# Anti-Corrosion Technology for Offshore Wind Farms

*By Colin Pawsey*

Offshore wind turbines are designed to have a service life of 20-25 years, but corrosion can cause ongoing problems for operators in terms of maintenance, and in doing so, have a significant effect on the overall cost of energy. The aggressive conditions at sea require specialist coatings to protect the structure above and below the water, and although techniques have been borrowed from other marine industries, offshore wind farms have their own individual characteristics to contend with.

**The offshore environment**

The harsh environment offshore requires highly effective anti-corrosion coatings and the difference in exposure compared with onshore turbines is vast. Onshore exposure generally consists of cyclical dew or condensation, with or without minor salinity, and exposure to sunlight, resulting in moderate corrosion at weak points and damaged areas of the coating. In an offshore environment, anti-corrosion coatings have to protect structures above and below the water line, and at the splash zone, and are subjected to humidity with high salinity, UV light, wave action, and storms. Onshore corrosivity is evaluated at around C3, which equates to a thickness loss of 25-50 µm. The coatings used for offshore applications are rated in the category C5, and can provide a dry film thickness of more than 1000 µm.

**Corrosion protection technology**


Source: Hempel

The majority of turbines in operation across Europe today are supported by monopile foundations, and these are the test case for new coating systems coming to the market. However, any new ideas and innovations must also be prepared for the next generation of turbines which are likely to use different types of foundations. As the industry progresses more data has been gathered from previous installations and lessons are being learned from wind farms where corrosion has caused issues. Monitoring systems are also being introduced which can continually monitor turbines for structural health, and report on the state of corrosion in real time. There are also innovative new coatings being developed to provide better protection for the offshore sector, and this is a good opportunity to look at some of the new technology

in anti-corrosion protection.

**Hempel AvantGuard**

Hempel has been a long time supplier of high performance coatings to the wind industry, and in September this year announced the launch of HEMPADUR AvantGuard, a portfolio of three new anti-corrosive zinc primers designed for tough C4 and C5 corrosive conditions.

Based on the company's new AvantGuard technology, the primers are significantly longer-lasting than zinc epoxies, but can be applied using the same techniques. The technology stems from the discovery in 2006 that only around a third of the zinc in standard zinc epoxies had an anti-corrosive effect. Hempel set about creating a primer that would exploit the other two-thirds through greater zinc activation. Approximately 7,000 laboratory hours led to the development of AvantGuard, which is aimed specifically at structures in tough environments that will benefit from low maintenance costs and long maintenance intervals.

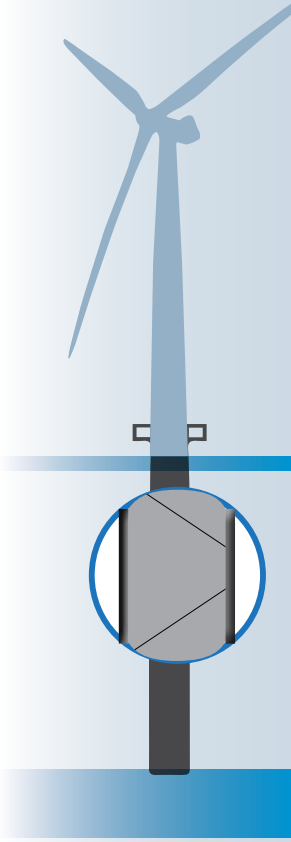
The primers use hollow glass spheres and a proprietary activator to activate more zinc in the coating. The resulting coating is able to provide much greater galvanic protection than standard zinc primers, and also enables barrier and inhibitor protection. According to Hempel, this unique formulation also contributes to the coating's mechanical strength through a 'self-healing' process. In a standard protective system the zinc primer is often the weakest point, and is most susceptible to cracks as the steel expands and contracts. With the AvantGuard primers, the glass spheres absorb most of the impact to prevent cracks from developing, while the sub-products formed during zinc activation occupy the space left by the 'micro-crack' to prevent it from developing further.

The technology will be of interest to the offshore wind industry, having shown increased durability in extensive testing. Hempel state that the salt spray test according to ISO 12944 showed excellent corrosion properties; reduced rust creep and enhanced corrosion protection was shown in the cyclic corrosion test (ISO 20340) Norsok M 501 revision 6; and low water permeability shows enhanced corrosion resistance through the barrier effect.

**Design and fabrication considerations**

While coatings and ICCP systems are the first line of defence against corrosion, the design and fabrication of the steel structure is also critical for long term protection. Before the coating can be applied, the structure must be constructed in a way that is suitable to accept the primer successfully. Coatings can only protect accessible surfaces and the design must reflect this. EN ISO 12944, part 3, design considerations, recommends that appropriate distances required for tools in corrosion protection work are respected. The standard also provides guidance on the minimum dimensions for openings that provide access to confined areas, the minimum dimensions for narrow spaces between surfaces, and the incorporation of design features that can be used to avoid deposits accumulating or water being trapped.

A further standard, ISO 8501, part 3, preparation grades of welds, edges, and other areas with surface imperfections, should also be considered during fabrication. The standard is relevant to steel construction, rather than primer application, and gives recommendations about the condition of the steel surface if paints are to be applied later for long term corrosion protection. For offshore structures, preparation grades P2 or P3 should be specified, depending on the type of structure. These grades require the steel surface to be free of welding splatters and slags, pores, undercuts and laminations. The surface should also be dressed (by grinding) to remove irregular shapes and sharp-edged profiles.



**Summary**

Anti-corrosion protection is vital for the long term health of the offshore wind industry. The experiences of early wind farms have shown that corrosion offshore is more of an issue than first thought, and the harsh conditions that wind turbines are exposed to are vastly different to those experienced on land. The high salinity, humidity, and wave action around the splash zone create different problems, and corrosion protection must be much more robust.

New technologies are required to provide protection for larger turbines in deeper water and harsher conditions, with new types of foundations. While the majority of anti-corrosion systems are based around monopile foundations – as this is the common type throughout Europe – there will be a need to transfer these technologies to other foundation types in the near future. Advances such as Hempel's new AvantGuard technology will be hugely beneficial to the wind industry as the activation of the additional zinc in the primers creates longer-lasting protection. The 'self-healing' aspect of the primers is also an advantage, particularly as wind farms move further from the coast, and repairs become even more expensive. ICCP systems will also help the industry to move forward. These systems are preferential to conventional cathodic systems which use sacrificial anodes and release the material into the sea.

The development of sophisticated monitoring systems alongside these new technologies will aid operators over the lifetime of the wind farm. The ability to constantly monitor each turbine and substructure for structural health and corrosion will reduce inspection time, repair time, and ultimately the cost of maintenance.

Corrosion is an issue for the offshore wind industry and will be a long term problem for wind farms; it is something that must be managed from initial design and fabrication, through to installation, operation and maintenance.

***About the Author:***

Colin Pawsey is a freelance technical journalist, focusing on new trends and technologies in the renewable energy and automotive sectors. He is a regular contributor and writing consultant to Wind Energy IQ and Automotive IQ, and is also the founder of copywriting agency – Pure Copy.

***Sources:***

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