## Application Area: Corrosion

# Critical Pitting Temperature (CPT) as per ASTM G150

**Keywords**

Autolab, ASTM, Corrosion, Critical Pitting Temperature, CPT, pX1000

**Summary**

This application note is based on the ASTM standard G150, developed to test the resistance of stainless steel, and other alloys related to stainless steel, on pitting formation at elevated temperature. This is achieved by determining the potential-independent critical pitting temperature (CPT), defined as the lowest temperature at which pitting evolution occurs. The CPT experiment consists of applying a potential to the specimen while the cell temperature is raised and recording the current.

**Experiment**

A Metrohm Autolab PGSTAT302N equipped with a pX1000 module was used to apply the potential and measure the current and temperature signals. A Metrohm Ag/AgCl 3 mol/L KCl reference electrode, inside a Lugging capillary, was used, together with a Metrohm Pt sheet as counter electrode and a Metrohm Pt1000 temperature sensor to measure the temperature of the cell. The electrolyte used in this study was an aqueous solution of 1 mol/L NaCl.

The specimen under investigation was a disk of stainless steel 430, with a diameter of 11 mm and 1 mm thick. The surface area exposed to the electrolyte was 1 $cm^2$. The disk was cleaned with isopropyl alcohol before insertion into the sample holder.

In this study, a 1 L Metrohm Autolab corrosion cell which meets the ASTM standard G5 was used. This jacketed corrosion cell has an inlet and an outlet for water or other heating/cooling liquids to control the temperature. The temperature of the cell was controlled via a Julabo HE-4 thermal bath.

Nitrogen gas was bubbled into the solution during the preparation and above the solution during the measurement, to remove oxygen dissolved inside the solution to prevent premature pitting formation. During the entire experiment, the solution was stirred using a magnet stirrer.

First, the solution was cooled to 6 °C, then the open circuit potential (OCP) was measured for 30 minutes. An overpotential of 100 mV above OCP was applied and the temperature was raised to 80 °C, with a rate of 1 °C/min. Based on ASTM G150, the applied potential must be 700 mV versus SCE (25 °C) in order to explore the potential independent CPT. This anodic potential needs to be applied for 60 ± 5 s before the temperature increase.

According to the ASTM G150, the CPT is defined as the temperature at which the current density exceeds 100 µA/$cm^2$ for one minute.

**Discussion**

In Figure 1, the current vs. time (blue line) and temperature vs. time (red line) curves are shown.

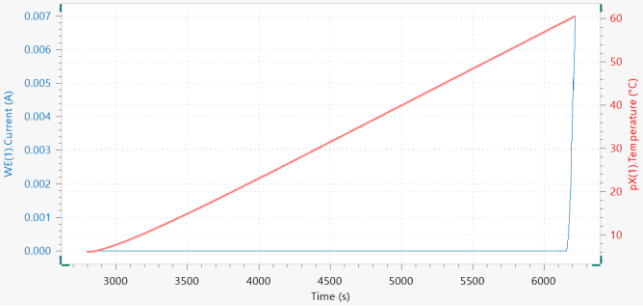


Figure 1 - Current vs. time (blue line) and temperature vs. time (red line) plots of CPT of stainless steel 430 in 1 mol/L NaCl aqueous solution.

The blue plot corresponds to the current and it clearly shows the current value is 0 A for about 1 hour. As soon as the temperature reaches the value of approximately 59 °C, the current suddenly increases from 0 A to values up to 7 mA. This value is much higher than the value of 100 µA/$cm^2$ set as a threshold for CPT measurement. Figure 2 shows the current versus the temperature for the CPT measurement. The Y-axis is zoomed in order to make the current before the CPT more visible. The value is 0 Amp until to 59 °C without any indication of any corrosion current.

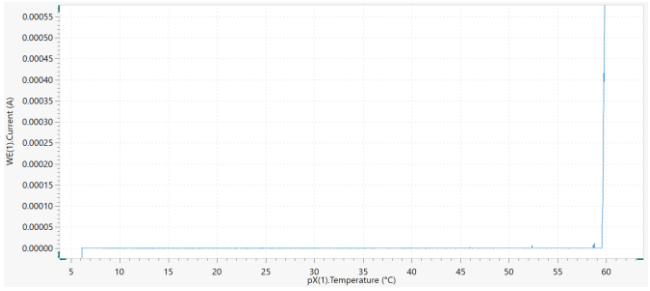


Figure 2 - The current vs. temperature plot extracted from Figure 1.

It should be stressed that in this experiment, current and current density have the same values, as the sample area was 1 $cm^2$.

The procedure has some modifications, with respect to the ASTM G150. According to the ASTM standard, the thermal profile should start from 0 °C with a rate of 1 °C/min. However, in our set up the lower temperature of the thermal bath was limited to 6 °C as it contained water.

Also, the ASTM standards suggests to polarize the specimen to 700 mV vs. saturated calomel electrode (SCE), corresponding to approx. 730 mV vs. Ag/AgCl 3 mol/L KCl. Pits were formed immediately at this high potential because of type of stainless steel used in this experiment. On the other hand, a potential of 100 mV vs OCP was enough to have a pit formation at elevated temperature.

## Conclusions

This application note shows how to perform an electrochemical pitting temperature experiment based on ASTM standards G150. A stainless steel 430 specimen was used, showing a CPT of approximately 59 °C, at 100 mV vs. OCP.

## References

[1] ASTM G150 – Standard test methods for electrochemical critical pitting temperature testing of stainless steel.

[2] ASTM G5 – Standard reference test method for making potentiodynamic anodic polarization measurements.

## Date

July 2018 AN-COR-006

## For more information

Additional information about this application note and the associated NOVA software procedure is available from your local **Metrohm distributor**. Additional instrument specification information can be found at **www.metrohm.com/en/products/electrochemistry**.