UL 6142

STANDARD FOR SAFETY

Small Wind Turbine Systems

UL Standard for Safety for Small Wind Turbine Systems, UL 6142

First Edition, Dated November 30, 2012

Summary of Topics

This revision of ANSI/UL 6142 dated September 29, 2020 includes the removal of references to the Standard for Power Conversion Equipment, UL 508C, and replacement with reference to the Standard for Adjustable Speed Electrical Power Drive Systems – Part 5-1: Safety Requirements – Electrical, Thermal, and Energy UL 61800-5-1; 4.9.2, 4.10.1, 9.2.3, and Appendix A.

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 July 31, 2020.

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Small Wind Turbine Systems

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Commitment for Amendments

This standard is issued jointly by the American Wind Energy Association (AWEA) and Underwriters Laboratories Inc. (UL). Comments or proposals for revisions or any part of the standard may be submitted to UL at any time. Revisions to this standard will be made only after processing according to the standards development procedures of UL. AWEA and UL will issue revisions to this standard by means of revised or additional pages bearing their date of issue.

This ANSI/UL Standard for Safety consists of the First Edition including revisions through September 29, 2020.

The most recent designation of ANSI/UL 6142 as an American National Standard (ANSI) occurred on September 1, 2020. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, Title Page (front and back), or the Preface.

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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Preface

This is the common AWEA and UL standard for Small Wind Turbine Systems. It is the first edition of AWEA 6142, and the first edition of UL 6142.

This common standard was developed and processed in accordance with the accredited standards development procedures of Underwriters Laboratories Inc. (UL).

This standard has been approved by the American National Standards Institute as an American National Standard.

Note: *Although the intended primary application of this standard is stated in its scope, it is important to note that it remains the responsibility of the users of the standard to judge its suitability for their particular purpose.*

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SMALL WIND TURBINE SYSTEMS

INTRODUCTION

1 Scope

1.1 These requirements cover small wind turbine systems (WT) and electrical subassemblies. With respect to this standard, small WT are considered to be wind turbines where a user or service person cannot or is not intended to enter the turbine to operate it or perform maintenance. These units are intended for use in stand-alone (not grid-connected) or utility interactive applications. Utility-interactive, grid-tied WT are operated in parallel with an electric power system (EPS) to supply power to common loads.

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 control and protection functions evaluated per this document are to be coordinated with the mechanical and structural limitations specified in AWEA 9.1, Small Wind Turbine Performance and Safety Standard, the IEC 61400 series documents, or Germanischer Lloyd: Guideline for the Certification of Wind Turbines documents.

1.3 These requirements do not cover:

a) WT generating systems intended for off-shore installation.

b) WT generating systems intended for hazardous locations;

c) Mechanical or structural integrity of the WT system or subassemblies;

d) Verification that the manufacturer-defined controls and protection limits maintain the WT system within its safe mechanical and structural limits;

e) Mechanical loading of ladders, hoist supports, elevator mounting means, scaffolding, personnel tie offs, or other personnel load-bearing functional parts.

1.4 The wind turbine products covered by these requirements are intended to be installed in accordance with the National Electrical Code, ANSI/NFPA 70.

1.5 The evaluation of products to this standard includes evaluation of all features and functions incorporated in or available for the turbine, or referred to in the documentation provided with the turbine, if these features or functions can affect compliance of the product with this standard.

1.6 Turbines where a user or service person is intended or required to enter the turbine to operate or perform maintenance on the turbine are considered to be large wind turbine systems and are covered in the Outline of Investigation for Wind Turbine Generating Systems, UL 6140.

1.7 These requirements cover WT rated 1500 Vac or less.

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 Appendix A for a list of standards covering components used in the products covered by this standard. See also Section 4, Special Components and Subassemblies of WT.

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 covered by this standard, or

b) Is superseded by a requirement in this standard.

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

2.2 Units of Measurement

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

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

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

3.2 CHARGE CONTOLLER – A device intended to control the charging process of storage batteries or other energy storage device.

3.3 DIVERSION CHARGE CONTROLLER – A charge controller that regulates the charging process by diverting power from energy storage to AC loads, DC loads, or to an EPS.

3.4 DIVERSION LOAD – An electrical load that consumes power diverted to it by a diversion charge controller or diversion load controller.

3.5 DIVERSION LOAD CONTROLLER – A regulation device or system that diverts wind generator output power to AC loads, DC loads or to an EPS.

3.6 DOWN TOWER – Wind turbine location that is at ground level or near ground level, such as the base level of the turbine tower.

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

3.8 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.

3.9 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.

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

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

3.12 OVERVOLTAGE CATEGORY – Grouping of products based on typical installed location with respect to overvoltage protection and available energy:

a) Category IV - Primary Supply Level. Overhead lines and cable systems including distribution and its associated overcurrent protective equipment (equipment installed at the service entrance).

b) Category III - Distribution Level. Fixed wiring and associated equipment (not electrical loads) connected to the primary supply level, Category IV.

c) Category II - Load Level. Appliances and portable equipment and the like connected to the distribution level, Category III.

d) Category I - Signal Level. Special equipment or parts of equipment such as low-voltage electronic logic systems, remote controls, signaling and power limited (per Article 725 of National Electrical Code, ANSI/NFPA 70) circuits connected to the load level, Category II.

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

3.14 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.

3.15 RATED POWER – The highest output power of the wind turbine when operating at a wind speed of up to 11 m/s (24.6 mph).

Note: The method for measuring wind turbine power output is specified in IEC 61400-12-1, Power Performance Measurements of Electricity Producing Wind Turbines.

3.16 SMALL TURBINE – A wind turbine where a user or service person cannot or is not intended to enter the turbine to operate it or perform maintenance.

3.17 TOWER – A pole or other wind turbine support structure.

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

3.19 UP TOWER – Wind turbine location that is at or above the top of the tower such as in the nacelle and hub.

3.20 WIND TURBINE OUTPUT CIRCUIT – The circuit conductors between the internal components of a small wind turbine (which might include an alternator, integrated rectifier, controller, and/or inverter) and other equipment.

CONSTRUCTION

4 Special Components and Subassemblies of Wind Turbines

4.1 General

4.1.1 WT and subassemblies other than those noted in 2.1, Components and this section shall comply with applicable portions of the Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources, UL 1741, or the Standard for Industrial Control Equipment, UL 508. Constructions and subassemblies not covered by the previously mentioned UL standards shall comply with the National Electrical Code, ANSI/NFPA 70.

4.1.2 Components and subassemblies shall be suitably rated for the installation location of the component within or outside the turbine. Internal turbine environmental conditions often include dripping of water and other non-corrosive liquids, and falling dust, dirt, and other debris. Type 12 or 5 enclosure ratings address the environment of most internal wind turbine components and enclosures.

4.1.3 Equipment enclosures shall be constructed of sufficient mechanical strength to withstand the foreseeable mechanical forces during operation or service of the turbine. Such forces include, but are not limited to, rotational sway.

4.2 Wiring

4.2.1 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 the Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources, UL 1741, in addition to the requirements in this section.

4.2.2 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.

4.2.3 All wiring within a WT that is accessible to users or service personnel or run vertically up the tower shall be either in a raceway or be rated for tray cable usage. The following meets the intent of the 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) Extra hard usage cord that complies with the Standard for Flexible Cords and Cables, UL 62.

f) Armored cable in accordance with the Standard for Armored Cable, UL 4.

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.

4.2.4 Tray cables shall be installed in accordance with ANSI/NFPA 70 Article 300.

4.2.5 Wiring within a rotating hub shall be additionally protected from mechanical damage and from loose debris that may impact wiring during hub rotation. Such protection may be provided by enclosures or conduit complying with one of the following or the equivalent:

a) Standard for Metallic Outlet Boxes, UL 514A,

b) Standard for Conduit, Tubing, and Cable Fittings, UL 514B,

c) Standard for Nonmetallic Outlet Boxes, Flush-Device Boxes and Covers, UL 514C,

d) Mechanical shielding.

Exception: Wiring that is low voltage, limited energy and not part of the Safety Related Control System defined in Section 8 need not to comply with 4.2.5.

4.2.6 Wiring subjected to exposure to water or oil during normal or abnormal conditions such as a gasket or seal leak shall be suitably rated for the condition.

4.2.7 Wiring subjected to UV exposure during operation shall be rated for exposure to sunlight.

4.2.8 Wiring exposed or subjected to wear, abrasion, or impact from operation of the turbine or located in a user or service person traffic area, shall be provided with additional protection to prevent damage to the electrical insulation.

4.3 Splices and Connections in Power Cables

4.3.1 Splices in power circuit cables shall be provided with insulation suitable for the circuit in which it is used, including voltage rating, thermal rating and mechanical protection.

4.3.2 Strain relief shall be provided within 24 inches of the spliced connection to prevent tensile forces on the conductors and splice.

4.3.3 For WT applications that subject the splices to temperatures below minus 30°C, additional testing may be required to verify the ability of the connection and the insulation to withstand those temperature extremes. This requirement applies regardless of whether the WT is operating under those conditions.

4.3.4 Spliced connections in WT power circuits operating at 1000 V or less shall be assembled in accordance with the splice manufacturer's instructions using the tool specified by the splice connector manufacturer. The tool shall be calibrated per the manufacturer's specifications. The assembly operation shall be performed within the rated installation ambient temperature range as specified by the connector manufacturer.

4.3.5 For splice connections in power circuits operating at 1000 V or less, the finished assembly shall comply with the applicable testing requirements of the Standard for Wire Connectors, UL 486A-486B regardless of the applied voltage. Splice connections operating between 600 V and 1000 V, shall be subjected to the Insulation Puncture tests at a test voltage of 2000 V plus 2.25 times circuit operation voltage. The Flashover Tests shall be conducted in accordance with Insulation puncture and flashover test voltages, Tests A and B (Table 28) of UL 486A-486B for 600 (1000) V. The testing shall be performed using the same conductor type and style in the WT application.

4.3.6 Splice connectors employed in power circuits above 1000 V shall comply with the requirements of the IEEE 386, Standard for Separable Insulated Connector Systems for Power Distribution Systems Above 600 V.

4.4 Cable drip loop

4.4.1 If operation of the wind turbine may result in twisting of flexible cables, such as the connecting cables between rotating parts (nacelle) and parts of the fixed structure (tower or foundation), the operational conditions of use shall not cause damage to the conductors or their insulation. The evaluation shall address service life, electrical and environmental operating conditions of the subassembly.

4.4.2 Controls that prevent damage to conductors or their insulation including rotational limits shall be considered part of the Safety Related Controls System evaluation of this document. The control shall be designed so that resetting to the neutral position is possible. See Section 8, Safety Related Controls System (SRCS).

4.4.3 Where multiple cables are grouped and tied together, the cable having the largest outer diameter shall be rated or evaluated for the additional weight-carrying capability of all the cables that are attached.

Exception: Other fixtures where the load is not transferred from one cable to another during twisting need not comply with this requirement.

4.4.4 Cable size and temperature rating shall be based upon Article 310 of the National Electrical Code, ANSI/NFPA 70 or based upon the temperature tests from the Standard for Industrial Control Equipment, UL 508, or the Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources – UL 1741, including representative size and number of cables fully twisted, carrying maximum normal current and including electrical terminations similar in distance in the end product.

4.5 Bus bars

4.5.1 Sections of bus shall be suitably attached to the tower or to components of the tower intended to support the bus. The compliance of the attachment method shall be determined by subjecting a representative bus to Impact, Static Load, and Flexing tests.

4.5.2 Bus shall be guarded or insulated to prevent unintentional contact in accordance with the following:

a) Bus shall be enclosed by grounded metal at each work platform for a minimum of 9 feet (2.8 meters) above each platform.

b) In areas other than work platforms, bus shall be metal enclosed, enclosed in a nonmetallic enclosure complying with the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, or the conductors shall be protected by insulation and jacket that would be required of comparable tray cables specified by the:

1) Outline of Investigation for Flexible Motor Supply Cable and Wind Turbine Tray Cable, UL 2277,

2) Standard for Electrical Power and Control Tray Cables with Optional Optical-Fiber Members, UL 1277, or

3) Standard for Thermoplastic-Insulated Wires and Cables, UL 83.

4.5.3 Where cables are connected to bus assemblies, suitable wiring terminals shall be provided. Where the anticipated movement of the tower assembly causes movement of the cable or bus assembly, strain relief shall be provided to prevent movement of the connection.

4.5.4 Performance requirements shall be based on the Standard for Busways, UL 857, for bus rated 600 V or less and on the Standard for Metal Enclosed Bus, IEEE C37.23, for bus rated more than 600 V. Performance testing shall include electrical and mechanical tests. See 4.5.5 and 4.5.6.

4.5.5 The following electrical tests shall be conducted:

a) Continuous Current (Heating),

b) Dielectric Withstand (Applied Potential) for all voltage ratings,

c) Impulse Withstand for bus rated more than 2.2 kV,

d) Short Circuit Withstand for bus assemblies rated up to 600 V, and

e) Momentary and Short-Time tests for bus assemblies rated greater than 600 V.

4.5.6 The mechanical tests specified in (a), (b), and (c) shall be conducted. The parameters for vibration and flexing tests are to be determined based on the amount of flexing transmitted to the bus assembly through movement of the wind turbine and tower under anticipated extreme conditions determined based upon the WT calculations in IEC 61400-1, Wind turbines – Part 1: Design requirements for small wind turbines:

a) Impact Tests – Room temperature ambient and cold impacts shall be conducted on the enclosure, housing or insulator as specified in the following standards as applicable:

1) Standard for Busways, UL 857, or

2) Standard for Metal Enclosed Bus, IEEE C37.23, or

3) Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, or

4) Standard for Thermoplastic-Insulated Wires and Cables, UL 83.

b) Static Load Test – The bus bar and the lower structural support shall be subjected to a force of 4 times the normal load of the fully assembled longest bus bar in the system. This test force shall include any additional weight of connection cables. Bus bar sidewall supports, guides and associated brackets are to be subjected to a force of 4 times the maximum normal operating force encountered during tower movement. As a result of the loading test, there shall not be permanent deformation, breakage, dislocation, cracking or other damage to the system or mounting structure.

c) Flexing Test – The bus bar shall be subjected to a flexing test to simulate expected deflection and forces on bus bars and support structure over the wind turbine expected life in its intended installation location. IEC 61400-2, Wind turbines – Part 2: Design requirements for small wind turbines, shall be used to define and quantify this expected mechanical operating environment over time. The test excursion movements required for this test shall be 1-1/2 times the calculated movement of the bus bar system. Before the test, the bus bar assembly is to be subjected to loading on the top of the bus bar section to simulate the loading of the upper sections of bus bar, insulator and cables. Forces are to be cyclically applied to the bus bar to represent movement of the actual tower. As a result of the loading test, there shall not be permanent deformation, breakage, dislocation, cracking or other damage to the system or mounting structure.

Exception: Mechanical means to mitigate bus bar stress and force may preclude the need to perform a mechanical flexing test.

4.5.7 The dielectric tests shall be performed following each of the above tests. Following the above tests, the bus bar enclosures shall prevent accessibility to electrically live parts as determined by application of the accessibility probe.

4.5.8 Following the above tests, the Leakage Current Test shall be performed for polymeric-enclosed bus bars in accordance with the Standard for Industrial Control Equipment, UL 508.

4.6 Switchgear

4.6.1 Switchgear shall comply with the applicable switchgear standard:

a) Standard for Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear, UL 1558,

b) Standard for Low-Voltage Switchgear and Controlgear – Part 1: General Rules, UL 60947-1,

c) Standard for Low-Voltage Switchgear and Controlgear – Part 4-1: Contactors and Motor-Starters – Electromechanical Contactors and Motor-Starters, UL 60947-4-1A,

d) Standard for Low-Voltage Switchgear and Controlgear – Part 5-2: Control circuit devices and switching elements – Proximity switches, UL 60947-5-2,

e) Standard for Low-Voltage Switchgear and Controlgear – Part 7-1: Ancillary Equipment –Terminal Blocks for Copper Conductors, UL 60947-7-1,

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

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

h) Outline of Investigation for Medium Voltage Circuit Breakers and Metal-Clad Switchgear, UL 1670,

i) Outline of Investigation for Medium Voltage Metal-Clad Switchgear, UL 1671,

j) Standard for Metal Clad Switchgear, IEEE C37.20.2,

k) Standard for Metal-Enclosed Interrupter Switchgear, IEEE C37.20.3.

4.6.2 Switchgear installed within the tower assembly is considered to be installed in an indoor location but may be subjected to dripping water. Enclosures for switchgear shall not have openings on the top surface, unless such openings are protected by a drip hood that prevents entrance of falling water.

Exception: Compliance may be determined via the applicable end product test per the Standard for Enclosures for Electrical Equipment, Non-Environmental Considerations, UL 50.

4.6.3 The switchgear shall be rated for the application and service conditions of the turbine system.

Note: As an example, the normal service conditions for Metal-Clad Switchgear are defined in IEEE C37.20.2 to include an ambient air temperature of minus 30 to 40 °C. If the anticipated temperature within the tower assembly is less than minus 30 °C, supplemental heating may be required.

4.7 Panelboards

4.7.1 Panelboards installed within the tower assembly shall comply with the Standard for Panelboards, UL 67.

4.8 Transformers

4.8.1 Power transformers rated 600 Vac or less shall comply with the applicable standard:

a) Standard for Specialty Transformers, UL 506,

b) Standard for Dry-Type General Purpose and Power Transformers, UL 1561,

c) Standard for Low Voltage Transformers – Part 1: General Requirements, UL 5085-1,

d) Standard for Low Voltage Transformers – Part 2: General Purpose Transformers, UL 5085-2, or

e) Standard for Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers, UL 5085-3.

4.8.2 Power transformers rated greater than 600 Vac shall comply with the requirements in the Standard for Transformers, Distribution, Dry-Type – Over 600 Volts, UL 1562.

4.8.3 Overcurrent protection for power transformers shall comply with Article 240 Part IX, Overcurrent Protection Over 600 V, Nominal of the National Electrical Code, ANSI/NFPA 70.

4.8.4 Instrument transformers shall comply with one or more of the applicable standards:

a) IEEE C57.13, Standard Requirements for Instrument Transformers,

b) IEEE C57.13.2, Standard Conformance Test Procedures for Instrument Transformers,

c) IEEE C57.13.6, Standard Requirements for High Accuracy Instrument Transformers.

4.8.5 Cast core transformers shall comply with Test Procedure for Thermal Evaluation of Insulation Systems for Dry-Type Power and Distribution Transformers, Including Open-Wound, Solid-Cast, and Resin-Encapsulated Transformers., IEEE C57.12.60.

4.8.6 Oil-filled transformers shall comply with General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers, IEEE C57.12.00, and Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers, IEEE C57.12.90.

4.8.7 Autotransformers shall comply with the applicable standard:

a) Standard for Dry-Type General Purpose and Power Transformers, UL 1561,

b) Standard for Low Voltage Transformers – Part 1: General Requirements, UL 5085-1,

c) Standard for Low Voltage Transformers – Part 2: General Purpose Transformers, UL 5085-2, or

d) Standard for Industrial Control Equipment, UL 508.

4.9 Hub

4.9.1 Assemblies and components in the rotating hub shall be suitable for the expected rotating motion of the assembly.

4.9.2 To prevent damage by loose materials, electrical components shall be housed in electrical cabinets within the hub. The electrical cabinets shall be provided with doors secured by latches which require a tool to lock and unlock the doors. The enclosures shall comply with the applicable enclosure requirements of the Standard for Industrial Control Equipment, UL 508, 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 Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources, UL 1741.

4.10 Converter/Inverter

4.10.1 The Converter/Inverter assembly of a WT shall comply with the Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources, UL 1741.

Exception: A wind turbine inverter or converter may be evaluated to the construction requirements of the Standard for Adjustable Speed Electrical Power Drive Systems – Part 5-1: Safety Requirements – Electrical, Thermal, and Energy, UL 61800-5-1, if it additionally complies with the performance requirements in UL 1741.

4.11 Lightning protection systems

4.11.1 Lightning Protection Systems on a WT shall comply with NFPA 780, Standard for Installation of Lightning Protection Systems, Including Chapter 9 – Wind Turbine Generator Systems, and IEC 61400-24, Wind Turbine Generator Systems – Part 24: Lightning protection.

4.11.2 Components of the Lightning Protection System shall comply with the Standard for Lighting Protection Components, UL 96.

4.11.3 Surge suppression components shall comply with the Standard for Surge Protective Devices, UL 1449.

4.12 Slip rings

4.12.1 General

4.12.1.1 Slip rings used for transmission of power, control, or signal circuits within rotating elements of the wind turbine shall be evaluated to the requirements of the Standard for Industrial Control Equipment, UL 508.

4.12.1.2 The temperature test specified in UL 508 shall be conducted with the unit rotating as intended in its end-use installation as well as in a fixed position.

4.12.1.3 The slip ring circuits and ground paths shall withstand fault current levels in accordance with UL 508, or shall have short circuit ratings equal to or greater than the overcurrent protection provided in the end-use installation.

4.12.2 Slip ring overload

4.12.2.1 The slip ring is to be mounted and enclosed to represent its end application, and the unit is to be tested with a load current and time duration as indicated in 4.12.2.2. The unit shall be tested at rated voltage ±15 percent. The slip ring shall not show evidence of ignition, sealant leakage, cracking, breakage, or similar physical damage.

4.12.2.2 For a slip ring with integral overcurrent protection, the overload current is to be 135 percent of the overcurrent protective device rating. For a slip ring without integral overcurrent protection, the overload current is to be 135 percent of the current rating of the maximum size branch circuit to which the slip ring can be properly connected. The overload test current is to be applied for 1 hour for test currents up to 81 A and 2 hours for test currents greater than 81 A. Alternatively, multiple circuits (above and below 81 A) may be tested for 2 hours, if deemed appropriate for the evaluation. The integral overcurrent protective device is to be shunted out of the circuit for this test.

4.12.2.3 If no integral or external overcurrent protection is provided, the test in 4.12.2.2 shall be conducted using a current value that can be supplied to the unit continuously by the WT source circuit, plus 10 percent. The test shall be conducted until ultimate results occur, but shall not last more than 7 hours.

4.12.2.4 Following the overload conditioning, the slip ring shall again be subjected to the UL 508 Dielectric Withstand Test and there shall be no breakdown between conductors or between conductors and dead metal parts.

4.13 Gearboxes

4.13.1 The electrical features of a gearbox assembly shall comply with the requirements of the Standard for Industrial Control Equipment, UL 508. This may include, but is not limited to, heaters, coolant pumps, fans, sensors, and their interconnection.

4.13.2 Wiring on the gearbox shall comply with UL 508, as well as Subsection 4.2, Wiring, of this standard.

4.14 Hoists and winches

4.14.1 Hoists and winches shall comply with the requirements of the Standard for Hoists, UL 1340, which is applicable only to hoists and winches for tools, supplies, and materials.

4.15 Fire alarms

4.15.1 Control panels that incorporate fire alarm functions shall comply with the Standard for Control Units and Accessories for Fire Alarm Systems, UL 864. Unless otherwise characterized by the WT manufacturer's specifications, the fire alarm systems of a WT are considered to be for the purpose of property protection only, as defined by NFPA 72, the National Fire Alarm Code.

4.15.2 Fire Protection systems shall comply with NFPA 850, Recommended Practice for Fire Protection for Electric Generating Plants and High Voltage Direct Current Converter Stations, Chapter 10, Identification and Protection of Hazards for Wind Turbine Generating Facilities.

4.16 Emergency stop

4.16.1 Emergency stops shall comply with the manual shutdown requirements in Section 8, Protection and shutdown system, of IEC 61400-2, Wind turbines – Part 2: Design requirements for small wind turbines.

Note: The disconnection from the EPS, as initiated by the Emergency Stop, shall not rely on the control system as defined in Section 8, Safety Related Controls System (SRCS). Refer to the control system flow chart in Interaction of the Controls and Safety System, Appendix 2A, in Germanischer Lloyd: Guideline for the Certification of Wind Turbines.

4.16.2 Emergency stop functions shall be designed to be initiated by a single human action.

Exception: An EPS is not required to be installed at the factory if the WT is marked to indicate:

a) That the EPS disconnect means is required to be provided and installed by the field assembler/installer,

b) The location of EPS disconnect means, and

c) That the electrical requirements for EPS disconnect means shall be provided.

4.16.3 The emergency stop shall meet the following requirements:

a) It shall override all other functions and operations in all modes,

b) Power or energy to the moving parts, which causes a hazardous condition(s), shall be removed as quickly as possible without creating other hazards (e.g. rotors pitching to reduce hub rotation), and

c) The reset of the command shall not restart the machinery but only permit restarting.

4.16.4 The reset of the stop function shall not initiate any hazardous conditions.

4.16.5 It shall not be possible to restart the WT until all emergency stop or emergency off commands have been manually reset.

4.16.6 The emergency stop actuator shall comply with the Standard for Industrial Control Equipment, UL 508, and Low-voltage switchgear and control gear. Part 5-5: Control circuit devices and switching elements – Electrical emergency stop device with mechanical latching function, IEC 60947-5-5.

4.16.7 Following engagement, the emergency push button shall remain in the engaged position.

4.16.8 Actuators of emergency stop devices shall be colored RED. The background immediately around pushbuttons and disconnect switch actuators used as emergency stop devices shall be colored YELLOW. The actuator of a pushbutton-operated device shall be of the palm or mushroom-head type and shall affect an emergency stop when depressed. The RED/YELLOW color combination shall be reserved exclusively for emergency stop or emergency off applications.

4.17 Cable trays and wireways

4.17.1 Cable trays shall comply with Article 392 and wireways shall comply with Article 376 of ANSI/NFPA 70 National Electrical Code.

4.17.2 Metallic cable tray and wireway assemblies shall be investigated for bonding between sections and shall comply with the mechanical testing for bus bars in 4.5.6 (b) and (c).

4.18 Hydraulic electromechanical components

4.18.1 Hydraulic electromechanical components shall be rated for the normal and foreseeable abnormal pressures of operation.

4.18.2 There shall be no risk of fire, electric shock, or injury to persons as a result of the operation of pressure relief means. Pressure relief means and system drains shall be located so as to not allow released liquid to fall, spray, leak, or drip on electrical components or systems unless they are rated for exposure to the released hydraulic liquid including the foreseeable range of release pressure conditions.

4.19 Alternators, generators and motors

4.19.1 Rotating machines shall comply with the following, as applicable:

a) the Standard for Rotating Electrical Machines – General Requirements, UL 1004-1,

b) the Standard for Impedance Protected Motors, UL 1004-2,

c) the Standard for Thermally Protected Motors, UL 1004-3.

d) the Standard for Electric Generators, UL 1004-4.

e) the Standard for Servo and Stepper Motors, UL 1004-6.

f) the Standard for Electronically Protected Motors, UL 1004-7.

g) the Standard for Inverter Duty Motors, UL 1004-8.

4.20 Energy storage units

4.20.1 General

4.20.1.1 Standby batteries shall comply with the requirements for Uninterruptible Power Supply Batteries in the Standard for Standby Batteries, UL 1989 or Outline of Investigation for Batteries for Use in Light Electric Rail (LER) Applications and Stationary Applications, UL 1973.

4.20.1.2 Energy storage capacitors shall comply with the applicable requirements of UL 810A, Electrochemical Capacitors.

4.20.1.3 Lithium batteries shall comply with the applicable requirements of the Standard for Household and Commercial Batteries, UL 2054.

4.20.1.4 Vented or wet-cell type batteries shall be used in orientations that prevent loss of electrolyte from normal and foreseen abnormal, motion vibration and rotation.

4.20.1.5 Vented or wet-cell type batteries shall be mounted within ventilated areas complying with Outline of Investigation for Batteries for Use in Light Electric Rail (LER) Applications and Stationary Applications, UL 1973.

4.20.1.6 Energy storage devices mounted in moving parts of the WT (e.g. nacelle or hub) shall be of a type not adversely affected by the anticipated motion and conditions of use.

4.20.1.7 Energy storage devices intended to provide power for protective functions or braking systems shall comply with the Capacity Test in the Standard for Standby Batteries, UL 1989, and demonstrate sufficient capacity to perform the protective function or braking action.

4.20.1.8 The energy storage unit intended to be used inside a WT shall be provided with the WT.

4.20.1.9 A battery supply contained in a remote cabinet that is investigated separately – that is not included in the investigation of a WT – shall comply with the applicable requirements of the Standard for Uninterruptible Power Systems, UL 1778. An input or output of a WT system intended for the connection of a separate, external battery supply shall be provided with overcurrent protection in accordance with the requirements of UL 1778.

4.20.1.10 Subassemblies providing uninterruptible power supply functions shall comply with the applicable requirements of the Standard for Uninterruptible Power Supplies, UL 1778.

4.20.2 Battery mounting

4.20.2.1 A battery shall be located and mounted so that the terminals of cells will be prevented from contacting the terminals of adjacent cells, or metal parts of the battery compartment, as the result of shifting of the battery.

4.20.2.2 The casing of a battery installed in a rotating hub shall comply with the requirements of an electrical enclosure, or the battery shall be mounted inside an electrical enclosure to prevent damage to the battery from loose parts in the rotating hub.

4.20.2.3 To reduce the risk of leakage of the electrolyte as a result of damage to the battery case by a battery mounting means, a battery mounting means shall not cause undue stress to the battery case. See 4.20.2.4 and 4.20.2.5.

4.20.2.4 A battery mounting means consisting of a bracket, strap, or similar means that extends around the top, sides, or both, of the battery shall not cause undue compression to the walls of the battery. While other constructions may be accepted if they are determined to be equivalent, the following types of brackets or straps meet the intent of this requirement:

a) A bracket or strap constructed of a nonrigid polymeric material,

b) A metal bracket or strap with a flexible, foamed, or similar material between the bracket or strap and the battery walls, and

c) A metal bracket, which when tightened as intended, provides a clearance, minimum not specified, between the bracket and the battery walls. See 4.20.2.5.

4.20.2.5 Where determining the adequacy of the clearance for the mounting means described in 4.20.2.4 (c), the following factors shall be taken into consideration:

a) Dimensional tolerances of the bracket and overall dimensions of the battery case, and

b) Slight increase of the overall dimensions of the battery after use.

4.20.2.6 A metal case or container of a battery, such as an alkaline battery, shall be insulated or spaced away from contact with uninsulated live parts of the assembly if such contact may result in a short circuit.

4.20.2.7 An enclosure or compartment housing batteries employing metal containers or cases that are conductively connected to a battery electrode shall be constructed so that the batteries are insulated or spaced from each other, or otherwise physically arranged, to prevent short-circuiting of part or all of the battery supply after installation.

4.21 Disconnect Devices

4.21.1 Each supply source of the WT shall be provided with a lockable disconnect that positively prevents the startup and operation of the circuit. The sources would typically include the Area EPS or Local EPS and generator.

Note: A rotor lock is considered a suitable means to lockout the generator as a supply circuit.

4.21.2 In addition to the requirements of 4.21.1, a system-by-system review shall be completed to determine if additional lockable disconnects are necessary. Systems that require lockable disconnects are those that require repair or maintenance with the main supplies energized, such as motors and heaters. A review of the service and maintenance manuals shall be used to assist in this review.

4.21.3 When a disconnection device is provided, it shall:

a) Open all ungrounded conductors,

b) Consist of either a manually operated switch or circuit breaker, and

c) Be marked to identify the disconnect device, switch, or breaker for the specific power circuits.

4.22 Charge controllers

4.22.1 Charge controllers shall comply with the Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources, UL 1741 and Article 694 of the National Electrical Code, ANSI/NFPA 70.

5 Spacings

5.1 Spacings within components or equipment shall be in accordance with the requirements of the standard for such components or equipment. The spacings requirements in 5.2 – 5.5 are applicable between components and equipment within the WT equipment.

5.2 Notwithstanding 5.1, the electrical spacings within WT equipment rated 1500 V or less shall comply with the spacings requirements in the Standard for Industrial Control Equipment, UL 508.

5.3 Regarding 5.2, UL 508, references the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840, as a means to determine alternative spacings requirements that account for product, installation, and application-specific conditions. The requirements in 5.4 and 5.5 define the base line Pollution Degree and Overvoltage Category for WT systems that shall be used when applying UL 840.

5.4 Pollution Degree 3 is to be applied to determine Creepage spacings in general locations within a wind turbine. Pollution Degree 4 shall be applied to Creepage spacings where conductive pollution such as brush dust or brake dust may be present.

Exception: Steps can be taken to control or reduce the pollution degree at the creepage distance by design features or the consideration of the operating characteristics of the product. Pollution degree 2 can be achieved by reducing the possibilities of debris accumulation and condensation or high humidity at the creepage distance. Pollution Degree 2 can be achieved through filtered ventilation and a means to prevent condensation. Continuous application of heat, through the use of heaters or continuous energizing of the equipment when it is in use, can be used to control condensation. Continuous energizing is considered to exist when the equipment is operated without interruption every day and 24 hours per day or when the equipment is operated with interruptions of duration which do not permit cooling to the point that condensation occurs.

5.5 Overvoltage Category IV shall be applied to determine Clearance spacings in general locations within a wind turbine.

Exception: Use of additional surge suppression protection as specified in 5.6 may be used to reduce the Overvoltage Category below IV.

Note: Direct or nearby lightning strikes can induce high over voltage conditions in EPS circuits and wind turbine circuits throughout the hub, nacelle and tower. Surge protective devices, if used, shall be installed in close proximity to the equipment being protected.

5.6 In accordance with 6.3 and as defined by the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840, clearance distances may be reduced through the use of Surge Protective Devices (SPDS) that limit overvoltage circuit conditions. When an overvoltage protective device is used, it shall comply with the requirements in the Standard for Surge Protective Devices, UL 1449. To reduce circuits below Overvoltage Category IV, surge protective devices shall be provided both down-tower to protect from EPS surges and up-tower to protect from atmospheric discharges. The WT shall incorporate a means to indicate the failure of surge protective devices relied upon to reduce Clearances.

5.7 Where the operating voltage is not apparent due to switching circuits or buck boost circuits, the product spacings shall comply with the worst case operating voltages for that portion of the circuit as determined by the Maximum-Voltage Measurements Test in the Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources, UL 1741.

6 Components and Circuits Rated or Operating between 601 and 750 Volts

6.1 Components for use in wind turbine system applications operating between 601 and 750 V shall be evaluated per 6.2 – 6.4 when:

a) There is an absence of a component standard for greater than 600 V use, and

b) There are published component requirements for 600 V use, and they are applied as defined by this section.

6.2 Spacings for components operating between 600 and 750 V shall comply with Table 6.1 unless the individual 600 V component standard spacings are greater than the values in the table. If so, the individual 600 V component standard spacings shall be applied.

Note: This requirement addresses components such as circuit breakers with larger service spacings.

Table 6.1
Minimum Spacings

Potential involved, 601 - 750 volts	Location	Minimum spacings, inches	(mm)
Between any uninsulated live part and an uninsulated live part of opposite polarity, an uninsulated grounded part other than the enclosure, or an exposed metal part	Through air	0.55	(14.0)
	Through oil	0.45	(11.4)
	Over surface air	0.85	(21.6)
	Over surface oil	0.62	(15.7)
Between any uninsulated live part and the walls of a metal enclosure, including fittings for conduit or armored cable	Through air or oil	0.80	(20.3)
	Over surface	1.00	(25.4)

6.3 If spacings in the individual 600 V component standard (for components operating between 601 and 750 V) are less than the values indicated in Table 6.1:

a) The spacings in Table 6.1 shall be applied, or

b) The individual 600 V component standard spacings shall be applied if the Overvoltage Category and Pollution Degree of the component installation location (within the wind turbine equipment), are such that the 600 V component standard spacings are equal to or greater than the 601 – 750 V system specific spacings required in 5.3.

Note: This requirement addresses components such as heaters with smaller industrial control based spacings.

6.4 All tests shall be performed as required by the published component standard except the applied input voltage shall be based on the component nominal operating voltage.

7 Grounding

7.1 WT and subassemblies shall be provided with a grounding means that is compliant with both the National Electrical Code, ANSI/NFPA 70, and the Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources, UL 1741.

8 Safety Related Controls System (SRCS)

8.1 General

Note 1: IEC 61400-2, Wind turbines – Part 1: Design requirements for small wind turbines, defines several critical controls and protection functions that are required to be evaluated to maintain the turbine within its mechanical and structural limitations. The example below describes an evaluation means and test for the overspeed control and protection functions.

From a simplified electrical controls and protection point of view, the electrical control and protection systems will monitor the turbine speed. It may do so by measuring a frequency or corresponding voltage *related to the turbine speed. At some predefined speed limit, "trip limit", the turbine electrical controls and protection systems will perform some function or functions within a predefined amount of time to prevent an overspeed condition. The trip limits, responses, and response times are set by the turbine manufacturer based upon its mechanical structural evaluation. The mechanical structural evaluation of a wind turbine is outside the scope of UL 6142, but the evaluation of the controls and protection are critical to the safe operation of a wind turbine and must be properly evaluated to prevent catastrophic failures.*

As required by UL 6142 and also IEC 61400-2, these electrical control and protection functions need to be evaluated for proper operation during normal and abnormal failure conditions. Evaluating the electrical controls and protection limits and response times are a critical part of the wind turbine electrical safety.

IEEE 1547, Interconnecting Distributed Resources with Electric Power Systems, includes an accurate and well documented test method to evaluate trip limits and response times that can easily be applied to evaluate turbine protection and control systems. The use of IEEE 1547 additionally provides clear and easy to understand guidance on how to incorporate the EMC related testing (also generically referenced in 61400 standards) in conjunction with the trip limit testing. This methodology allows for reduced overall testing for manufacturers that include and combine grid interconnection testing along with the evaluation of these controls and protection systems.

Note 2: The use of IEEE 1547 for the evaluation of SRCS should not be confused with the requirements for grid interconnection located in section 9.

8.1.1 The Safety Related Controls System (SRCS) described and addressed within this document embodies the “Controls System” and “Protection System” functions defined in IEC 61400-2, Wind turbines – Part 1: Design requirements for small wind turbines, and Germanischer Lloyd: Guideline for the Certification of Wind Turbines documents, GL-IV.

8.1.2 The WT control and protection systems shall be designed to comply with IEC 61400-2, Wind turbines – Part 1: Design requirements for small wind turbines, and the control and protection functions shall be evaluated independently as specified in this section.

8.1.3 The WT controls functions identified in IEC 61400-2, Wind turbines – Part 1: Design requirements for small wind turbines, shall be evaluated in the same manner as the utility interconnection voltage and frequency trip limits in IEEE 1547, Interconnecting Distributed Resources with Electric Power Systems. A control or protection system response is required to occur when the WT operating parameters reach a specific limit or activation level. The operational limits are programmed into the WT SRCS and the operational parameters are specified in the manufacturer’s documented ratings for the equipment. The testing shall take into account the effects on distance between the input sensors and the controls and protection equipment.

8.2 Protection functions

8.2.1 The WT protection functions identified in IEC 61400-2, Wind turbines – Part 1: Design requirements for small wind turbines, shall be evaluated in the same manner as the utility interconnection voltage and frequency trip limits in IEEE 1547, Interconnecting Distributed Resources with Electric Power Systems. See 8.1.3.

8.2.2 Additional protection functions that are determined necessary to mitigate a risk of electric shock or fire, shall be evaluated in accordance with the requirements of this section.

8.2.3 Compliance with 8.2.1 and 8.2.2 shall be achieved by demonstrating compliance with:

a) One of the following:

1) The Standard for Software in Programmable Components, UL 1998,

2) The Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, UL 60730-1A (protective control), or

3) IEC 61508, Functional safety of electrical/electronic/programmable electronic safety-related systems – Part 1: general requirements, or

4) ISO 13849, Safety of machinery – Safety-related parts of control systems – Part 1: general principles for design.

b) Redundant systems complying with 8.2.4 – 8.2.7.

8.2.4 In accordance with 8.2.3, redundant systems shall be diverse, independent, and have all possible combinations of firmware/software version (s) and intended hardware platform (s) subject to functional testing. By diverse and independent, it is meant that "faults with a common cause" shall be prohibited. During the evaluation of the protection function the control function shall be disabled and vice versa. Lightning is a common cause that shall be specifically addressed under this evaluation.

8.2.5 Each combination of microprocessor model, manufacturer and firmware/software version used in the production of a WT shall be evaluated in accordance with 8.2.4. Revisions to any portion of the combination of software and/or critical hardware shall require re-evaluation of the WT protection system.

8.2.6 For units with firmware/software that is in compliance with the Standard for Software in Programmable Components, UL 1998, subsequent firmware/software revisions may be entitled to a limited re-evaluation in accordance with risks identified in this section and as addressed by the subsequent UL 1998 evaluation of the revised firmware or software. The scope of the re-evaluation shall be defined by the potential impact of the firmware or software revisions on the SRCS or WT.

Exception: IEC 61508, Functional safety of electrical/electronic/programmable electronic safety-related systems – Part 1: general requirements, ISO 13849, Safety of machinery – Safety-related parts of control systems – Part 1: general principles for design, or derivative standards may be used in place of UL 1998.

8.2.7 The turbine manufacturer-defined SRCS control and protection function trip limits and response times shall comply with the following requirements in IEEE 1547.1, Conformance Test Procedures for Equipment Interconnecting Distributed Resources with Electric Power Systems:

a) General Requirements, section 4;

b) Temperature stability, 5.1;

c) Test for response to abnormal voltage conditions, 5.2;

d) Response to abnormal frequency conditions, 5.3; and

e) Interconnection integrity, 5.5.

Exception: Controls that comply with the Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, UL 60730-1A (protective control) or IEC 61508, Functional safety of electrical/electronic/programmable electronic safety-related systems – Part 1: general requirements, meet the intent of the requirement.

Note: The specific EMC testing in IEEE C37.90, Relays and Relay Systems Associated with Electric Power Apparatus, and IEEE C62.41, IEEE Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits, required by the Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources, UL 1741 and IEEE 1547 are considered *equivalent or more stringent than the generic reference to 61000-6-1, 61000-6-2 and 61000-4 tests referenced by IEC 61400, Wind turbines – Part 1: Design requirements.*

8.3 Abnormal conditions for safety related controls system

8.3.1 The turbine SRCS shall be subjected to the Component Short- and Open-Circuit Test and the Loss of Control Circuit Test specified in the Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources – UL 1741. Both the control system and protection system shall be evaluated independently. The following fault conditions shall be included in the Loss of Control Circuit Test:

a) Complete loss of control power,

b) Loss of one conductor of a polyphase control power circuit,

c) Control power undervoltage and overvoltage conditions.

8.3.2 The overvoltage and undervoltage test conditions noted in 8.3.1 shall be based on:

a) The manufacturer's rated grid interconnection voltage limits, and

b) Four times the longest manufacturer rated grid interaction trip limit event or four times the longest turbine shut down period, whichever is greater.

8.3.3 As a result of the tests specified in 8.3.1 and 8.3.2, the (SRCS) system shall initiate a safe and controlled shutdown of the turbine and cessation of output power.

8.3.4 Each SRCS protection and control function defined in IEC 61400-2, Wind turbines – Part 1: Design requirements for small wind turbines , shall be subjected to manufacturing production line test to verify the trip limit setting and response times per the manufacturer’s specifications.

9 Utility grid interaction

9.1 General

9.1.1 WTs rated for connection and operation with an EPS shall be evaluated for the intended purpose as specified in this section. The WT shall operate safely over the manufacturer's specified range of grid interconnection operation, such as zero voltage ride through (ZVRT), low voltage ride through (LVRT), high voltage ride through (HVRT) or other defined limits of operation. This shall be verified by operating the WT at several points including the minimum and maximum voltage, frequency, and duration limits of the manufacturer's specified range of operation.

9.2 Performance

9.2.1 Utility interactive WTs intended for connection at electric utility distribution levels shall comply with the applicable requirements of:

a) The Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources – UL 1741,

b) IEEE 1547, Interconnecting Distributed Resources with Electric Power Systems, and

c) IEEE 1547.1, Conformance Test Procedures for Equipment Interconnecting Distributed Resources with Electric Power Systems.

Exception: A WT need not be evaluated per these requirements if it is marked in accordance with 13.7 and the instructions specified in 15.3.

9.2.2 For utility interactive WTs that perform Low Voltage Ride Through (LVRT) electric grid support, the wind turbine generating system (WTGS) shall be evaluated in accordance with IEC 61400-21, Wind turbines – Part 21: Measurement and assessment of power quality characteristics of grid connected wind turbines, to confirm the manufacturer's declared electrical and power quality ratings.

Exception: A WT need not be evaluated per these requirements if it is marked in accordance with 13.7 and the instructions specified in 15.3.

9.2.3 Utility interactive WTs shall be evaluated for compliance with the manufacturer's specifications and shall not result in electric shock, fire, or energy hazards as defined by the Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources – UL 1741, or the Standard for Adjustable Speed Electrical Power Drive Systems – Part 5-1: Safety Requirements – Electrical, Thermal, and Energy, UL 61800-5-1.

9.2.4 WT utility interconnection normal operation mode is defined as operation at any point within the adjustable limits (operational parameters) of frequency, voltage, current, power factor, and reactive loading (for power factor correction mode where the turbine acts as a load).

9.2.5 WT utility interconnection abnormal operation mode is defined as operation at any point between the WT utility interconnection normal operation mode limits and the most extreme of the WT-rated operational limits. This range is typically evaluated when the protection functions are evaluated using IEEE 1547, Interconnecting Distributed Resources with Electric Power Systems, and IEEE 1547.1, Conformance Test Procedures for Equipment Interconnecting Distributed Resources with Electric Power Systems.

9.2.6 A unit that is marked in accordance with 13.7 shall be evaluated in accordance with the Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources – UL 1741, during utility interconnection normal operation mode. (The requirements in UL 1741 that reference IEEE 1547 and IEEE 1547.1 and any related marking requirements should not be used.) A WT shall comply with all UL 1741 tests during all normal operational modes including, but not limited to, generation sub-synchronous, synchronous, super-synchronous and active power factor correction if the WT is provided with these functions.

9.2.7 A WT shall comply with the abnormal requirements of the Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources – UL 1741, while the turbine is operated in utility interconnection abnormal operation mode.

10 Manual Shutdown

10.1 Shutdown of the turbine shall:

a) Result in a controlled rapid transition from rotation and power production to standstill of the rotor and yaw motion, and

b) De-energize or interrupt the turbine output power circuit.

10.2 Turbines with a swept area greater than or equal to 40 m^2 shall be provided with a manual shutdown button/switch and a shutdown procedure. An emergency stop, if provided, that complies with Subsection 4.16 of this document is considered to comply with the manual shutdown requirement.

10.3 Turbines with a swept area less than 40 m^2 are not required to be provided with a manual shutdown button/switch if they are provided with a manual shutdown procedure. For these turbines with limited wind swept area, the shutdown shall result in an idle state where the turbine is allowed to rotate at a slower speed and de-energize or interrupt the turbine output power circuit. For turbines that are not intended to be serviced while on top of the tower, the lowering of a turbine on a tilt-up tower or similar means is acceptable as a means to bring the turbine to a standstill.

11 Self-Excitation

11.1 WT systems shall be protected from unintentional self-excite during all foreseeable loading and unloading conditions including loss of grid connection for grid tied turbines. Verification of compliance with this requirement shall consider both normal and single-fault conditions.

12 Ratings

12.1 WT system level components shall include the applicable ratings in accordance with the Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources, UL 1741.

12.2 A WT generator assembly that is intended to be connected to an external inverter, external control system or unit, or both, shall include ratings for:

a) Rated power,

b) Maximum output power,

c) Maximum output voltage,

d) Maximum output current,

e) Operating voltage range, and

f) Operating frequency range.

MARKINGS

13 System and Subassembly Components

13.1 Unless otherwise stated, all markings shall be permanent. The following types of markings or the equivalent meet this requirement:

a) Molded,

b) Die-stamped,

c) Paint-stenciled,

d) Stamped or etched metal that is permanently secured, or

e) Indelibly stamped on a pressure-sensitive label complying with the Standard for Marking and Labeling Systems, UL 969.

13.2 A unit shall be plainly and permanently marked where it is readily visible after installation with:

a) The manufacturer's name, trademark, or other descriptive marking by which the organization responsible for the product is able to be identified – hereinafter referred to as the manufacturer's name,

b) A distinctive catalog number or the equivalent,

c) The electrical ratings, which shall include:

1) Rated power,

2) Maximum output power,

3) Maximum output voltage,

4) Maximum output current,

5) Operating voltage range, and

6) Operating frequency range.

d) The date or other dating period of manufacture not exceeding any three consecutive months. The repetition time cycle of a date code shall not be less than 20 years. The date code shall not require reference to the manufacturer's records to determine when the unit was manufactured.

Exception No. 1: The manufacturer's identification is able to be in a traceable code when the unit is identified by the brand or trademark of a private labeler.

Exception No. 2: The date of manufacture is able to be abbreviated in a nationally accepted conventional code, or in a code affirmed by the manufacturer.

13.3 A WT system shall be marked with the electrical ratings defined in section 12.

13.4 A WT system shall be provided with a plaque that includes basic instructions on how to shut down the turbine.

13.5 Each WT disconnect device shall be marked to indicate it is a disconnect and also marked for the specific circuit it controls.

13.6 When a WT generator assembly is intended for connection with an EPS and complies with the Utility Compatibility requirements of the Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources, UL 1741, it shall be marked "Utility-Interactive" or the equivalent.

13.7 As required by the exceptions in 9.2.1 and 9.2.2, the unit shall be permanently marked with the following marking that is readily visible adjacent or near the unit's ratings marking: "WARNING" and the following or equivalent: "This unit has not been evaluated for utility interconnection protective functions. This unit shall be provided with external utility relay protection in accordance with local codes and local utility requirements." The information on this marking shall additionally be placed in the unit’s instruction manual as required by 15.3.

13.8 The symbols described in items (a) – (c) shall be used as specified:

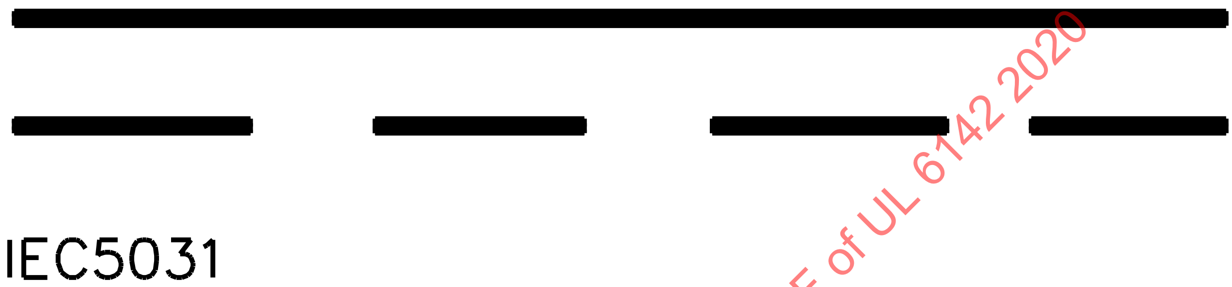
a) A circuit intended to be connected to a dc circuit shall be identified by markings indicating that the circuit shall be dc. The symbol illustrated in Figure 13.1 meets the requirement for this marking. See 13.9.

b) A circuit intended to be connected to an ac circuit shall be identified by markings indicating that the circuit shall be ac. The markings shall include the supply-circuit frequency or supply-circuit frequency-range rating (cycles per second, cycles/second, hertz, c/s, cps, or Hz). The symbol illustrated in Figure 13.2 meets the requirement for this marking. See 13.9.

c) The number of phases shall be indicated when the unit is designed for use on a polyphase circuit. The symbol illustrated in Figure 13.3 is equivalent to the word "phase." See 13.9.

Figure 13.1

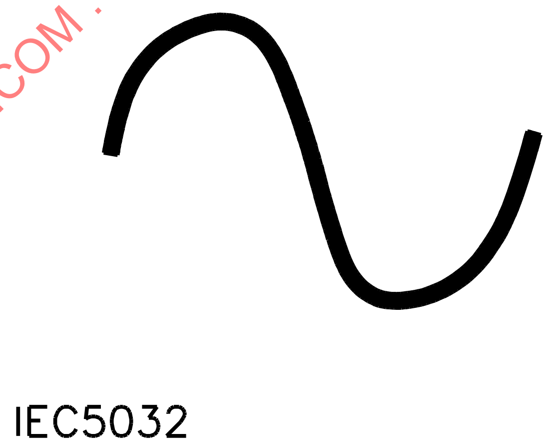
Direct current supply symbol



IEC Publication 417, Symbol 5031

Figure 13.2

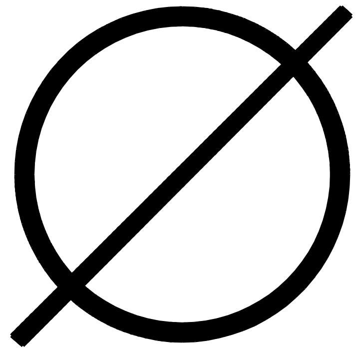
Alternating current supply symbol



IEC Publication 417, Symbol 5032

Figure 13.3

Phase symbol



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13.9 When a symbol referenced in 13.8 (a), (b), and (c) is used, the important safety instructions shall identify the symbol.

13.10 The operating positions of a handle, knob, or other means intended for manual operation by the user shall be marked.

13.11 Wiring terminals shall be marked to indicate the intended connections for the unit, or a wiring diagram coded to the terminal marking shall be securely attached to the unit.

Exception: The terminal markings are not required when the wire connections are evident.

13.12 Field-wiring terminals shall be marked to indicate the appropriate wire conductor type (e. g., copper, aluminum), wire sizes, tightening torque, and wire insulation temperature rating

Exception: When tightening torque ratings are included in the installation instructions provided with the unit, they are not required to be marked on the unit.

13.13 A pressure wire connector or stud-and-nut type terminal intended for connection of an equipment-grounding conductor shall be identified by:

a) Being marked "G," "GR," "GND," "Ground," "Grounding," or equivalent,

b) A marking on a wiring diagram attached to the unit, or

c) The symbol illustrated in Figure 13.4 on or adjacent to the connector or on a wiring diagram provided on the unit. See 13.14.