Remote Sensoring for an Offshore Windfarm Maintenance System

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Introduction

In the current offshore wind energy market high cost efficiency is a major factor. While budgets become more limited, the demands for the structures are constantly increasing. Wind turbine park owners (and operators) now request a lifetime of 25 years or more for their off shore structures.

The integrity of wind turbine structures can be assessed in several ways including static strength, fatigue and impact strength of both the above- and under water parts. Corrosion, on the other hand, receives less attention even though it is ranked in the top 3 failure mechanisms for structures in general. Key aspects are coating degradation in the tower and foundation, as well as, Microbiologically Influenced Corrosion (MIC) in enclosed areas.

To achieve a 25 years lifetime, a robust asset management system must be developed that is fed with reliable data. The system must include the remote assessment and monitoring of corrosion, including MIC.

Objectives

The main objective of this research project is to investigate the use of remote sensors in offshore windfarms. TNO has investigated the possibility of using two types of commercially available corrosion sensors in an integrated maintenance concept: a coating degradation sensor based on EIS technology, and a sensor for measuring biological activity that can indicate MIC.

Methods

The coating health monitor is based on the electrical impedance technology. A laboratory EIS test setup (Figure 1) was compared to a small sized sensor with tape electrodes as reference electrodes and a connection to the steel substrate as working electrode. Steel panels with two different coatings were exposed to sea water at ambient temperature and measured after 1, 7, 13, 21, 27, 34 and 180 days. The measurements were executed after the panels were dried with cloths and the aluminium reference elctrodes were attached on the panels. The impedance at 0.2, 0.5 and 0.9 Hz was measured by the sensor. The laboratory setup measured continuously from 100 kHz to 0.1 Hz.

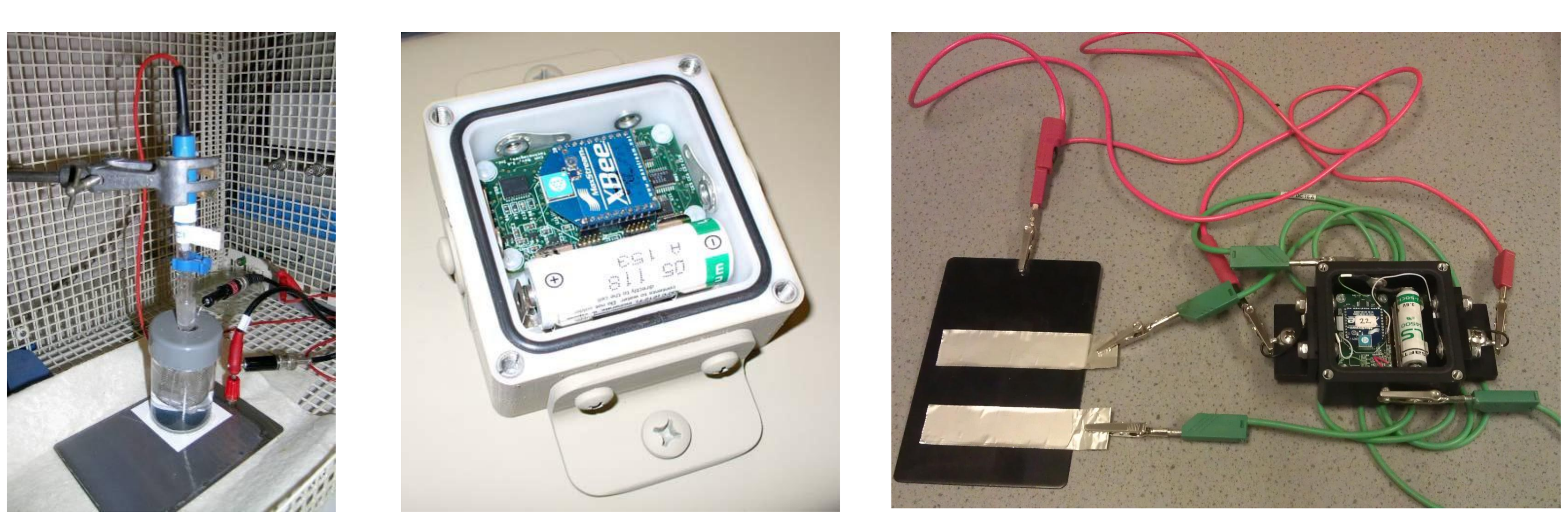

Figure 1:Laboratory EIS setup and coating health sensor.

The MIC sensor used is also an electrochemical sensor based on detecting changes in the applied current needed to achieve a pre-set potential in an identical set of electrodes. The electrodes are physically not in contact but can be short circuited either by the presence of electrolyte or by a biofilm growing on top of them. The response of the sensor to laboratory grown microorganisms in artificial seawater, natural seawater with sediment (containing natural microbial communities) and the influence of stagnation and redox conditions were assessed using a setup similar to that of Figure 2. In addition to the biofilm sensor, redox-potential, oxygen content and pH, and OCP for several metal coupons were performed.

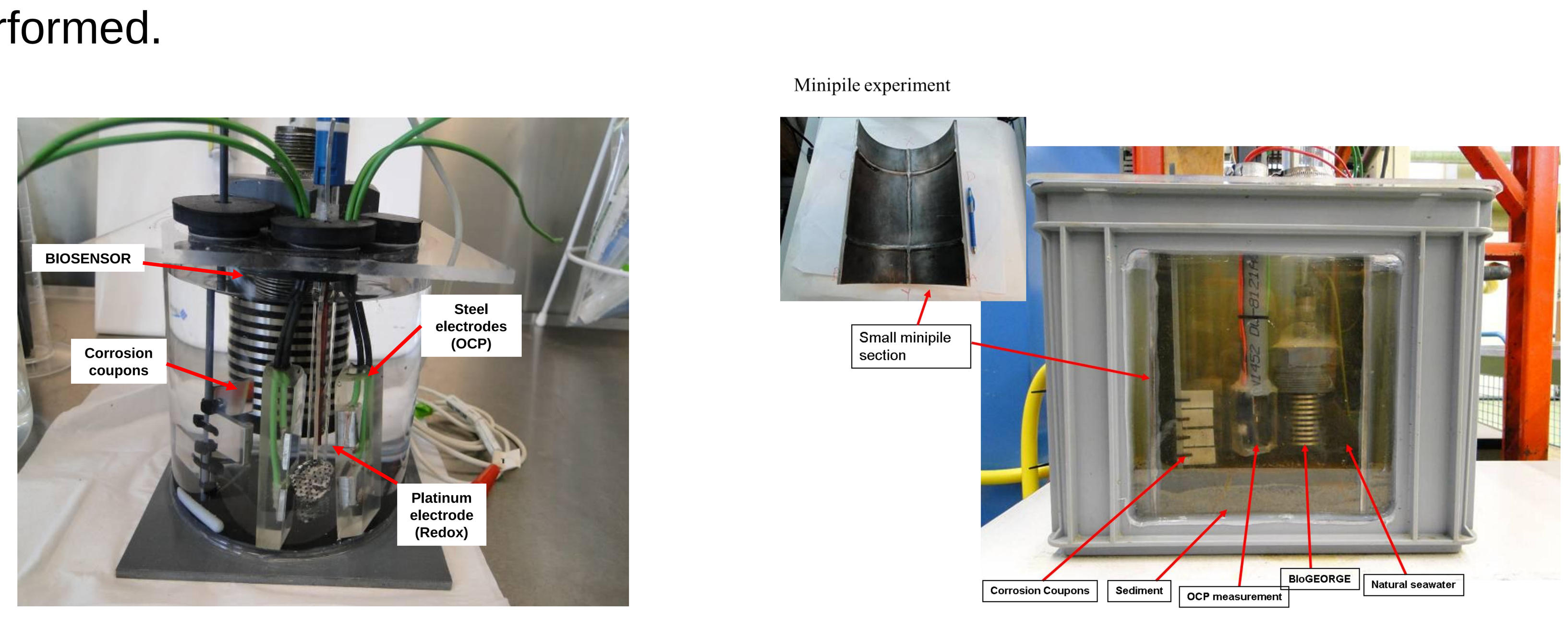

Figure 2: Laboratory Biosensor monitoring set. Left: Monitoring in artificial seawater. Right: monitoring in natural seawater conditions

Results

The coating degradation sensor was tested to compare the method with conventional laboratory EIS measurements. Correlation between the sensor output and the laboratory EIS measurements showed significant differences between the two types of measurements. It appears that the used technique, and the results, are very dependent on the set up of the measurements and the surface condition of the coating.

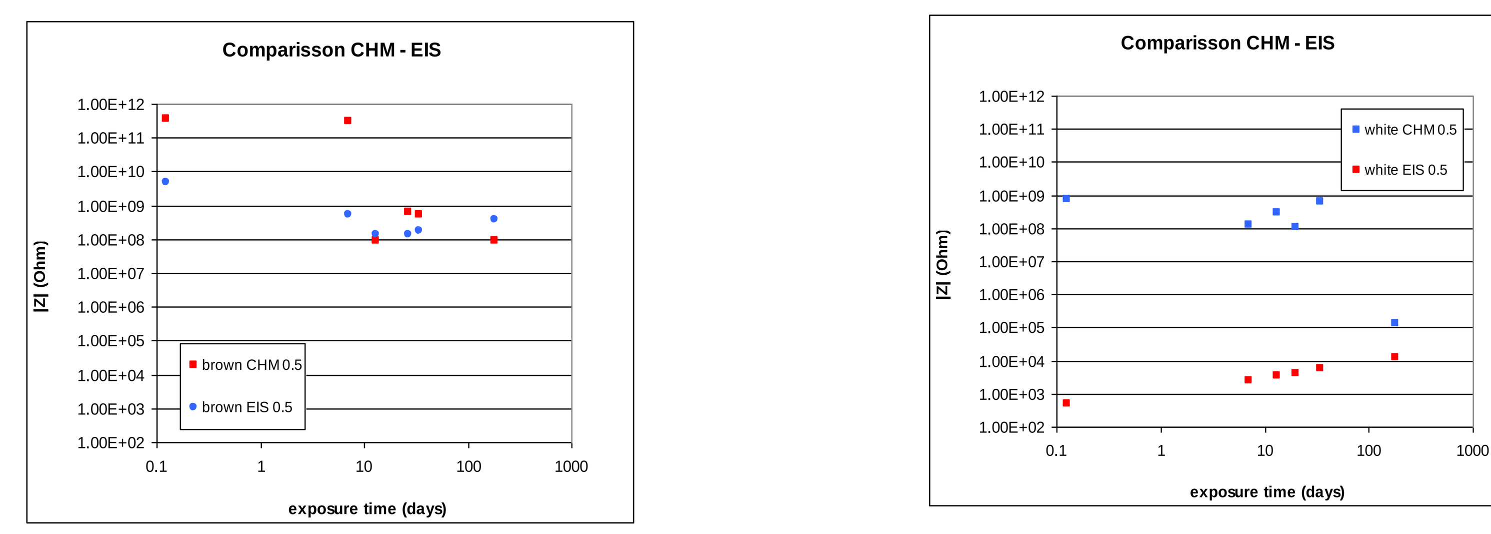

Figure 3:Comparisson of EIS and CHM results of a polyester coating and a metal containing coating.

The biological activity sensor has been tested with laboratory grown bacteria in artificial sea water and also a semi-real life scale in natural sea water with sediment. Preliminary results show that the biological activity sensor is capable of detecting and measuring activity that could generate favourable conditions for biological corrosion. Further investigation is aimed at the influence of physical and chemical constituents of sea water on the sensor response.

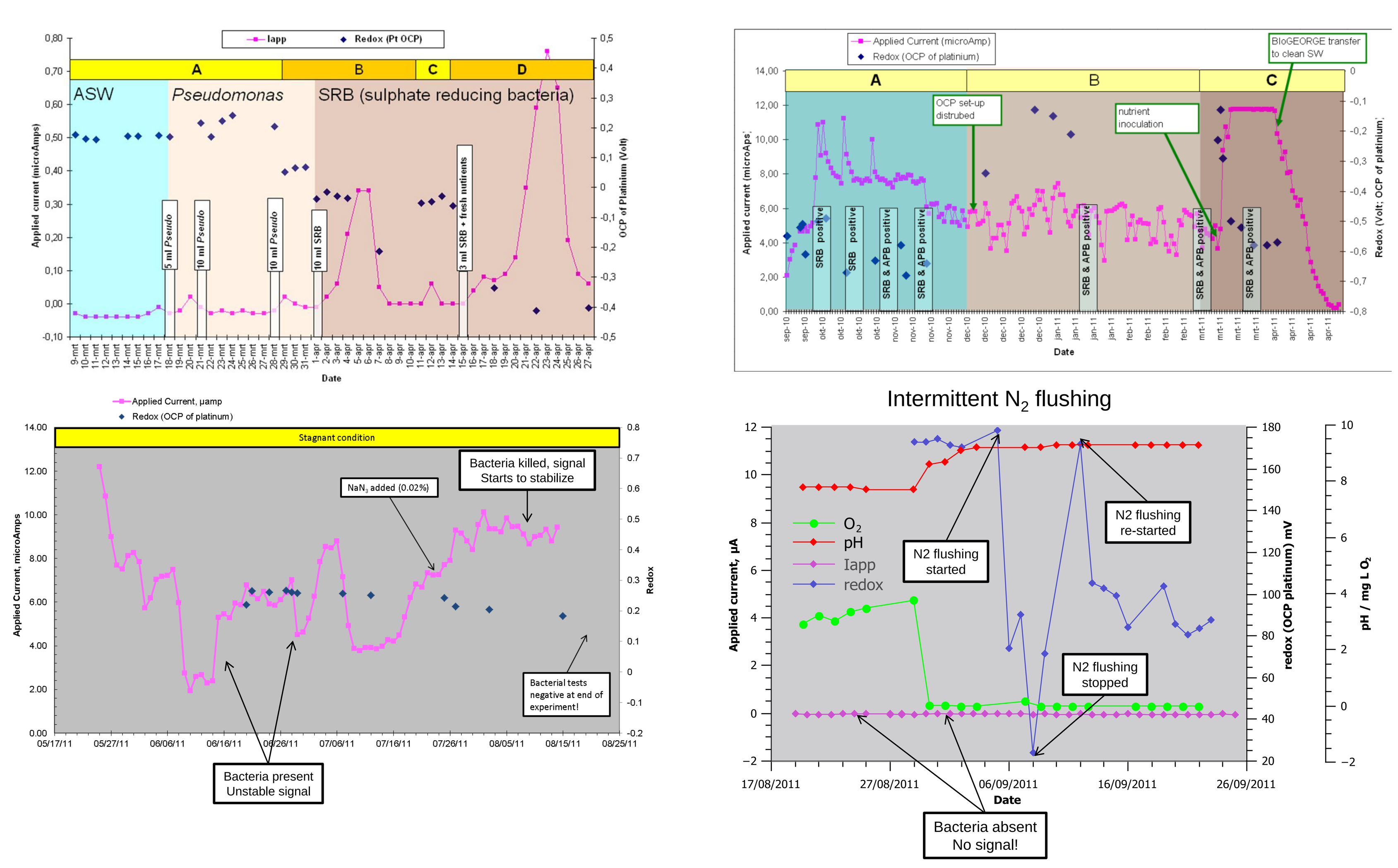

Figure 4: Laboratory Biosensor monitoring signal at different conditions and its response to the presence of microorganisms.

Conclusions

From the results it is concluded that the coating health sensor is capable of detecting coating degradation, but that its measurements should not be take as absolute and must be related to a reference measurement. The performance of the sensor is very sensitive to the adhesion of the electrode tape to the coating and the wetness of the coating.

The MIC sensor is capable of detecting the presence of biofilms especially those composed of SRB. Aeration, stagnant and low redox conditions did not influence the sensor response unless microorganisms were present. It looks the sensor is actually responding to bacterial attachment and growth in its surface.

A major cost reduction can be achieved by improving corrosion prevention and monitoring. Tailor made solutions and monitoring of corrosion on critical components will result in improved operational integrity, reduced costs (O &and M) and higher efficiency of offshore wind energy. The use of adequate sensors can help increasing asset integrity and reduce maintenance costs.

References

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2. - Microbiologically Influenced Corrosion (MIC) in Ship Tank Environments, A. Heyer, F. D'Souza, G. Ferrari, J.M.C. Mol and J.H.W. de Wit, M2I, 2008