UL 6141

STANDARD FOR SAFETY

Wind Turbines Permitting Entry of Personnel

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UL Standard for Safety for Wind Turbines Permitting Entry of Personnel, UL 6141

First Edition, Dated May 20, 2016

Summary of Topics

This revision of ANSI/UL 6141 dated July 30, 2021 includes the addition of reference to the Standard for Energy Storage Systems and Equipment, UL 9540, as UPS functionality; 4.21.1.10

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 January 8, 2021.

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UL 6141

Standard for Wind Turbines Permitting Entry of Personnel

First Edition

May 20, 2016

This ANSI/UL Standard for Safety consists of the First Edition including revisions through July 30, 2021.

The most recent designation of ANSI/UL 6141 as an American National Standard (ANSI) occurred on July 27, 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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INTRODUCTION

1 Scope

1.1 These requirements cover large wind turbine systems (WT) that are equipped with electrical subassemblies and permit the entry of personnel. With respect to this standard, WT permitting entry of personnel are considered to be wind turbines where a user or service person may, or is intended to, enter the turbine to operate it or perform maintenance. These WT are intended for use in utility-interactive, grid-tied applications that operate in parallel with an electric power system (EPS) to supply power to common or stand-alone loads. This standard includes requirements for WT intended for EPS grid connections at transmission, sub-transmission, and distribution levels depending on the specifications of the specific WT.

1.2 The WT power, control and protection systems are evaluated only to the extent that they function within the manufacturer's specified limits and response times. These control and protection functions are evaluated with respect to risk of electric shock and fire. It is intended that the electrical subassemblies that address power transfer and control and protection functions evaluated per this document are to be coordinated with the mechanical and structural evaluation of the WT in accordance with the IEC 61400 series of documents.

1.3 These requirements do not cover:

a) Wind turbine generating systems intended for offshore installation,

b) Mechanical or structural integrity of the WT or subassemblies,

c) Verification that the manufacturer-defined controls and protection limits maintain the WT within its safe mechanical and structural limits,

d) Compliance with specific grid interconnection standards or requirements.

1.4 The wind turbine products covered by these requirements are intended to be installed in multiple installation locations and jurisdictions which may include installation codes including, but not limited to, the National Electrical Code, ANSI/NFPA 70, the National Electrical Safety Code (NESC), and NFPA 79, Electrical Standard for Industrial Machinery.

1.5 The wind turbine products covered by this standard are considered to be machines that include inherent internal hazards that make them unsuitable for access by the general public.

1.6 The users, operators and service persons that enter this equipment are expected to have the necessary knowledge of its operation and reasonably foreseeable hazards. These individuals are expected to be equipped with the necessary equipment for the application and hazard.

1.7 The evaluation of products to this standard includes the evaluation of all features and functions incorporated in or available for the WT that can affect compliance of the WT with this standard. This includes references in the documentation for the WT.

1.8 Small WT and electrical subassemblies are defined as wind turbines where a user or service person is not intended or required to enter the WT to operate or perform maintenance on the WT. Small wind systems are covered in the Standard for Small Wind Turbine Systems, UL 6142.

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2 General

2.1 Components

2.1.1 Except as indicated in 2.1.2, a component of a product covered by this standard shall comply with the requirements for that component. See Appendices A – C for a list of standards covering components used in the products covered by this standard.

2.1.2 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 or system covered by this standard,

b) Is superseded by a requirement in this standard, or

c) Is not relied upon for compliance with the National Electric Code, ANSI/NFPA 70, and other U.S. installation codes, provided the component addresses the performance and safety critical aspects necessary for the end application as determined by the evaluation in this standard.

Note: the following provides guidance for item (c) –

1) Integral WT components relied upon to interconnect with and/or protect system components, system wiring, loads, etc. shall be of the type(s) defined in the applicable portion of the National Electric Code and shall comply with the applicable portions of the UL standards or standards referenced in the National Electric Code and in Appendix A for that component type or function. They shall be suitable for the application within the end product application, including the end product ratings and including foreseeable abnormal conditions. Examples include, but are not limited to, branch overcurrent protection, switches, disconnects, wire, cable, connectors, contactors, etc.

2) External WT system components (not integral to the WT) shall comply with applicable UL standard for that component.

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

2.1.4 Specific components are 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.

2.1.5 Components and subassemblies of the overall WT shall be evaluated and found suitable for their operation over the rated normal operating range of electrical and environmental conditions within the WT per the WT manufacturer's specifications.

2.1.6 These components and subassemblies shall also perform per the manufacturer's specifications during defined abnormal conditions, such as WT shutdown and abnormal electric utility grid conditions.

2.1.7 For additional requirements, reference Section 4, Special Components and Subassemblies of Wind Turbines.

2.2 Units of Measurement

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

2.2.2 All references to AC voltages within this standard shall be considered to be RMS unless otherwise specified.

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2.2.3 All references to DC voltages within this standard shall be considered to be maximum cyclic voltages unless otherwise specified.

2.2.4 All references to voltages that are not specified as AC or DC shall be considered to be the nominal line-to-line AC RMS voltage.

2.3 Undated References

2.3.1 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.

3 Glossary

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

3.1 DOWN TOWER – The space in and around a wind turbine location that is at or near ground level such as the base level of the turbine tower.

3.2 ELECTRIC POWER SYSTEM (EPS) – Equipment or facilities that deliver electric power to a load(s). The most common example of an EPS is an electric utility.

3.3 MAXIMUM CURRENT(S) – The maximum peak current(s) a wind turbine will produce. There may be several maximum current ratings defined for a product or system, such as alternator/generator output, inverter/converter output, and control output circuits.

3.4 MAXIMUM OUTPUT POWER – The maximum average power output a wind turbine in normal steady-state operation will produce over a one minute period of time. Note that the peak power output can be greater.

3.5 MAXIMUM VOLTAGE – The maximum peak voltage a wind turbine will produce during operation, including open circuit conditions.

3.6 MEDIUM VOLTAGE – More than 1000 Vac or 1500 Vdc.

3.7 NACELLE – The housing or enclosure for the alternator/generator and other wind turbine parts that is generally located at the top of the tower.

3.8 OVERVOLTAGE – Any voltage having a peak value exceeding the corresponding peak value of maximum steady-state voltage at normal operating conditions.

3.9 OVERVOLTAGE CATEGORY – A numeric classification that defines a transient overvoltage condition:

a) Overvoltage categories I, II, III, and IV are used per IEC 60664-1, Insulation coordination for equipment within low-voltage systems – Part 1: Principles, requirements and tests.

b) The term "overvoltage category" in this standard is synonymous with "impulse withstand category" used in IEC 60664-4-44, Low-voltage electrical installations – Part 4-44: Protection for safety – Protection against voltage disturbances and electromagnetic disturbances.

3.10 PERSONAL PROTECTION SYSTEM – Emergency stop system intended primarily to provide protection from moving, rotational, or electrical danger for personnel in the wind turbine.

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3.11 POLLUTION – Any addition of contaminants, solid, liquid or gaseous (ionized gases), and moisture that may produce a reduction of dielectric strength or surface resistivity.

3.12 POLLUTION DEGREE – The level of pollution present at the location on or in a product where the clearance and creepage distance measurement is made and can be controlled by the design of the product. For example, enclosures can be used to achieve pollution degree 3, heaters within enclosures can help achieve pollution degree 2, and encapsulation can be used to achieve pollution degree 1:

a) Pollution Degree 1: No pollution or only dry, nonconductive pollution. The pollution has no influence.

b) Pollution Degree 2: Normally, only nonconductive pollution; however, a temporary conductivity caused by condensation may be expected.

c) Pollution Degree 3: Conductive pollution or dry, nonconductive pollution that becomes conductive due to condensation that is expected.

d) Pollution Degree 4: Pollution that generates persistent conductivity through conductive dust or rain and snow.

3.13 POLYMERIC MATERIAL – Materials that are either natural or synthetic and are primarily composed of chained molecules of monomers, combinations of monomers, combined polymers, crosslinking agents, fillers, colorants, and other materials.

3.14 RATED POWER – The output power of the wind turbine when operating at its rated wind speed in accordance with IEC 61400-12-1, Wind turbines – Part 12-1: Power performance measurements of electricity producing wind turbines.

Note: The method for measuring wind turbine power output is specified in IEC 61400-12-1.

3.15 SAFETY RELATED CONTROLS SYSTEM (SRCS) – Assembly of equipment that includes the critical controls and protection functions that maintain the wind turbine within its mechanical and structural design limitations. This includes the evaluation of electrical control and protection functions, limits, operation, and response times during normal, abnormal, and failure conditions. The SRCS may include electromechanical components.

3.16 SWITCHGEAR – The combination of switching and interrupting devices that are used with associated control, instruments, metering, protective, and regulating accessories. Switchgear also includes associated interconnections and other electrical accessories, and supporting structures used primarily for the generation, transmission, distribution, and conversion of electric power.

3.17 SWITCHGEAR ASSEMBLY – Assembled indoor or outdoor equipment provided with a supporting structure, one or more enclosures, conductors, electrical interconnections and other accessories that includes switching, interrupting, control, instrumentation, metering, protective, and regulating devices.

3.18 TURBINE PROTECTION SYSTEM – System intended primarily to provide protection for a wind turbine structure in the event of the following conditions: short circuits, excessive vibration, rotor or generator overspeed, extreme temperature, or extreme wind.

3.19 UP TOWER – The space in and around a wind turbine location that is at or above the top of the tower such as in the nacelle and hub.

3.20 WIND TURBINE (WT) – A device or system of subassemblies that convert wind energy to electric power and typically consists of an overall structure including; tower, nacelle, hub and blades as well as the associated internal equipment.

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3.21 WIND TURBINE OUTPUT CIRCUIT – The circuit conductors or equipment connected to the turbine output terminals or conductors where the turbine is intended to be connected to the electric power system (EPS).

WIND TURBINE EQUIPMENT AND SUBASSEMBLIES

4 Special Components and Subassemblies of Wind Turbines

4.1 General

4.1.1 For the purpose of this standard, the medium voltage requirements are to be applied to circuits that operate at greater than 1000Vac / 1500 Vdc nominal.

4.1.2 WT equipment and subassemblies, other than those noted in this section and 2.1, Components, shall comply with (at minimum) one of the following standards:

a) The Standard for Industrial Control Panels, UL 508A;

b) The Standard for Adjustable Speed Electrical Power Drive Systems – Part 5-1: Safety Requirements – Electrical, Thermal and Energy, UL 61800-5-1, or

c) UL 60947 Low-Voltage Switchgear and Controlgear – Part 1: General Rules along with any of the following UL 60947 part 2 standards:

1) UL 60947-4-1, Low-Voltage Switchgear and Controlgear – Part 4-1: Contactors and Motor-Starters – Electromechanical Contactors and Motor-Starters;

2) UL 60947-4-2, Low-Voltage Switchgear and Controlgear – Part 4-2: AC Semiconductor Motor Controllers and Starters I Contactors and Motor-Starters;

3) UL 60947-5-1, Low-Voltage Switchgear and Controlgear – Part 5-1: Control Circuit Devices and Switching Elements – Electromechanical Control Circuit Devices;

4) UL 60947-5-2, Low-Voltage Switchgear and Controlgear – Part 5-2: Control Circuit Devices and Switching Elements - Proximity Switches;

5) UL 60947-7-1, Low-Voltage Switchgear And Controlgear – Part 7-1: Ancillary Equipment – Terminal Blocks for Copper Conductors;

6) UL 60947-7-2, Low-Voltage Switchgear and Controlgear – Part 7-2: Ancillary Equipment – Protective Conductor Terminal Blocks for Copper Conductors

7) UL 60947-7-3, Low-Voltage Switchgear and Controlgear – Part 7-3: Ancillary Equipment – Safety Requirements for Fuse Terminal Blocks.

4.1.3 Regarding 4.1.2 (a) when used outside the scope parameters of the Standard for Industrial Control Panels, UL 508A, an evaluation shall be performed on the means to keep the internal temperature within the limits of UL 508A. If not feasible, testing per the Standard for Industrial Control Equipment, UL 508 shall be performed for the worst case normal rated equipment use application.

Exception: Equipment and subassemblies not covered by Section 8, Safety Related Control Systems, that include components rated for at least the evaluated rated ambient temperature need not be tested per UL 508.

4.1.4 Where the standards referenced in 4.1.2 do not address the needs of the equipment or subassembly, NFPA 79, Electrical Standard for Industrial Machinery, shall be applied.

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4.1.5 Equipment and subassemblies shall be rated for the electrical an environmental installation location of the component inside or outside the turbine. Internal turbine environmental conditions may include exposure to water, corrosive, non-corrosive liquids, falling dust, dirt, and other debris that might occur. For WTs where oil films or leaks may be expected based on the normal operation or maintenance tasks, enclosures, including gaskets, shall be suitably rated for ingress of the expected type and amount of oil.

4.1.6 The acceptable WT enclosure rating shall be determined from the manufacturer's instructions and description of the intended use during manufacturing, transport, installation, operation and maintenance. Enclosures shall be rated using:

a) Standard for Enclosures for Electrical Equipment, Environmental Considerations, UL 50E,

b) IEC 60529, Degrees of Protection Provided by Enclosures (IP Code), or

c) NEMA 250, Enclosures for Electrical Equipment (100 Volts Maximum)

Note: NEMA 250 or UL 50E Types 3R, 3RS, 5 or 12 enclosure ratings or IEC 60529 enclosure ratings of IP43, IP54, or IP65 address the environment of most internal wind turbine components and enclosures.

4.1.7 Equipment enclosures shall be constructed of sufficient mechanical strength to withstand the foreseeable mechanical forces during normal operation and service of the turbine. Such forces include, but are not limited to, rotation, rotational sway, yaw, and foreseeable forces imparted by personnel or equipment on the enclosures.

4.1.8 Enclosures or equipment that may be used by operators or service personnel, such as a step, hand hold, or lean support, shall have the mechanical strength and rigidity to maintain the enclosure's required properties as defined in this section including, but not limited to, electrical spacings and access to live parts.

4.1.9 For internal areas of the WT where users or service persons are intended to enter the turbine to operate or service it, polymeric materials such as polymeric enclosures, polymeric access barriers, walls of a nacelle, or insulation on the walls of a turbine shall be rated as follows. Any single unbroken section greater than 10 square feet (0.93 m^2) or a single linear dimension greater than 6 feet (1.83 m), shall have a maximum flame spread index and smoke developed index as shown in Table 4.1 as tested in accordance with the Standard for Test for Surface Burning Characteristics of Building Materials, UL 723.

Exception No. 1: The following are not required to comply with this requirement:

a) Wire and cables,

b) Materials less than 0.036 inch (0.9 mm) thick directly applied to walls, floors, or ceiling surfaces,

c) Elevators complying with 4.26.

Exception No. 2: Turbines with automatic fire suppression are allowed to use Up Tower limits for all turbine locations.

Table 4.1
Large area polymeric smoke and flame ratings

Tower location	Flame spread index	Smoke developed index
Down tower and tower[a]	25	450
Up tower	200	450

[a] Applies to enclosed assemblies and does not apply to open lattice constructed.

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4.1.10 A material with a flame-spread rating higher than that specified in 4.1.9 may be used as the exterior finish or covering on any portion of the enclosure if the rating of the combination of the base material and finish or covering complies with 4.1.9.

4.1.11 Brake systems shall prevent ignition of adjacent combustible materials and potential fluids (contained or leaked) through coordination of design features.

4.2 Wiring

4.2.1 General requirements

4.2.1.1 Internal wiring within subassemblies and components that are not covered by component standards shall comply with the Standard for Industrial Control Equipment, UL 508, or IEC 60204-1, Safety of machinery – Electrical equipment of machines – Part 1: General requirements (Chapter 12 and 13), or NFPA 79, Electrical Standard for Industrial Machinery (Chapters 12 and 13) in addition to the requirements in this section.

4.2.1.2 Wiring that is subject to movement, flexing, or twisting during operation of the wind turbine shall be investigated in accordance with 4.4, Cable drip loop, for suitability in the conditions of use and rated life or cycle time.

4.2.1.3 All wiring within a WT that is accessible to users or service personnel or runs vertically up the tower shall be either in a raceway or be rated for tray cable usage. The following meets the intent of this requirement:

a) Multiconductor cable complying with the Outline of Investigation for Flexible Motor Supply Cable and Wind Turbine Tray Cable, UL 2277, and marked for wind turbine usage;

b) Power-limited circuit cabling complying with the Standard for Power-Limited Circuit Cables, UL 13, suitable for Tray Cable usage (Types CMG, CM, CL2, CL3, PLTC, CMR, CL2R, CL3R, CMP, CL2P, CL3P);

c) Optical fiber circuits complying with the Standard for Optical Fiber Cable, UL 1651;

d) Power cabling complying with the Standard for Thermoplastic-Insulated Wires and Cables, UL 83, or the Standard for Thermoset-Insulated Wires and Cables, UL 44, and additionally marked for cable tray usage (“CT”, “For Cable Tray Use”, “For CT Use”, or “For Use in Cable Trays”) or marked "FT4";

e) For voltages greater than 2kV, cabling complying with the Standard for Medium Voltage Power Cables, UL 1072, and additionally marked for cable tray usage (“CT”, “For Cable Tray Use”, “For CT Use”, or “For Use in Cable Trays”) or marked "FT4";

f) Extra hard usage cord that complies with the Standard for Flexible Cords and Cables, UL 62;

g) Cables that comply with the Standard for Cables for Non-Power-Limited Fire-Alarm Circuits, UL 1425;

h) Metal-clad cables that comply with the Standard for Metal-Clad Cables, UL 1569.

Exception: Wiring within a component need only meet the requirements for the component.

4.2.1.4 Wiring within the turbine shall comply with the NEC-based wiring requirements in 4.2.2 or IEC-based wiring requirements specified in 4.2.3.

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4.2.2 NEC-based wiring requirements

4.2.2.1 Wiring within the WT shall be compliant with applicable articles of the National Electrical Code, ANSI/NFPA 70, such as:

a) Article 215.2 for minimum rating and size of feeders;

b) Article 300.3(C) for minimum rating of conductors of different systems in same raceway;

c) Article 392 for tray cables;

d) Article 445.13 for ampacity of conductors for generators;

e) Article 455.6 for conductors of phase converters.

4.2.2.2 The designs specified in 4.2.2.1 that are used shall be referenced on the turbine marking plate.

4.2.3 IEC-based wiring requirements

4.2.3.1 Wiring supplied with the WT and installed by the manufacturer or installed by qualified personnel in accordance with the manufacturer's installation procedures shall be referenced on the turbine's marking plate and shall be comply with the following:

a) Wiring integral to the WT shall be of the types specified in 4.2.1.3, and shall be sized in accordance with IEC 60364-5-52:2009, Low-voltage electrical installations – Part 5-52: Selection and erection of electrical equipment – Wiring systems;

b) Current-carrying rating shall be based on IEC 60364-5-52:2009, Table B.52.1 to and including Table B.52.13;

c) Derating factors for temperatures different that 30°C shall be based on IEC 60364-5-52:2009, Table B.52.14;

d) Derating factors for a group of cable or multi-conductor cables shall be based on IIEC 60364-5-52:2009, Table B.52.17, Table B.52.20, and Table B.52.21.

4.2.4 Wiring ampacity verification

4.2.4.1 If the methods of verifying ampacity cannot be established, a temperature evaluation shall be performed.

4.2.4.2 The evaluation specified in 4.2.4.1 shall be an engineering calculation based on proven techniques or a test performed under the conditions specified in 4.2.4.3 – 4.2.4.5. At the conclusion of the evaluation, the temperature recorded shall not:

a) Be so high as to constitute a risk of fire;

b) Be so high as to adversely affect any materials employed in the equipment;

c) Exceed the temperature limit for any individual component within the equipment.

4.2.4.3 Protective devices or circuitry shall not trip during the test.

4.2.4.4 For equipment provided with a thermostat or other thermal protective device, temperatures are to be measured with all parts operating simultaneously since the heating of one part may affect the heating of another part.

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