Offshore wind structures are exposed to an extremely corrosive environment. As a result, corrosion rates of steel are high, >0.5 mm/year, and coating systems must perform extremely well. Jo van Montfort from Bjond, gives PES his professional viewpoint on some of the pitfalls of the current certification processes and outcomes. This means all stakeholders involved need to increase their level of knowledge in this area.

The value of testing coating systems for offshore wind structures
The most important requirement for a coating system for an offshore wind structure in the leading directive, DNVGL-RP-0416, is as follows: ‘Sufficient attention must be paid to the design life of the structure and the economic aspects of repairing the coating if necessary (and realistic).’ In our opinion this means 25 years maintenance free, because repairing/maintaining a coating system under offshore conditions is undesirable, almost impossible and very expensive (x1000 versus a paintjob onshore).

Therefore, the durability ranges in the latest leading coating standard EN ISO 12944 have been revised. Now a very high (VH) durability range has been included, which means the first maintenance work should not be necessary for 25 years. In the former version and until now this was for 15 years. The question is how to achieve that?

Current situation

In the offshore wind industry, guidelines and standards such as DNVGL-RP-0416 (Lit. 4) and EN-ISO 12944 are used as a basis for selecting a coating system. According to the DNVGL-RP-0416 directive, coating systems must be pre-qualified in accordance with recognized standards, e.g. NORSOK M-501, EN ISO 12944, ISO 20340).

In the recently updated EN-ISO 12944 (Lit. 3) standard, a new atmospheric corrosivity category is also defined: CX which is more aggressive than the previous C5-M category and applicable for offshore areas with high salinity.

In this standard, under section 5, it is clearly stated that the selection of a paint system for a specific situation, should preferably be based on experience gained from using the system in similar circumstances. It also states that results from artificial-ageing tests must be used with caution and that it is difficult to reliably rank paint systems of very different compositions, according to the artificial-ageing tests in the laboratory. It further says: ‘this can sometimes lead to efficient protective paint systems being rejected because they cannot pass these tests.’

Unfortunately, the reverse also occurs, as we have seen ourselves and this is supported by Weinell et al. (Lit. 1), where NORSOK approved coating systems fail within a few years.

Due to insufficient knowledge and experience in this area, mandatory testing according to recognized standards is imposed, without properly understanding the poor relationship with the required long maintenance-free lifespan. One could call this ‘unconscious incompetence’.

Not only we, but also others (Lit. 1), acknowledge that pre-qualification tests alone are not sufficient to obtain the right coating systems for actual application. All experts agree that the lifetime of a coating system, as well as the material properties, also depend a lot on the quality of surface preparation, the coating thickness and the quality of workmanship. Since these factors are usually the most uncertain elements, strict quality control (QC) has to be enforced during production.

We believe that strict QC does not prevent premature failure of coating systems, which are not suitable for practical application conditions. When for example more than 3 layers are required and a substantial amount of solvents (>10%) are added there is considerable risk of undetected issues during application, which could lead to early failures.

Our observations

Unfortunately, we note that standards do not take unequivocal positions when it comes to selecting coating systems for offshore conditions. As a result, mandatory tests are imposed to create a ‘certainty’ by pre-qualifying the coating system and, in the worst case, to certify the project.

To explain why this is a ‘false/insufficient certainty’ we first have to look a little further into what testing a coating actually entails. Testing means that the coating system is applied under perfect, controlled circumstances, on a perfectly prepared flat panel.

These panels are exposed to accelerated aging tests. The primary focus is to test resistance to water or moisture, and salt fog, as an indication of wet adhesion and barrier properties.

In real practice, we never encounter perfect circumstances, nor perfect surface preparation. Added to which, failures almost always never occur on the flat parts. They mainly arise on edges, bolted connections, notches, welds etc. Locations where there is a serious chance of internal (tensile) stress inside the coating, which results in micro...
meso, macro cracks. The tolerance of the coating systems for these effects is not included in the recognized and mandatory tests (Lit. 2).

Effective accelerated aging lab testing should simulate the failure modes in the field such as:

• Tolerance for deviating conditions with regard to substrate pre-treatment and environmental conditions by use of physical testing.
• Premature coating failure at sharp edges, corners, and weld seams.
• Measuring development of mechanical properties as a function of (accelerated) aging tests.
• Etc.

To cover this NACE has published several test standards for offshore coatings, to qualify both new construction and maintenance coatings for atmospheric, splash zone, water ballast tank and water immersion areas. NACE standards also include physical testing, such as thermal cycling, edge retention and film flexibility, while in most cases only the coating corrosion resistance is tested.

The durability is of course also linked to the chemical and physical characteristics of the coating system, e.g. the type of binder and the dry-film thickness. The influence of these characteristics on the durability can be evaluated by artificial-aging tests.

Apart from this we and ISO 12944 emphasize that results from artificial-aging tests must be used with caution. This is because artificial ageing will not necessarily have the same effect as natural exposure. Many factors have an influence on the progress of degradation, and, in the laboratory, it is not possible to accelerate all of them in the appropriate way. It is therefore almost impossible to rank paint systems, made up of very different
compositions, based only on artificial-ageing tests in the laboratory.

In our own practice we always take into account this apparently unpredictability of protective coatings. We fully underline the approach as presented in EN-ISO 12944-9. This standard says that the selection of a paint system for a specific situation should preferably be based on experience from the use of the system in similar cases. The reason is that the durability of a paint system depends on many external factors, such as the environment, the design of the structure, the surface preparation, and the application and drying procedures.

It is recommended that natural-exposure trials always be undertaken so that, in the long term, such anomalies can be resolved.

However, it should be recognized that the main problem when using only this approach, is that it will take many years before a suitable coating can be selected. Therefore, it is important first to understand the failure mechanisms and recognize them in an early stage during natural exposure and accelerated testing. For example, cracking due to internal stress may lead to excessive coating failure and corrosion after only 2-5 years outdoor exposure. When conducting microscopical analysis and measuring mechanical properties, such as tensile strength, modulus of elasticity and strain capacity, clear distinctions can be made between coating systems at an early stage during the testing.

Coatings are very complex materials and when extremely high performance is required, a high level of experience and expertise is necessary. Looking beyond the existing standards and guidelines is essential to avoid extremely high maintenance and repair costs.

Considering this, we at Bjond would argue for:
- Making all participants involved aware of the need to engage independent expertise with the aim of saving costs in the long term.
- An increase in the level of knowledge on coatings for designers and contractors by working with experts at an early stage of the design process.
- A clear fit for purpose selection procedures for coatings based on the relationship between construction type (paintability), life expectancy and costs.
- Coordinating leading standards and guidelines with each other so that they occupy the same and above all unambiguous position when it comes to selecting coating systems for offshore conditions.

Lit.3. EN-ISO 12944-9, Protective paint systems and laboratory performance test methods for offshore and related structures