UL 1112

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Marine Electric Motors and Generators (Cranking, Outdrive Tilt, Trim Tab, Generators, Alternators)

Underwriters Laboratories Inc. (UL)
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UL Standard for Safety
for
Marine Electric Motors and Generators (Cranking, Outdrive Tilt, Trim Tab, Generators, Alternators), UL 1112

Third Edition, Dated September 5, 1997

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Standard for

Marine Electric Motors and Generators (Cranking, Outdrive Tilt, Trim Tab, Generators, Alternators)

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An effective date included as a note immediately following certain requirements is one established by Underwriters Laboratories Inc.

Revisions of this standard will be made by issuing revised or additional pages bearing their date of issue. A UL Standard is current only if it incorporates the most recently adopted revisions, all of which are itemized on the transmittal notice that accompanies the latest set of revised requirements.

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FOREWORD

A. This Standard contains basic requirements for products covered by Underwriters Laboratories Inc. (UL) under its Follow-Up Service for this category within the limitations given below and in the Scope section of this Standard. These requirements are based upon sound engineering principles, research, records of tests and field experience, and an appreciation of the problems of manufacture, installation, and use derived from consultation with and information obtained from manufacturers, users, inspection authorities, and others having specialized experience. They are subject to revision as further experience and investigation may show is necessary or desirable.

B. The observance of the requirements of this Standard by a manufacturer is one of the conditions of the continued coverage of the manufacturer's product.

C. A product which complies with the text of this Standard will not necessarily be judged to comply with the Standard if, when examined and tested, it is found to have other features which impair the level of safety contemplated by these requirements.

D. A product employing materials or having forms of construction which conflict with specific requirements of the Standard cannot be judged to comply with the Standard. A product employing materials or having forms of construction not addressed by this Standard may be examined and tested according to the intent of the requirements and, if found to meet the intent of this Standard, may be judged to comply with the Standard.

E. UL, in performing its functions in accordance with its objectives, does not assume or undertake to discharge any responsibility of the manufacturer or any other party. The opinions and findings of UL represent its professional judgment given with due consideration to the necessary limitations of practical operation and state of the art at the time the Standard is processed. UL shall not be responsible to anyone for the use of or reliance upon this Standard by anyone. UL shall not incur any obligation or liability for damages, including consequential damages, arising out of or in connection with the use, interpretation of or reliance upon this Standard.

F. Many tests required by the Standards of UL are inherently hazardous and adequate safeguards for personnel and property shall be employed in conducting such tests.

INTRODUCTION

1 Scope

1.1 These requirements cover engine-cranking motors, outdrive-tilt motors, power trim-tab motors, generators, and alternators rated less than 50 volts direct current.

1.2 The products covered by these requirements are intended for installation and use in accordance with the applicable requirements of the Standard for Fire Protection of Pleasure and Commercial Motor Craft, NFPA 302, or the United States Coast Guard.

1.3 The requirements also cover components, such as cranking motor solenoids, generator or alternator voltage regulators, and connecting wiring provided by the product manufacturer.

1.4 These requirements cover nonignition-protected components that are intended to be mounted outside of spaces requiring ignition-protected equipment and are marked accordingly [see 18.1(e)], as well as ignition-protected components.

1.5 A product that contains features, characteristics, components, materials, or systems new or different from those covered by the requirements in this Standard, and that involves a risk of fire, electric shock, or injury to persons shall be evaluated using the appropriate additional component and end-product requirements as required to maintain the level of safety as originally anticipated by the intent of this Standard. A product whose features, characteristics, components, materials, or systems conflict with specific requirements or provisions of this Standard is not judged to comply with this Standard. Where appropriate, revision of requirements are proposed and adopted in conformance with the methods employed for development, revision, and implementation of this Standard.

2 Glossary

2.1 For the purpose of this standard, the following definitions apply.

2.2 CRANKING MOTOR (STARTER) – A high torque motor integrally mounted on the engine and intended to turn the engine over at a rotational speed sufficient for starting purposes.

2.3 FULLY CHARGED (BATTERY) – A condition resulting when the electrolyte of a battery is at:

a) The full charge specific gravity specified by the manufacturer; and

b) The maximum liquid level.

2.4 IGNITION-PROTECTED PRODUCT – A product constructed so that:

a) A flammable hydrocarbon mixture surrounding it is not ignited if a normally occurring electrical arc, spark, or heat source ignites the flammable hydrocarbon mixture inside the product;

b) The electrical arc, spark, or heat source has insufficient energy to ignite the flammable mixture; or

c) The source of ignition is hermetically sealed from the surrounding mixture.

An ignition-protected product does not necessarily comply with the requirements for an explosion-proof product as applied to U.S. Coast Guard inspected vessels or as defined by the National Electrical Code, ANSI/NFPA 70-1996, Errata Note No. 1.

2.5 OUTDRIVE-TILT MOTOR – A high torque motor used in conjunction with a worm gear, hydraulic pump, or other power converting mechanism to change the angle of trim of a boat by changing the tilt of the marine outdrive assembly.

2.6 POWER TRIM-TAB MOTOR – A high torque motor used in conjunction with a worm gear, hydraulic pump, or other power converting mechanism to change the angle of external trim tabs so as to change the fore and aft trim of a boat.

3 General

3.1 Units of measurement

3.1.1 If a value for measurement is followed by a value in other units in parentheses, the first stated value is the requirement.

3.2 Components

3.2.1 Except as indicated in 3.2.2, a component of a product covered by this standard shall comply with the requirements for that component. See Appendix A for a list of standards covering components generally used in the products covered by this standard.

3.2.2 A component is not required to comply with a specific requirement that:

a) Involves a feature or characteristic not required in the application of the component in the product covered by this standard; or

b) Is superseded by a requirement in this standard.

3.2.3 A component shall be used in accordance with its recognized rating established for the intended conditions of use.

3.2.4 Specific components are recognized as being incomplete in construction features or restricted in performance capabilities. Such components are intended for use only under limited conditions, such as certain temperatures not exceeding specified limits, and shall be used only under those specific conditions for which they have been recognized.

CONSTRUCTION

4 Frame and Enclosure

4.1 A product shall be formed and assembled to have the strength and rigidity necessary to withstand the stresses to which it may be subjected, such as:

a) A stalled rotor condition;

b) Application of 125 percent of rated input voltage;

c) Vibration;

d) Mechanical shock; and

e) In the case of generators, alternators, and starting motors that are integrally attached to the engine block, their use as a step.

4.2 A removable band or cover that forms part of an ignition-protected enclosure shall be constructed to permit its removal and replacement in the field with standard American or metric wrenches or screwdrivers, without rendering the ignition-protected construction ineffective.

4.3 An external edge, projection, or corner shall not be sufficiently sharp to constitute a risk of injury to persons in normal use and maintenance of the product.

4.4 The intended method of mounting shall permit the product or accessory to be reinstalled after removal for servicing so that it will maintain a fixed relationship to the prime mover or other structure to which it is secured when subjected to the vibration and shock loads encountered in normal marine service. See Vibration Test, Section 10, and Shock Test, Section 11.

5 Protection Against Corrosion

5.1 An iron or steel part shall be protected against corrosion by enameling, galvanizing, or other equivalent means. See Salt-Spray Corrosion Test, Section 16.

Exception: This requirement does not apply to bearings or laminations, or to parts, such as machine screws and washers, that are not necessary for the product to perform its intended function.

5.2 The thickness of a sheet steel and cast iron part is to be considered when judging resistance to corrosion.

6 Insulating Material

6.1 A material used for mounting an uninsulated current-carrying part shall be porcelain, phenolic composition, or other material acceptable for a marine environment.

6.2 Vulcanized fiber may be used for insulating bushings, washers, separators, and barriers, but not for the sole support of uninsulated current-carrying parts.

6.3 A thermoplastic material may be used for the sole support of uninsulated current-carrying parts, provided the material:

a) Is a type previously investigated and found acceptable for the application; or

b) Complies with the requirements in 6.4.

6.4 Thermoplastic material not previously investigated and found acceptable for the application may be used for the sole support of uninsulated current-carrying parts if:

a) An examination of the product following the tests described in Sections 10 – 15 reveals no cracking, distortion, or other degradation to the extent that the operation of the product is impaired;

b) Following continuous exposure for 500 hours in an air oven maintained at a temperature of 10E – 15EC (18E – 27EF) above the maximum temperature obtained on the material during the Operation Temperature Test, Section 12, an examination of the material reveals no cracking, distortion, or other degradation to the extent that the operation of the product is impaired;

c) The product complies with the requirements in Stray Current Leakage Test, Section 13, following the conditioning specified in (b); and

d) The material is classed 94V-2 or less flammable in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

6.5 A small molded part, such as a brush cap, shall have the mechanical strength and rigidity necessary to withstand the stresses of actual service, without cracking, distortion, or other degradation to the extent that the operation of the product is impaired. Brush caps shall be secured or located so that they are protected from mechanical damage.

ELECTRICAL ASSEMBLY

7 General

7.1 A cranking motor, generator, or diode-rectified alternator may be of the grounded type using the engine block as the ground return conductor. A voltage regulator, reverse current relay, or other accessory not integrally mounted on the engine shall have all electrical circuits insulated from the housing and mounting provisions with materials acceptable for use in damp locations.

7.2 An external terminal shall be located to permit the intended field connection to be made and to prevent the accumulation of water. Also, see 18.3.

7.3 An external electrical conductor provided as an integral part of the product shall be stranded copper. The minimum insulated wire size shall be No. 16 AWG (1.3 mm^2) for single wires, and No. 18 AWG (0.82 mm^2) for multiple wires in a common jacket, sheath, or bundle.

Exception No. 1: Short lengths of solid copper may be used for high current applications, such as between the cranking motor and cranking motor solenoid, if:

a) The terminations are immediately adjacent to each other; and

b) Relative movement is not possible between the terminations.

Exception No. 2: A pigtail connection less than 7 inches (178 mm) in exposed length may be No. 18 AWG (0.82 mm^2) wire.

7.4 The insulation on external wiring shall be acceptable for use in damp or wet locations, resistant to oil, and rated 75EC (167EF) minimum.

7.5 A generator or diode-rectified alternator shall be constructed for use with a voltage regulator that will maintain an output voltage between 2.15 and 2.4 volts per cell under a no load condition with a lead acid battery fully charged at 25 ±2EC (77 ±4EF); or a voltage regulator that can be adjusted to a value between 2.15 and 2.4 volts. See 19.1(d).

7.6 A generator or diode-rectified alternator shall be constructed for continuous operation at rated output in an ambient temperature of 60EC (140EF).

7.7 Internal wiring, other than coil windings, shall be stranded copper acceptable for the application. The insulation on internal wiring shall be rated for a temperature of 75EC (167EF) or higher.

PERFORMANCE

8 General

8.1 The same test sample shall be subjected to the tests described in Sections 10 – 13 and 15 in the order presented. All other tests may be conducted on separate samples.

9 Cold Test

9.1 External wiring, such as a pigtail connection or a wiring harness to a voltage regulator, shall not exhibit cracks in the insulation when tested as described in 9.2.

9.2 The wiring is to be conditioned in a cold chamber maintained at minus 25 ±2EC (minus 13 ±4EF) for not less than 2 hours. Immediately following the conditioning, the wiring or harness is to be wound at a uniform rate of approximately 10 seconds per turn for six complete turns, with adjacent turns touching, onto a mandrel that has been cooled to the same temperature as the wire being tested. The diameter of the mandrel is to be as specified in Table 9.1.

Table 9.1
Mandrel diameters

Wire size,[a]		Mandrel diameter,[b]	
AWG	(mm^2)	Inches	(mm)
18	(0.82)	0.313	(7.95)
16	(1.3)	0.313	(7.95)
14	(2.1)	0.313	(7.95)
12	(3.3)	0.375	(9.53)
10	(5.3)	0.563	(14.30)
8	(8.4)	0.688	(17.48)
6	(13.3)	1.250	(31.75)
4	(21.2)	1.375	(34.93)
2	(33.6)	1.563	(39.70)
1	(42.4)	2.688	(68.28)

[a] For a wiring harness, the mandrel diameter is to be based on the largest wire size.

10 Vibration Test

10.1 A product, together with any accessories, shall withstand the test described in 10.2 – 10.7 without development of a malfunction that would impair intended operation.

10.2 The product is to be mounted on the vibration machine to simulate an intended installation. Any mounting hardware provided by the manufacturer is to be used for this test. If alternate methods of mounting can be used, the test is to be conducted with the method that produces the highest stress levels. If the manufacturer provides alternate mounting brackets, the test is to be repeated with each of the mounting brackets. The sample need not be operational during the test, but is to be tested in accordance with 10.7 after the vibration in each axis.

10.3 Wiring installed to permit operation of a motor-operated product during this test is to be stranded copper of a size and construction acceptable for the current and voltage rating of the product. Wiring is to be installed to simulate intended installation, with slack but without loops. The wiring is to be secured to the vibration table or test fixture during this test.

10.4 A product intended to be mounted on an engine (such as an alternator, generator, cranking motor, trim motor, or tilt motor), is to be subjected to a variable frequency vibration along three axes; the first is to be coincident with the motor, alternator, or generator shaft, the second is to be a horizontal axis perpendicular to the shaft, and the third is to be a vertical axis perpendicular to the shaft. The product is to be vibrated for 8 hours in each axis (total of 24 hours) at a peak-to-peak amplitude of 0.040 ±0.001 inch (1.02 ±0.03 mm). The frequency of vibration is to be continuously varied, at a uniform rate, from 10 to 60 to 10 hertz every 4 minutes.

10.5 A product not intended to be mounted on an engine is to be tested in accordance with 10.4, except that the peak-to-peak amplitude is to be 0.020 ±0.001 inch (0.51 ±0.03 mm) and the sample is to be vibrated for 4 hours in each axis (total of 12 hours).

10.6 For these tests, peak-to-peak amplitude is defined as the maximum displacement of sinusoidal motion (total displacement).

10.7 At the end of each 8- or 4-hour test period, a motor is to be energized at rated voltage and operated under a no-load condition for 5 seconds. The motor shall operate as intended.

11 Shock Test

11.1 A product shall withstand 5000 shock impacts without development of a malfunction that would impair normal operation, unacceptable damage to the mounting means, displacement of components, or reduction of the electrical spacings provided.

11.2 The sample used in the Vibration Test, Section 10, is to be mounted as intended in a rigid test fixture that, in turn, is to be mounted on a test table. The assembly is then to be subjected to 5000 shock impacts, each having a 10 g (98 m/s^2) peak acceleration and a 20- to 25-millisecond duration as measured at the base of the half-sine shock envelope. The test sample need not be operational during this test.

11.3 The machine used for this test is to be of the automatic cycling type producing a half-sine shock pulse at the specified acceleration level and duration. The acceleration and shock pulse duration are to be measured by a piezoelectric accelerometer mounted on the test machine platform on an axis parallel to the axis of motion.

11.4 The sample is to be mounted so that its center of gravity is as close as possible to the geometric center of the machine platform. Wiring installed to permit operation of the product during this test is to be in accordance with 10.3.

11.5 At the end of the test, a motor is to be energized at rated voltage and operated under a no-load condition for 5 seconds. The motor shall operate as intended.

12 Operation Temperature Test

12.1 A generator, diode-rectified alternator, tilt motor, or trim motor, and any associated accessories, when tested under the conditions described in 12.2 – 12.5, shall not:

a) Emit flame, molten metal, flaming or glowing particles, or flaming drops;

b) Experience temperature rises at specific points greater than the applicable value specified in Table 12.1, except as noted in 12.6; and

c) Experience temperatures on any exposed exterior surface in excess of 150EC (302EF).

12.2 A generator or diode-rectified alternator is to be mounted on either a marine engine or a test stand with a prime mover having the necessary horsepower and rotational speed to simulate the operational range of the product as specified by the manufacturer.

12.3 A generator or diode-rectified alternator is to be tested at cut-in, 1500, 2000, 3000, and 4000 rotations per minute and at the maximum recommended rotational speed, while delivering maximum output at each speed. Additional speeds may be used if deemed necessary to establish the shape of the output curve. Output voltage is to be measured at the output terminals. Thermocouples are to be attached to the enclosure, stationary windings, brush assembly, and to other electrical components, accessories, and connections. At each speed, the product is to be operated until temperatures stabilize, or for 1 hour, whichever occurs first. Temperatures are to be considered stable when two successive temperature readings taken at 15 minute intervals show no increase in temperature. The test is to be conducted with the voltage regulator, reverse current cutout, and other auxiliary equipment specified for the product in place. The test is to be conducted at an ambient temperature of 60 ±2EC (140 ±4EF).

12.4 A trim or tilt assembly is to be tested at 60 ±2EC (140 ±4EF) ambient and at 125 percent of rated voltage under simulated maximum operating load conditions by subjecting the complete product to 100 cycles of the following operational sequence, with a 5 minute cool down period between each sequence.

a) Starting from a mid-position, the sample is to be operated until it reaches one extreme operating position, (bow up or bow down), and the switch or control held in position for 1 second after the drive unit has reached its mechanical stop.

b) The sample then is to be operated until it reaches the extreme opposite position and the switch or control held in position for 1 second after the drive unit has reached its mechanical stop.

Table 12.1
Temperature rises

Materials and components	Maximum rise	
	EC	EF
A. MOTORS[a]		
1. Class A insulation on windings of direct-current motors:		
a. In open motors:		
Thermocouple method	65	117
Resistance method	75	135
b. In totally enclosed motors:		
Thermocouple method	70	126
Resistance method	80	144
2. Class B insulation on windings of direct-current motors:		
a. In open motors:		
Thermocouple method	85	153
Resistance method	95	171
b. In totally enclosed motors:		
Thermocouple method	90	162
Resistance method	100	180
B. COMPONENTS		
1. Relay, solenoid, transformer, and other coils[a]:		
a. Class 105 insulation system:		
Thermocouple method	65	117
Resistance method	85	153
b. Class 130 insulation system:		
Thermocouple method	85	153
Resistance method	105	189

(Continued)

Table 12.1 (Cont'd)

Materials and components	Maximum rise	
	EC	EF
2. Other components and materials:		
a. Fiber used as electrical insulation or bushings	65	117
b. Varnished cloth insulation	65	117
c. Thermoplastic material[b]	c	
d. Phenolic composition used as electrical insulation or as parts where deterioration will impair product operation[b]	125	225
e. Fuses	65	117
f. Sealing compound	d	
C. CONDUCTORS		
1. Rubber or thermoplastic-insulated wires and cords[e]	35	63
D. GENERAL		
1. At any point within a terminal box or wiring compartment in which power supply conductors are to be connected, including such conductors	35	63

[a] Ordinarily, coil or winding temperatures are to be measured by thermocouples. However, if the coil is inaccessible for mounting a thermocouple (for example, a coil immersed in sealing compound) or if the coil wrap includes thermal insulation or more than 1/32 inch (0.8 mm) of cotton, paper, rayon, or similar insulation, the change-in-resistance method is to be used. The thermocouple is to be mounted on the integrally applied insulation on the conductor. At a point on the surface of a coil where the temperature is affected by an external source of heat, the temperature rise measured by a thermocouple may be 15EC (27EF) more than the specified value, provided that the temperature rise of the coil, as measured by the resistance method, is not more than that specified in the table.

[b] These limitations do not apply to compounds that have been investigated and found to be acceptable for higher temperatures.

[c] Shall not attain a temperature higher than the temperature rating of the material minus 25EC (45EF).

[d] Shall not attain a temperature higher than the melting point of the material minus 40EC (72EF).

[e] Rubber-insulated conductors within a Class A insulated motor, rubber insulated motor leads, and rubber insulated flexible cord entering a motor may be subjected to a temperature rise of more than 35EC (63EF), provided a braid is employed on the conductor.

12.5 When determining the temperature by the change-in-resistance method (see note[a] to Table 12.1), the windings are to be at room temperature at the start of the test. The temperature of a winding is to be calculated by using the following equation:

$$T = \frac{R}{r}(k + t_1) - k$$

in which:

T is the temperature in degrees C,

R is the resistance of the coil at the end of the test in ohms,

r is the resistance of the coil at the beginning of the test in ohms

t_1 is the room temperature at the beginning of the test in degrees C, and

k is 234.5 for copper and 225.0 for electrical conductor grade (EC) aluminum. Values of the constant (k) for other grades must be determined.

12.6 If a temperature rise on insulation exceeds a value specified in Table 12.1 or if the insulation system used is not mentioned in Table 12.1, the acceptability of the insulation may be determined in accordance with the following:

a) A generator or diode-rectified alternator is to be placed in a circulating air oven maintained at a temperature 10EC (18EF) higher than the maximum temperature obtained during the procedure specified in 12.3 for a continuous period of 500 hours.

b) A motor-operated product is to be placed in a circulating air oven maintained at a temperature 10EC higher than the maximum temperature obtained during the procedure specified in 12.4 for a continuous period of 500 hours.

c) Following the 500 hour oven exposure, and while still in a heated condition, the product shall comply with the requirements in Stray Current Leakage Test, Section 13.

d) Following the test specified in (c), the product shall operate as intended when energized at rated voltage under a no-load condition.

13 Stray Current Leakage Test

13.1 A product, other than a diode-rectified alternator, shall withstand the application of a 500-volt, direct-current potential between current-carrying parts and noncurrent-carrying ground for 1 minute, during which time the leakage current shall not exceed:

a) 1 milliampere for a continuously operated product; or

b) 3 milliamperes for an intermittently operated product.

13.2 A diode-rectified alternator shall withstand a direct current potential equal to the peak reverse rating of the diodes between current-carrying parts and noncurrent-carrying ground for 1 minute, during which time the leakage current shall not exceed 1 milliampere.

13.3 The test is to be conducted while the product is still heated following the Operation Temperature Test, Section 12, except that for an internally grounded product, the test may be conducted on a sample that has been oven-heated to the maximum temperature obtained in the test described in Section 12, in order to permit disassembly of the sample to disconnect the grounding means.

13.4 The applied potential is to be increased at a rate of approximately 50 volts per second until the specified value is reached, and is to be maintained for 1 minute. The potential is then to be reduced to zero at the same rate at which it was applied.

14 Abnormal Operation Tests

14.1 Overload test

14.1.1 When a product is tested as described in 14.1.2, 14.1.3, or 14.1.4, as applicable, a temperature on any exposed surface, or on a connected mechanism (see 14.1.3), shall not exceed 150EC (302EF).

14.1.2 A motor provided with thermal protection is to be energized at rated voltage and an ambient temperature of 60 ±2EC (140 ±4EF) for 72 hours with the rotor locked.

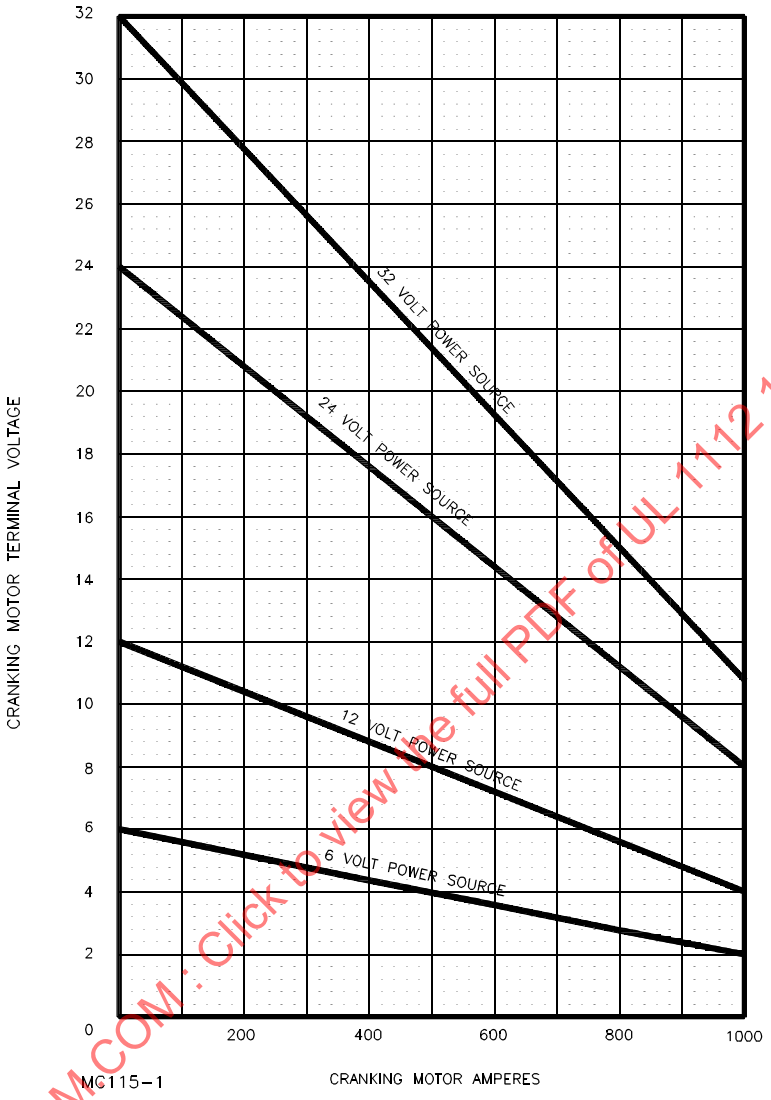
14.1.3 A motor not provided with thermal protection is to be tested in conjunction with the load (pump or mechanism) used in the intended application, at rated voltage and an ambient temperature of 60 ±2EC (140 ±4EF), and using the overcurrent protection recommended by the manufacturer; as follows:

a) The control switch is to be held in the extreme upward or downward position for 4 hours or until the overcurrent device opens.

b) The overcurrent-protective device then is to be replaced or reset and the motor is to be energized with the rotor locked condition for 4 hours, or until the overcurrent-protective device opens.

14.1.4 A cranking motor is to be tested with the rotor locked, at the applicable voltage specified in Figure 14.1, for 15 seconds.

Figure 14.1
Cranking motor voltages



14.2 Mechanical strength test

14.2.1 A generator, alternator, or cranking motor that may be used as a step after installation shall withstand a load of 250 pounds-force (1.11 kN) applied to the least-supported surface likely to be used. The load is not to be applied to collector ring covers, voltage regulators, or other small nonstructural enclosure extensions.