

## Corrosion Evolution and Quantitative Corrosion Monitoring of Q355 Steel for Offshore Wind Turbines in Multiple Marine Corrosion Zones

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**Abstract** Offshore wind power technology has garnered significant attention for its high resource utilization and minimal environmental impact. However, the steel structures of wind turbines are susceptible to corrosion in harsh marine environments. This study focuses on Q355 steel, commonly employed in offshore wind turbines. An environmental test apparatus was constructed to simulate atmospheric, splash, tidal, and underwater zones. Samples, including corrosion coupons, electrically connected corrosion coupons, and vertical steel strips, were prepared and subjected to measurement of corrosion mass loss and electrochemical properties. The composition of corrosion products and the characteristics of corrosion morphology were statistically analyzed. The results show that corrosion is most severe in the splash zone, followed by the tidal zone, with minimal corrosion observed in the atmospheric zone. The corrosion rate remains stable in the underwater zone. A macro-corrosion cell effect of vertical steel strips near the waterline was revealed, with distinct cathode and anode areas formed above and below the low tide line, leading to localized inhibition and acceleration of corrosion. Additionally, a corrosion monitoring sensor based on electromechanical impedance was proposed, demonstrating a significant linear regression relationship between the conductance peak frequency of the sensor and the mass loss of the corrosion coupon. Building upon this, a prediction method for mass loss of electrically connected corrosion coupons was proposed. Finally, the monitoring method was validated based on corrosion mass loss of vertical strip steel. This article elucidates the corrosion mechanism of Q355 steel in marine environments and validates the proposed corrosion monitoring method. The research offers a solid theoretical foundation for the design, safety assessment, and lifespan prediction of offshore wind turbine structures.

**Keywords** Offshore wind turbines, Q355 steel, Corrosion zones, Corrosion evolution, Corrosion monitoring