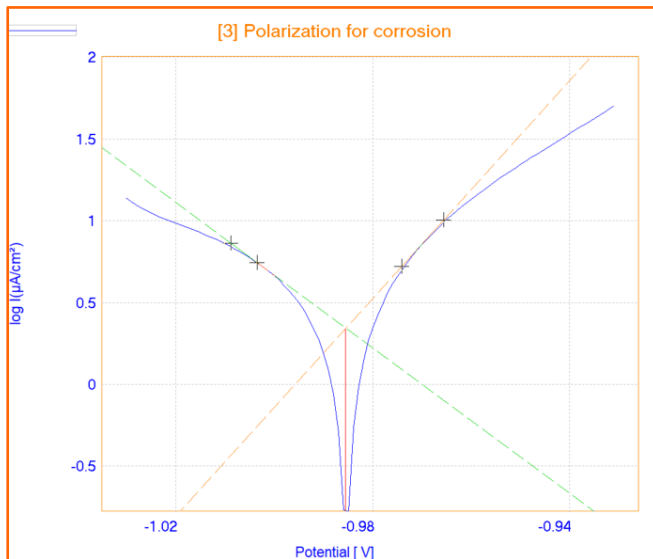


## Corrosion AP-C01



## Polarization For Corrosion (Tafel)



This Application Note describes how the Polarization for Corrosion (Tafel) method works by giving an example with Iron nail.



## Introduction

The field of corrosion measurement, control, and prevention covers varied spectrum of technical activities.

Within the sphere of corrosion control and prevention, there are technical options such as cathodic and anodic protection, materials selection, chemical dosing, chemical inhibitors and the application of internal and external coatings.



Electrochemical corrosion measurement employs a variety of techniques to determine how corrosive the environment is and at what rate metal loss is being experienced. It gives information about the corrosion mechanism and possibility to compare different metal alloys and inhibitors.

The Polarization for corrosion tests from OrigaMaster software is used to improve the signal to noise ratio of linear voltammetries at different scan rates. Such polarization curves can be processed under Tafel Analysis with confidence.

## Parameters

The Parameter of the Polarization test is shown in figure 1.

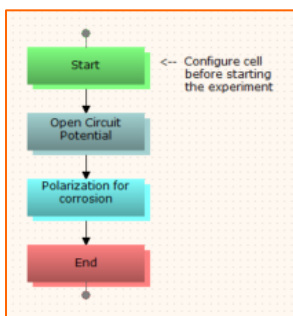


Figure 1: The sequence

Properties	
Display all Details Graph	
<b>Polarization for corrosion</b>	
Waiting time (sec.)	20
Stabilisation time (sec.)	4
Scan rate (mV/sec.)	0.1666
Initial potential (mV)	free
Potential 1 (mV)	-50, FREE
Potential 2 (mV)	50, FREE
Maximum range	Auto
Minimum range	Auto
Analog Filter	Auto
Open circuit at end	Yes

Figure 2: The parameters



The sequence consists of 2 methods:

**Method 1:** Open Circuit Potential (OCP)

Here it is defined as 30 minutes.

**Method 2:** Polarization for Corrosion.

Sweeping the potential. Sweep of potential is started at potential of Free after 20 second. Then it is continued to reach  $-50\text{mV}$  versus free (Potential 1) through  $0.16\text{mV/s}$  and then the test terminate on  $50\text{mV}$  (Potential 2) versus Free (OCP).

**TIPS:** Before start the polarization test, it is highly recommended to measure the OCP at least for 30 minutes let the metal arrives at stable potential.

## Results

Figure 3 shows the polarization curve of ionic nail immersed in salty solution. Figure 4 shows the scheme of the method, which is potential vs time.

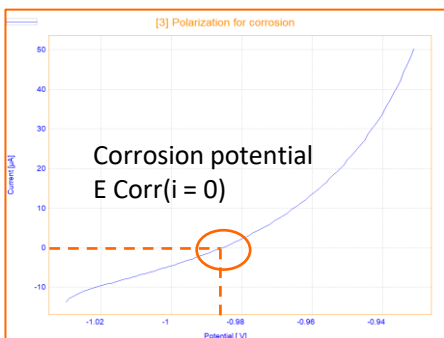


Figure 3: Polarization curve of Iron

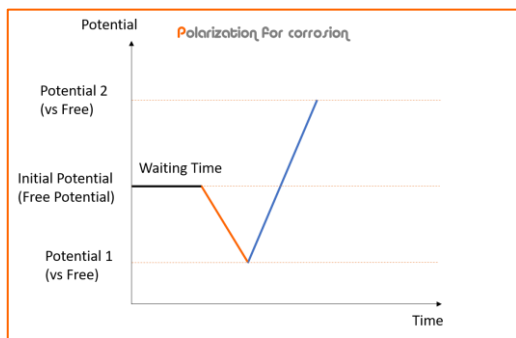


Figure 4: Scheme of the method

**NOTE:** In order to process with Tafel and calculate the corrosion values, the curve should go through zero current point (Current = 0 A). The Polarization for corrosion method is optimized to get the perfect curve and so the perfect Tafel. But, Tafel can be done from other curves made with other methods. It just requires to go through zero current point.



As it is shown in Figure 5, many data of corrosion are extracted through software by clicking on "Tafel method" bottom:

- **Corrosion Potential =  $E(i=0)$ :** The potential in which the corrosion start. This is a thermodynamic aspect of corrosion phenomena.
- **Resistance of Polarization =  $R_p$ :** It is equal to resistance of metal to be corroded.
- **Corrosion Current =  $i_{corr}$ :** The amount of current passed through the corrosion electrochemical cell. This is a kinetic aspect of corrosion phenomena.
- **Corrosion Rate:** The corrosion is expressed in loss of metal thickness per year, and its unit could be mm/year (mm/Y) or  $\mu\text{m}/\text{year}$  ( $\mu\text{m}/\text{Y}$ ).

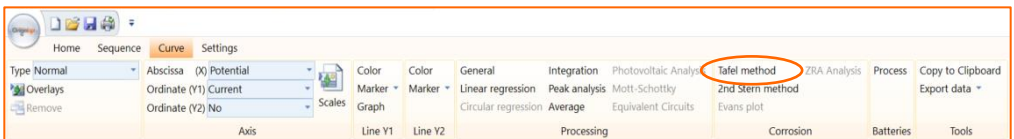


Figure 5: Corrosion analysis is accessible in « Tafel Method » bottom

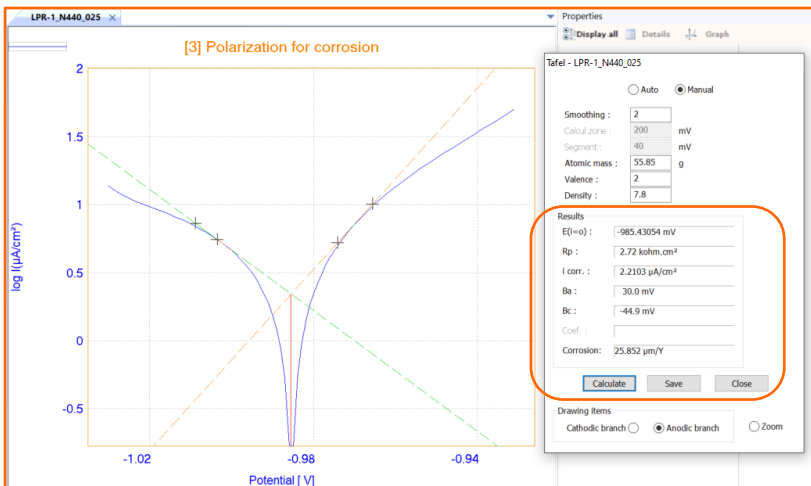


Figure 6: Thanks to user friendly software, corrosion data could be achieved easily

**NOTE:** Mils per year or MPY is used to give the corrosion rate in a pipe, a pipe system or other metallic surfaces. The expression MPY is mostly used in the United States.

1 mm = 39.37 mil



The Tafel method is based on the search for the Tafel lines on a  $\log(i) = f(E)$  voltammetric curve. This curve must have a potential for which the measured current is equal to zero. The intercept of the 2 Tafel lines (anodic and cathodic lines) extrapolated at the zero current potential gives a point the co-ordinates of which are the  $E(i = 0)$  corrosion potential and  $i_{corr}$ , corrosion current (Figure 7).

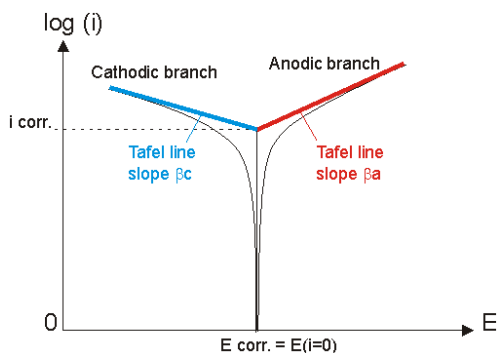


Figure 7: Data extracted through Tafel curve

## Tafel processing: Automatic or Manual

There are two methods of calculating the corrosion data through Tafel curve.

- **Auto:** the software calculate the corrosion parameters automatically. But it is important to define the correct calculation zone and segment.

### **Calcul. zone**

Enter, in mV, a potential interval within which the search for the Tafel parameters will be performed.

This interval lies on either side of the corrosion potential  $E(i=0)$  with the Calcul. zone as the interval amplitude. The Calcul. zone could not include less than 10 points of the voltammetric curve.

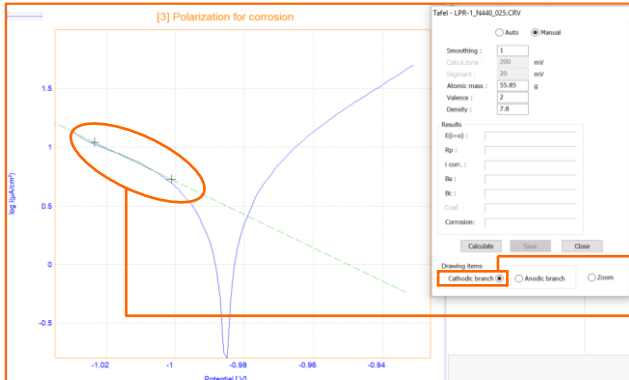
### **Segment**

Enter, in mV, the interval within which OrigaMaster will try to fit the curve to a line. This segment is moved all around the Calc. zone interval defined above. The Segment cannot include less than 5 points of the voltammetric curve.

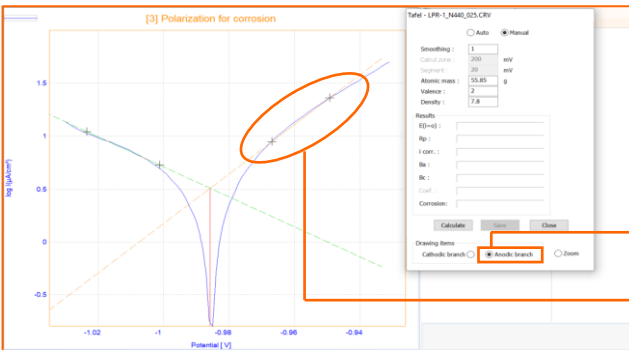


# Application Note

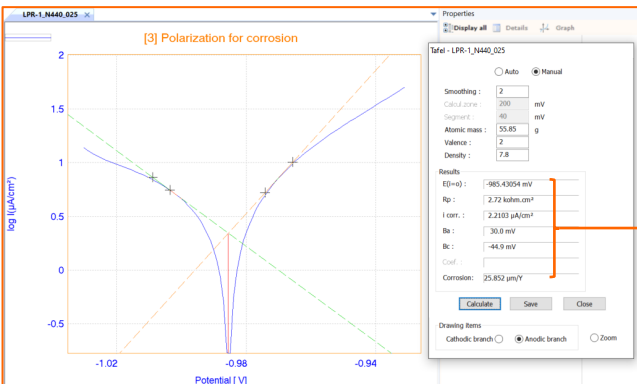
- **Manual:** In manual way, the user can manually choose the anodic and cathodic lines.



By selecting the "Cathodic Branch", the user can choose the cathodic calculation zone.



By selecting the "Anodic Branch", the user can choose the anodic calculation zone.



By clicking on the "Calculate" the corrosion data will be calculated.

Figure 8: How to manually get corrosion data



## Tafel curve: Horizontal or Vertical shape

It is possible for user to get the horizontal Tafel curve following these steps:

1. Change the axis: X axis as current and the Y1 axis as Potential.
2. Open the "General" window by clicking on "General" bottom.
3. Select the "log(|X|)" in Abscissa and click Ok.

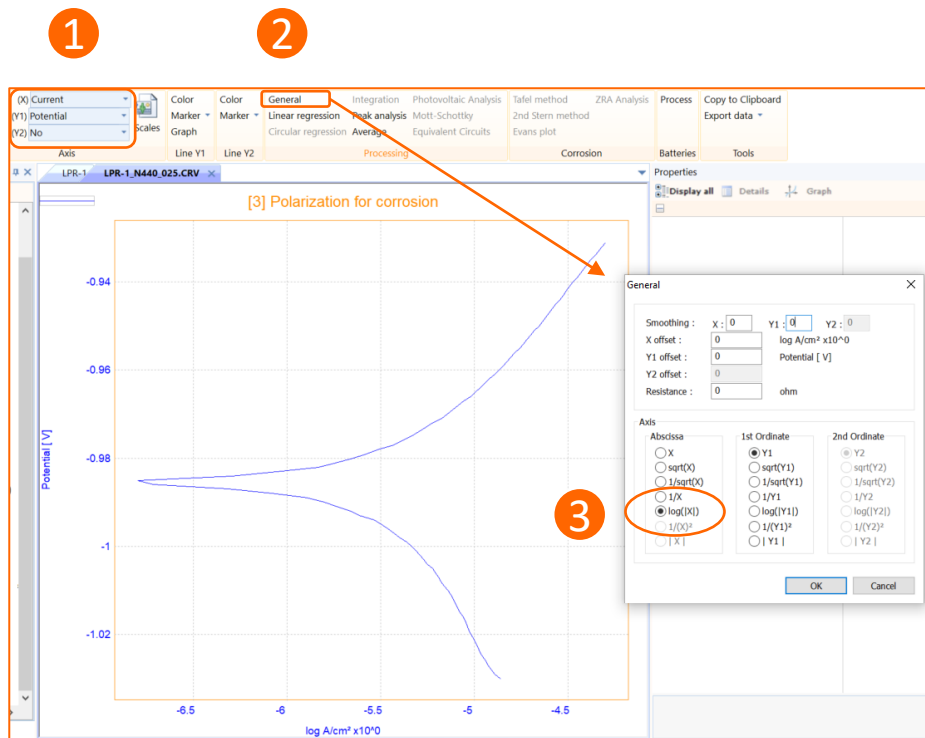


Figure 9: Horizontal Tafel curve

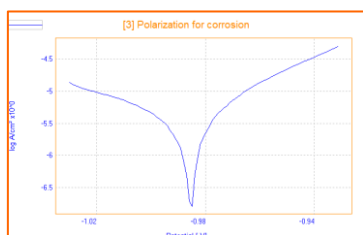


Figure 10: Vertical shape

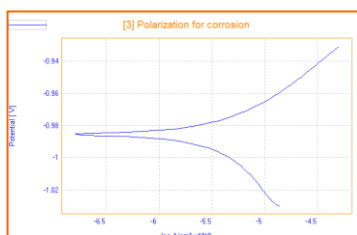


Figure 11: Horizontal shape



# Overlay

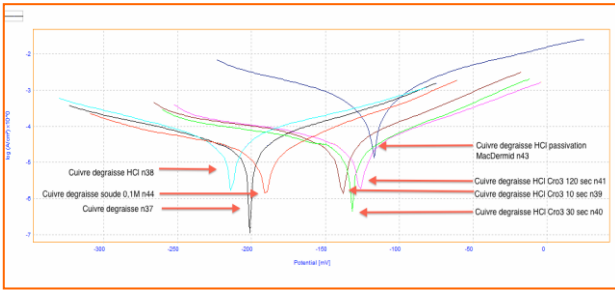


Figure 12: Overlay of 7 Tafel curves from CERN in Geneva

With the Overlay tool, comparing different Tafel curves from different metals or different coatings is ideal.

On the left, it's a coating analysis on Copper, made by the CERN, with the OrigaStat – OGS100.

# Instrument and Electrodes



Figure 13: OrigaFlex OGF500



Figure 14: Electrochemical cell

## Electrode setup

Reference Electrode (REF)	Calomel Type: OGR003
Counter Electrode (AUX)	Platinum wire Ø1mm Type: OGV005
Working Electrode (WRK)	Iron Nail
Electrolyte	NaCl 2M
Instrument	OrigaFlex OGF500
Software	OrigaMaster

**REF**  
Calomel



**AUX**  
Platinum wire Ø1 mm



**WRK**  
Iron Nail



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