In situ electrochemical characterization of corrosion in the Ghent-Terneuzen canal

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Upon discovery of extensive microbiologically induced corrosion on the hull of a yacht in the marina of Zelzate in 2021, extensive surveys of corrosion patterns were conducted along the neighbouring Ghent-Terneuzen Canal. However, while uniform corrosion is easily monitored with (albeit time-consuming) mass loss measurements on steel coupons, or even in real time with electrochemical sensors, pitting corrosion is hard to address *in situ*.

Due to the complexities of measuring these corrosion forms in field conditions, four electrochemical tests were employed to characterize and assess their feasibility: Linear Polarization Resistance (LPR), Linear Polarization Curve (LPC), Cyclic Polarization Curve (CPC), and Critical Pitting Temperature (CPT). To this end, a floating setup with three electrodes was created, hooked up to a Palmsens 4 potentiostat (Palmsens, the Netherlands). The tests were conducted on two steel grades, S235 and 316L, which were exposed to canal water across different immersion times (one day, one week and one month) and on three locations (near Ghent in the south, in Zelzate and in Terneuzen, near the lock towards the Scheldt).

Analysis of the results highlights the performance and limitations of each method, revealing significant differences in corrosion patterns within a single water mass. LPR revealed that corrosion is highest in Zelzate and Terneuzen, and lowest in Ghent. probably due to differences in salinity. The method also indicated the formation and breakdown of a passivation layer, which was confirmed by the LPC test.

CPC showed that the passivation layer of 316L steel effectively develops over time, especially in Zelzate, and to a lesser degree in Ghent and Terneuzen. E_{rep} values were consistently higher in Ghent, indicating a faster reformation of the passivation layer, probably due to the lower salt concentration. The critical pit potential increased with exposure time, and was highest in Ghent, indicating a stronger resistance to pitting corrosion. CPT followed a salt gradient as well, with Ghent having the highest CPT values, and Terneuzen the lowest, indicating a lower resistance to pitting corrosion.

These results may also have been influenced by microbial activities, as shown, for example, in Zelzate, where samples initially corroded rather fast, but where corrosion slowed down due to the build-up of a biofilm. As such, this research contributes to a deeper understanding of corrosion dynamics in the Ghent-Terneuzen Canal, emphasizing a larger need for targeted monitoring and mitigation strategies.

Keywords
Corrosion; Electrochemistry; In Situ Measurements; Maritime Innovation