



UL Wind Turbine Safety Standards

**Presentation for SMART Wind Consortium Electrical Systems Subgroup
Electrical Systems Subgroup Kickoff
Washington D.C.
March 26, 2015**

**Chris Storbeck, P.E.
Staff Engineer, UL LLC**

Agenda

Wind Standards Overview and Background

UL 6142 Details

UL 6141 Highlights



Wind Turbine Standards Overview

- Europe

IEC 61400 Series

- IEC 61400-1: *Wind turbines – Part 1: Design Requirements*
- IEC 61400-2: *Wind Turbines – Part 2: Design Requirements for Small Wind Turbines*

- IEC 61400-11: *Acoustic Noise Measurement Techniques*
- IEC 61400-21: *Measurement and Assessment of Power Quality...*
- *-12: Power Performance; -4: Gearboxes; -23: Blade Testing; etc.*



Wind Turbine Standards Overview

- North America, Small Wind

American Wind Energy Association

- AWEA Small Wind Turbine Performance and Safety Standard (2009)
 - *Based on IEC 61400-2*

UL

- UL 6142: Standard for Safety for Small Wind Turbine Systems (2012)
 - *Co-published with AWEA, AWEA 6142*

Canadian Standards Association (CSA)

- CAN/CSA-C61400-2-08
 - *Based on IEC 61400-2*



Wind Turbine Standards Overview

- North America, Large Wind

American Wind Energy Association

- *Recommended Practice for Compliance of Large Land-based Wind Turbine Support Structures (ASCE / AWEA RP2011)*
- *AWEA Offshore Compliance Recommended Practices (2012)*

UL

- *UL 6141: Large Wind Turbine Systems (committee draft as of 2015)*

Canadian Standards Association (CSA)

- CAN/CSA-C61400-1-08; C61400-11; C61400-12; C61400-24



IEC 61400 Details

IEC 61400 series thoroughly addresses:

- Structural and Mechanical design
- Power Quality
- Lightning Protection

IEC 61400 series includes few details for:

- Control and Protection Systems
- Electrical Construction



IEC 61400 Details – Electrical Issues

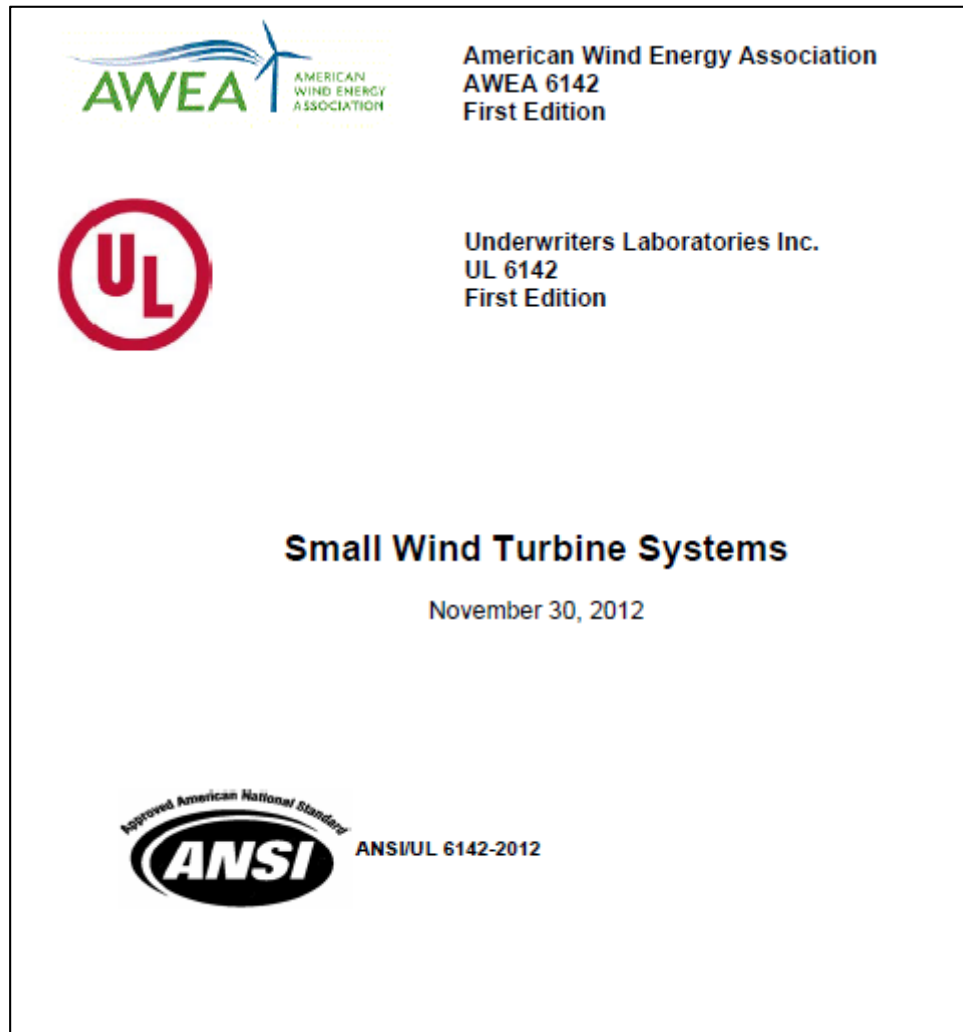
IEC 61400 references other IEC standards for Electrical component and system compliance

- IEC 61400 and the referenced standards are not US National Standards
- IEC electrical standards are not harmonized with North American electrical standards or recognized by regulations (e.g. OSHA)

North American Authorities Having Jurisdiction question the suitability of the IEC-based certifications.



UL 6142 – ANSI American National Standard for Electrical Safety of Small Wind Turbines



AWEA AMERICAN WIND ENERGY ASSOCIATION
American Wind Energy Association
AWEA 6142
First Edition

UL
Underwriters Laboratories Inc.
UL 6142
First Edition

Small Wind Turbine Systems
November 30, 2012

Approved American National Standard
ANSI ANSI/UL 6142-2012



Agenda

Wind Standards Overview and Background

UL 6142 Details

UL 6141 Highlights



Small vs. Large Wind

UL 6142 and UL 6141 Definition:

“...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.”

IEC 61400 Definition:

“a system of 200 m² rotor swept area or less that converts kinetic energy in the wind into electrical energy”
(Equivalent rotor diameter = 16 meters)



UL 6142 Content – Construction Requirements

Construction requirements for the overall assembly (not the components) may come from UL 1741 or UL 508. (cl. 4.1.1)

- Enclosures
- Corrosion Protection
- Protection of Users and Service Personnel (accessibility to hazards)
- Wire Bending Space
- Electrical connections
- Grounding and Bonding
- Separation of Circuits
- Insulating Materials
- etc.



UL 6142 Content - Components

- Components shall comply with standards applicable to the component.
- Special Components identified in Section 4 shall comply with additional requirements in this standard.



UL 6142 Content - Section 4: Special Components and Subassemblies of Wind Turbines

Wiring	Panelboards	Slip Rings	Cable Trays and Wireways
Splices and Connections in Power Cables	Transformers	Gearboxes	Hydraulic Components
Cable Drip Loop	Hub	Hoists and Winches	Alternators, Generators and Motors
Bus Bars	Converter/Inverter	Fire Alarms	Energy Storage Units
Switchgear	Lightning Protection Systems	Emergency Stop	Disconnect Devices
			Charge Controllers



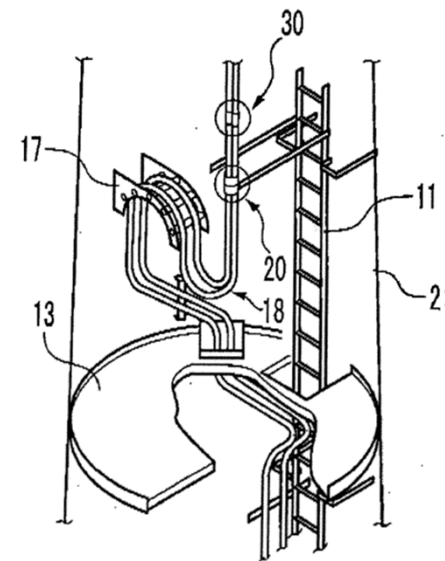
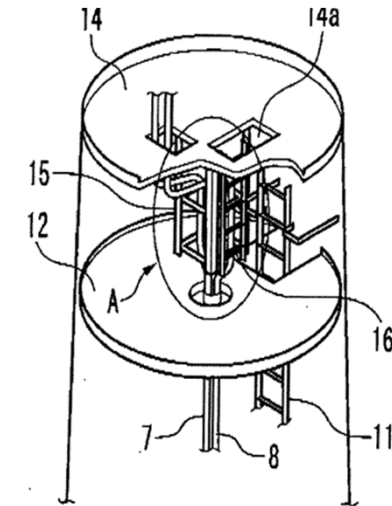
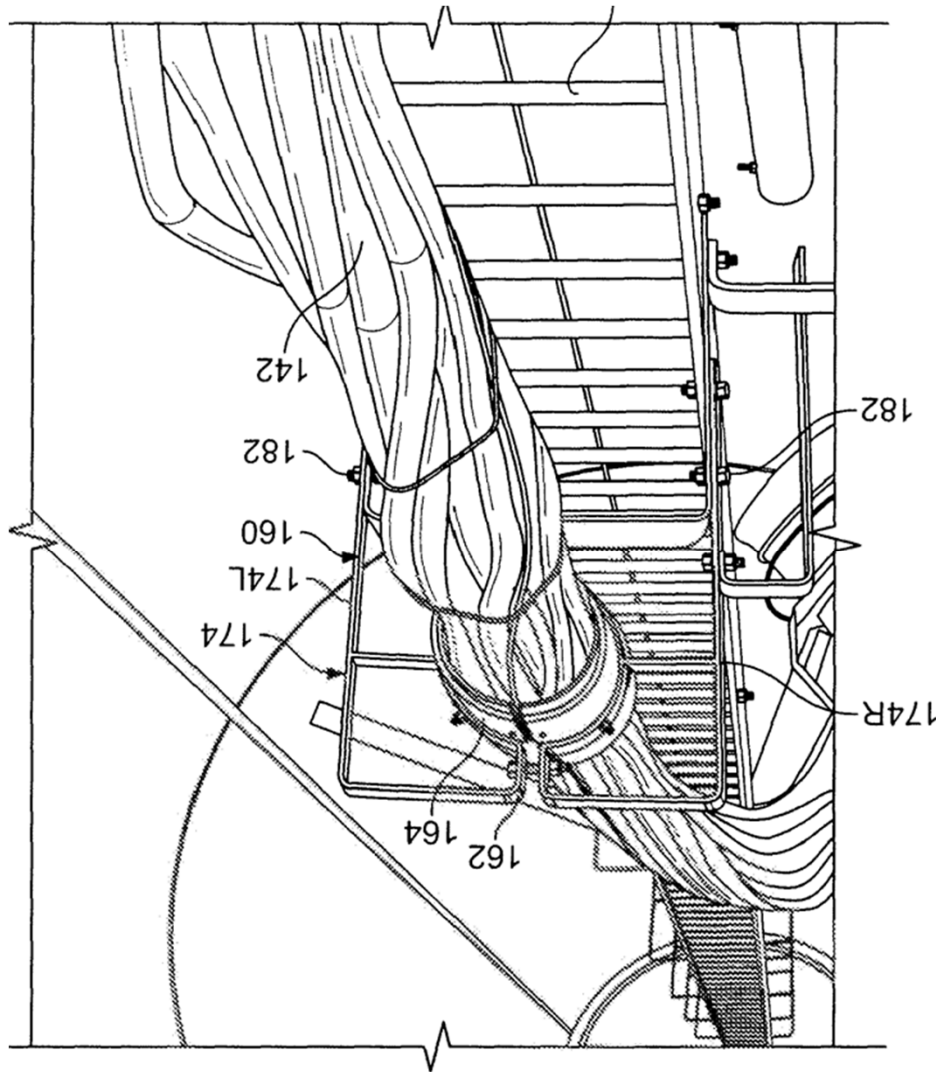
UL 6142 Content - Section 4: Special Components and Subassemblies of Wind Turbines

Wiring	Panelboards	Slip Rings	Cable Trays and Wireways
Splices and Connections in Power Cables	Transformers	Gearboxes	Hydraulic Components
Cable Drip Loop	Hub	Hoists and Winches	Alternators, Generators and Motors
Bus Bars	Converter/Inverter	Fire Alarms	Energy Storage Units
Switchgear	Lightning Protection Systems	Emergency Stop	Disconnect Devices
			Charge Controllers



UL 6142 Content – Special Components

Cable Drip Loop:



UL 6142 Content – Special Components

Cable Drip Loop:

- “...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.”
- Based on UL research, conductors carrying current will experience more strand breakage than un-energized conductors.



UL 6142 Content – Special Components

Converter / Inverter:

- 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 Power Conversion Equipment, UL 508C, if it additionally complies with the performance requirements in UL 1741.*
- Low Voltage Ride-Thorough, if provided, shall be tested according to IEC 61400-21



UL 6142 Content – Special Components

Slip Rings:

- These requirements do not apply to generator slip rings, only yaw or hub slip rings.
- Construction Requirements per UL 508.
- Some testing required while rotating.
- Overload testing of circuits and ground paths, based on upstream overcurrent protection.



UL 6142 Content – Special Components

Alternators, Generators and Motors:

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**.

Per UL 1004-1, Insulation systems shall comply with:

- **UL 1446** (ASTM D2519, D3145, D5642) (up to 1000 Volts)
- **IEEE 1776** (Over 1000 Volts)



UL 6142 Content

- Section 5: Spacings
 - Refers to UL 508 and UL 840.
- Section 6: Components and Circuits Rated or Operating between 601 and 750 Volts
 - Provides spacings guidance when a > 600V standard does not exist.
- Section 7: Grounding
 - Refers to the National Electrical Code (NFPA 70) and UL 1741.



UL 6142 Content – Section 8: Safety Related Controls System (SRCS)

- Similar to IEC 61400 series, identify what the “control” and “protection” functions are
- Test them for their response limits and their response times
- Control System shall comply with:
 - the Functional Safety standards referenced (cl. 8.2.3) or
 - Redundant systems may be provided.



Agenda

Wind Standards Overview and Background

UL 6142 Details

UL 6141 Highlights



UL 6141: Highlights

- NFPA 79, Electrical Standard for Industrial Machinery – Referenced for various design requirements
- Does not require National Electric Code (NFPA 70) compliance
- References some IEC component standards and more US/UL versions harmonized with IEC standards
 - UL 61800 – power converters
 - UL 60947 - switchgear



Summary

UL 6142:

- Addresses small wind turbine electrical safety in the context of United States electrical safety codes.
- References existing Industrial Control Equipment and Distributed Generation standards for many construction requirements.
- Provides guidance for the evaluation of common components of wind turbines.
- Requires evaluation and testing of turbine safety controls.
- Does not require field testing; lab testing can cover all requirements.



Summary

UL 6141, same points as UL 6142, plus:

- Addresses electrical safety issues for personnel working inside the machine.
- Does not require NEC compliance.



UL's Partners for Comprehensive Wind Industry Services

- **West Texas A&M University**
 - Excellent test location for real-world turbine testing
 - Certification and R&D testing
- **DEWI-OCC**
 - Global Certifications
- **DEWI**
 - Wind Farm site assessment
 - Large wind turbine testing: power performance, mechanical loads, etc.



THANK YOU.



Chris Storbeck
Christian.s.storbeck@ul.com
847-664-1501

UL Customer Service:
877-ULHELPS