Member of the FM Global Group

Examination Standard for Electric Heaters for Use in Class I, II and III, Division 1, and Catalytic Heaters for Use in Class I, Division 1 and 2, Group D, Hazardous (Classified) Locations

Class Number 7320

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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 and catalytic heaters for hazardous (classified) locations; herein referred to as heaters.

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 sets performance requirements for permanently installed electric heaters, electric air heaters, immersion (paint, fluids, etc.) heaters, heating elements and catalytic heaters rated 600 volts or less. This standard does not apply to electric trace heating.

1.2.2 The requirements of this standard reflect tests and practices used to examine characteristics of electric and catalytic heaters for hazardous (classified) locations for the purpose of obtaining certification. Electric and catalytic heaters for hazardous (classified) locations having characteristics not anticipated by this standard may be certified if performance equal, or superior, to that required by this standard is demonstrated

1.2.3 The standard is intended to be used in conjunction with FM Approvals Examination Standard 3600 - Electrical Equipment for use in Hazardous (Classified) Locations, General Requirements, which includes the general requirements that apply to all types of hazardous (classified) location protection methods.

1.3 Basis for Requirements

For general basis of 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

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

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

FM Approvals Examination Standard 3616 - Dust-Ignitionproof Electrical Equipment, General Requirements

1.9 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 Voltage Withstand – The ability of the heating element 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 capacitively coupled current, which may be conveyed between exposed conductive surfaces or a heating element and ground.

Sheathed Heating Element – Typically, a resistance element that is encased in magnesium oxide or a similar insulating material that is, in turn, surrounded by a metal sheath.

Catalytic Heater – A type of heater which produces self-sustaining heat through a chemical reaction without the use of an open flame. Typically, the heat produced can be maintained at a lower controlled rate, through fuel pressure and flow, versus that of uncontrolled combustion.

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, 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 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.

2.2 Requirements for Samples for Examination

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

- The test samples shall be a complete assembly with all components mounted in a manner consistent with the manufacturer’s instructions and intended application.
- Sample requirements to be determined by the certification agency

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

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

3 GENERAL REQUIREMENTS

3.1 Review of Documentation

3.1.1 During the initial investigation 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 examination results may further define the limits of the final certification.

3.2 Construction

3.2.1 The electrical components, such as heater elements, switches, thermostats, etc. shall be assembled in an enclosure suitable for the intended application.

3.2.2 A heating element shall have a sheath thickness ≥ 3/32 inch (2.4 mm); unless

3.2.2.1 The element is cast in metal not less than 1/8 inch (3.2 mm) thick over the sheath; or

3.2.2.2 The element complies with the dielectric voltage-withstand tests in 4.3 and the routine tests in 4.7.

3.2.3 Bonding and Grounding

3.2.3.1 All dead metal parts of a heater shall be electrically bonded to the terminal intended for the connection of the equipment grounding conductor.

3.2.3.2 When provided, supplementary grounding or bonding connection facilities on the exterior of the heater enclosure shall provide for the effective connection of a conductor with a cross-sectional area of at least 4 mm^2 (10 AWG) or equivalent.

3.2.4 Temperature-Limiting Devices

3.2.4.1 Temperature-limiting devices (thermal cutoffs, manually resettable devices, etc.) shall be designed such that replacement of the device is possible without disrupting or damaging other connections, components or internal wiring.

3.2.4.2 Thermal cutoff devices, used to prevent the risk of overheating of the heater enclosure exterior surface, meeting the requirements of the Thermal-Cutoff Tests in Section 4.5 and the requirements of 3.2.4.1 above are considered satisfactory.

3.2.5 Catalytic Heaters for Division 1

In addition to the requirements of 3.2.5.1 to 3.2.5.3, catalytic heaters for Division 1 must also comply with the requirements for Division 2 in 3.2.6.

3.2.5.1 The heater shall be supplied with an on/off switch connected by a suitable wiring method in accordance with Article 501.10 of the NEC. The switch, when located within the hazardous area, shall be suitably rated for the intended application. The switch shall be located within the vicinity of the heater as the installation permits.

3.2.5.2 A mushroom, push-button or equivalent emergency shut-off switch shall be located near the unit and must be suitable for use in Class I, Division 1, Group D hazardous locations.

3.2.6 Catalytic Heaters for Division 2

3.2.6.1 An examination of the manufacturer's applicable drawings and specifications shall be made to verify that the heaters are constructed of materials considered suitable for its intended application.

3.2.6.2 Operational tests shall verify that the heaters can start, operate and shut down as specified by the manufacturer and in a consistent, safe manner. The sequence of operation shall be evaluated for any potential hazards.

3.2.6.3 External contours shall be such so as not to allow ordinary combustibles such as wood, paper, etc. to be placed on any of the unit's heated surfaces.

3.2.6.4 Electrical components shall be appropriately rated for the atmosphere in which the heater is to be installed.

3.2.6.5 The pre-heating element shall be NRTL listed and subjected to the dielectric test according to 4.3.1. The requirements of 4.3.2, 4.4 and 4.7.2 shall not apply.

3.2.6.6 Catalytic heaters shall be supplied with an automatic safety shut-off valve and manual ball valve for emergency gas shut down.

3.3 Markings

In addition to the marking information required in accordance with FM Approvals Examination Standard 3600, FM Approvals Examination Standard 3615 and FM Approvals Examination Standard 3616, as applicable, the heater shall be marked with the following information:

3.3.1 The electrical rating in volts, amperes and either volt-amperes or watts. The ratings shall include the number of phases for heaters used on a polyphase circuit and shall also include the frequency, if necessary, due to a motor, relay coil or other control device. Heaters designated for use with alternating current only or direct current only shall be marked to indicate as such.

3.3.2 For immersion or paint heaters, the maximum operating pressure in pounds per square inch (kPa).

3.3.3 If any point within a terminal box or wiring compartment of a permanently connected heater in which the power-supply conductors are intended to be connected, including such conductors themselves, attains a temperature more than 75°C (167°F) during the temperature tests of Section 4.2, the heater shall be marked "For supply connection, use wires rated for at least ____°C (____°F)" or with an equivalent statement and the temperature shall be in accordance with Table 1. This statement shall be located at or near the point at which the supply connections are to be made and shall be clearly visible both during and after installation of the heater.

Table 1
Terminal-box marking

Temperature attained during test in terminal box or compartment[a]	Temperature marking
61 – 75°C (142 – 167°F)	75°C (167°F)
76 – 90°C (169 – 194°F)	90°C (194°F)
91 – 105°C (195 – 221°F)	105°C (221°F))
106 – 165°C (222 – 329°F)	165°C (329°F)
166 – 215°C (330 – 419°F)	215°C (419°F)
a Based on a 40°C (104°F) ambient or marked elevated ambient, when applicable.	

3.3.4 Catalytic Heaters

3.3.4.1 When applicable, large bold warning labels shall be applied to the heater with high visibility to keep the heating surface clear of combustible materials.

3.3.4.2 The manufacturer's normal hourly BTU input rating.

3.3.4.3 The manufacturer's normal manifold pressure in inches water column.

3.3.4.4 The minimum and maximum permissible gas supply pressures for the purpose of input adjustment.

3.3.4.5 The type of gas for which the heater is equipped to operate.

3.3.4.6 The words "Catalytic Infrared Heater".

3.3.4.7 For heaters that can be angle-mounted, the maximum angle of mounting.

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 Temperature-Limiting Devices

4.1.1 Stretching or similar displacement of the heater element wire shall not cause permanent displacement or distortion that could affect the performance of the heater.

4.1.2 A thermal cutoff used to reduce the risk of overheating of the exterior surfaces of the heater enclosure shall not be adversely affected by aging and shall open the electrical circuit under the conditions described in the Thermal-Cutoff Test in Section 4.5.

4.2 Temperature Tests

4.2.1 General

4.2.1.1 Tests are to be conducted at rated frequency and voltage. If the input voltage is defined as a range, the test voltage shall be the upper limit of the input range. If the applied test voltage results in a measured input wattage less than the marked wattage rating of the heater, the test voltage shall be increased until the measured input wattage equals the marked wattage rating.

Note: Other than for temperature testing purposes as required by this clause, the input wattage to the heater shall not exceed 105% of the maximum rated input wattage or volt-ampere rating marked on the heater.

4.2.1.2 If a heater employs a motor, in addition to the heating element, the voltage applied to the motor shall be rated voltage, unless the input voltage is defined as a range, in which case, the input voltage shall be the upper limit of the input range.

4.2.1.3 A temperature-limiting device in a heater shall not open during normal operation. See Section 4.2.2.4.

4.2.1.4 A heater which is intended to be mounted in a specific position shall be tested as such. Instructions for mounting shall be marked on the heater. For all other heaters, temperature tests shall be conducted in the position determined to achieve the greatest heating effect on exterior surfaces.

4.2.1.5 For paint or immersion heaters, water shall be permitted to be substituted for paint or intended process fluid as long as the water flow is equivalent to the rated fluid flow.

4.2.2 All Heaters (excluding catalytic heaters)

4.2.2.1 A heater, when operated in accordance with Section 4.2.2.2 – 4.2.2.4, shall not exceed the temperatures shown in Table 2.

Table 2
Maximum temperatures – all heaters

Point of temperature measurement	Maximum temperature °C (°F)[a]
1. Insulated wire	b
2. Black-painted wood on which an air heater may be mounted or to which the heater is adjacent	105 (221)
3. Any point within a terminal box or a wiring compartment in which field-installed conductors are connected, including the conductors, unless the heater is marked in accordance with 3.3.3	75 (167)

a Maximum temperatures based on a 40°C (104°F) ambient temperature or the maximum rated ambient temperature, if greater.

b 15°C (27°F) more than the temperature rating of the wire.

4.2.2.2 During the test, an automatic temperature-regulating control is to be shunted out of the circuit. A fan or blower, if provided as part of the heater, is to be disconnected.

4.2.2.3 For compliance with item 2 of Table 2, an air heater shall be installed in the intended position on, or adjacent to, a black-painted surface of a wall consisting of nominal 3/8 inch (9.5 mm) thick plywood fastened to the shorter sides of trade size 2 by 4 inch vertical wooden studs placed on 16 inch (406 mm) centers. Two or more such walls are to be fastened together to form a 90 degree angle. The height and length of the walls are to be such that they extend not less than 2 feet (610 mm) beyond the physical limits of the heater under test. The heater is to be located as close to the sides of the wall angle as its construction allows. The heater is to be placed relative to the walls so that maximum heating occurs on the walls, except that the heater may be spaced away from the walls so that temperature rises of more than 65°C (117°F) are not attained if the heater is marked accordingly.

4.2.2.4 To determine that a thermal cutoff does not open during normal operation, the heater is to be operated for at least 168 hours.

4.2.3 Heaters for Class I Locations (excluding catalytic heaters)

4.2.3.1 A heater for Class I locations shall be operated until constant temperatures are attained.

4.2.3.2 The heater is to be operated in air. An air heater is also to be operated in air with two layers of cheesecloth secured over the top of the heater and draped over the entire front.

Exception: A ceiling-mounted heater is not tested with cheesecloth.

4.2.3.3 Paint Heaters

4.2.3.3.1 For testing purposes, the exterior surfaces of the heater are to have three coats of nitrocellulose-base paint (containing at least 30% by weight of nitrocellulose). The paint is to be applied with a brush and allowed to dry between each coat. The final coat is to be allowed to dry before the temperature test is conducted.

4.2.3.3.2 A paint heater shall not exceed 150°C (302°F) on any external surface and there shall be no apparent change in the paint coating, such as discoloration.

4.2.4 Heaters for Class II Locations

4.2.4.1 A heater for Class II locations shall be operated, in air, at 110% of the voltage specified in Section 4.2.1.1 until constant temperatures are attained.

4.2.4.2 Opening of a temperature limiting device is acceptable during the test.

4.2.5 Heaters for Simultaneous Use in Class I and Class II Locations

The maximum temperatures are to be determined under the conditions specified in Section 4.2.4.1.

4.2.6 Catalytic Heaters for Class I Locations

4.2.6.1 Catalytic Heaters for Division 1

4.2.6.1.1 Division 1 equipment shall also be subjected to the tests for Division 2 equipment according to clause 4.2.6.2.

4.2.6.1.2 Two (2) thermal ignition (not energy ignition) tests: one with NEC Group D liquid, Heptane and one with NEC Group D gas, Propane. The tests shall be conducted according to clauses 4.2.6.1.2.1 and 4.2.6.1.2.2.

4.2.6.1.2.1 The test samples will be placed into an open front chamber capable of being closed off with a plastic diaphragm. The heater will be energized and allowed to be brought up to operating temperature. The plastic diaphragm will be placed over the opening of the chamber and a heptane vapor-air mixture will be introduced into the chamber starting from zero up to the upper flammability limit of heptane-air (6.7% ± 0.1%). The test shall be repeated five times with no ignition of the heptane-air mixture. The electric starter heater shall be energized for the entire test.

4.2.6.1.2.2 The test samples will be placed into an open front chamber capable of being closed off with a plastic diaphragm. The electric starter heater will be energized for 20 minutes to warm up and stabilize. The plastic diaphragm will be placed over the opening of the chamber and a constant, low velocity stoichiometric (4.2% ± 0.1%) propane-air mixture will be introduced into the chamber. The heaters will be started and allowed to reach a stabilized temperature. The gas supply to the heaters will be turned off allowing them to cool down. The external propane-air mixture will be turned off when the surface temperature falls below 200°C (392°F). The test shall be repeated five times with no ignition of the propane-air mixture.

4.2.6.2 Catalytic Heaters for Division 2

4.2.6.2.1 A temperature gradient for each model shall be recorded with the heater operating in the vertical position, at rated pressure and with the pre-heating element energized at rated voltage. Maximum and minimum gradient temperatures for each heater model shall be tabulated excluding the burner surface. This test will be used to qualify the marked temperature class (T-Code) of the equipment, therefore heater surface temperatures and air ambient shall be monitored.

4.2.6.2.2 The heater shall be operated until constant temperatures are attained and once attained, shall be operated for not less than 1 hour. Combustible materials, both paper and wood, shall be exposed directly on the external surface of the heater (excluding the burner surface) at the maximum temperature location as determined in 4.2.6.2.1. If the manufacturer specifies minimum clearances, the combustibles may be placed at the minimum clearances for the test. The combustibles shall not burn (open flame) or ignite as a result of this test. Charring or discoloration on the contact surface of the material is not considered a failure. The paper is to be a 12 inch (30.5 cm) x 12 inch (30.5 cm) sheet of Kraft-type, unbleached, medium weight and uncoated paper. The wood is to be a 12 inch (30.5 cm) length of a standard 1 x 12 kiln-dried, Douglas fir board. Prior to the test, the paper and wood shall be stored at 22°C (72°F) and 50% RH for 24 hours.

4.2.6.2.3 Flammability tests shall be conducted on catalytic heater samples. Three tests are to be conducted by spraying vapor-air mixes of the representative Group D materials listed in Table 3 onto each operating heater face (1) during the start-up cycle, (2) after operating temperatures have stabilized and (3) during the shut-down cycle. The test materials are to be vaporized or atomized in air using a pump-sprayer, automatic spray nozzle or other equivalent means. The catalytic heater shall be operated at rated fuel pressure for natural gas and liquefied petroleum (LP) gas and with the pre-heating starter element energized at rated voltage +10%, throughout the testing. In each case, no ignition of the fuel vapors shall occur. For catalytic heaters for Division 1, these tests are replaced by the tests of 4.2.6.1.2.

Table 3
Ignition temperature from *Fire Protection Guide to Hazardous Materials,* NFPA HAZ10

	Ignition Temperature	
Material	**°F**	**(°C)**
Acetone	869	(465)
Methanol	725	(385)
Heptane	399	(204)
MEK	759	(403)
Petroleum Naptha	550	(287)
Octane	403	(206)
Toluene	896	(480)

4.2.6.2.4 A representative sample heater shall be subjected to a vibration test for 8 hours, cycled 10-30 Hz at an amplitude of 0.02 inch (0.51 mm). After the vibration cycling, there shall be no loosening of any parts or other noticeable damage as a result of this test. The heater shall then be started to verify that there is no operational deterioration. Surface temperatures shall not exceed those obtained in 4.2.6.2.1.

4.3 Dielectric Voltage-Withstand Test

4.3.1 Heaters or the pre-heating element of a catalytic heater shall withstand, without breakdown the application of a 60-hertz essentially sinusoidal potential of 2U + 1000 volts applied between live parts and exposed dead metal parts for one minute where, U equals the rated voltage or upper limit of the defined voltage range for the heater under test.

4.3.2 Heating elements having a sheath with a wall thickness less than 3/32 inch (2.4 mm) and not cast in metal having a thickness of not less than 1/8 inch (3.2 mm) over the sheath shall withstand without breakdown the following dielectric voltage-withstand tests:

4.3.2.1 Three samples shall be subjected to 6000 cycles of 1 minute on and 4 minutes off – ambient air cooling. Following this cycling. a 60 hertz essentially sinusoidal potential of 2U + 1000 volts shall be applied between live parts and exposed dead metal parts for one minute, where U equals the rated voltage or upper limit of the defined voltage range for the heater under test.

4.3.2.2 A sample shall be subjected to 50 cycles of 5 minutes on and 25 minutes off with the heater element immersed in water during the off period. Following this cycling, a 60 hertz essentially sinusoidal potential of 2U + 1000 volts shall be applied between live parts and exposed dead metal parts for one minute, where U equals the rated voltage or upper limit of the defined voltage range for the heater under test.

4.3.2.3 A sample shall be subjected to 50 cycles of 5 minutes on and 25 minutes off with 5 minutes of air ambient cooling and 20 minutes at -40°C (-40°F) air cooling during the off period. Following this cycling, a 60 hertz essentially sinusoidal potential of 2U + 1000 volts shall be applied between live parts and exposed dead metal parts for one minute, where U equals the rated voltage or upper limit of the defined voltage range for the heater under test.

4.3.2.4 A sample shall be subjected to a 35 hour vibration test (1/32 inch or 0.8 mm movement at a rate of 2000 cycles per minute). Following the vibration test, a 60 hertz essentially sinusoidal potential of 2U + 1000 volts shall be applied between live parts and exposed dead metal parts for one minute, where U equals the rated voltage or upper limit of the defined voltage range for the heater under test.

4.3.2.5 Three samples shall be subjected to impact testing (see 4.3.2.6). Following the impact tests and while in a thoroughly heated condition, a 60 hertz essentially sinusoidal potential of 2U + 1000 volts shall be applied between live parts and exposed dead metal parts for one minute, where U equals the rated voltage or upper limit of the defined voltage range for the heater under test.

4.3.2.6 For the impact test in 4.3.2.5, the heating element is to be placed on a flat steel base at last 1-1/2 inches wide. A 50 pound (22.7 kg) weight having a flat base with dimensions of approximately 6 by 4 inches (152 by 102 mm) is to fall freely through a vertical guide from a 3 ft (0.9 m) height and strike the element sheath of an unfinned element. If the element is provided with fins for its entire length, the weight is to strike the fins. If an element is partially finned, two impact tests are to be conducted; once on the fins and once on the sheath.

4.4 Additional Requirements for Heating Elements

4.4.1 Resistance to Moisture Test

4.4.1.1 Heating elements shall be conditioned for 60 days at a temperature of 90 ±4°F (32 ±2°C) and 85 ±5% relative humidity.

4.4.1.2 Following the conditioning in Section 4.4.1.1, the insulation resistance of a heating element shall not be less than 50 kohms after being operated to thermal stabilization and must comply with the dielectric voltage-withstand test in Section 4.3.

4.4.2 Thermal Endurance Test

4.4.2.1 Heating elements shall be subjected to 1000 cycles of heating and cooling with each cycle consisting of 60 minutes energized and 20 minutes de-energized. During the thermal endurance test, the sheath of the heating element is to be grounded through a 3 ampere fuse and the heating element sample is to be connected to a supply voltage not less than 110% of the test voltage.

4.4.2.2 As a result of the tests in Section 4.4.2.1:

4.4.2.2.1 The heating element shall not rupture nor otherwise exhibit any mechanical damage;

4.4.2.2.2 There shall be no emission of flame or molten metal; and

4.4.2.2.3 The fuse connected to the element sheath shall not open.

4.5 Thermal-Cutoff Test

4.5.1 The heater is to be operated with separate thermal cutoffs five times according to voltage, frequency and wattage specified in Section 4.2.1.1 and with any thermally operated control devices in the heater short-circuited. During the test, the enclosure is to be connected through a 3 ampere fuse to ground. Each thermal cutoff shall comply with the requirements in Section 4.5.2.

4.5.2 A thermal cutoff shall open the circuit in the intended manner without causing the short-circuiting of live parts and without causing live parts to become grounded to the enclosure.

4.6 Low- Level Cutoff Test

4.6.1 Overload - A low- level cutoff switch shall be subjected to 50 cycles of operation at 150% of the maximum rated current at the test voltage specified in Section 4.2.1.1, including power factor considerations for the equipment being evaluated. As a result of these tests, there shall be no electrical or mechanical malfunction of the low- level cutoff switch, nor welding or undue pitting or burning of the contacts.

4.6.2 Endurance - The switch used for the test in Section 4.6.1 shall be subjected to 6000 cycles of operation at rated load, including power factor considerations for the equipment being evaluated, with the enclosure connected to ground through a 6 ampere fuse. The internal pressure during the test shall be equal to the rating of the pressure-relief valve. As a result of these tests, there shall be no electrical or mechanical malfunction of the low- level cutoff switch, nor welding or undue pitting or burning of the contacts.

4.6.3 Pressure - With the fluid level lowered to the point at which the low- fluid cutoff switch assumes an off position and with the heating element connected as described in Section 4.2.1.1, the heater is to be draped with cheesecloth as described in Section 4.2.3.2. Upon increasing pressure, the cutoff switch shall be made to close the circuit and then the cutoff switch shall open the circuit when the cutoff is released.

4.6.4 Moist Ammonia-Air Stress Cracking Test (For low-level cut-offs with brass floats)

4.6.4.1 Three test samples are to be subjected to physical stresses normally imposed on or within a part as the result of assembly with other components. Such stresses are to be applied to the sample prior to and maintained during the test. Samples with threads intended to be

used for installing the product in the field are to have the threads engaged and tightened to the torque specified in Table 4. Teflon tape or pipe compound shall not be used on the threads.

Table 4
Torque requirements for threaded connections

Nominal thread size inches	Torque pound-inches (N·m)
1	1200 (135.6)
1-1/4	1450 (163.8)
1-1/2	1550 (175.1)
2	1650 (186.4)
2-1/2	1750 (197.7)
3	1800 (203.4)

4.6.4.2 The three samples are to be degreased and continuously exposed in a set position for ten days to a moist ammonia-air mixture maintained in a glass chamber approximately 12 by 12 by 12 inches (305 by 305 by 305 mm) having a glass cover.

4.6.4.3 Approximately 600 ml of aqueous ammonia having a specific gravity of 0.94 is to be maintained at the bottom of the glass chamber below the samples. The samples are to be positioned 1-1/2 inches (38.1 mm) above the aqueous ammonia solution and supported by an inert tray. The moist ammonia-air mixture in the chamber is to be maintained at atmospheric pressure at a temperature of 93 ±4°F (34 ±2°C).

4.6.4.4 After being subjected to the tests of 4.6.4.1 – 4.6.4.3, a brass float of a low- level cutoff containing more than 15% zinc, shall show no evidence of cracking, rupture, distortion or delamination when examined using 25X magnification.

4.7 Routine Tests

4.7.1 Dielectric Voltage-Withstand Test

Heaters or the pre-heating element of a catalytic heater shall withstand, without breakdown, the application of a 60-hertz essentially sinusoidal potential of 2U + 1000 volts applied between live parts and exposed dead metal parts for one minute, where U equals the rated voltage or upper limit of the defined voltage range for the heater under test. Alternatively, test potentials 20% higher may be applied for at least one second.

4.7.2 Heating Elements with Sheath Wall Thickness < 3/32 inch (2.4 mm)

4.7.2.1 Air-Leakage Test

Each heating element is to be immersed in a water bath and, on application of air at a pressure of 100 psig (690 kPa) to the open ends, there shall be no air leakage through the enclosure wall (sheath).

4.7.2.2 Dielectric Voltage-Withstand Test

Following the air-leakage test in 4.7.2.1, each heating element shall withstand, without breakdown, a 60 hertz essentially sinusoidal potential applied between live parts and exposed dead metal parts. The test potential is to be:

4.7.2.2.1 2500 volts applied for one second for a heating element tested in a cold condition; or

4.7.2.2.2 2U + 1000 volts applied for one minute, where U equals the rated voltage or upper limit of the defined voltage range for the heater under test for a heating element tested at its maximum normal operating temperature.

5 OPERATIONS REQUIREMENTS

See FM Approvals Examination Standard 3600.

6 BIBLIOGRAPHY

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

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

ANSI/UL 823 – Electric Heaters for Use in Hazardous (Classified) Locations

ANSI/UL 1030 – Sheathed Heating Elements

NFPA HAZ10, Fire Protection Guide to Hazardous Materials