



Member of the FM Global Group

Examination Standard for Electric Submersible Motors for Use In Class I, Division 1, Hazardous (Classified) Locations

Class Number 3650

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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.

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1 INTRODUCTION

1.1 Purpose

1.1.1 This standard states testing and certification requirements for electric submersible motors for Class I, Division 1 hazardous (classified) locations.

1.1.2 Testing and certification criteria may include, but are not limited to, 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 basic requirements for the construction and testing of electric submersible motors.

1.2.2 This standard is intended to be used in conjunction with FM Approvals Examination Standard 3600- Electrical Equipment for Use in Hazardous (Classified) Locations - General Requirements; and FM Approvals Examination Standard 3615 - Explosionproof Electrical Equipment General Requirements.

1.3 Basis for Requirements

See FM Approvals Examination Standard 3600.

1.4 Basis for Certification

See FM Approvals Examination Standard 3600.

1.5 Basis for Continued Certification

See FM Approvals Examination Standard 3600.

1.6 Effective Date

The effective date of this certification 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 eighteen (18) months after the publication date of the standard for compliance with all requirements.

1.7 System of Units

See FM Approvals Examination Standard 3600.

1.8 Terms and Definitions

For purposes of this standard, the following terms apply, as well as joint construction definitions given in FM Approvals Examination Standard 3615:

Dielectric Withstand Voltage – The ability of the motor to withstand certain voltages applied between current-carrying parts and dead-metal parts for a specified period of time without flashover or puncture.

Leakage Current – A current, including a capacitive coupled current, that may be conveyed between exposed conductive surfaces and ground.

Guide-Rail System – Apparatus used to raise or lower a submersible pump motor into a pit.

Lift Hoist Assembly – Means by which the pump or pump motor may be lifted and moved for the purpose of conducting maintenance, installation, etc.

Submersible Pump Motor – Rotating machine that transforms electrical energy into mechanical energy used to drive the wet end.

Submersible Pump – Combination of the wet-end and submersible pump motor designed to be connected together as an integral assembly and may be provided as a complete unit.

Wet End – Mechanical assembly required to be driven by rotational motion for the purpose of pumping, grinding, or mixing the intended fluid.

1.9 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 edition cited applies.

FM Approvals Examination Standard 3600, Electrical Equipment for use in Hazardous (Classified) Locations, General Requirements

FM Approvals Examination Standard 3615, Explosionproof Electrical Equipment, General Requirements

National Electric Code®, NFPA 70.

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

ANSI/UL674, Electric Motors and Generators for Use in Hazardous (Classified) Locations

ANSI/UL1004-1, Rotating Electrical Machines- General Requirements

ANSI/UL1004-3, Thermally Protected Motors

2 GENERAL INFORMATION

2.1 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 format, electrical schematics, nameplate format, brochures, sales literature, spec. sheets, installation, operation and maintenance manuals, 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.

2.2 Requirements for Samples for Examination

2.2.1 Following authorization of a certification examination, the manufacturer will be required to submit samples for examination and testing based on the following:

- Sample requirements to be determined by the certification agency.

2.2.2 The test samples will typically be a complete assembly with all components mounted in a manner consistent with the manufacturer's instructions and intended application; but the exact sample requirements will be specified by the certification agency either as part of the proposal or subsequent to a detailed design review after authorization of the proposal.

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

2.2.4 The manufacturer shall submit samples representative of production. Any decision to use data generated using prototypes is at the discretion of the certification agency.

2.2.5 It is the manufacturer's responsibility to provide any necessary test fixtures, such as those which may be required to evaluate the electric submersible motors.

3 GENERAL REQUIREMENTS

3.1 Marking

- 3.1.1** In addition to the marking information required in accordance with FM Approvals Examination Standard 3600, electrical submersible motors shall be marked with the following information:

Precautionary Information — the words:

“WARNING - TO REDUCE THE RISK OF IGNITION OF HAZARDOUS ATMOPHERES, DO NOT OPEN WHILE CIRCUITS ARE LIVE” or equivalent wording.

- 3.1.2** The following marking requirements are in addition to the applicable hazardous location marking requirements specified in FM Approvals Examination Standards 3600 and 3615.

- a) Manufacturer’s name or identification;
- b) Machine catalogue or model number;
- c) Rated voltage;
- d) Full load amperes, watts or kilowatts, or both;
- e) Rated speed;
- f) Rated horsepower or output wattage if over 93 watts (1/8 hp);
- g) Rated temperature rise or the insulation system class;
- h) Rated ambient temperature if greater the 40°C (104°F);
- i) Rated frequency- expressed in one of the following terms: hertz or Hz;
- j) Number of phases, if greater than 1;
- k) A continuous duty motor shall be marked ”Continuous” or “Cont”;
- l) A direct current motor shall be marked to indicate the winding type- straight shunt, stabilized shunt, compound, or series;
- m) A multi-speed motor, other than a shaded pole or a permanent split capacitor motor, shall be marked with the amperes and voltage at each speed;
- n) A motor rated for short time or intermittent duty shall be marked on the nameplate with the words ‘Intermittent Duty’ or “Int Duty” and with the time rating in minutes or hours, or a combination of minutes and hours. The rating maybe for “on” time only or include specifications for both “On” and “Off” periods;
- o) Maximum Rated Submersible depth (for Submersible motors only).

- 3.1.3** Thermally protected motors – The product nameplate shall include the marking Thermally Protected as these are thermally protected motors.

- 3.1.4** Cord Markings – A submersible wastewater motor provided with a flexible cord shall be permanently marked with instructions for cord replacement. The motor shall be permanently marked, See instruction Manual for cord replacement, or the equivalent, with the required information contained in the instructions accompanying the motor.

- 3.1.5** Leakage Detectors – Where single electrode leakage detectors are provided, the motor shall be permanently marked with the open circuit voltage and current rating and with an indication that the circuit must be an isolated secondary circuit.

3.2 Manufacturer's Installation and Operation Instructions

3.2.1 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.

3.3 Calibration

3.3.1 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.

3.3.2 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 CONSTRUCTION REQUIREMENTS

4.1 General

All joints in the construction of the electrical submersible motor equipment enclosure, whether permanently closed or designed to be opened from time to time, shall fit together with tolerances specified on the manufacturer's documentation to provide effective sealing against the ingress of fluids.

4.2 Enclosure Joint Construction

Joint construction shall satisfy the requirements of FM Approvals Examination Standard 3615.

4.3 Leakage Detectors

Electrical submersible motors shall be provided with a means of detecting the entrance of water into the electrical enclosure. Electrical leakage detectors shall comply with either the requirements for Class I, Division 1, Group (as applicable), or shall be:

- Oil immersed, and
- contain no normally arcing or sparking components; and
- operate at temperatures below the marked temperature class.

4.4 Single-Electrode Leakage Detectors

A submersible pump motor may be provided with a single-electrode leakage detector that utilizes the equipment grounding conductor as the return path if:

- The leakage detection circuit is supplied by an isolating transformer; and
- the leakage detection open-circuit voltage is less than 30 Vrms, 60 V peak, 60 Vdc; and
- the leakage detection current is 0.5 mA or less; and
- the motor is permanently marked as described by 3.1.5.

4.5 Thermal Protection Devices

External surface temperature shall be limited by the use of a temperature limiting device that opens the motor circuit directly or is intended to be connected to operate the controller in the motor circuit. The maximum surface temperature shall be determined by 5.6.

4.6 Guide Rail System Materials

Materials of the guide rail system, which may move with respect to one another, shall be constructed of non-sparking materials. Materials not known to be non-sparking shall be subjected to the tests described in 5.8.

4.7 Protective Ground

4.7.1 General

All dead metal parts of a portable motor shall be electrically bonded to the terminal for the connection of the grounding conductor of the power-supply cord. The terminal for the connection of an equipment grounding conductor shall have a permanent identification that is readily recognizable during installation and that is one of the following:

- a) A terminal screw that is not removable and has a green-colored head that is hexagonal, slotted, or both;
- b) a hexagonal green-colored nut that is not removable from a threaded terminal stud;
- c) a visible pressure wire connector having a green-colored body or appendage that is not removable from the connector;
- d) the grounding symbol as illustrated below in Figure 1;
- e) a concealed pressure wire connector identified in accordance with 4.7.2.

Figure 1- Protective Ground Symbol



4.7.2 Wire Connector

For a pressure wire connector at the equipment grounding terminal located within the insulating body and not readily visible, the wire-entrance hole for a connection to that terminal shall be identified by one of the following:

- a) A distinct green-colored area immediately adjacent to the wire-entrance hole;
- b) the letter or word “G”, “GR”, “GND”, “GROUND”, “GROUNDING”, or “GREEN”, distinctively marked immediately adjacent to the wire-entrance hole in letters not less than 1.6 mm (1/16 inch) high; or
- c) the grounding symbol illustrated in Figure 1 marked adjacent to the wire entrance hole, also see 4.7.3.

4.7.3 Symbol

If the symbol in Figure 1 is used alone, the symbol shall be defined in the installation instructions provided with the motor.

5 PERFORMANCE REQUIREMENTS

5.1 General

This section describes the tests and required results to show equipment compliance to the requirements of Clause 4. Unless otherwise specified, all tests are conducted under prevailing laboratory conditions with respect to temperature, humidity, and atmospheric pressure.

5.2 Leakage Detectors

5.2.1 Single-Electrode Leakage Detector probes shall be subjected to a dielectric strength test at 2500 Vrms or 3500 Vdc with respect to ground for one minute without insulation breakdown.

5.2.2 Dual-Electrode Leakage Detector probes shall be subjected to dielectric strength tests at 2500 Vrms or 3500 Vdc with respect to ground, and with respect to each other, for one minute each, without insulation breakdown.

5.3 Submergence Test

Submersible pump motors shall be tested by submerging the motor in water such that the highest surface of the motor is at least 150% of the rated depth below the surface of the water for a period of one hour. The enclosure need not be submerged to 150% of rated depth if an equivalent pressure differential between the interior and exterior of the enclosure is maintained for the required period of time. This differential shall be achieved either by reducing the air pressure inside the enclosure or pressurizing the water surrounding the enclosure. At the conclusion of the test the pump motor shall be removed from the water, dried, disassembled and inspected for water within the enclosure. The test is satisfactory if no water is found within the motor enclosure.

5.4 Lift Hoist Test

The Lift Hoist assembly(s) shall be tested to ensure its ability to lift the combined weight of the pump motor and mechanical pump assembly. The assembly shall be subjected to a pull force, in the intended direction of lifting, equal to four times the maximum combined weight of the motor and wet end. The test force shall be maintained on the assembly for one minute. As a result of the test, there shall be no mechanical damage to the Lift Hoist assembly. If the motor does not include a wet end, the instructions shall specify the maximum permitted weight of an attached wet end, and the test shall be conducted based on this weight specification.

5.5 Cord-Pull Test

5.5.1 One of the following two tests shall be conducted on the strain relief assembly of cord connected motors. As a result of these tests, there shall be no:

- Cuts, rips, tears, or other damage to the cord insulation; or
- breakage of the strain relief mechanism, damage to any part exposing bare live parts, or damage to the grounding path continuity; or
- movement of more than 3/32 (2.4 mm) of the conductors, conductor insulation, or outer jacket.

5.5.2 A strain relief where the associated cord is used at a full load current of not more than 30 Amperes shall be subjected to a direct pull of at least 150 pounds (667 N), along the axis of the strain relief, for one minute.

5.5.3 A strain relief where the associated cord is used at a full load current of greater than 30 Amperes shall be subjected to a direct pull of at least 300 pounds (1334 N), along the axis of the strain relief, for one minute.

5.6 Temperature Rise Tests

- 5.6.1** This testing will determine temperature class (T-code) assignment to the motor, as well as compliance of motor insulation class rating, cable cord temperature rating and thermal protection device rating. The final temperature shall be considered to have been reached when the rate of rise of temperature does not exceed 2 K/h. For guidance on the testing of converter fed motors refer to Appendix “D”.
- 5.6.2 Running Overload Tests** - The motor shall be connected to its rated supply and control equipment with the load gradually increased until surface temperatures stabilize with the temperature limiting device cycling on and off. Alternatively, the motor rotor shall be locked while gradually increasing the supply voltage until surface temperatures stabilize with the temperature limiting device cycling on and off. The surface temperature shall not exceed the marked temperature class.
- 5.6.3 Locked Rotor Tests** - A motor provided with a temperature limiting device in the motor control circuit is to be operated at rated load until surface temperatures stabilize. The rotor is then locked and the temperature limiting device allowed to cycle on and off until temperatures stabilize. The surface temperature shall not exceed the marked temperature class.
- 5.6.4 72 Hour Locked Rotor Test** - A motor provided with a temperature limiting device in the motor circuit is to be operated at rated load until surface temperatures stabilize. The rotor of the motor is then locked and the temperature limiting device permitted to cycle on and off for 72 hours. The surface temperature shall not exceed the marked temperature class.
- 5.6.5 Locked Rotor Endurance Test** - A motor provided with a temperature limiting device in the motor circuit is to be operated on its rated supply with the rotor locked. The temperature limiting device shall be permitted to cycle on and off for 15 days. Subsequent to the locked rotor tests, the motor shall be subjected to dielectric tests.

5.7 Determination of Explosion Pressure with Motor Running

In addition to the measurement of explosion pressures with the motor at rest per the requirements of FM Approvals Standard 3615- Explosionproof Electrical Equipment General Requirements, explosion pressures shall be measured with the motor operating at or near rated speed.

5.8 Guide Rail Tests

Materials of the guide rail system which are in motion with respect to one another shall be subject to a mechanical spark test. A sample of the material shall be contacted with a Norton, Metallite Type R228, Grit 80-X disk (or equivalent) operated at roughly 1725 revolutions per minute. The heated metal particles expelled shall be observed. If visible sparks are observed, an additional investigation is necessary to determine any ignition capability.

5.9 Dielectric Voltage Withstand Test

Each motor shall withstand without electrical breakdown, the application of a potential at a frequency within the range of 40- 70 Hertz or a direct current potential, at a magnitude and for duration as described in Appendix A, Table A1, Condition A:

- Between the primary wiring, including connected components, and accessible dead metal parts that are likely to become energized: and
- Between primary wiring and accessible low voltage – 42.4 volts peak AC, 60 volts DC or less- metal parts, including terminals and connector contacts.

5.10 Protective Ground Tests

The grounding protection wiring shall be suitable sized per the NEC Table 250-122. The resistance of the grounding path between the terminal for connection of the grounding conductor of the power-supply cord and dead metal parts of a portable motor required to be bonded in accordance with 4.7 shall not exceed 0.1 ohm.

5.11 Additional Requirements

Additional tests may be required, at the discretion of the examination body, depending on design features and results of any foregoing tests.

Any test following a failure shall be acceptable only at the discretion of the certification agency and with a technical justification of the conditions or reasons for failure.

5.12 Routine Tests

As a routine production test, the motor shall be subjected to the dielectric tests of Appendix C, Table C1, Condition A or B.

6 OPERATIONS REQUIREMENTS

See FM Approvals Examination Standard 3600.

7 BIBLIOGRAPHY

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

ANSI/NFPA 70, National Electrical Code® (NEC®)

IEC 60034-29, Rotating electrical machines – Part 29: Equivalent loading and superposition techniques
Indirect testing to determine temperature rise

APPENDIX A: Dielectric Voltage Withstand Test

(Normative)

- A.1. The unit shall withstand without electrical breakdown the application of an alternate current potential at a frequency within the range of 40-70 hertz or a direct current potential:
- Between the primary wiring, including connected components, and accessible dead metal parts that are likely to become energized: and
 - Between primary wiring and accessible low voltage – 42.4 volts peak AC, 60 volts DC or less-metal parts, including terminals and connector contacts.
- A.2. The test duration and potential shall be as described in either condition A or B of Table A1.

Table A1. Test Condition.

Machine Voltage Rating, Volts	Test Potential VAC	Condition A		Condition B		
		Test Potential VDC	Time, seconds	Test Potential VAC	Test Potential VDC	Time, seconds
Rated more than 42 V AC peak or 60 DC	1000 + 2U ^a	1400 + 2.8U ^a	60	1200 + 2.4U ^a	1700 + 3.4U ^a	1
Rated less than 42 V AC peak or 60 DC or less	500	700	60	600	850	1
^a = Maximum Rated voltage						

- A.3. The test potential is to be gradually increased to the required value and the full value is to be applied for 1 second or 60 seconds, as required.
- A.4. The unit shall be at intended operating temperature, at room temperature, or at any intermediate temperature for the test.
- A.5. The test shall be conducted when the unit is fully assembled. It is not intended that the machine be unwired, modified, or disassembled for the test.

APPENDIX B: Temperature Rise Testing of Converter-Fed Electric Motors

(Informative)

The maximum surface temperature rise of converter-fed motors should be determined under “worst case” conditions using one of the test methods below:

Specific converter– A machine should be tested with the intended converter.

Comparable converter– A machine may be tested using a comparable converter when sufficient information is available to judge the comparability. Additional safety factors may be applied to account for the degree of comparability.

Sinusoidal supply– The machine torque should be proportional to the square of the speed.

- The motor should be loaded to maximum load at rated speed.
- The alternative temperature determination methods detailed in IEC 60034-29 may also be applied.
- Additional safety factors may be applied to account for the degree of comparability.

Provision of appropriate direct thermal protection, normally in the stator winding, which has sufficient margin to be able to detect and prevent excessive temperatures at the rotor bearings, bearing caps, and shaft extensions. The margin may be determined by test or by calculation