UL 1004-9

STANDARD FOR SAFETY

Form Wound and Medium Voltage Rotating Electrical Machines

UL Standard for Safety for Form Wound and Medium Voltage Rotating Electrical Machines, UL 1004-9

First Edition, Dated January 29, 2016

Summary of Topics

This revision of ANSI/UL 1004-9 dated March 29, 2021 includes the following changes in requirements:

– Removed Reference to UL 508C; 2.1

– Editorial Corrections to Table 6.1

Text that has been changed in any manner or impacted by UL's electronic publishing system is marked with a vertical line in the margin.

The revised requirements are substantially in accordance with Proposal(s) on this subject dated October 2, 2020 and January 29, 2021.

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Standard for Form Wound and Medium Voltage Rotating Electrical Machines

First Edition

January 29, 2016

This ANSI/UL Standard for Safety consists of the First Edition including revisions through March 29, 2021.

The most recent designation of ANSI/UL 1004-9 as an American National Standard (ANSI) occurred on March 18, 2021. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

Comments or proposals for revisions on any part of the Standard may be submitted to UL at any time. Proposals should be submitted via a Proposal Request in UL's On-Line Collaborative Standards Development System (CSDS) at https://csds.ul.com.

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CONTENTS

INTRODUCTION

CONSTRUCTION

PERFORMANCE

MANUFACTURING AND PRODUCTION TESTS

MARKINGS

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INTRODUCTION

1 Scope

1.1 This Standard is intended to be read together with the Standard for Rotating Electrical Machines – General Requirements, UL 1004-1. For machines covered by UL 1004-9, only the following Sections of UL 1004-1 are applicable: Components; Mechanical Assembly; Frame and Enclosure; Grounding; Grounding Identification; Protection Against Corrosion; Factory Wiring Terminals and Leads; Spacings (when rated 1,000 V or less); and Current-Carrying Parts. For these Sections, the requirements of UL 1004-1 apply unless modified by this Standard.

1.2 For the purposes of this Standard, the term "machine" is representative of and equivalent to the terms rotating electrical machine and rotating machine, and is understood to mean all manner of electric motors and generators covered by the scope of this Standard. The term "machine" is understood to apply to both AC and DC machines.

1.3 These requirements apply to field-installed machines with form wound windings and rated for applications between 460 V and up to 34,000 V.

1.4 This standard also applies to field-installed machines employing random wound windings and rated for applications above 1,000 V and up to 7,200 V.

1.5 Machines intended for use in hazardous locations as defined in the National Electrical Code, NFPA 70, may have additional requirements to be met as specified in the National Electrical Code, NFPA 70.

1.6 These requirements do not cover sealed (hermetic type) motor-compressor parts, which are evaluated under the Standard for Household and Similar Electrical Appliances, Part 2: Particular Requirements for Motor-Compressors, UL 60335-2-34.

1.7 These requirements do not cover special generators (such as hydrogen cooled (turbo) generators) rated 10 MVA and above which are covered under IEEE C50.12, IEEE Standard for Salient-Pole 50 Hz and 60 Hz Synchronous Generators and Generator/Motors for Hydraulic Turbine Applications Rated 5 MVA and Above; IEEE C50.13, IEEE Standard for Cylindrical-Rotor 50 Hz and 60 Hz Synchronous Generators Rated 10 MVA and Above; or IEC 60034-3, Rotating electrical machines – Part 3: Specific requirements for synchronous generators driven by steam turbines or combustion gas turbines.

2 Components

2.1 Solid-state controllers shall comply with the Standard for Adjustable Speed Electrical Power Drive Systems – Part 5-1: Safety Requirements – Electrical, Thermal and Energy, UL 61800-5-1, or the Standard for Controllers for Use in Power Production, UL/ULC 6200.

3 Units of Measurement

3.1 Values stated without parentheses are the requirement. Values in parentheses are explanatory or approximate information.

4 Undated References

4.1 Any undated reference to a code or standard appearing in the requirements of this standard shall be interpreted as referring to the latest edition of that code or standard.

5 Glossary

5.1 For the purpose of this Standard, the following definitions apply.

5.2 CYCLOALIPHATIC EPOXY – Epoxy resin consisting of two components that react with each other forming a hard, inert material. Cycloaliphatic epoxies (where “cycloaliphatic” is used as the curing agent) are noted for higher resistance to moisture and UV breakdown compared with non-cycloaliphatic epoxies.

5.3 FORM WOUND MACHINE – A rotating electrical machine using insulated rectangular shaped conductors that are wrapped with additional electrical insulation over the entire coil prior to insertion and are precisely positioned and formed into coils.

5.4 RANDOM WOUND MOTOR – A motor using insulated round magnet wire conductors in which the winding turns occupy random positions in a slot.

5.5 RTD/ETD – Resistance Temperature Detector/Embedded Temperature Detector installed within the machine near the windings to measure temperatures (when used as a measurement device for the Temperature test).

CONSTRUCTION

6 Spacings

6.1 Machines rated 1,000 V or less

6.1.1 Machines with rated voltages not exceeding 750 V shall comply with the spacing requirements in the Table for “Minimum acceptable spacings at field wiring terminals for voltages up to 750” of UL 1004-1. Machines with rated voltages between 751 V and 1,000 V shall comply with the spacing requirements in the Table for “Minimum acceptable spacings at field wiring terminals for voltages over 750” of UL 1004-1.

6.2 Machines rated greater than 1,000 V

6.2.1 The spacing between field-wiring terminals of opposite polarity, and spacing between a field-wiring terminal and any other uninsulated metal part, including removal of metal enclosures shall not be less than that specified in Table 6.1.

6.2.2 Spacings shall be measured with wire of the appropriate size for the rating connected to the terminals as in actual service.

Table 6.1
Minimum spacings for voltages above 1,000 V

Parts involved	Maximum voltage	Minimum spacings, mm (inch)											
		Between bare live parts of opposite polarity				Between bare live parts and non-current-carrying metal				Between bare live parts and removable metal enclosures			
		Through-air		Over-surface		Through-air		Over-surface		Through-air		Over-surface	
Wiring terminals for installer	2,400	25	(1)	50	(2)	25	(1)	50	(2)	25	(1)	50	(2)
	4,200	50	(2)	88	(3.5)	50	(2)	88	(3.5)	50	(2)	88	(3.5)
	7,200	100	(3.9)	125	(4.9)	100	(3.9)	125	(4.9)	100	(3.9)	125	(4.9)
	12,000	125	(4.9)	160	(6.3)	125	(4.9)	160	(6.3)	125	(4.9)	160	(6.3)
	13,800	150	(5.9)	200	(7.9)	150	(5.9)	200	(7.9)	150	(5.9)	200	(7.9)
	18,000	175	(6.9)	250	(9.8)	175	(6.9)	250	(9.8)	175	(6.9)	250	(9.8)
	23,000	305	(12)	460	(18.1)	305	(12)	460	(18.1)	305	(12)	460	(18.1)
	28,000	405	(15.9)	620	(24.4)	405	(15.9)	620	(24.4)	405	(15.9)	620	(24.4)
	34,000	455	(17.9)	690	(27.2)	455	(17.9)	690	(27.2)	455	(17.9)	690	(27.2)

6.2.3 Insulating liner or barriers may be used to reduce spacings below those in Table 6.1 provided the construction complies with the Dielectric Voltage-Withstand Test, Section 9.

6.2.4 The creepage distances are based on applications at altitudes below 1,000 m (3,280 feet). The spacings in Table 6.1 shall be increased 3 percent for every 300 m (984 feet) above 1,000 m (3,280 feet).

7 Insulation Systems

7.1 Insulation systems shall comprise materials that have been shown by service life experience or test to have suitable thermal endurance when operating at the temperature limit declared. Compliance shall be demonstrated by one of the following methods:

a) Insulation systems without suitable field experience may be used provided the insulation system in question (candidate system) complies with Procedure C – Single-point thermal ageing test in IEC 61858 – Part 2: Electrical insulation systems – Thermal evaluation of modifications to an established electrical insulation system (EIS) – Part 2: Form-wound EIS, when tested against a system previously found to be acceptable for service at the rated temperature class;

b) A modified or a new insulation system complying with the requirements of IEC 60034-18-31, Part 18-31: Functional evaluation of insulation systems – Test procedures for form-wound windings – Thermal evaluation and classification of insulation systems used in rotating machines;

c) For form wound machines rated 15,000 V or less, using IEEE 1776, Recommended Practice for Thermal Evaluation of Unsealed or Sealed Insulation Systems for AC Electric Machinery Employing Form-Wound Pre-Insulated Stator Coils for Machines Rated 15000 V or Below, is considered to meet the intent of this requirement; or

d) The manufacturer's declaration with supporting documents such as test reports to established standards and documentation of machines using the materials with service life experience reports.

8 Electrical Insulation

8.1 Materials used to support terminals or live parts other than magnet wire shall be constructed of materials that have been shown by experience or test to have suitable thermal and electrical properties suitable for the temperatures measured during intended use. Compliance shall be demonstrated by one of the following methods:

a) Materials have been evaluated and found acceptable in accordance with the applicable requirements covering mechanical and electrical property considerations in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C;

b) Phenolic, ceramic, porcelain, and cycloaliphatic epoxies are able to be used without additional evaluation;

c) Materials used to support live parts on machines rated 1,000 V or less are considered acceptable when exhibiting flame, volume resistivity, electric strength, Comparative Tracking Index (CTI), High Current Arc Resistance Ignition (HAI), and Hot-Wire Ignition (HWI) properties shown in Table 8.1 and used within established thermal ratings for the temperatures measured during intended use; or

d) The manufacturer's declaration with supporting documents such as test reports to established standards and documentation of machines using the materials with service life experience reports.

Table 8.1
Performance levels

Flame rating	Volume resistivity	Dielectric strength	CTI	HAI	HWI
	(ohm-cm) (dry/wet)	(Volts)	(PLC)	(PLC)	(PLC)
HB	50/10 x 106	5,000	2	1	2
V-2, VTM-2	50/10 x 106	5,000	2	2	2
V-1, VTM-1	50/10 x 106	5,000	2	2	3
V-0, VTM-0	50/10 x 106	5,000	2	3	4

PERFORMANCE

9 Dielectric Voltage-Withstand Test

9.1 A Dielectric Voltage-Withstand Test shall be carried out after all other tests. The machine shall withstand without breakdown the application of a 40 – 70 Hz or a direct current potential equal to the value shown in Table 9.1 for the applicable conditions. The voltage potential is to be present for 1 minute.

Table 9.1
Dielectric voltage potential

Application of voltage	Test potential, AC	Test potential, DC
Primary wiring or terminals and dead metal parts	1,000 V + twice the machine's rated voltage	1.7(1,000 V + twice the machine's rated voltage)
Primary wiring or terminals and low-voltage circuits – 42.4 V peak ac, 60 V dc or less	1,000 V + twice the machine's rated voltage	1.7(1,000 V + twice the machine's rated voltage)
Brushless exciter fields and dead metal parts (dc exciters rated 350 V or less)	10 times the machine's rated voltage or 1,500 V, whichever is greater	1.7(10 times the machine's rated voltage) or 2,550 V, whichever is greater
Brushless exciter fields and dead metal parts (dc exciters rated greater than 350 V)	2,800 V + twice the machine's rated voltage	1.7(2,800 V + twice the machine's rated voltage)
AC excited stators (fields) and dead metals parts	1,000 V + twice the machine's rated voltage	1.7(1,000 V + twice the machine's rated voltage)
Accessory devices and dead-metal	1,000 V+ twice the accessory's rated voltage or 1,500 V, whichever is greater	1.7(1,000 V + twice the accessory's rated voltage) or 2,550 V, whichever is greater