



The Value of Rotor Blade End of Warranty Inspections

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With the purchase of a wind turbine, the owner/operator typically receives a warranty valid for a 2 to 5 year period. Nearing the end of this initial warranty period, it is critical that the owner/operator perform an End of Warranty (EOW) inspection on their rotor blades before deciding on how the turbines are to be serviced and maintained for the remainder of their design life. It is also common that the EOW inspection is called for in term loan agreements. This inspection is important even if the owner/operator plans to continue with the Original Equipment Manufacturer (OEM) service team.

What is involved?

An EOW inspection of wind turbine rotor blades should involve, at a minimum, external inspections from the ground and up-tower internal and external inspections. Inspections must focus on the current condition of the rotor blades exterior laminate, bond-lines and coating, inclusive of Leading Edge (LE) protection, aerodynamic elements (such as stall strips, vortex generators) and internal laminate and structural components (such as shear web(s), blade shell bond-lines). Additional checks of the Lightning Protection System (LPS) continuity, Aerodynamic Alignment of Rotor Blades and Dynamic Balance of the Rotor should also be performed to ensure that measureable defects and their subsequent future repair costs are not inherited by the owner/operator themselves.

Following the recommendations of the turbine OEM, or industry regulated norms such as IEC 61400-24, the continuity of the LPS should be verified at least every 2 to 4 years depending on the level of LPS installed in the blade. A faulty LPS can lead to costly repairs or possible blade replacement and downtime in the event of a lightning strike. At the same time the LPS of the blade is checked, it is also important to ensure the drain hole(s) of the blade is open. Clogged drain holes can lead to rotor mass imbalances, and in the event of a lightning strike, severe blade damage may occur due to the superheating and expansion of the trapped fluid.

By performing a complete Dynamic Balance of the Rotor, both aerodynamic and mass imbalances can be reduced to acceptable levels, thereby reducing the vibrations seen by the rotor, drive train, and other major turbine components. Correction of aerodynamic imbalances must be completed prior to mass imbalance determination and correction. When effects known to cause aerodynamic imbalances are not investigated and understood, they can masquerade as mass imbalances and over correction of the mass imbalance may occur. If subsequent mass imbalances are discovered, they will require correction through the addition of mass to the blades themselves. Large imbalances may even require the replacement of individual blades and the subsequent repetition of the Dynamic Balancing program. This program will reduce fatigue loads on the rotor and drive train components, reducing wear and helping the individual components to realize their expected service life.

Who performs the inspections?

The EOW inspections must be performed by either third party contractors or the owner/operator themselves. When owner/operators do not have the required knowledge and experience in-house to perform these inspections, third party companies are generally selected. The company selected to perform these inspections must have knowledge of the composites used and construction methods employed during rotor blade fabrication. An aerodynamic understanding of the blades operation is required to assess the installation of the blades on the rotor, aerodynamic elements on the blades and the effect of defects/anomalies discovered during the inspections on turbine performance and blade life expectancy.

Due Diligence of Owner and Operator to Perform:

It is the due diligence of the owner/operator to perform the EOW inspections. As the initial warranty period of the turbine is set to expire these inspections will provide information on the current status of the blades, quality of the service and maintenance currently being performed and budgeting for future maintenance and inspection. Failure to assess the condition of the blades will leave future repair costs to the owner/operator, reducing wind farm profitability and decreasing turbine availability.



The planning for these inspections, which should have been a committed component of the initial budget planning of the wind farm, will ensure that the inspections are performed during lower wind times (typically in the summer), reducing stand-by due to inclement weather, and lost production due to unavailability in high winds. 100% Wind Farm inspection is recommended to ensure that the status of all turbines is known and the benchmark for each individual turbine is set.

Value Added:

Third party companies that perform these inspections will assess their findings, compile results into reports and provide recommendations to the owner/operator on what actions are required. In general, it is the third party recommendations that are provided to the OEM by the wind farm owner/operator. The third party will then work with the owner/operator to evaluate the OEM's responses and help generate the plan for future repair, maintenance and inspection. Close evaluation of the OEM's responses is required to ensure that the rationale for acceptance of the defects/anomalies discovered during the inspections is sufficient to mitigate their future risk to the blade.

Through the report findings, the owner/operator gains information on the overall quality of their blades, and the wear and replacement characteristics of the blade and blade components such as LE protection and aerodynamic elements. This information allows them to establish a benchmark to evaluate the blades against for subsequent inspections. In the event that on-site delivery inspections were also performed, the inspection findings provide a more accurate picture of which areas of the blades will require the highest frequency of inspection and repair, as the third party and owner/operator can more clearly recognize the areas which are susceptible to defect formation.

Additionally, and quite commonly the largest benefit to the owner/operator, if manufacturing defects which were not discovered by the quality department of the OEM during initial manufacture are found, the EOW inspections will ensure that their repair cost does not come upon the owner/operator themselves.

Cost:

A rotor blade inspection team, performing blade interior and exterior inspections only, will generally consist of two inspectors and one turbine operator who perform inspections on two turbines per day at a cost of approximately \$2,000 - \$2,500 per turbine. A fully comprehensive EOW inspection, inclusive of blade interior and exterior inspections, LPS continuity checks, and Dynamic Rotor Balancing will cost approximately \$5,000 - \$6,000 per turbine plus crane fees and be performed by multiple teams, sequentially working their way through the wind farm. Depending on the size of the wind farm, it is not uncommon to employ 2 to 4, or more, teams to perform these inspections. Performing these inspections sufficiently in advance of warranty expiry will allow the owner/operator to have an open and productive dialogue with the OEM based on the EOW inspection findings.

A comprehensive EOW inspection program will remove unknowns from future turbine operation and help generate a clear costing model for future turbine maintenance, inspection and repair. The due diligence to perform these inspections falls onto the owner/operator themselves as these findings will provide the necessary knowledge to properly formulate an effective program to limit repair costs, increase turbine availability and ensure overall turbine performance.