

EVOLUTION IN SAFETY

Promoting global wind turbine safety through the collaborative development of codes and standards.

By Kenneth Boyce



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ACROSS THE GLOBE. wind power generation resources continue to grow. As an example, the United States ranks second in global wind power, with more than 13 GW of new wind power installed in 2012 to pass the 60 GW milestone for installed wind power capacity.¹ The U.S. wind base experienced 28 percent growth in 2012 and wind power was the source of more than 40 percent of all new U.S. power capacity in 2012.² The U.S. Department of Energy has indicated that wind could supply 20 percent of the U.S. electricity by 2030—requiring some 300GW of new wind generating capacity.³

With this type of rapid development and deployment of new wind resources, standards become critical for supporting consistent market expectations, performance benchmarks, and fundamental design features—most importantly including safety. While many of the incidents were minor, safety incidents involving wind turbines over a five-year period in the United Kingdom were recently reported as occurring at approximately the rate of one per day.⁴ As more wind turbines are installed, new technologies are introduced to meet market and performance objectives, and the existing turbine population ages, looking to new and evolving safety standards in the



against damage from all hazards during the planned lifetime.”⁵ The standard is a holistic document that covers many aspects of the design, installation, and use of sophisticated electromechanical equipment, and IEC 61400-1 is supplemented by numerous parts to focus on specific design or performance aspects, or types of wind turbine equipment and installations; for example, IEC 61400-2, *Wind turbines – Design requirements for small wind turbines*. However, it is notable that of over 90 pages of requirements in IEC 61400-1, approximately five focus on electrical safety of the equipment, controls and protection. In those few pages, IEC 61400-1 does identify the need to evaluate most critical aspects of a wind turbine: electrical aspects, control system functions, protection system functions and critical components. However, as the IEC 61400 documents are written today, they do not provide detailed guidance on how to adequately evaluate these critical aspects. Work was recently initiated to review enhancements to the specific requirements for electrical safety.

SAFETY STANDARDS AND CODES FOR THE U.S. MARKET

In order to help support a safe deployment of wind turbine system infrastructure during this projected period of rapid and significant growth, UL has led the collaborative development of national standards addressing the safety of wind turbine systems, with a focus on the electrical safety, performance of the controls and protection systems, as well as prevention of fire within the equipment. These efforts recognize that there are some fundamental differences between the installation requirements of the IEC 60364 series and the prevailing U.S. codes such as ANSI/NFPA 70, *the National Electrical Code* (NEC), and differences in other important safety requirements. As a result, two wind turbine safety standards have been developed by UL: UL 6141, *Standard for Safety for Large Wind Turbine Systems*, and UL 6142, *Standard for Safety for Small Wind Turbine Systems*. Each of these standards have been developed through a standards technical panel comprised of equipment producers, users, technology experts, scientists, regulatory authorities, and other technical experts with an interest in these specific products. The standards have been developed using a consensus-based approach, and at this time both standards have achieved the required support within the panels to establish consensus. The American National Standard for safety of small wind turbines was jointly published last year by UL and the American Wind Energy Association (AWEA) as ANSI/UL 6142/AWEA 6142. UL 6141 has reached consensus, and UL is working with the standards panel to finalize the publication as an American National Standard in the near future.

Because these requirements will constitute the American National Standards for safety, assuring

design and development phase provides many benefits in supporting a safe wind infrastructure.

INTERNATIONAL ELECTROTECHNICAL COMMISSION STANDARDS

The International Electrotechnical Commission (IEC) has published the IEC 61400 series of standards to help establish these types of standardized expectations. IEC 61400-1, *Wind Turbines - Design Requirements*, outlines minimum design requirements for wind turbines. The standard “specifies essential design requirements to ensure the engineering integrity of wind turbines. Its purpose is to provide an appropriate level of protection

compliance with the requirements for exporters, buyers, owner/operators, and other involved parties is an important measure for demonstrating due diligence in addressing workplace and consumer safety, supporting easy equipment installation and acceptance, and establishing confidence among customers. Based on the critical role of these standards for the U.S. market, the following overview provides significant aspects of the requirements for design and testing.

These standards focus on the safety of the wind turbine systems. However, they do not cover mechanical or structural integrity of the wind turbine system or subassemblies, or verification that the manufacturer-defined controls and protection limits maintain the system within its safe mechanical and structural limits. The wind turbine 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 established performance and safety standards, such as the IEC 61400 series documents. They focus on land-based turbines, and do not specifically cover turbines for offshore installation.

Both standards contain fundamental requirements related to wind turbine safety. These include important safety features such as: electrical safety of the internal subassemblies; protection of internal assemblies from mechanical abuse; disconnecting means; emergency stop and manual shutdown protocols; protection from self-excitation; lightning protection; safety markings and instructions; and grid connectivity (based on a number of options that address the particular needs and conditions of the grid utility).

UL 6142/AWEA 6142 covers small wind turbines for which a user or service person cannot or is not intended to enter the turbine to operate it or perform maintenance, with rated output of 1500 V ac maximum. The standard addresses compatibility of equipment with the installation safety requirements of the NEC. This includes compliance with Article 694, Article 705 for Interconnected Electric Power Production Sources, as well as critical safety features such as conductor and equipment protection and grounding.

UL 6141 covers large wind turbines for which a user or service person may, or is intended to, enter the turbine to operate it or perform maintenance. UL 6141 addresses compatibility of equipment with the installation safety requirements of ANSI/IEEE C2, the National Electrical Safety Code (NESC) and the NEC as applicable. For the NEC, this includes compliance with critical safety features such as working space, conductor

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and equipment protection, grounding and Article 705 for Interconnected Electric Power Production Sources. For large wind turbines, there are some additional requirements unique to these larger products. These address topics including protection from flame spread within the turbine, and requirements for medium voltage equipment as applicable.

The NEC addresses safe installation of systems and equipment that are not under the exclusive control of a utility, as addressed by specific requirements in Section 90.2. The new 2014 Edition of the NEC has just been published by the National Fire Protection Association, and it contains important new requirements for safety of wind turbine installations in Article 694, "Wind Electric Systems". The new edition of the NEC applies to all wind systems regardless of rating, eliminating the previous scope limitation to turbines having a rating up to 100 kW. Another new addition requires that wind systems be listed and labeled for the application. A new revision also expands on the previous limitation for a maximum of 600V rating for wind systems for dwellings, to allow systems up to 1000 V for other applications.

HARMONIZATION INITIATIVES

The publication of these standards is a milestone in supporting the safe deployment of wind turbine generating systems in the U.S. market. However, as a global organization, UL focuses on supporting global realization of our public safety Mission and supporting our global customer base in distribution of their products. With these objectives in mind, there are several initiatives that are either underway or may be pursued in the future.

First, UL has integrated key concepts from, or references to, IEC standards into these national standards where relevant. This was performed with the intention of bridging the gap between the IEC standards and the prevailing requirements in applicable U.S. standards and installation codes. For example, safety related controls system requirements are coordinated with IEC 61400 requirements, and additional requirements for the performance of the integrated equipment were added based on prevailing local issues. This approach allows the use of relevant approaches from the IEC standards while ensuring that significant local issues are addressed in a holistic and comprehensive manner.

Additionally, UL is very active in IEC Technical Committees to support the development of the best worldwide requirements for safety and performance. UL is participating in a leadership role in a collaborative effort in IEC TC 88 in the further development and enhancement of the IEC 61400 requirements for electrical safety. This initiative will draw on the efforts of the standards panels that have generated the requirements of UL 6141 and UL 6142, with appropriate modifications made to reflect the global nature of the IEC 61400-1 requirements. In the past, such efforts have

been very successful in the renewable energy sector, with benefits being seen in standards work on products such as solar power and inverters. Such efforts allow the best efficiency and outcome of the IEC standards development process, allowing balanced consideration while leveraging existing, relevant content in the development process.

In the future, harmonization of the U.S. national standards with the IEC 61400 requirements is also an option. UL looks to international harmonization as an important consideration in supporting global product development and distribution, where the relevant industries and UL are supportive of the need for the effort. As the wind industry continues to refine product offerings and market strategies, additional consideration will be given to the benefits of harmonization.

SUMMARY

As the global wind infrastructure sustains rapid growth, compliance with relevant standards provide validation of design principles and establish due diligence in addressing critical attributes such as safety. The IEC 61400 series of standards provides important information for addressing safety and performance of wind turbine systems. Efforts to address unique issues within the U.S. market has led to development of two safety standards, UL 6141 for large wind turbines and UL 6142/AWEA 6142 for small wind turbines. These standards, which are being published as American National Standards, contain key product safety requirements for the electrical system, electrical safety and controls system, grid connection, and related safety issues. Evolving Code requirements are promoting safety of wind installations, in part through reliance on the evaluation of turbines to the applicable product safety standards. In the future, collaborative efforts will lead to continued exchange of best practices and opportunities for broader harmonization. Development of these standards, and their use by the manufacturing community in design and development of wind turbine products, supports maximal safety and performance of the burgeoning wind infrastructure. ✨

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