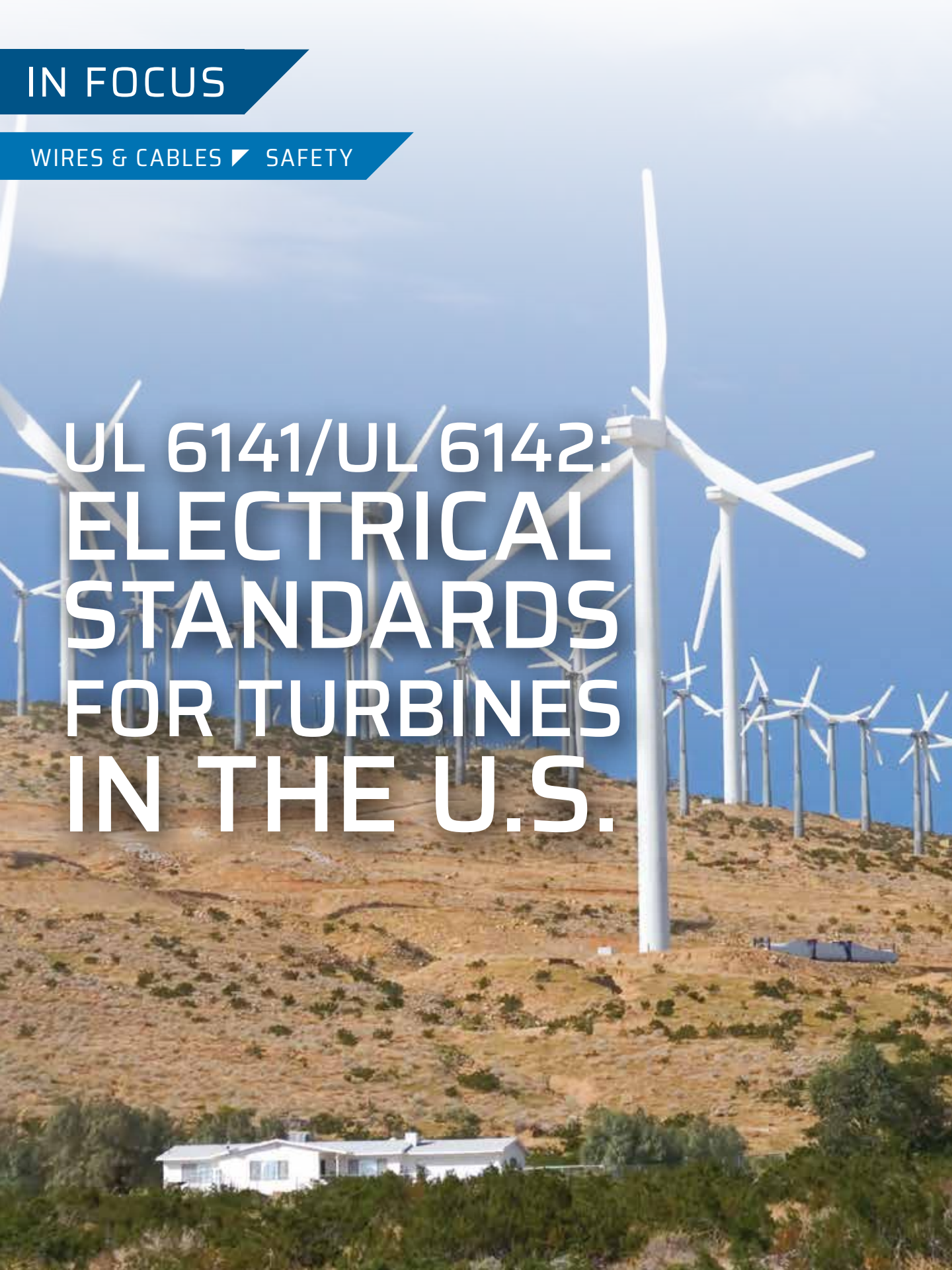

UL 6141/UL 6142: ELECTRICAL STANDARDS FOR TURBINES IN THE U.S.

For many years, there were no national safety standards specifically for wind turbines in North America. (Courtesy: Helukabel)

Retrofitting legacy wind turbines and maintaining current capacity with UL-listed products ensures that your systems comply with today's safety standards regulating the North American market.

By JAMES MOORMAN

Wind turbines are built to last an average of 20 years or more before they are either repowered — which requires a major component overhaul — or decommissioned and no longer deemed a viable operating wind turbine. Not only are the exteriors exposed to environmental extremes, but the mechanical components have to withstand even more, for example, cable abrasions in the drip loop from constant twisting as the hub rotates to maximize wind efficiency, exposure to fluids and oils from potential pitch system and/or yaw failures, and slip-ring cable assemblies that travel through the gearbox, which are exposed to extreme heat that can cause component degradation over time.

Legacy fleets operating today and approaching the end of their service life will be analyzed by asset owners and technicians on whether these aging turbines can be overhauled to continue operating or be decommissioned. For wind-farm operators who decide to overhaul and repower their existing machines, re-using their existing infrastructure is a possibility as long as the components put into the existing towers are compliant with the current standards.

MEETING TODAY'S STANDARDS FOR WIND TURBINES

Underwriters Laboratories (UL) standards 6141 and 6142, which were enacted in 2016/2017, aim to simplify the process of receiving final approval for wind turbines through local Authorities Having Jurisdiction (AHJ) inspectors. In the U.S., local AHJs need to certify that products are safe to use in accordance with general American installation regulations such as the National Electric Code (NEC), National Electrical Safety Code (NESC), and American National Standards Institute (ANSI)/Institute of Electrical and Electronics Engineers (IEEE) C2, among others. It is not always clear whether components that originally complied with the European CE standards also comply with American installation regulations. If there is any doubt, an AHJ inspector may shut down the project. UL 6141 and UL 6142 are the first

American safety standards developed specifically for wind turbines. They provide a set of rules that help AHJ inspectors with the approval process, making it more transparent and predictable for everyone involved.

UL AIMS TO HARMONIZE WITH IEC 61400

For many years, there were no national safety standards specifically for wind turbines in North America. The only guidelines AHJs had for reference was IEC 61400, which is the international standard for wind turbines issued by the International Electrical Commission (IEC). However, the IEC standard has been criticized in North America since it was published. Critics claimed it did not include enough provisions regarding the electrical safety of components, controls, and protection devices.

Therefore, UL developed national standards to supplement IEC 61400. These standards refer directly to IEC 61400-1 (Design Requirements) and IEC 61400-2 (Small Wind Turbines) and add technical requirements primarily focused on electrical safety, control, safety devices, and fire protection within the wind turbine. These UL standards — 6141 and 6142 —bridged the gap between the IEC standards.

ANSI issued UL 6141 as an American National Standard for Wind Turbines Permitting Entry of Personnel. UL 6141 applies to large-scale wind turbines, typically 1 MW and above, that can or may be entered by operators or service technicians for operation or maintenance.

UL 6142 has been acknowledged as a national standard for small wind-turbine systems by ANSI since it was first proposed in 2012. It applies to smaller, commercial-kW wind turbines found closer to residential areas and typically have a nominal capacity up to 1,500 V AC. Due to their size, most smaller turbines aren't large enough for operators/technicians to enter inside to perform maintenance or inspections, so they are either hinged to be laid down or climbed externally. There are smaller turbine types large enough to be entered and climbed by a tech, but they are still classified as a "small turbine." For these turbines, there are lock-out/tag-out procedures for operators and technicians to enter the turbine to perform maintenance.

Cables that have been exposed to oil and other lubricants for long periods can begin to crack as the plasticizers have been removed from the insulation, causing it to harden. (Courtesy: Helukabel)

Cables used in the drip loop that have low abrasion resistance often show wear due to the constant rubbing that occurs as the nacelle rotates. Over time, abrasion can wear down the jacket and insulation, exposing the conductor and creating risk to technicians and the machine. It's important to use cables with high-abrasion resistance to maximize their longevity in this critical area of the turbine. (Courtesy: Helukabel)

The power and data cables within the tower should also be inspected and replaced, if needed, during the retrofit. (Courtesy: Helukabel)

Both UL standards apply exclusively to onshore wind turbines and only affect new constructions or the refurbishing of wind turbines with a capacity greater than 500 kW. Existing legacy fleets systems do not need to be refitted to meet the UL standards until their end-of-service-life date comes due.

HOW DOES UL 6141 AFFECT THE USE OF CABLES?

UL 6141 focuses primarily on electrical safety and introduces several restrictions on how cables may be used in the future. The bottom line is that appliance wiring material (AWM) — in other words, cable that is UL recognized but is not UL Listed — may only be used minimally within the turbine. Up until now, AWM cables were frequently used throughout the various sections of the wind turbines. UL 6141 stipulates all accessible cables need to be installed in cable ducts or trays. If this is impractical or impossible — for example, in the cable loop — only so-called tray-rated cables, more specifically cables that are approved for exposed run (TC-ER), are allowed. The ER or "exposed run" approval allows cable to come out of the cable tray unprotected for ≤6 feet (1.8 meters) if it passes crush and impact tests. Cables in the down tower and nacelle are usually accessible and, therefore, must be certified for exposed run as well.

Tray cables that are designed to be used for exposed run applications are oil and flame resistant and fulfill the increased safety requirements of UL 6141. In fact, cables need to be UL listed to be classified as tray cable. Tray cable rated for 600 V falls under UL 1277 (Electrical Power & Control Tray Cable), while wind-turbine tray cables (WTTC), which are rated up to 1,000 V, are listed under UL 2277 (Flexible Motor Supply Cable and Wind Turbine Tray Cable). Unlisted AWM cables have not passed the specified tests and, therefore, are not suitable for exposed run applications. UL standards were already in place to regulate components in certain wind-turbine subsystems such as generators. These standards will continue to apply. Furthermore, UL 6141 will apply to areas not previously regulated by a standard.

Local AHJ inspectors already favored UL-listed components in the past because UL certification helps to standardize and accelerate approval processes. The recognition of UL 6141 as the national safety standard for American markets will make using UL-listed components even more prevalent in existing legacy fleets. While UL 6141 does not rule out the use of AWM cables completely, it does limit their use to such an extent that UL-listed cable products will be sought after more and more.

ABOUT THE AUTHOR

James Moorman is vice president of sales for Helukabel USA. Moorman has an extensive background in electrical cable and connection system applications for the industrial, wind energy, and utility markets. Between 2009 and 2019, he worked almost exclusively in the wind industry directly supporting OEMs, ISPs, and asset owners on cable and connection solutions for both the U.S. and global wind markets.

Top and above: The cables replaced during an overhaul can vary based on what equipment is being upgraded or repaired. With thousands of components in an entire turbine, a majority of the cables replaced are in the nacelle and the drip loop, where cables experience millions of torsion cycles over their lifespan. (Courtesy: Helukabel)