation class, rated ambient temperature, rated frequency, number of phases.

When hazard warnings are needed, the markings should be universally recognizable.

3.3.2 The model or type identification shall correspond with the manufacturer's catalog designation and shall uniquely identify the certification agency's mark of conformity.

3.3.3 The certification agency's mark of conformity shall be displayed visibly and permanently on the product and/or packaging as appropriate and in accordance with the requirements of the certification agency. The manufacturer shall exercise control of this mark as specified by the certification agency and the certification scheme.

3.3.4 All markings shall be legible and durable.

3.4 Manufacturer's Installation and Operation Instructions

3.4.1 The manufacturer shall:

- prepare instructions for the installation, maintenance, and operation of the product;
- provide facilities for repair of the product and supply replacement parts, if applicable; and
- provide services to ensure proper installation, inspection, or maintenance for products of such nature that it would not be reasonable to expect the average user to be able to provide such installation, inspection, or maintenance.

3.5 Calibration

3.5.1 Each piece of equipment used to verify the test parameters shall be calibrated within an interval determined on the basis of stability, purpose, and usage. A copy of the calibration certificate for each piece of test equipment is required. The certificate shall indicate that the calibration was performed against working standards whose calibration is certified and traceable to an acceptable reference standard and certified by an ISO/IEC 17025 accredited calibration laboratory. The test equipment shall be clearly identified by label or sticker showing the last date of the calibration and the next due date. A copy of the service provider's accreditation certificate as an ISO/IEC 17025 accredited calibration laboratory should be available.

3.5.2 When the inspection equipment and/or environment is not suitable for labels or stickers, other methods such as etching of control numbers on the measuring device are allowed, provided documentation is maintained on the calibration status of thus equipment.

4 PERFORMANCE REQUIREMENTS

4.1 General

4.1.1 The voltage of the test circuit for the performance tests shall be at rated voltage unless stated otherwise in the individual tests.

4.1.2 The tests are capable of being conducted in any order, as long as the dielectric voltage-withstand test of clause 4.8 is conducted on a motor in a heated condition.

4.1.3 When a single motor sample is used for several or all tests, only one dielectric voltage-withstand test of clause 4.8 shall be performed on the sample. It shall be performed after all other tests for that sample have been completed and the motor sample is in a heated condition. When a single motor sample is used for each test, the dielectric voltage-withstand test of clause 4.8 shall be performed as required on each sample.

4.2 Rated Performance Testing

4.2.1 One sample of a fire pump motor is to be connected to a source of supply and loaded to the rated horsepower multiplied by the rated service factor. The motor is to be operated at rated frequency and voltage. The service factor current is to be measured. Also, the full-load current is to be measured and the full-load power is to be calculated.

$P_{Mech} = P_{Elec} \cdot Eff. = \sqrt{3} \cdot U_{Line} \cdot I_{Line} \cdot \cos \varphi \cdot Eff.,$

where:

P_{Mech} is the mechanical power measured at the output shaft,
P_{Elec} is the electrical power,
Eff. is efficiency declared by the manufacturer,
U_{Line} is the line voltage,
I_{Line} is the line current, and
$\cos \varphi$ is the power factor.

4.2.2 All measurements must meet manufacturer’s published specifications.

4.3 Voltage Variation

4.3.1 An induction fire pump motor shall operate when subjected to a voltage of 10 percent higher and 10 percent lower than the nameplate voltage for each voltage rating. For motors with a voltage range, the test specified in 4.3.2 shall be performed at 110 percent of the maximum rated voltage and at 90 percent of the minimum rated voltage.

4.3.2 One sample of a fire pump motor is to be connected to a source of supply and loaded to the rated horsepower, multiplied by the rated service factor. The motor is to be operated at rated frequency and voltage. The voltage is then to be reduced to 90 percent of the rated voltage and operated for one minute. The voltage is then to be increased to 110 percent of the rated voltage and operated for one minute.

4.3.3 The motor must produce the expected speed and power according to manufacturer’s published specifications.

4.4 Temperature Rise Test

4.4.1 The temperature test is to be conducted with the machine under test delivering full rated mechanical output, multiplied by the rated service factor if provided.

4.4.2 Samples shall be provided for each unique housing, choosing the highest power variant for that housing. If testing of the highest power variant is satisfactory, the balance of lower powered variants shall be considered to be satisfactory.

4.4.3 The temperature test is to be conducted until thermal stabilization is attained. A temperature rise shall be considered to be constant when three successive readings, taken at intervals of 10 percent of the previously elapsed duration of the test (but not less than 10 minute intervals), are constant within 1.8 °F (1 °C).

4.4.4 With the exception of coils and windings, all temperatures are to be measured by a thermocouple. Thermocouples are to consist of wires not larger than 20 AWG (0.518 mm^2). The thermocouple wire shall conform to the requirements specified in the "Tolerances on Initial Values of EMF versus Temperature" tables in the Standard Specification and Temperature-Electromotive Force (EMF) Tables for Standardized Thermocouples, ANSI/ASTM E230/E230M.

4.4.5 The thermocouple is to be attached so that the welded bead is in direct contact with the component whose temperature is being measured. The contact point is to be held in place by a means that provides good thermal conductivity.

4.4.6 Temperature rise on materials or components shall not exceed the values specified in Table 4.3.

Table 4.3

Materials and components	**°F**	**(°C)**
1. At any point within a terminal box or wiring compartment of a permanently connected appliance in which power-supply conductors are to be connected in the field, including such conductors themselves.	140	(60)
2. Class H (180) Thermocouple method	329	(165)
3. Class N (200) Thermocouple method	356	(180)

4.5 Locked Rotor Test

4.5.1 A fire pump motor, including those rated for use with an inverter (variable frequency drive), is to be operated continuously for 24 seconds at rated voltage plus the service factor and rated frequency with the rotor locked. The locked-rotor current is to be measured during the first 3 seconds of the test.

4.5.2 A fire pump motor shall continue to operate and show no evidence of electrical breakdown as a result of the locked-rotor current evaluation specified in 4.5.1.

4.5.3 The measured locked-rotor current for a polyphase motor shall not exceed the values in ANSI/NEMA MG-1, Table 12-1A for 60 Hz motors and ANSI/NEMA MG-1, Table 12-1C) for 50 Hz motors when adjusted to the rated voltage. For voltages other than 230 V or 380 V, the locked-rotor current shall be inversely proportional to the voltages. (For example, for a 460 V motor, the maximum locked-rotor current at a given horsepower rating is half the maximum value at 230 V.)

4.5.4 After the locked-rotor operation and while still in a heated condition, the motor shall be subjected to the Dielectric Voltage-Withstanding Test of clause 4.8 without evidence of electrical breakdown. The motor shall operate after the application of the dielectric potential.

4.6 Cycle Testing

4.6.1 One sample of the motor is to be started at no load. The loading device is to then be adjusted so that the motor operates at rated voltage, frequency, and horsepower, including the service factor, for 5 minutes. After five minutes, the load is to be reduced to no load, the sample is to be disconnected from the power source and is to coast to a complete stop. Immediately after a complete stop is attained, the sample is to be started again. A total of twelve cycles of starting and stopping the motor are to be performed with 5 minute cool-down periods between each cycle.

4.6.2 When the characteristics of the intended pump are known and quantified and when agreeable to those concerned the total number of cycles shall be reduced by "modeling". The modeling method shall create the same level of heat that is generated in the field when the motor is connected to the pump. The modeling is to use the inertias and load levels and acceleration and deceleration times that would be experienced by the motor when coupled to the intended pump. When using inertias, consideration is to be given to the motor-pump inertia versus the motor-test load (Dynamometer, for example) inertia.

4.6.3 Throughout these test cycles, the machine under test must produce the rated speed and power without exceeding the maximum allowed winding temperatures as stated in Table 4.3

4.7 Environmental Testing

4.7.1 To protect against water ingress, electric motors for fire pump service require minimum rating equivalent to a NEMA open drip-proof type, Type 2, or have a minimum IEC rating of IP22.

4.7.2 One sample of a fire pump motor is to be subjected to the test requirements of NEMA 250, meeting those requirements for a rating of NEMA Type 2 or greater, or to the test requirements of IEC 60529, meeting those requirements for a rating of IP22 or greater.

4.7.3 Alternatively, the manufacturer may supply evidence of NEMA 250 or IEC 60529 ingress protection testing from an accredited laboratory.

4.8 Dielectric Testing

4.8.1 A sample of the electric motor for fire pump service shall withstand, without electrical breakdown, the application of an AC voltage at a frequency of 40 – 70 hertz or a DC voltage at a magnitude and duration as described in section 4.8.2, between the primary winding and accessible dead metal parts that are capable of becoming energized.

4.8.2 The test voltage is to be obtained from a continuously adjustable source. Starting at zero, the applied voltage is to be gradually increased to $1000\ V + V_{rating}$ when using an AC test source, or $1400 + 2.8V_{rating}$ when using a DC source, where V_{rating} is the electric motor voltage rating in volts.

4.8.3 The maximum test voltage is to be applied for 60 seconds.

5 MANUFACTURER'S REQUIREMENTS

5.1 Demonstrated Quality Control Program

5.1.1 A quality assurance program is required to assure that subsequent products produced by the manufacturer shall present the same quality and reliability as the specific products examined. Design quality, conformance to design, and performance are the areas of primary concern.

- Design quality is determined during the examination and tests and may be documented in the certification report.
- Continued conformance to this standard is verified by the certifier's surveillance program.
- Quality of performance is determined by field performance and by periodic re-examination and testing.

5.1.2 The manufacturer shall demonstrate a quality assurance program which specifies controls for at least the following areas:

- existence of corporate quality assurance guidelines;
- incoming quality assurance, including testing;
- in-process quality assurance, including testing;
- final inspection and tests;
- equipment calibration;
- drawing and change control;
- packaging and shipping; and
- handling and disposition of non-conforming materials.

5.1.3 Documentation/Manual

There should be an authoritative collection of procedures/policies. It should provide an accurate description of the quality management system while serving as a permanent reference for implementation and maintenance of that system. The system should require that sufficient records are maintained to demonstrate achievement of the required quality and verify operation of the quality system.

5.1.4 Records

To assure adequate traceability of materials and products, the manufacturer shall maintain a record of all quality assurance tests performed, for a minimum period of two years from the date of manufacture.

5.1.5 Drawing and Change Control

- The manufacturer shall establish a system of product configuration control that shall allow no unauthorized changes to the product. Changes to critical documents, identified in the certification report, may be required to be reported to, and authorized by the certification agency prior to implementation for production.
- Records of all revisions to all certified products shall be maintained.

5.2 Surveillance Audit

5.2.1 An audit of the manufacturing facility may be part of the certification agencies surveillance requirements to verify implementation of the quality assurance program. Its purpose is to determine that the manufacturer's equipment, procedures, and quality program are maintained to ensure a uniform product consistent with that which was tested and certified.

5.2.2 Certified products or services shall be produced or provided at, or provided from, location(s) disclosed as part of the certification examination. Manufacture of products bearing a certification mark is not permitted at any other location prior to disclosure to the certification agency.

5.3 Product Modification

5.3.1 The manufacturer shall notify the certification agency of changes in product construction, components, raw materials, physical characteristics, coatings, component formulation or quality assurance procedures prior to implementation.

5.4 Manufacturing and Production Tests

5.4.1 Test Requirement No. 1 - Measurement of winding resistance

The manufacturer shall measure winding resistance of each production unit to be sure that it is within design parameters.

5.4.2 Test Requirement No. 2 - No-load readings of current and speed

The manufacturer shall measure the no-load current and speed of each production unit at normal voltage and frequency to be sure that they are within design parameters.

5.4.3 Test Requirements No. 3 - High-potential testing

The manufacturer shall subject each production unit to a high-potential test as described in ANSI/NEMA MG-1, sections 3 and 12.3.

6 BIBLIOGRAPHY

ISO/IEC 17025, *General Requirements for the Competence of Testing and Calibration Laboratories*.