November 15, 2013

Jason Schroeder
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RE: Fire Safety of Vestas V112-3.3 MW

Mr. Schroeder,

Thank you for your recent inquiry about the risk of fire associated with the Vestas V112-3.3 MW wind turbine generator for Iberdrola's Wild Meadows project in the State of New Hampshire. Safety is Vestas' number one priority and Vestas takes the risk of fires very seriously. As described below, the V112-3.3 MW turbine is designed to minimize this risk.

Electrical Equipment

The importance of safety at Vestas means electrical safety is a major design focus for all Vestas wind turbines, including the V112-3.3 MW. Proper design and manufacture of electrical systems is essential for protection of personnel and minimizing risk of fires.

One source of potential fires in wind turbines is the high-voltage transformer, which in many other turbine models are oil-filled and hence flammable. The Vestas V112-3.3 MW eliminates this oil-based risk by using dry transformers that are air cooled and physically separated from other components in the nacelle. This minimizes the risk of an electrical arc and fire, and is the preferred configuration of the United States National Fire Protection Association (NFPA) code 850 (section 5.1.5.1).

Vestas turbines utilize a Condition Monitoring System (CMS) to monitor hundreds of signals throughout the turbine, including temperature, current, and voltage measurements, to ensure that the turbine is operating completely within normal bounds. The turbine is designed to safely de-rate or shut down if any parameter exceeds pre-set thresholds. Such use of CMS is recommended by the Confederation of Fire Protection Associations in Europe (CFPA E) document "Wind turbines fire protection guideline" (sections 4, 5.1.2, and 5.1.6).

In the case of an electrical arc incident, arc detectors are positioned to instantaneously detect the arc, safely shut down the turbine, and open the main switchgear. This system acts independently of the control system, and removes the energy source for the fire before it has a chance to ignite. The shutdown causes the blades to automatically pitch to an aerodynamically neutral position using stored hydraulic energy, causing the rotor to come to a complete stop within seconds, without requiring use of a mechanical disc brake. This is in accordance with CFPA E (section 5.1.2) and NFPA (section 10.5.1.3) recommendations.

There are multiple ionization smoke detectors located inside the nacelle as recommended by the CFPA E (section 5.2.1). The smoke detectors act independently from the turbine controller and automatically shut down the turbine and open the main switchgear of the turbine using the same procedures as the arc detectors.

A fire suppression system is also present in the electrical cabinet. The system consists of a pressure cylinder which contains the extinguishing agent 3M Novec 1230 which is a colorless, low odor fluid, low in toxicity, electrically non-conductive, and is an extremely effective fire suppression agent. Flexible tubing is attached to the cylinder/valve assembly and is routed throughout the cabinet. The tubing acts as a continuous linear thermal detector that ruptures upon direct flame contact or at approximately 177°C. Once the detection tubing is ruptured, the valve automatically opens, allowing the Novec 1230 agent to be distributed through the rupture point and onto the flame/heat source. A

pressure sensor in the system detects low pressure during a suppression event and automatically shuts down the turbine and opens the main switchgear, acting in the same manner as the arc detectors and smoke detectors.

Manufacturing quality is essential for ensuring the effectiveness of the turbine's electrical safety systems. Vestas uses state-of-the-art quality systems in its manufacturing facilities, and cascades many of these requirements to sub-suppliers, to ensure that product quality enhances fire safety. Sophisticated systems ensure that bolted connections are at the correct torque value, cable connections are secure, and the entire turbine functions properly before leaving the manufacturing facilities. Each turbine undergoes full-scale testing both in the factory and at the site before it is released for operation. Such quality systems are recommended by the CFPA E to ensure safe operation of wind turbines for their service life (section 5.4).

Lightning Strike

The V112-3.3 MW is designed according to lightning protection level 1 of the International Electrotechnical Commission (IEC) 62305 standard; the highest protection level, corresponding to safe conduction of lightning strikes up to 200 kA; this is the recommended level according to the CFPA E (section 5.1.1). The lightning protection system of the V112-3.3 MW is a proven design, refined over many previous turbine models, incorporating design best practices to ensure safe operation for the duration of the turbine's life. During the turbine design phase Vestas validated the performance of the lightning protection system according to all applicable IEC test standards in state-of-the-art facilities in Europe. This provided verification that the system is designed to transfer lightning strikes safely to ground, no matter where the turbine has been struck. The lightning protection system extends from the tips of the blades, around the entire nacelle, the tower, and into the foundation earthing system. This comprehensive approach to lightning protection is recommended by the CFPA E (section 5.1.1).

Hot Surfaces

Hot surfaces are kept to a minimum in the V112-3.3 MW. In order to bring the rotor to a safe stop, no matter what the wind conditions, the hydraulic pitch system is used, not the mechanical disc brake. This method of operation is reliable and proven across more than 20 years of Vestas wind turbine designs. Each blade of the wind turbine has its own pitch actuator, and in case of problems with the pitch system, only two blades are required to bring the rotor to a complete stop.

The mechanical disc brake in the V112-3.3 MW is only used for service activities (stopping rotation of the rotor so that the rotor lock pins can be installed) or when a technician physically presses the emergency stop button. Even during an emergency stop, the mechanical disc brake is only applied at low rotational speeds to decrease the amount of heat build-up, and the brake is automatically released after approximately 30 minutes so that brake friction doesn't cause excessive heat. The disc brake is covered for safety, according to the recommendations of the CFPA E (section 3.3.3)

Work Involving Fire Hazards

Welding, burning, grinding, and other work involving heat sources are not part of the standard maintenance plan of the turbine. Such work typically takes place in the factory during the manufacturing process, or in workshops in the case of component repair.

In the rare instance that "hot work" is required to be performed in the turbine (hot work in the turbine is avoided if possible) Vestas' work instructions include numerous requirements to ensure that personnel and equipment are safe. Precautions include ensuring the work area is free of any flammable materials, sufficient ventilation, fire blankets, ensuring that extinguishers are on hand, and clean-up and inspection of the work place after the job is finished. Technicians must complete appropriate documentation and obtain permits from site management before engaging in any hot work. Limitation and regulation of hot work is recommended by the CFPA E (section 5.1.5) and NFPA (section 16.3(5)).

Combustible Materials

The use of flammable materials in the turbine cannot be avoided for practical reasons, but Vestas makes efforts to manage these risks appropriately. For example, oil is used in the hydraulic pitch system and to lubricate the gearbox;

so the turbine continuously monitors oil pressures and oil levels to ensure that there are no leaks. If a leak is detected the turbine is automatically shut down and technicians need to visit the turbine and repair the issue before it can be re-started.

Materials that are not essential to the operation of the turbine are not left in the machine, including cleaning solvents, rags, papers, garbage, etc. This keeps the amount of flammable materials in the turbine to a minimum, as recommended by the CFPA E (section 5.1.3 and 5.1.4). Smoking is not allowed in Vestas wind turbines, in accordance with CFPA E recommendations (section 5.1.7).

Fire Fighting

Technicians have a standard safety kit that they bring when working on the turbines (in addition to their standard personal protective equipment including safety boots, safety glasses, gloves, fall arrest equipment, etc.). This includes a first aid kit, 5-6 kg CO_2 fire extinguisher, and emergency descent device. Fire blankets are required if any hot work is to be performed. These items are stored at the site office, not the turbine, because it is easier to maintain and inspect them on the ground than during turbine visits, which may be as long as 1 year apart if there are no turbine operation faults.

Technicians receive training and regular refresher courses on the proper usage of these items in the case of emergency situations, as the CFPA E recommends (section 5.1.8). Prior to each turbine visit technicians are required to check that fire extinguishers are in good condition and are not late on inspections.

Maintenance

The V112-3.3 MW turbine is designed with much more working space than other wind turbine models to ensure that technicians have enough open space to safely maintain, repair, and replace equipment as needed – an increase of 60% versus previous Vestas turbine models. In addition to fluorescent lighting along the entire height of the tower, and throughout the nacelle, skylights provide additional lighting during daytime hours. This allows technicians to properly see their work, ensure high quality, and clean up when the work is done; aspects that have been recognized by the CFPA E as important to fire safety (section 3.3.7)

While working on the turbine, technicians keep fire safety in mind at all times. Before performing any work on the turbine, technicians prepare thorough planning documents to describe the activities that are planned to take place in the turbine and the potential hazards associated with these tasks, including confined space and risk of fire assessments.

During annual service visits, technicians inspect and maintain a variety of components in the turbine that ensures safe operation. For example, electrical connections are inspected and re-tightened, oil filters are replaced, the disc brake is inspected, arc detectors are tested and cleaned, the transformer is inspected and cleaned, etc. These maintenance activities are considered by the CFPA E to be important steps that mitigate the risk of fires (section 5.1.6). Technicians are qualified to perform this work after attending regular and extensive training sessions at our North American training center in Portland, Oregon as well as on the job training and certification activities.

Conclusion

Vestas takes fire safety very seriously, which is shown in the design of the V112-3.3 MW wind turbine. Every aspect of the turbine from layout, to electrical design, to maintenance requirements have been developed to ensure years of safe and trouble-free operation. This wind turbine is an excellent fit for the Wild Meadows wind project and is designed to safely provide years of clean energy to the residents of New Hampshire.

Kind regards,

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