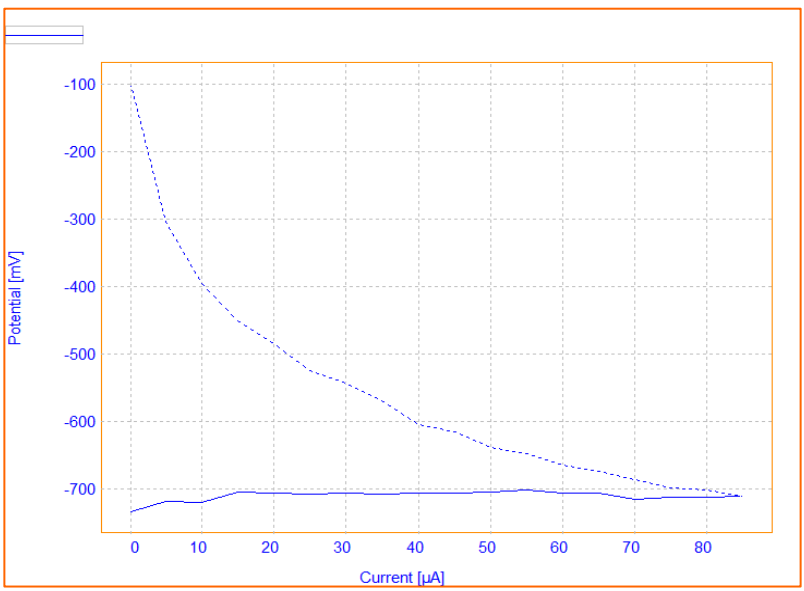
Application Note

Corrosion
AP-C03

Coupled Corrosion (Evans)



This Application Note describes how the Coupled Corrosion (Evans) method works by giving an example with Steel and Copper.

Introduction

Coupled corrosion refers to corrosion damage induced when two dissimilar materials are coupled in a corrosive electrolyte. It occurs when two (or more) dissimilar metals are brought into electrical contact under water. It could be also the same metal but under different conditions (Galvanic cell). When a galvanic couple forms, one of the metals in the couple becomes the anode and corrodes faster than it would all by itself, while the other becomes the cathode and corrodes slower than it would alone.

The driving force for corrosion is a potential difference between the different materials.
Thus, it's possible to "play" with the Galvanic Corrosion concept to protect from corrosion.
That's why, for instance a Zinc bloc is added to boats in order to avoid corrosion in the Iron (or Steel) hull.

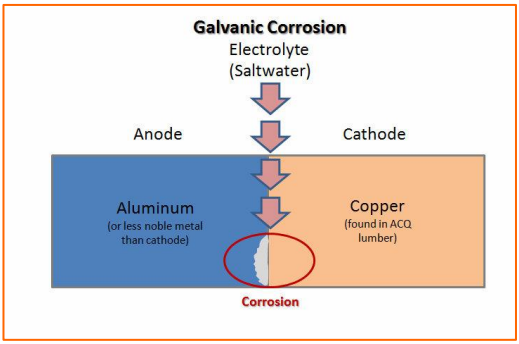


Figure 1: Scheme of Galvanic Corrosion concept

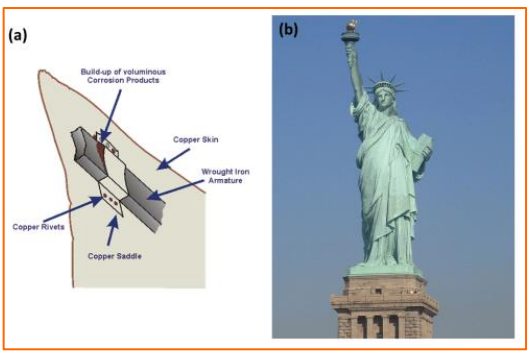


Figure 2: Example of the Statue of Liberty

EXAMPLE: Spectacular case of galvanic corrosion occurred in the Statue of Liberty (built in the 1880s), between the outer copper skin and the wrought iron support structure.
Anode = Iron.
Cathode = Copper.

HOW TO DETERMINE ANODE AND CATHODE

First of all, before starting any Coupled Corrosion experiment between two metals, it's mandatory to find out which one is the Anode or Cathode. In this example, we will use Steel and Copper.

METAL 1
Steel

METAL 2
Copper

1

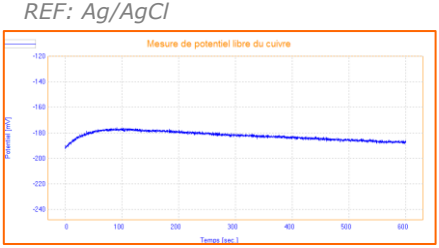
NOBLE METAL
Which one is a well-known noble metal? The less noble metal is the less corrosion resistant.

2

CORROSION POTENTIALS
Compare the two corrosion potentials. The lowest is the Anodic. The highest is the Cathodic. The Anodic index gives you some well know corrosion potentials. Another way is to perform an OCP experiment with the metal 1 and a 2nd OCP experiment with the metal 2.

1st OCP Test

WRK: Steel wire
AUX: Pt wire ⌀ 1mm
REF: Ag/AgCl



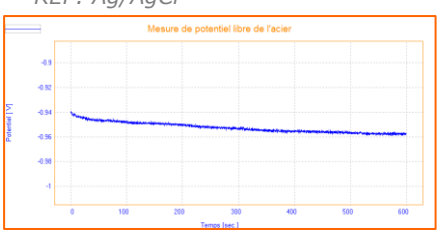
Potential = - 0.95 V

The lowest potential

ANODE

2nd OCP Test

WRK: Copper wire
AUX: Pt wire ⌀ 1mm
REF: Ag/AgCl



Potential = - 0.18 V

The highest potential

CATHODE

Experiment

As we know the Anode and Cathode, we can set the experiment as below:

- **Working electrode (WRK) = Anode = Steel**
- **Auxiliary electrode (AUX) = Cathode = Copper**
- **Reference electrode (REF) = Standard Reference = Ag/AgCl**

Parameters

The flow chart and parameters of the coupled corrosion are shown in figure 3.

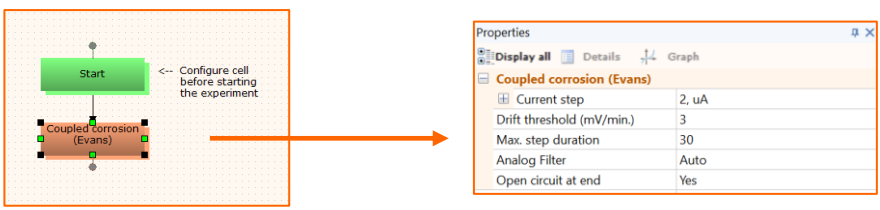


Figure 3: The parameters

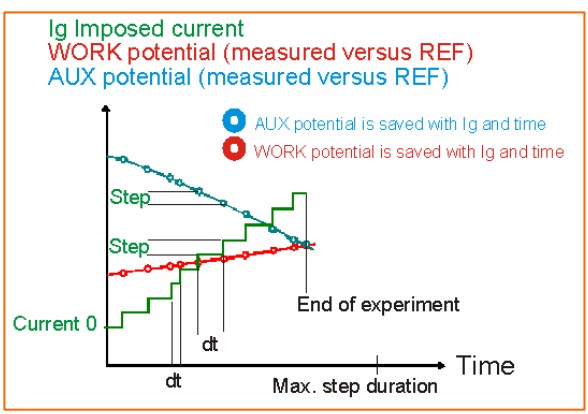


Figure 4: Scheme of the methode

PRINCIPLE

By applying a positive current ramp on the anodic metal, we record both potentials of Working (Anode) and Auxiliary metals (Cathode).
The current scan stops once the anodic and cathodic electrodes reach the same potential.

Results

Figure 5 shows the Evans plot of two metal samples. The electrochemical cell reaction is as below:

$$Fe(s) + Cu2+(aq) <=> Cu(s) + Fe2+(aq)$$

HOW TO GET EVANS PLOT

1

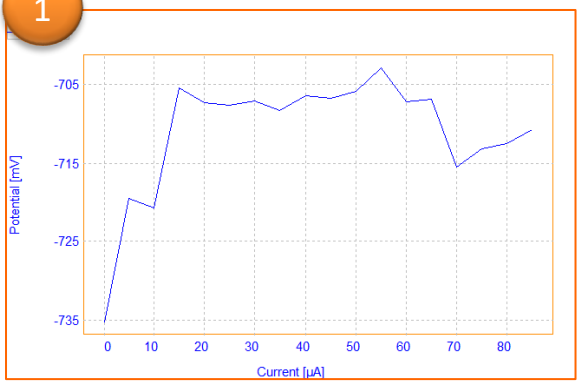


Figure 5: Raw data from Coupled Corrosion method

FIRST CURVE

The curve which is displayed at the end of the experiment is not EVANS plot. This is only the original curve with the raw data.

2

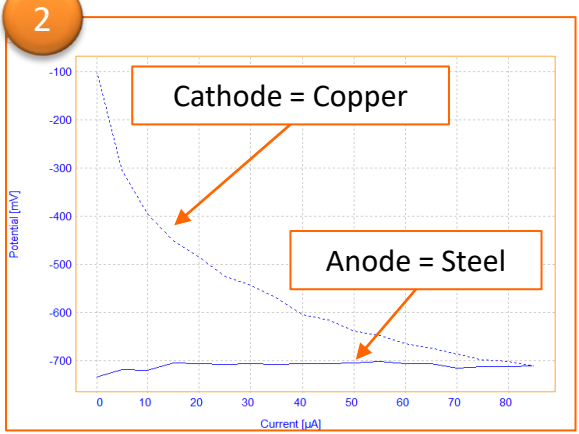


Figure 6: Evans curve

EVANS CURVE

To get the Evans type of curve, showing potentials of both Anodic and Cathodic electrodes (WRK and AUX), go to:

- Curve Tab
- Then in the "Type" box select EVANS

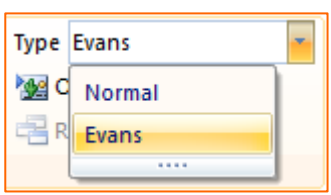


Figure 7: Selecting Type

TIPS: Many parameters can affect the shape of the curve: state of metal surface, metal purity, temperature and so on. Thus, your own curve can be a little different, but with a similar shape.

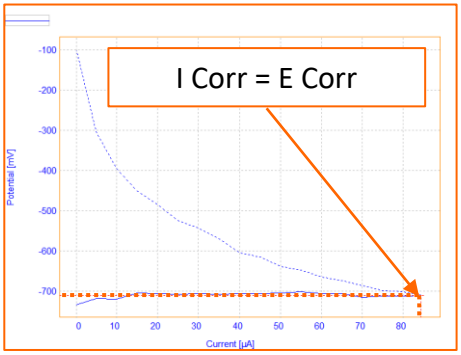


Figure 8: Evans plot

To obtain the common data of the Anodic and Cathodic electrodes, go to:

- Curve section
- Then, click on Evans plot (Corrosion)

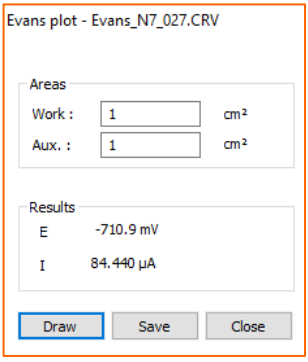


Figure 9: Data from Evans plot

The calculation is made under a surface of Working and Auxiliary electrodes.
By default, areas = 1 cm².

CONCLUSION: Coupled Corrosion or Galvanic Corrosion method can be used to test surface treatments, inhibitors or electrical insulators.
Thus, industrials can test different combination of materials for their application and find the optimized one.

Instrument and Electrodes

Figure 10: OrigaFlex OGF500

Electrode setup	
Reference Electrode (REF)	Ag/AgCl Type: OGR007
Counter Electrode (AUX)	Copper wire
Working Electrode (WRK)	Steel wire
Electrolyte	NaCl 0.7 M
Instrument	OrigaFlex OGF500
Software	OrigaMaster

OrigaLys ElectroChem SAS
Les Verchères 2
62A, avenue de l'Europe
69140 RILLIEUX-la-PAPE
FRANCE
☎ +33 (0)9 54 17 56 03
🖷 +33 (0)9 59 17 56 03
contact@origalys.com