

# Automated Corrosion Monitoring and Mitigation Framework for Steel Alloys in Deepwater Drilling Environments

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## Objective

To develop an automated system that monitors and mitigates corrosion in deepwater steel risers using real-time feedback to maintain safe protection and prevent hydrogen-induced cracking.

## Problem Statement

Sacrificial anodes protect deepwater risers passively with no real-time feedback, no ability to adapt to changing conditions, and no warning when protection fails, making corrosion damage undetectable until the riser is physically retrieved.

## Constrains & Specifications

### Constrains

- C1** Max potential -1150 mV (Prevent HIC)
- C2** Zero hazardous/corrosive emissions
- C3** Fully Removable mount
- C4**  $\geq 1000$  Vrms electrical isolation
- C5** API RP 16Q compliant

### Specifications

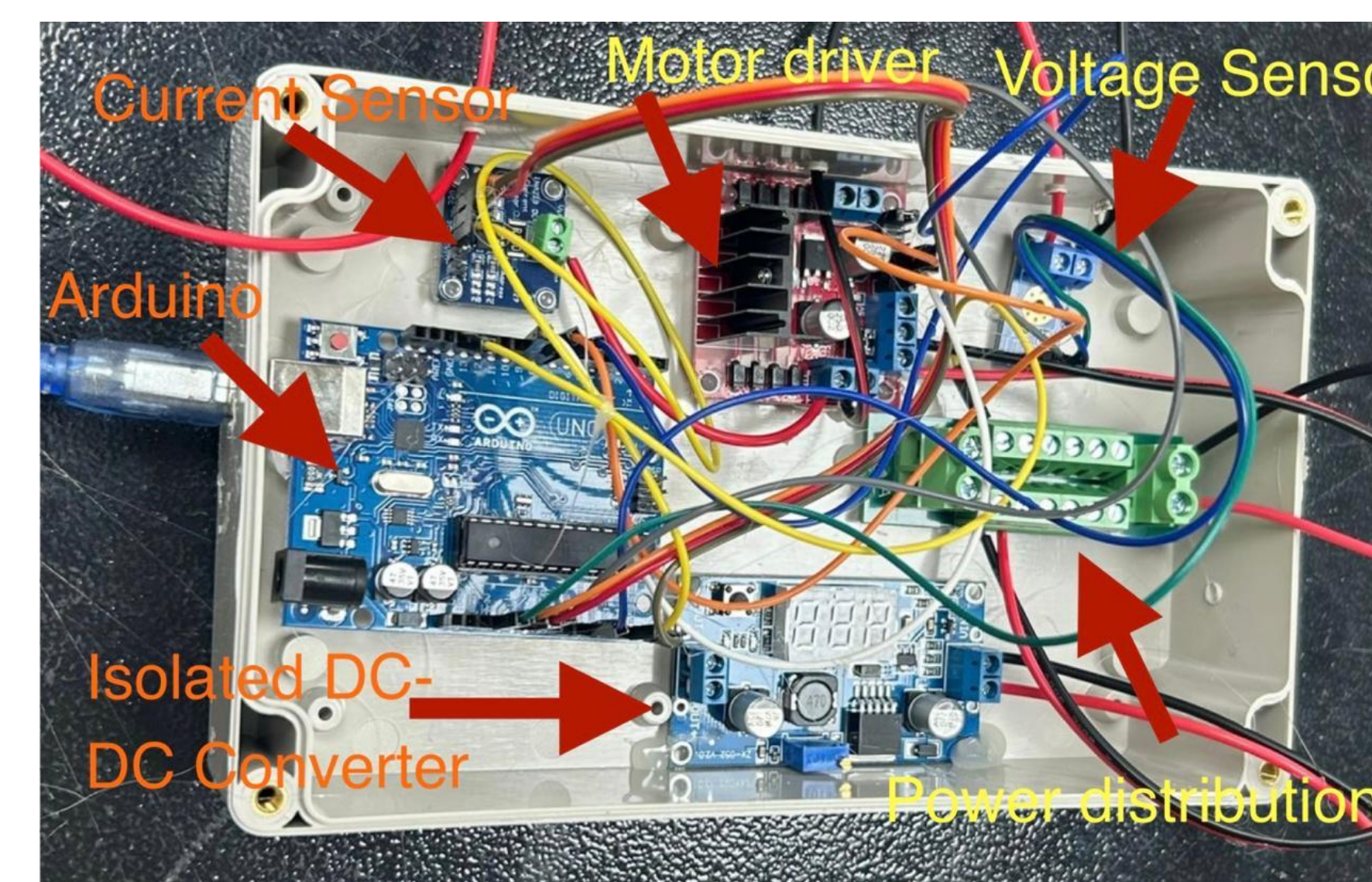
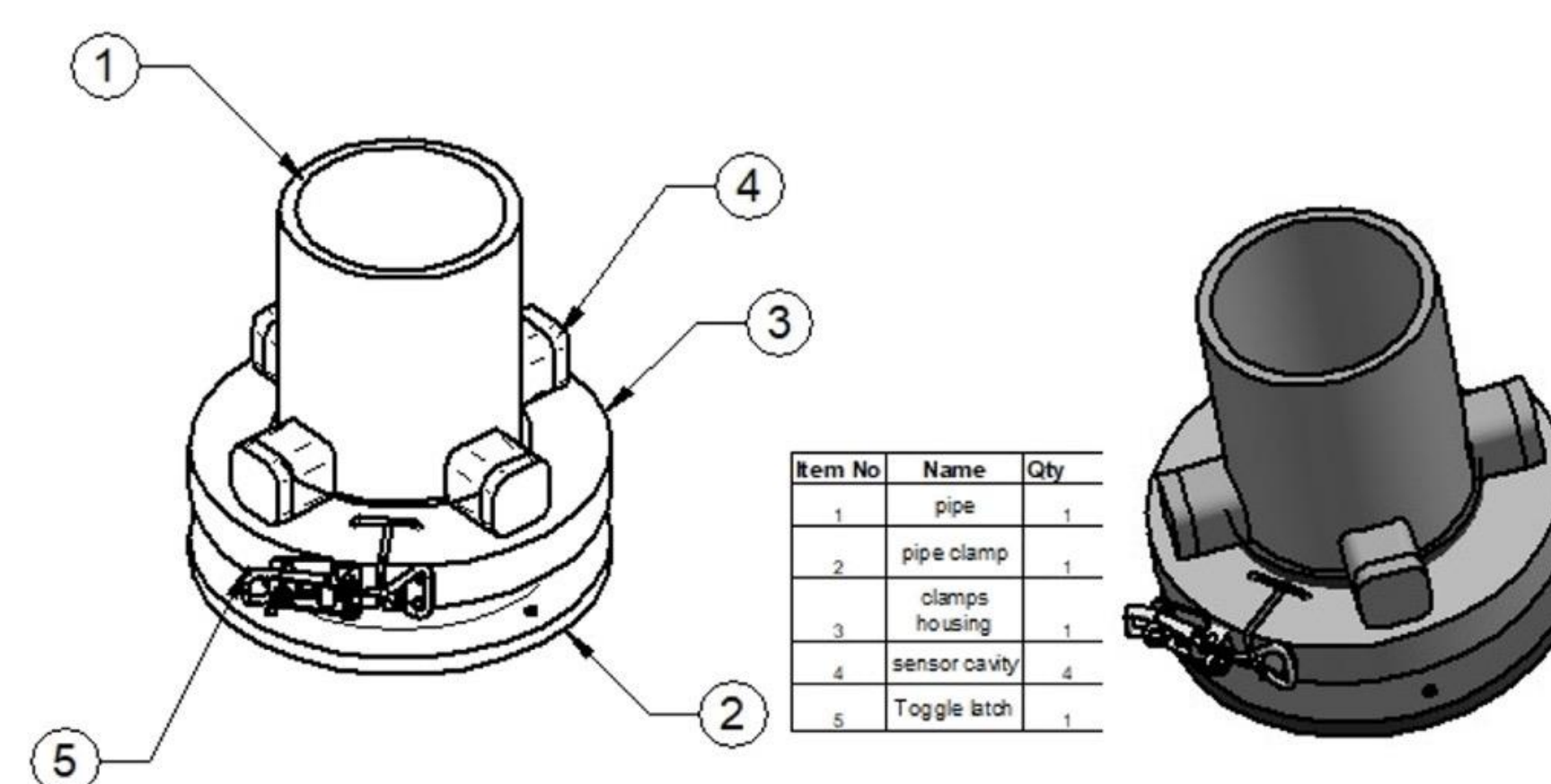
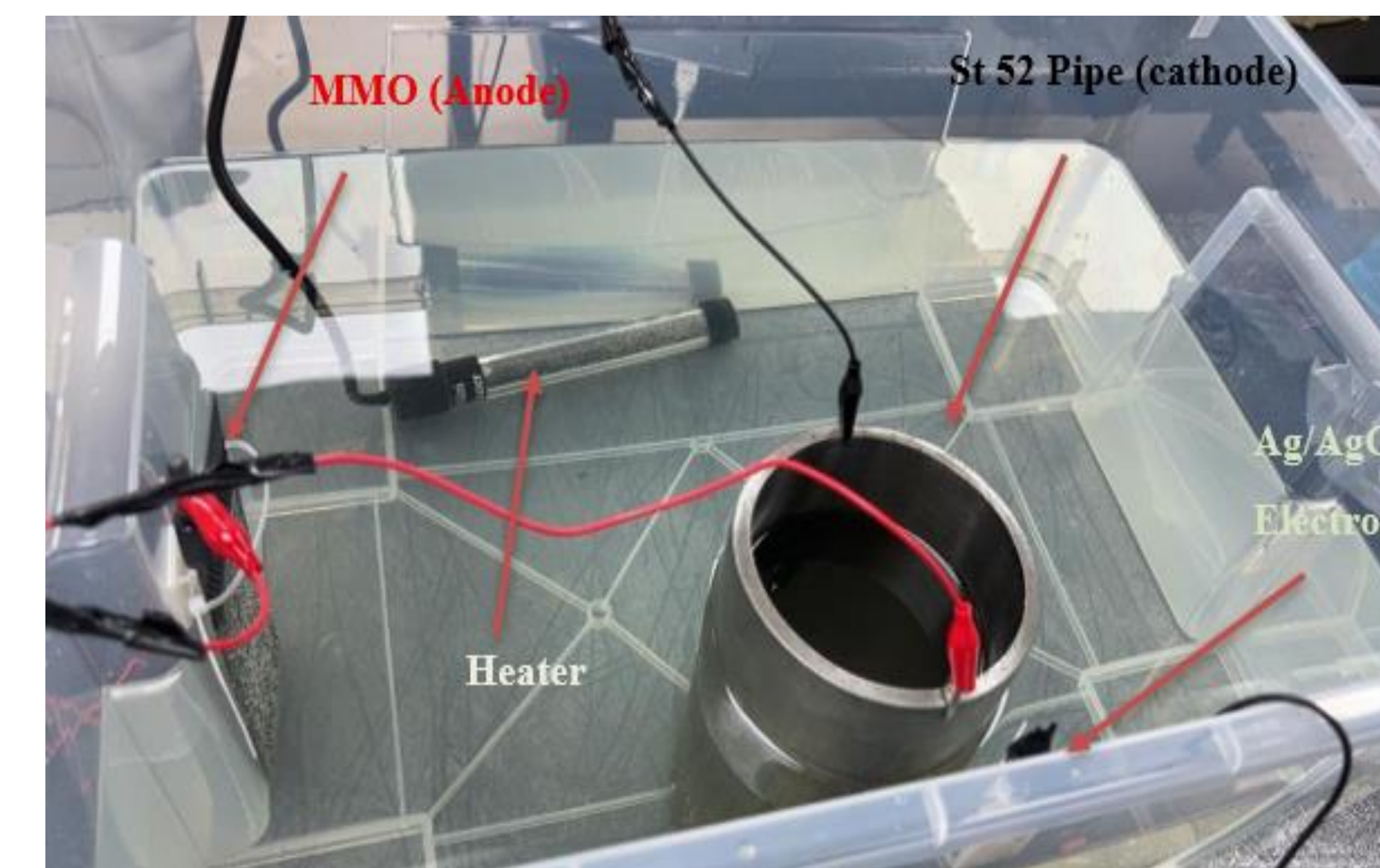
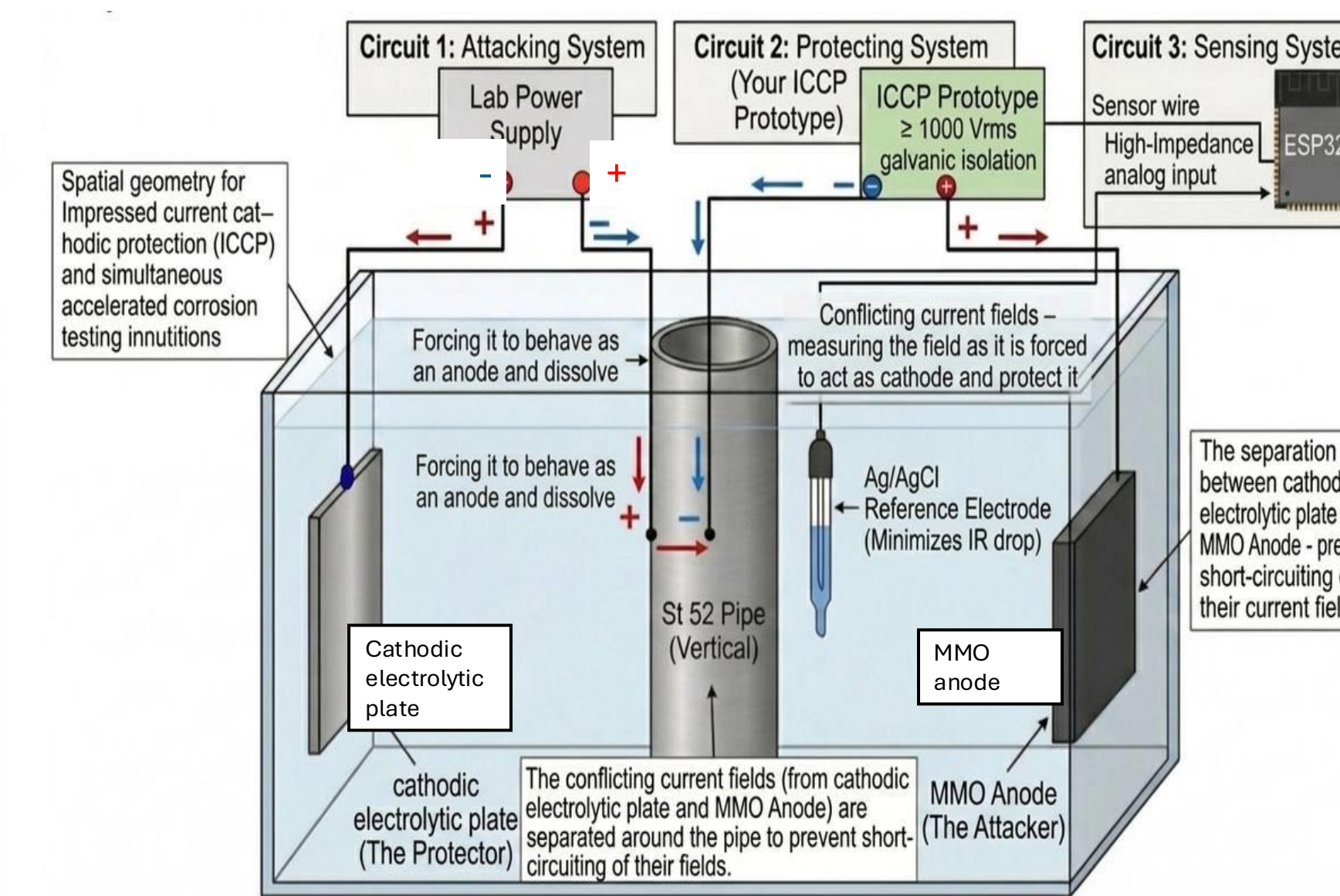
- S1** UT precision  $\pm 0.1$  mm
- S2** Zero cracking/HIC (CT verified)
- S3** Clamp axial load  $\geq 2$  kN (No slip)
- S4** Drag increase  $\leq 20\%$
- S5** Salinity 3–5 wt% ( $\pm 0.2\%$ )
- S6** pH 7.5–8.5 ( $\pm 0.1$  drift/4h)
- S7** Potential measured every 1s
- S8**  $\geq 12$ -bit control resolution
- S9** 100% sensor coverage
- S10** Detects wall loss  $\geq 1.2$  mm
- S11** Temp 25–35 °C ( $\pm 2$  °C)

### Integrated Specifications

- IS1** PID ICCP auto-maintains -800 to -1150 mV
- IS2** H<sub>2</sub> Veto  $> -1100$  mV; Corrosive-proof housing
- IS3** Real-time UT vs post-test CT (ASTM seawater)

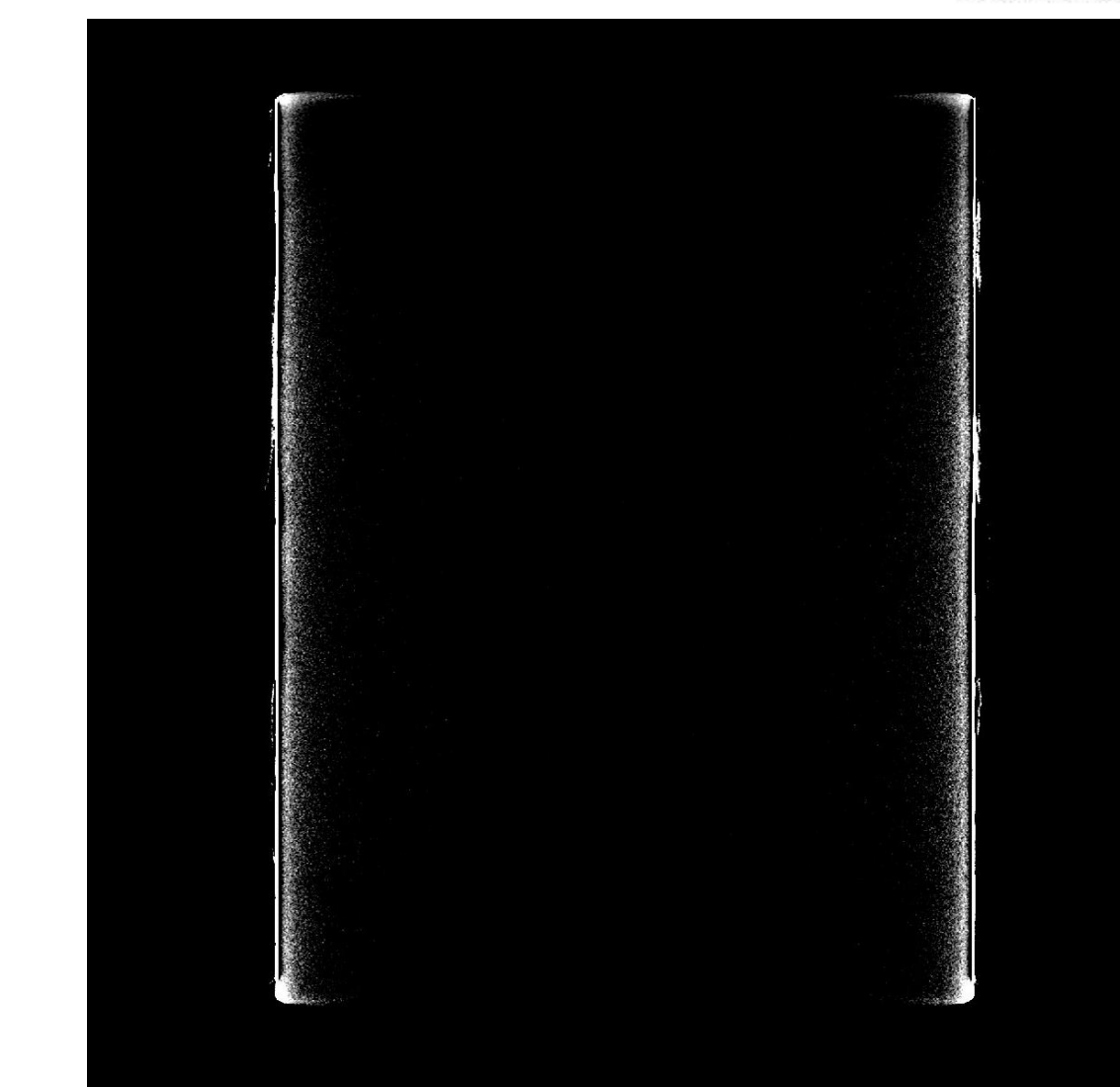
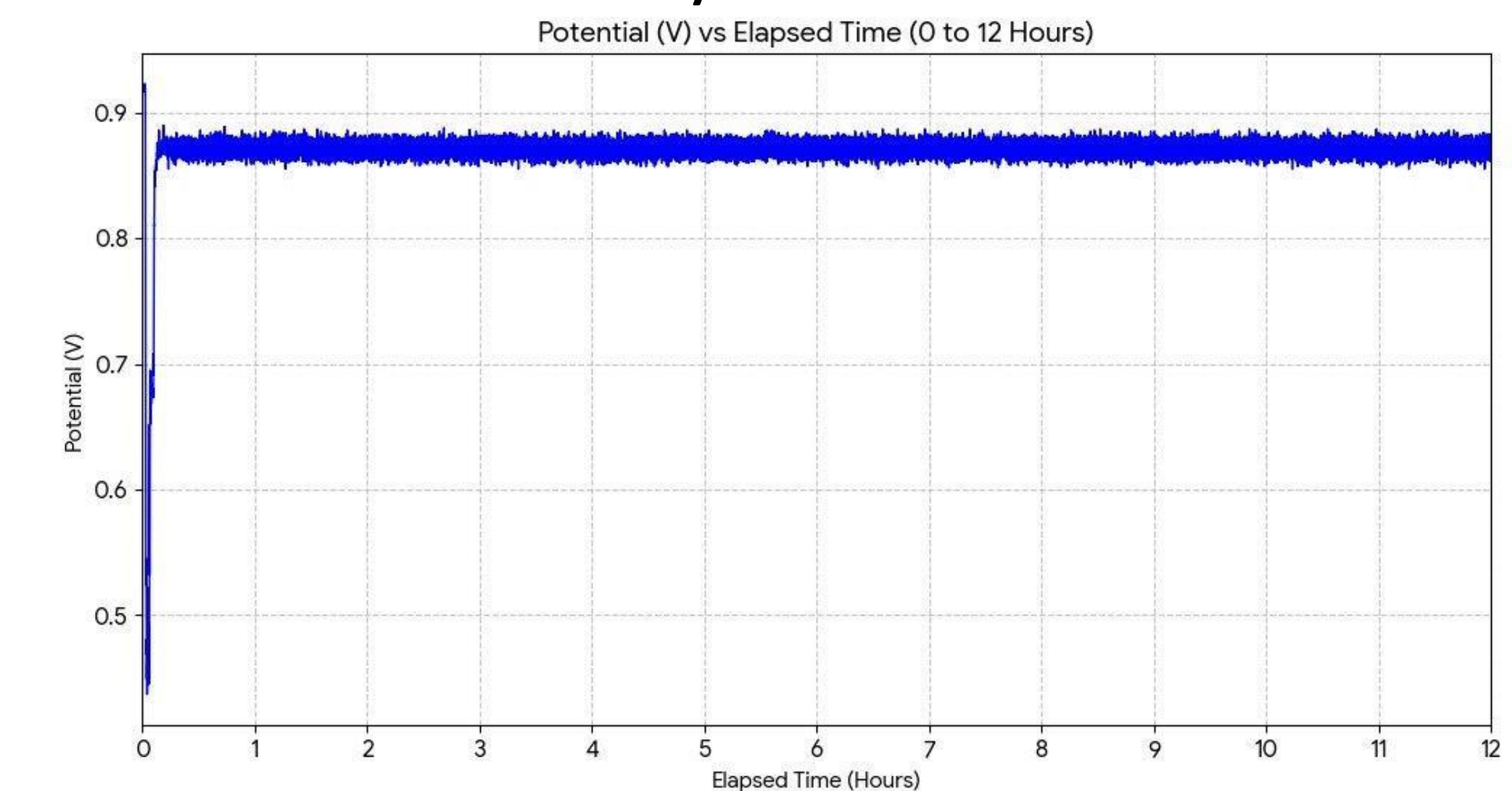
## Prototype Development

- **Key components:** St 52 steel pipe (200 mm,  $\phi 115$  mm, 7 mm wall) · MMO titanium anode · Ag/AgCl reference electrode · 4× UT sensors (5 MHz) · Arduino Uno + PID control · Carbon fiber split clamp · 26 L simulated seawater tank (3.5 wt% NaCl, pH 8.2, 27 °C)



## Validation and Verification

### • 12-Hour Stability Test & CT Scan



- Within -850 & -1150 mV during 12 h
- No HIC as it shown in the CT scan

## Conclusion

An active ICCP system successfully replaced sacrificial anodes, delivering stable protection while a -1100 mV clamp prevented hydrogen-induced cracking. UT and CT scans verified structural integrity with zero crack depth. Ultimately, the optimized, fully industry-compliant design achieved a  $\leq 15\%$  drag increase compare with the bare pipe.