COMUNICAÇÃO TÉCNICA

**Nº 179853**

# Water tratment to prvent the internal corrosin in iron-ore slurry pipeline

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*Trabalho apresentado no RIO PIPELINE AND LOGISTICS, 2025, Rio de Janeiro. 9 p.*



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# Water treatment to prevent the internal corrosion in iron-ore slurry pipeline

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# Water treatment to prevent the internal corrosion in iron-ore slurry pipeline


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# Summary

- Overview - Slurry Pipeline Minas-Rio
  - Objective
    - Methodology
      - Electrochemical tests
        - Injection of $Na_2SO_3$
          - Immersion tests
            - Results
              - Conclusion

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# The Minas-Rio project

**Mine**

**Plant**

**Slurry Pipeline**

The Minas-Rio project is in the state of Minas Gerais. It is a fully integrated iron ore export operation consisting of a mine, a processing plant, a slurry pipeline, and a dedicated export facility at the Port of Açu in Rio de Janeiro.

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# Minas-Rio Slurry pipeline by numbers

**529** km of extension

**33** passing through cities

**100** million tons of iron ore in May 2021

**600** nearly ships loaded since 2014

# The challenge

## Water corrosivity control

- Water is injected into the pipeline to separate iron ore batches and to ensure continuous pumping

- Reservoir water has a typical pH of 7.7
- Dam water has a typical pH of 10.8

- Initial test results indicated both water sources must be treated before being injected into the pipeline to prevent corrosion problems

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# Objective

This work aims to indicate the most **cost- and time-effective** water treatment to prevent internal corrosion of an iron ore slurry pipeline

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# Methodology

Material:

- API 5L X70 pipe specimens (same as Minas-Rio pipeline)

Medium:

- Reservoir water - conductivity of 25.4 µS/cm
- Dam water - conductivity of 608 µS/cm

Water treatment options:

- pH adjustment only
- sodium sulfite ($Na_2SO_3$) as an oxygen scavenger, followed by pH adjustment

# Methodology

## Strategies

Linear polarization measurements (±10 mV vs. OCP), according to ASTM G102,
for magnitude of corrosion rate

Anodic potentiodynamic polarizations
for identification of
the corrosion processes

# Methodology

## Strategies

Dynamic immersion tests were performed for 30 days

Three specimens were positioned in the loop each test

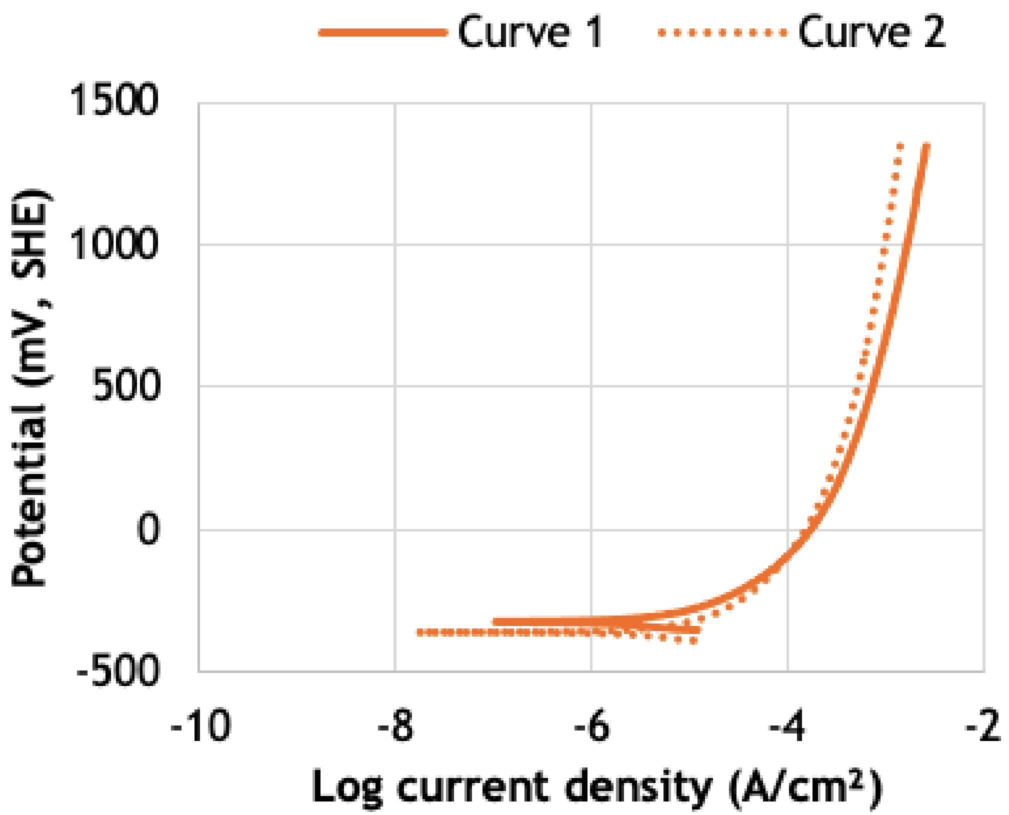
To obtain more representative corrosion rate

# Results and discussion

## First step - tests without $Na_2SO_3$

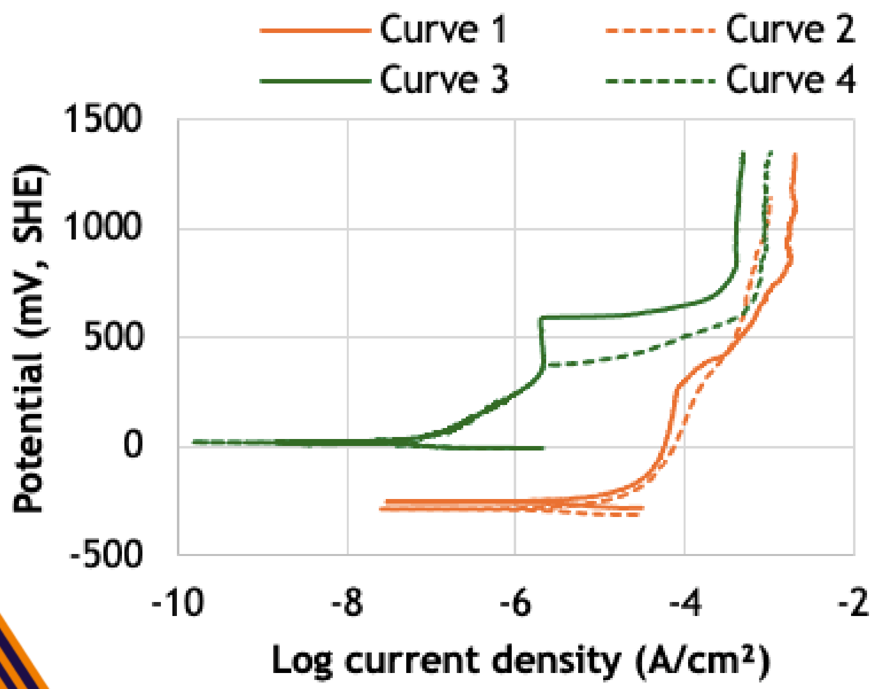
# Anodic polarization curves

## Reservoir water – pH 7.7

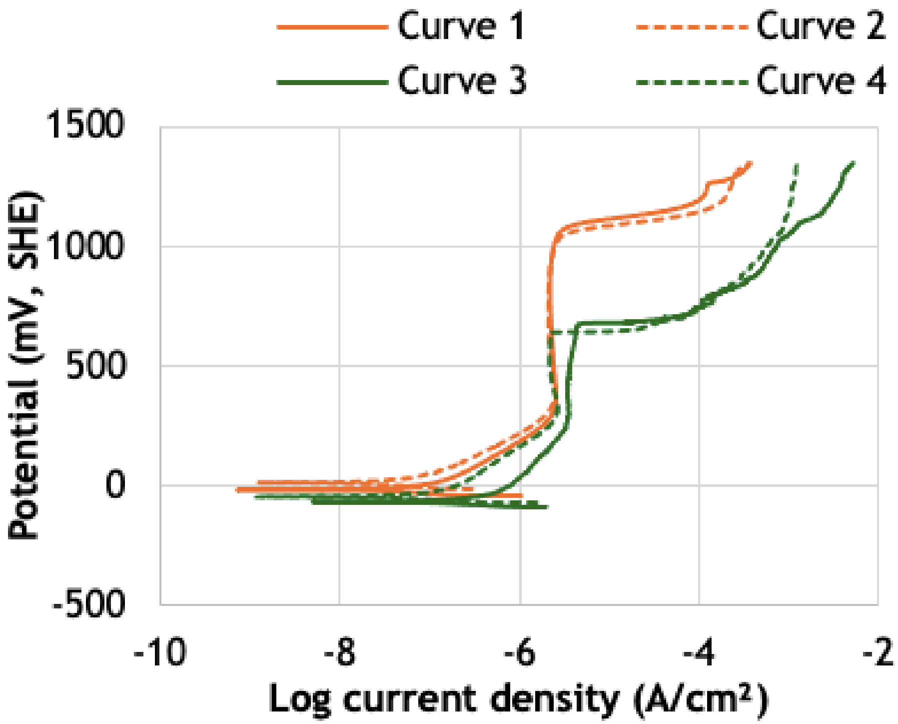



Reservoir water at the original pH (all tests without $Na_2SO_3$). The reservoir water promoted active corrosion on the steel surface, as expected because of the low pH.

# Reservoir water – pH 11.0 and 11.5



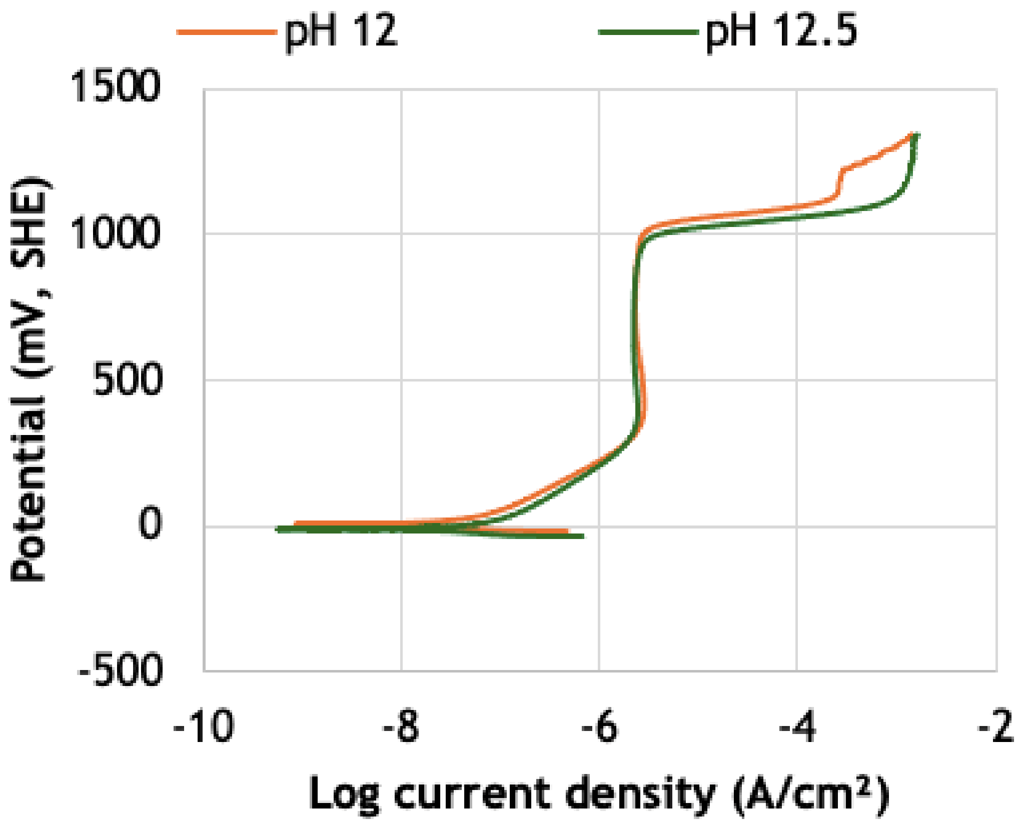

Reservoir pH = 11.0




Reservoir pH = 11.5

All tests without $Na_2SO_3$. At pH 11, both active corrosion and surface passivation were noted; at pH 11.5, surface passivation was noted, and the breakdown of the passive layer at potentials above (curves 1 and 2) and below (curves 3 and 4) 1000 mV vs. SHE.

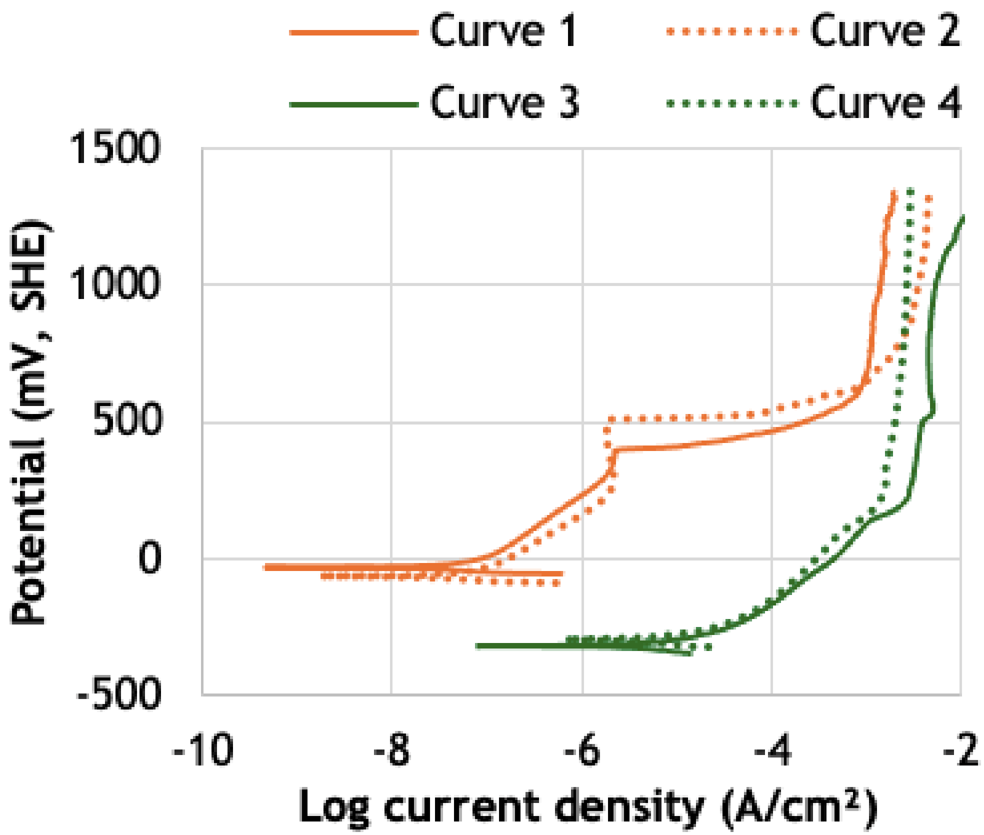
# Reservoir water – pH 12.0 and 12.5




All tests without $Na_2SO_3$. The polarization curves were reproducible, and the tests showed surface passivation with the breakdown of the passive layer above 1000 mV vs. SHE for all conditions.

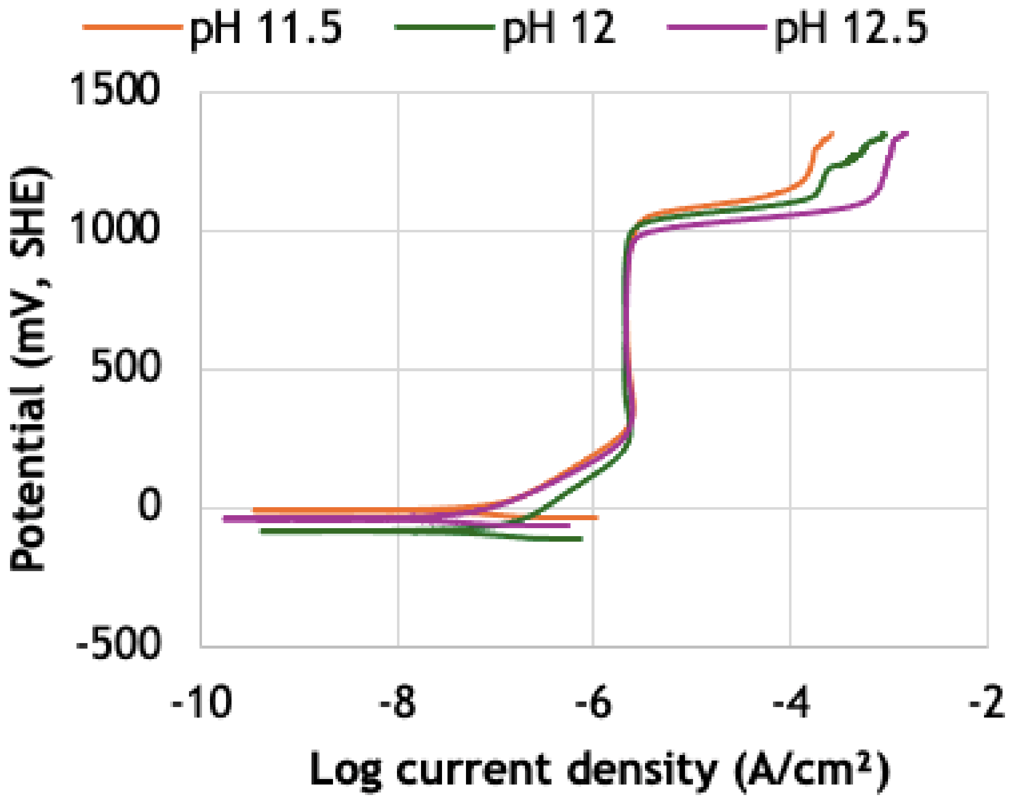
# Anodic polarization curves

## Dam water – pH 10.8




Dam water at the original pH (all tests without $Na_2SO_3$). The dam water presented two behaviors: active corrosion and passivation. The breakdown of the passive layer was between 300 mV vs. SHE and 500 mV vs. SHE.

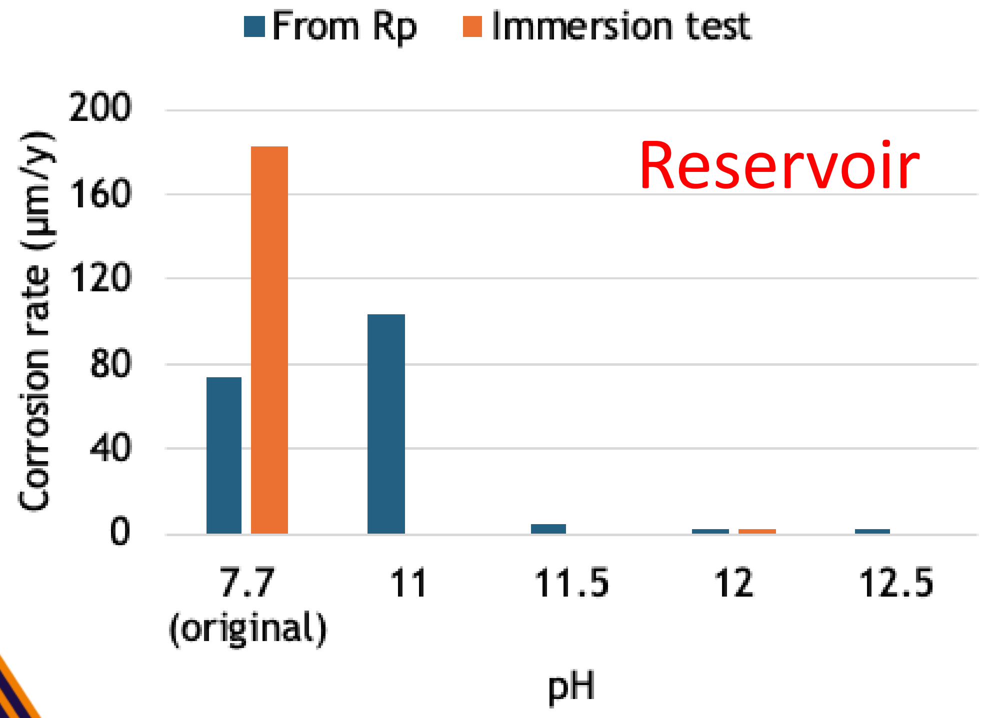
# Dam water – pH 11.5, 12.0 and 12.5

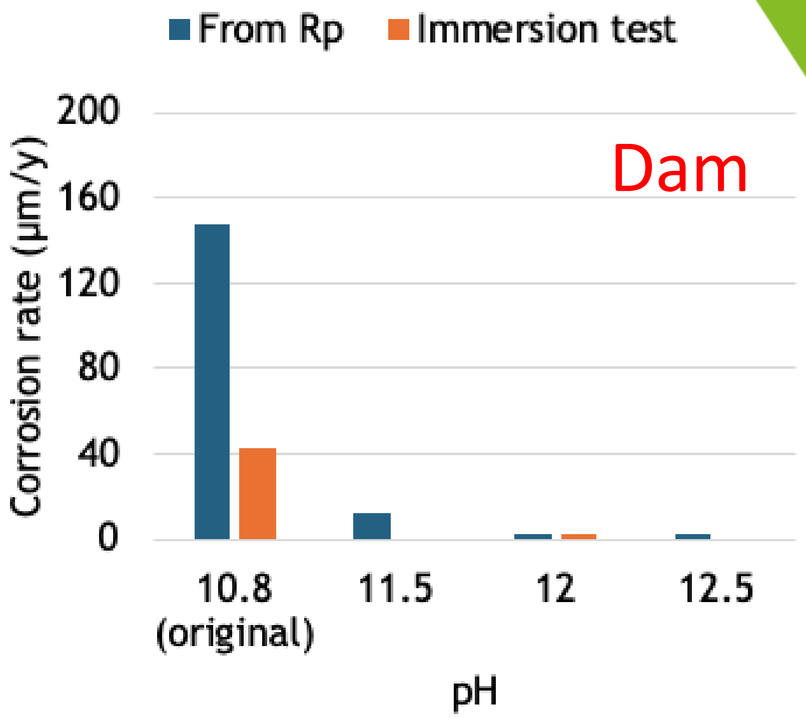



All tests without $Na_2SO_3$. The polarization curves were reproducible, and the tests showed surface passivation with the breakdown of the passive layer above 1000 mV vs. SHE for all conditions.

# Corrosion rate

## Rp and dynamic immersion tests



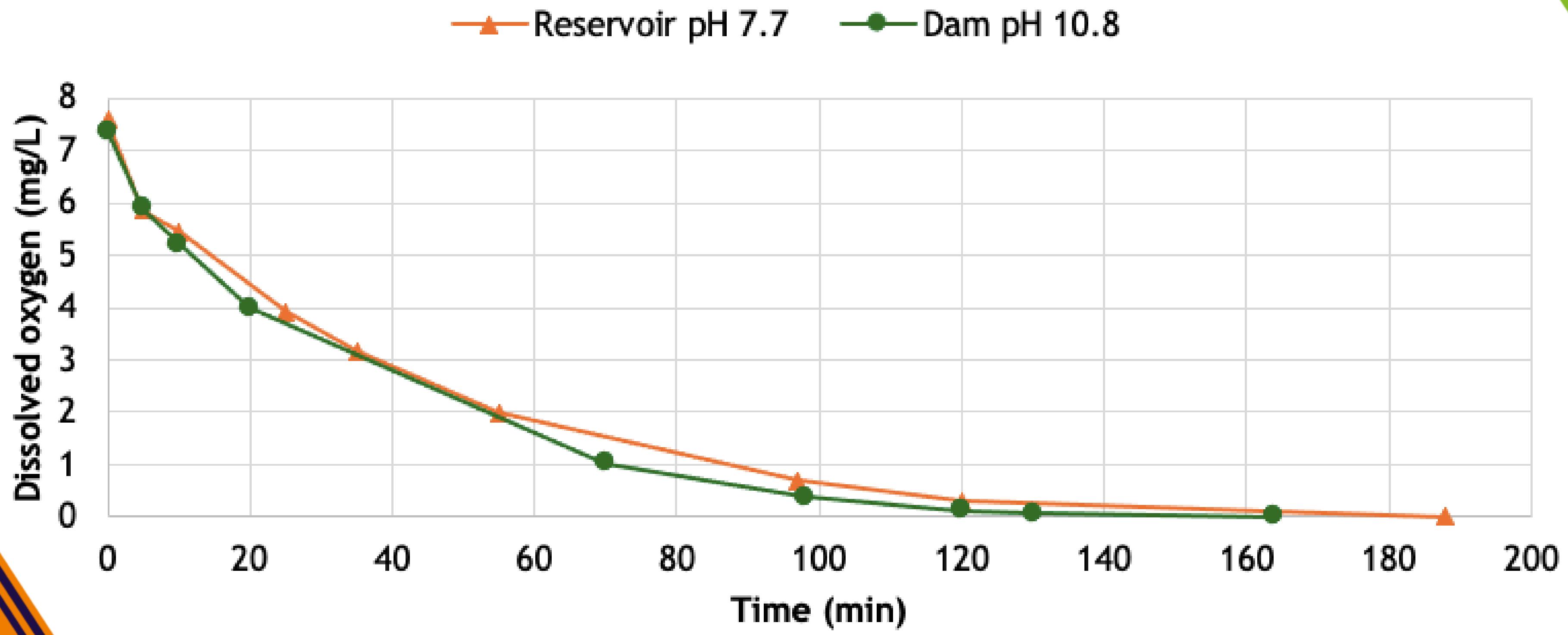

All tests without $Na_2SO_3$. The Rp corrosion rates yielded consistent results concerning the polarization curves. The dynamic immersion tests were performed at the original pH of both water sources and an adjusted pH of 12.

# Results and discussion

## Second step - tests with $Na_2SO_3$

# Oxygen scavenger test

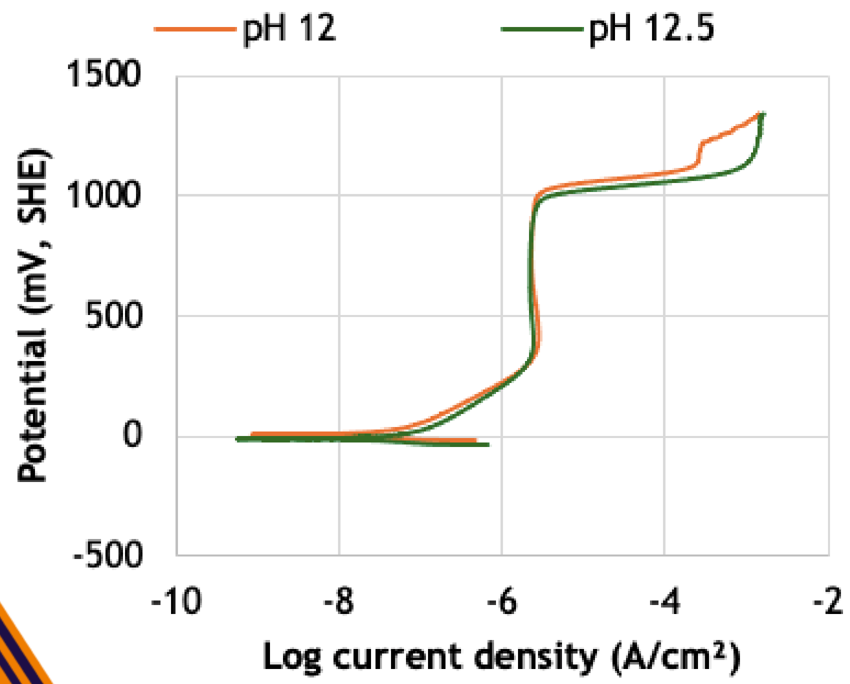
## Time required for $O_2$ = 0 after adding $Na_2SO_3$



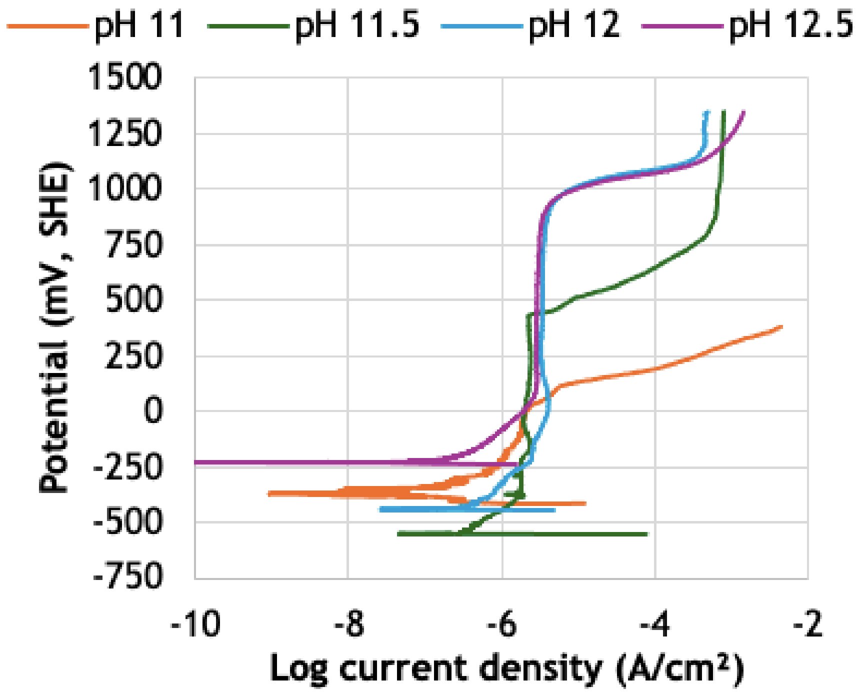

It can be observed that more than 2.5 h are required to reach this goal.

# Anodic polarization curves

## Reservoir water




without $Na_2SO_3$

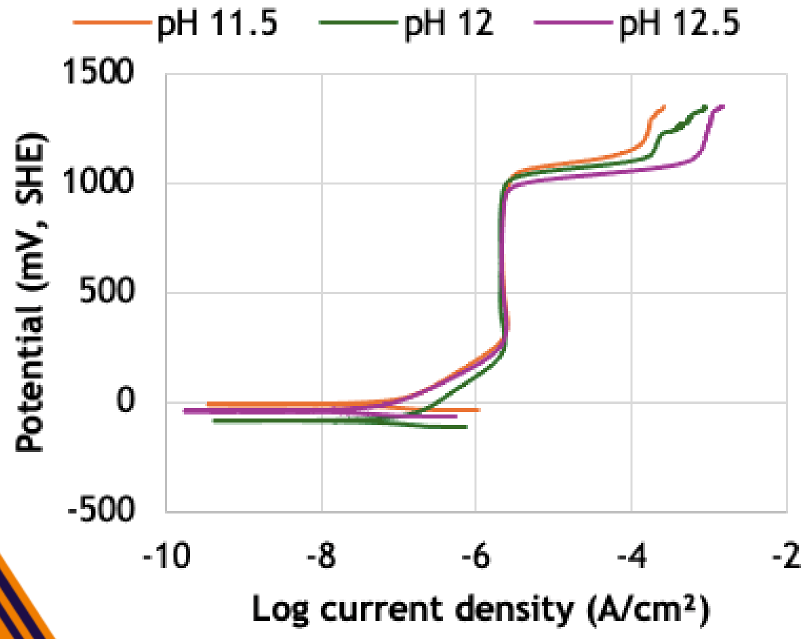



with $Na_2SO_3$

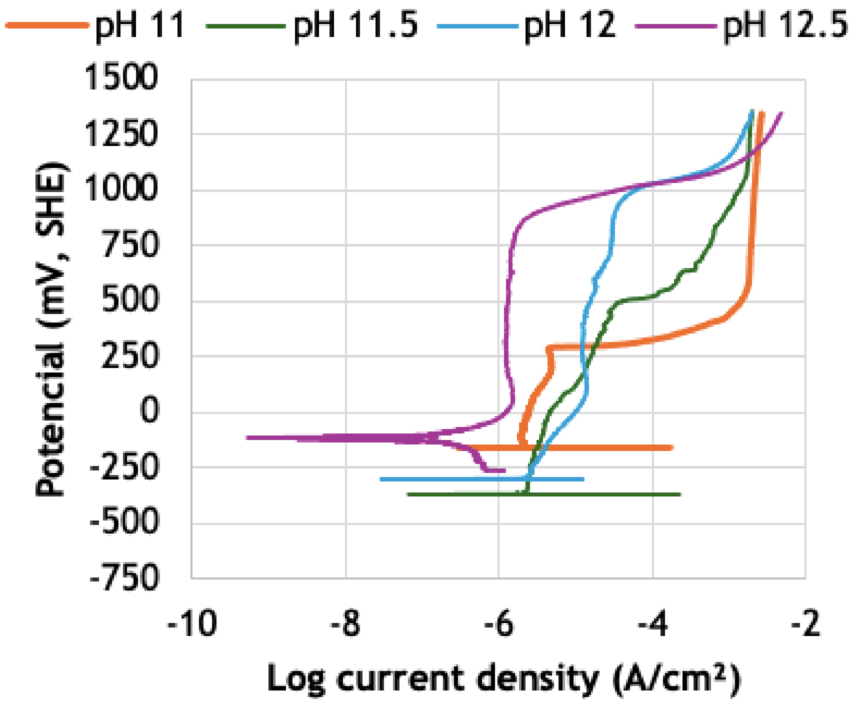
Adding $Na_2SO_3$ did not significantly change the behavior of the anodic polarization curves compared to the reservoir water without $Na_2SO_3$.

# Anodic polarization curves

## Dam water




without $Na_2SO_3$

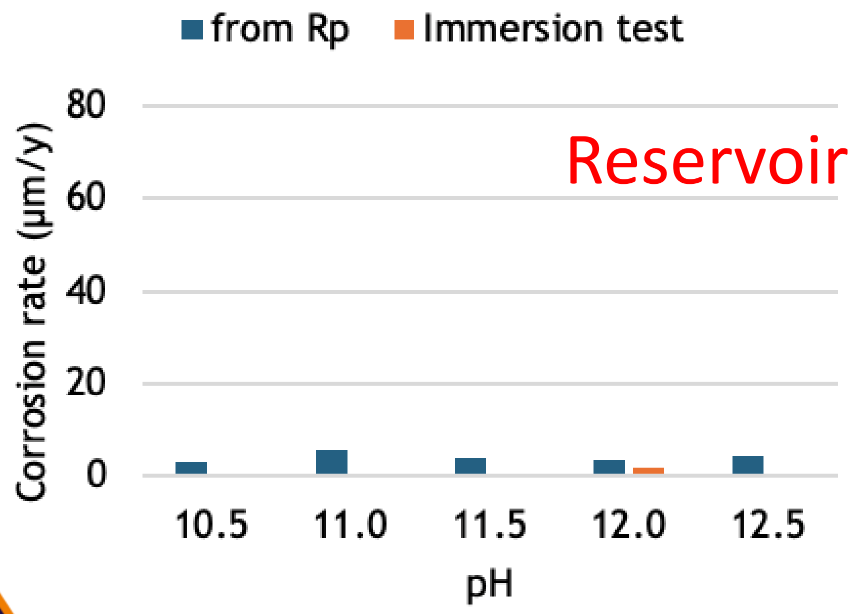


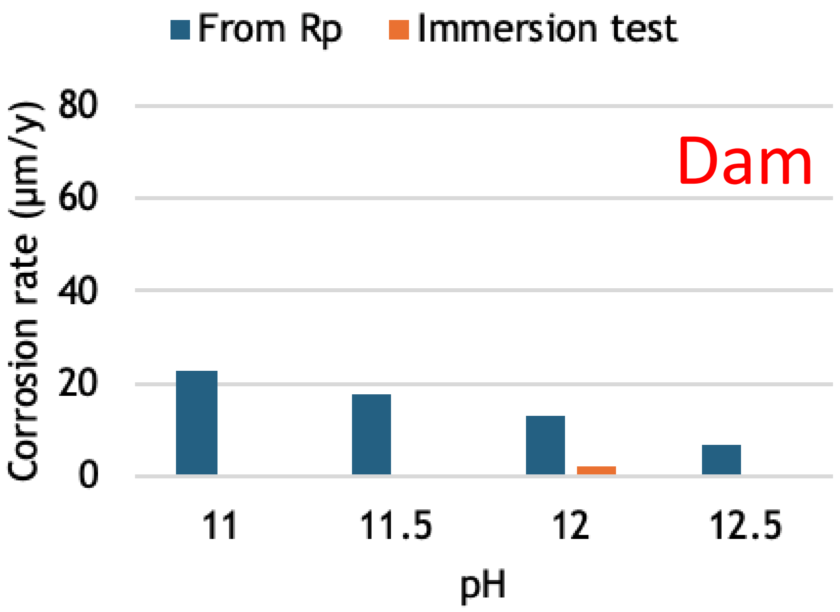

with $Na_2SO_3$

For the the dam water, except for pH 12.5, $Na_2SO_3$ impairs the performance of the protective layer for pH 11, 11.5, and 12.

# Corrosion rate – with $Na_2SO_3$

## Rp and dynamic immersion tests




The Rp corrosion rates yielded consistent results concerning the polarization curves. The dynamic immersion tests were performed at pH 12 and were consistent in the order of magnitude of the corrosion rate.

# Conclusions

- pH treatment can protect the steel pipelines for values equal to or above 12.0
  - - There is a tendency for steel to passivate at pH values between 11.0 and 11.5, but the breakdown of the passivation layer occurs at low potential values

- $Na_2SO_3$ treatment is limited by the time required for its effective action. In the field, waiting 3 hours for deaeration is impossible.

- The results leads to the conclusion that pH control alone is the best cost-effective treatment.

- However, when it is impossible to adjust the pH above 12, using $Na_2SO_3$ can be advantageous as it promotes the passivation of the steel surface.

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# Thanks for your attention!


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