

**ENDURES-RPT16081-E**

**Barrier properties of a new type of protective coating**

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# 1 Introduction

On request of Unicoatings International Marine B.V. laboratory measurements were carried out on barrier properties of a new type of protective coating.

Type of measurements is based on Electrochemical Impedance Spectroscopy (EIS). With this technique the sensitivity of organic coatings to ingress of water can be measured. Coatings that show good resistance to ingress of water are very likely to have good anticorrosive properties as well.

The measurements carried out in this project establish the initial properties of the coating. How the product behaves on the long run needs to be determined after longer exposure times. If necessary such measurements can be done in situ, so on coated objects that have been exposed in the field.

## 2 Materials and Methods

### 2.1 Coating

Unicoatings International Marine supplied Endures with two coated disks (diameter 23 cm). These aluminum disks were provided at both sides with different formulations of the product under investigation.

The sides of disk 1 were numbered side 1 and side 2 and the sides of disk 2 were numbered 3 and 4.

On request of Unicoatings the EIS measurements were carried out on sides 1, 2 and 4.

After completion of the EIS measurements both disks were mounted at a rack at the raft of Endures in the harbour of Den Helder for an exposure test to natural seawater. Figure 1 shows a picture of the disks when mounted on this rack, prior to immersion.

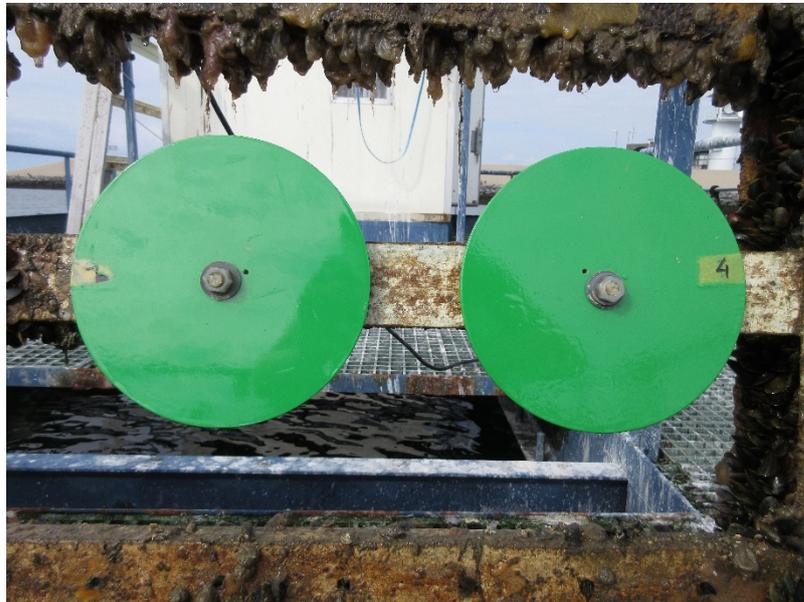


Figure 1. Overview of both disks when mounted at a rack of the Endures raft in the harbour of Den Helder after completion of the EIS measurements.

### 2.2 Barrier properties

Electrochemical Impedance Spectroscopy is done on defined surface areas of a coating exposed to artificial seawater as electrolyte. The coating is subjected to a DC potential and subsequent responses of the coating are measured by registering electrochemical processes between the metal substrate and electrolyte. From the measurement results the barrier properties of the coating can be derived.

The equipment used for the EIS-measurements consists of a CompactStat from Ivium Technologies and a laptop provided with Ivium Software. This equipment is suitable for measurements in the lab but can also be used for in-situ measurements, for instance in ship tanks or on pipelines.

The barrier properties of the Unicoatings product are measured on three different surfaces: sides 1 and 2 of disk 1 and side 4 of disk 2.

Whereas disk 1 had to be measured at both sides at the same time a dedicated test set up was made in which the disk was placed vertically and duplicate PVC elbow pipes were glued to each side of the disk.

In the elbow pipes perspex tubes were glued that were filled with artificial seawater (electrolyte) and in which the electrodes were exposed.

On disk 2 only side 4 was measured, this was done on the flat disk at the laboratory bench. Also this disk was provided with two perspex tubes (duplicate measurements) filled with artificial seawater.

On both disks EIS measurements were done in duplicate at day 0, day 1, day 7 and day 21. This measurement period of three weeks is sufficient to get good indication of the initial barrier properties of the coating under investigation.

In between the measurements the perspex tubes were covered with a rubber stopper to prevent evaporation of the electrolyte.

From the duplicate measurements average values were calculated and used in analysis of the results.

## 3 Results, conclusion and recommendation

### 3.1 Results

Two main parameters from EIS measurements are determinant for the barrier properties of protective coatings. These two parameters are:

- The  $R_c$  value, an indication for the resistance against ingress of water; a high value means good barrier properties.
- The  $Y_0$  value, related to the capacity of the coating. Normally, this value is increasing with age of the coating. The lower the speed of this, the better the coating will perform.

Figure 2 gives the measurement results for  $R_c$  values of the three coated surfaces and Figure 3 shows the results for  $Y_0$ .

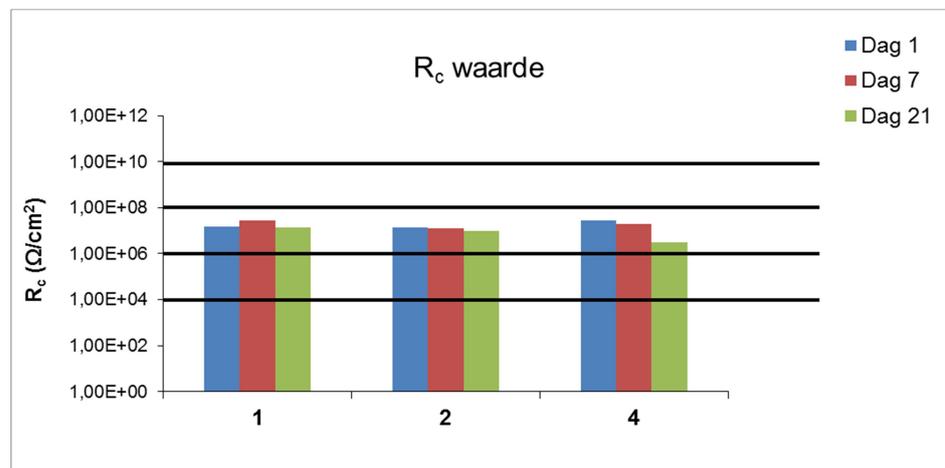


Figure 2.  $R_c$  values of 3 different samples of Unicoatings during a measurement period of 21 days. Samples 1 and 2 are front and back side of disk 1; sample 4 is back side of disk 2.

The initial resistance of all 3 coating samples is quite good with values around  $2 \times 10^7 \text{ Ohm/cm}^2$ .

Samples 1 en 2 remain stable at the same level as found on day 1. This indicates that samples 1 and 2 will have good barrier properties and may perform well as anticorrosive coatings.

For sample 4 the  $R_c$  value is slightly decreasing to approx.  $3 \times 10^6 \text{ Ohm/cm}^2$  after 21 days. This may indicate that this surface is slightly more susceptible to ingress of water.

From Figure 3 it is clear that on all three surfaces the value of  $Y_0$  is slightly increasing after day 1. As explained above an increase is what normally can be expected. The rate of increase is low, in comparison to a previous formulation of the Unicoatings product certainly a factor 10 lower.

For sample 4 the graph in Figure 3 does not show a faster increase of the  $Y_0$  value during 21 days in comparison to samples 1 and 2.

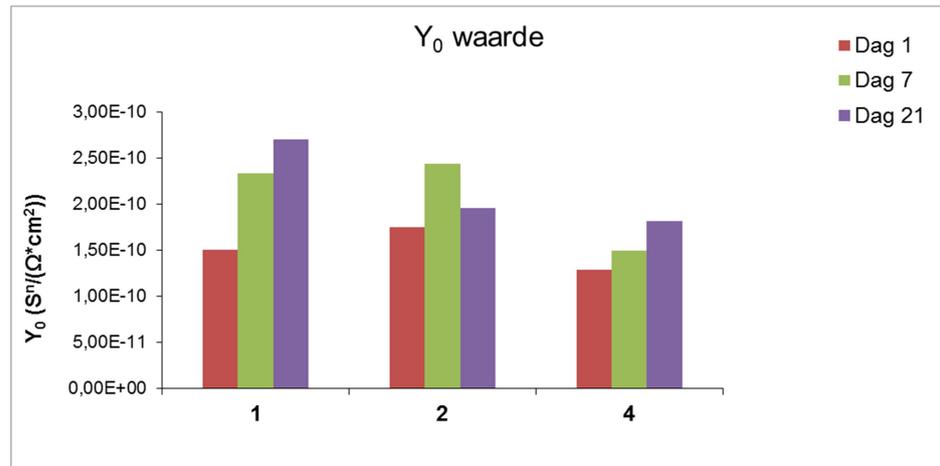


Figure 3.  $Y_0$  values of 3 different samples of Unicoatings during a measurement period of 21 days. Samples 1 and 2 are front and back side of disk 1; sample 4 is back side of disk 2.

### 3.2 Conclusion and recommendation

The coating product of Unicoatings as applied on sides 1, 2 and 4 of two different disks exhibits good initial barrier properties. Therefore it can be expected that this product may have good anticorrosive properties.

To sort out if the product can maintain good anticorrosive properties on the long run it is recommended to carry out repeated EIS measurements on coated disks or objects that have been exposed to various ageing regimes. Such measurements can also be done in situ, so on objects in the field.

## 4 Signature

Den Helder, October 21, 2016

ENDURES B.V.

A handwritten signature in blue ink, appearing to be 'S.J. Buter', with a long horizontal stroke extending to the right.

Mr. S.J. Buter  
Managing Director Endures B.V.

A handwritten signature in blue ink, appearing to be 'J.W. Klijnsstra', with a long horizontal stroke extending to the right.

Mr. J.W. Klijnsstra  
Author