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Corrosion Performance Testing of Aerospace Coatings

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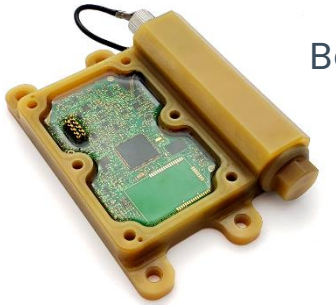
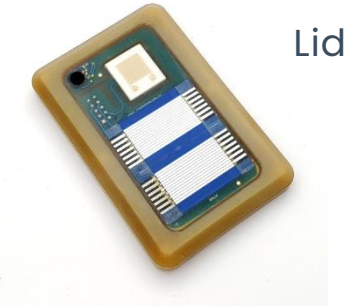
Systems

Acuity LS™

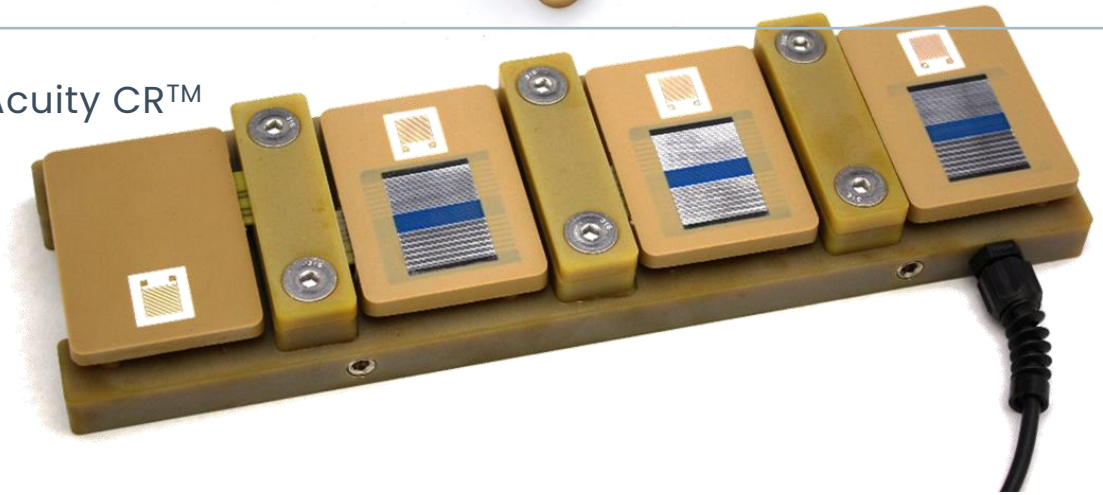


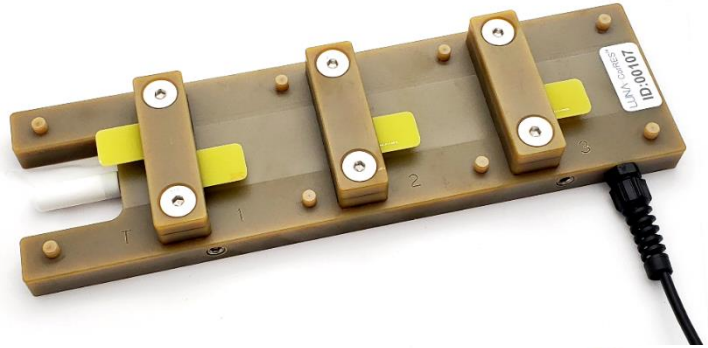
Base



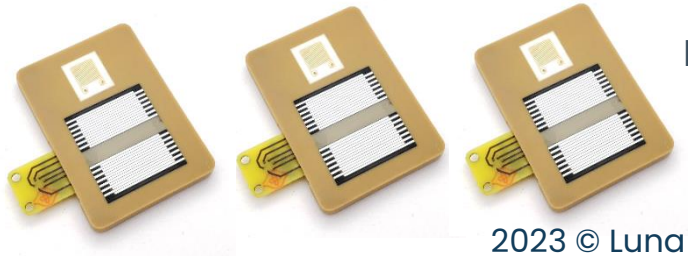
Lid-sensor Panels (LSP)

Acuity CR™





Base / Docking Platform



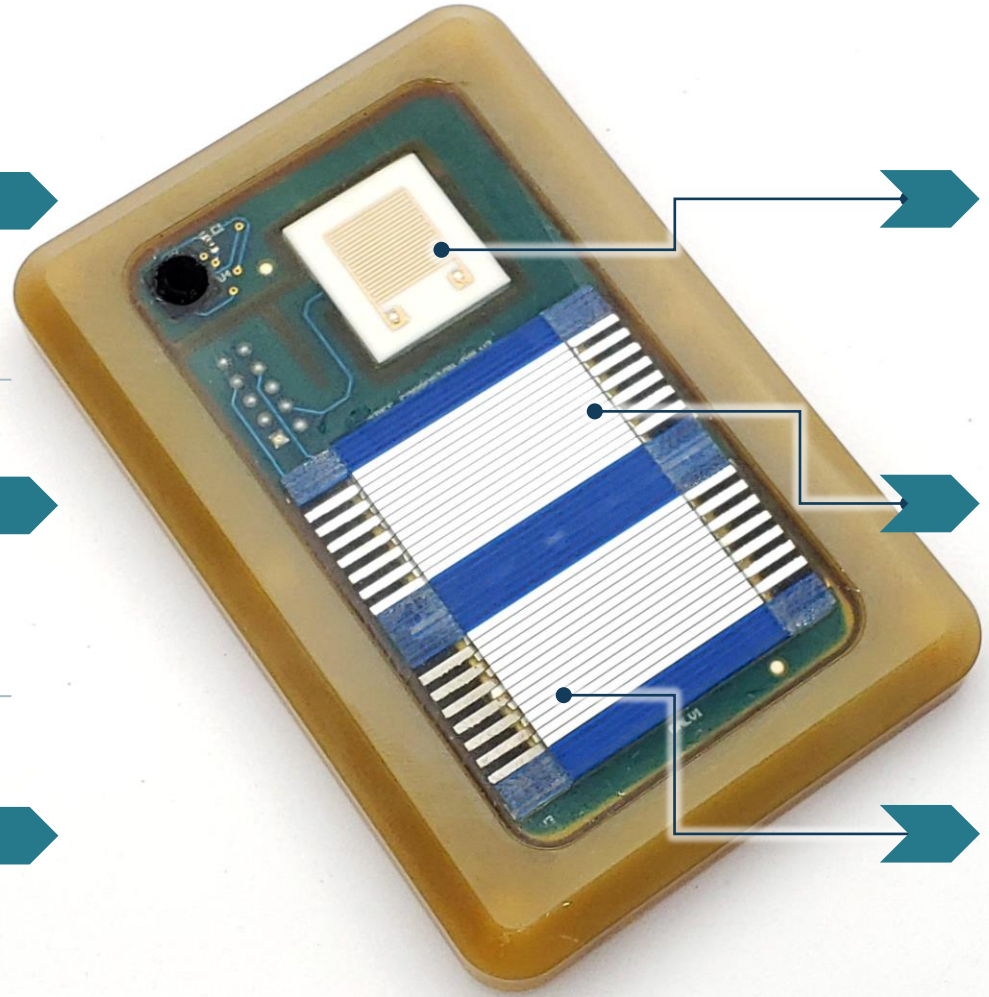
Multi-sensor Panels (MSP)

Continuous, Quantified Data

Salt loading and time-of-wetness

Single metal free corrosion

Mixed-material galvanic corrosion



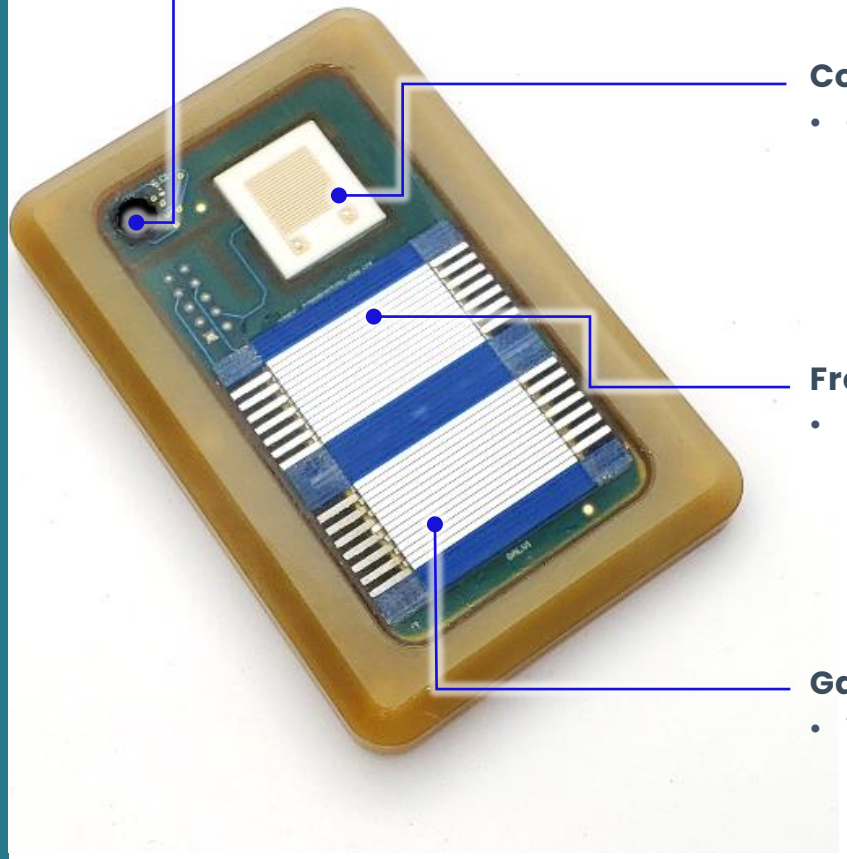
CONDUCTANCE
(RH & salt deposition)
Rate (µS) & Cumulative (C/V)

FREE CORROSION
Current (µA)
Cumulative (C)

GALVANIC CORROSION
Current (µA)
Cumulative (C

User-replaceable Sensor Panels

Lid-sensor Panel (LSP)



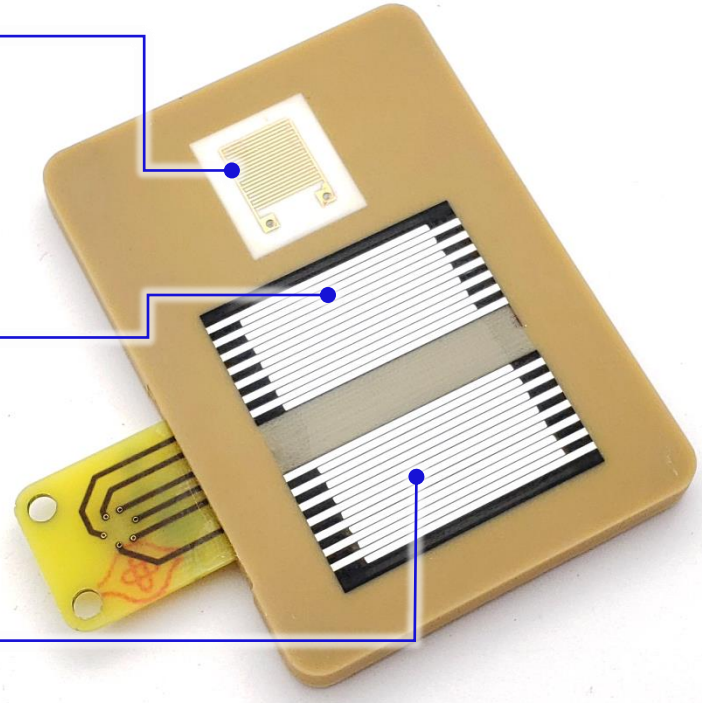
Air temperature & relative humidity

Contaminants loading (salts)
- Gold interdigitated electrode (IDE)

Free corrosion rate
- Single engineering alloy

Galvanic corrosion rate
- Two dissimilar materials

Multi-sensor Panel (MSP)



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Coating Performance Measurements

Issue and Objectives

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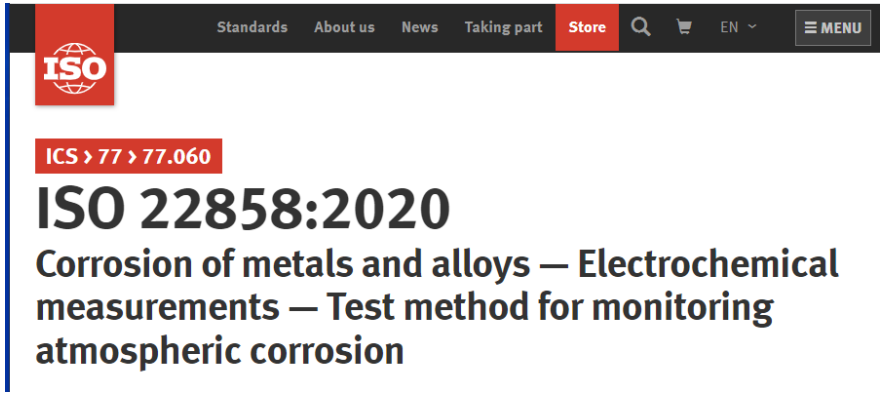
Coating Performance Testing

- Corrosion performance measurements are inadequate for accessing aerospace coating performance
  - Coating performance discrimination is poor
  - Measurement variability is so great that only outdoor testing and on asset evaluations are considered reliable
    - Performance determination can take years
- Testing often does not quantify failure modes of greatest significance to aircraft structural integrity
  - Localized corrosion / galvanic corrosion / environment assisted cracking
- Cost and time (10 – 15 years) to introduce a new coating system is excessive
  - Impairs risk mitigation for new acquisitions and regulatory compliance

Objectives and Goals

- Develop, demonstrate, and standardize advanced measurement methods for assessing coating performance
  - Produce electrochemical sensors and data collection system for rapid, accurate characterization of coating performance
  - Demonstrate in interlaboratory testing
  - Publish U.S. national standard test method

- Establish coating performance requirements based on metrics defined in the standard test method
- Adopt measurements and requirements within coating performance specifications



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Coating Performance Measurements

Measurement System – Acuity CR

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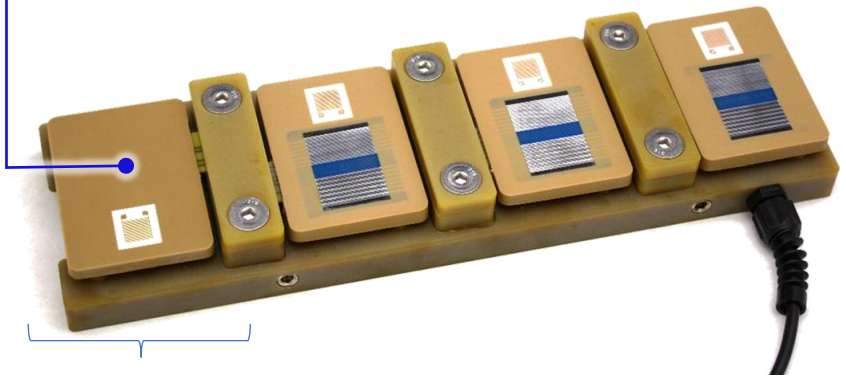
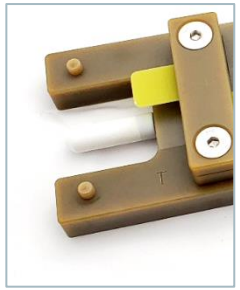
Acuity CR Corrosion and Coating Test System

- Replicate test panels with sensors that can be coated and scribed

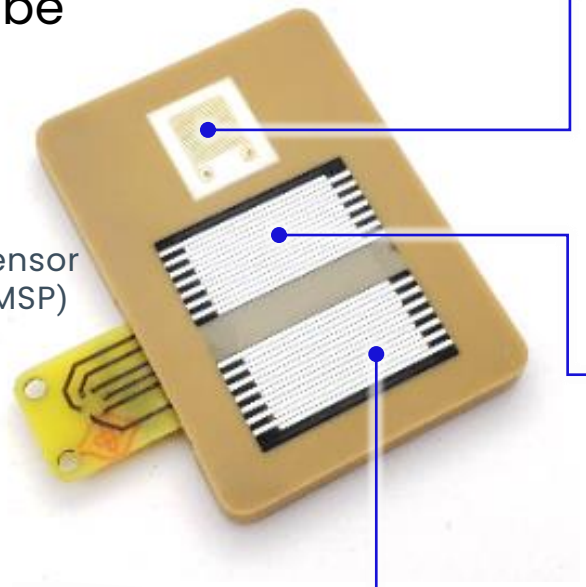
CONDUCTANCE & PANEL TEMP



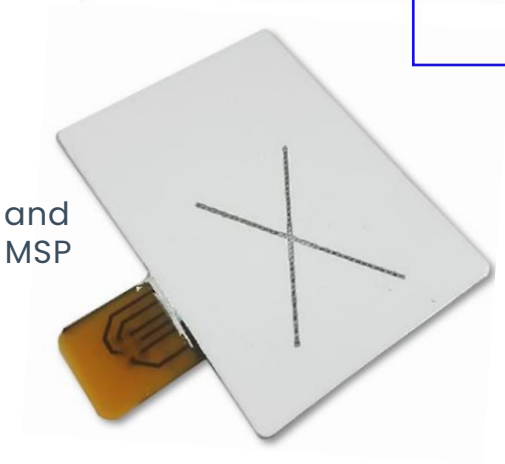


TEMPERATURE & RELATIVE HUMIDITY

Multi-sensor Panel (MSP)



Coated and scribed MSP



COATING CONDUCTANCE

- Gold interdigitated electrode (IDE)
- Impedance measurement; 20 mV peak-to-peak 10 Hz and 25 kHz
- Conductance (µS) & cumulative (C/V)

FREE CORROSION RATE

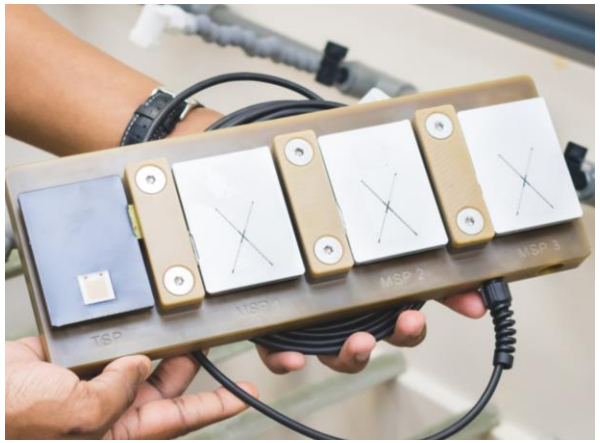
- Single engineering alloy IDE
- Low frequency impedance measurement; 20 mV peak-to-peak, 0.5 Hz
- Current (µA) & cumulative (C)

GALVANIC CORROSION RATE

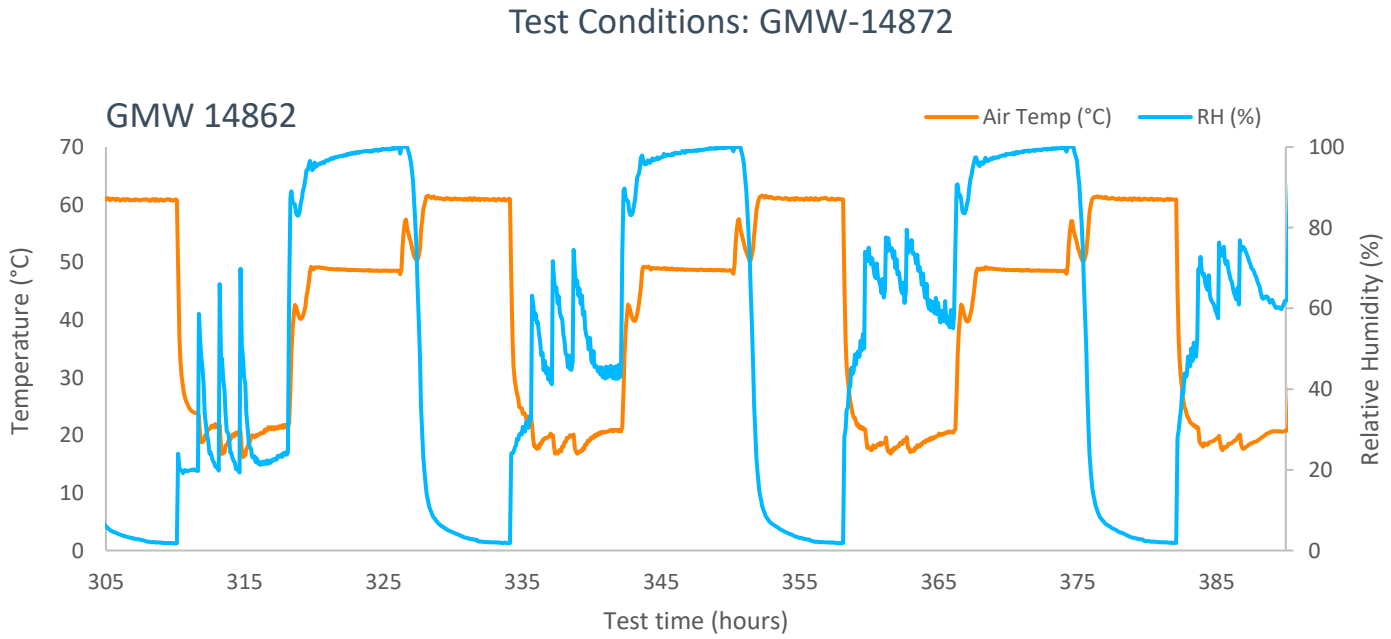
- Two dissimilar materials IDE
- Zero resistance ammeter
- Current (µA) & cumulative (C)

Acuity CR Corrosion and Coating Test System

- Measurement system continuously records environmental conditions, coating properties, and corrosion



Measure and store data



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Coating Performance Measurements

Test Materials and Experimental Methods

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Testing

- Multi-laboratory cyclic corrosion testing (GMW-14872) (ATTC-MG, NAWCAD, Luna Labs)
- Outdoor testing at Battelle Florida Materials Research Facility

Sensors	Materials
Free Corrosion	AA7075-T6
Galvanic	SS316 / AA7075-T6 or 4130 Steel / AA7075-T6

Materials	Description	Product
Pretreatment	Trichrome	Bonderite T5900
Primer	MIL-PRF-23377 Type I, Class C2	CA7233
	MIL-PRF-23377 Type I, Class C2	AD9318
	MIL-PRF-23377 Type I, Class N	02GN084
	MIL-PRF-85582 Type I Class N	44GN098
	Primer with no inhibitor	
Topcoat	MIL-PRF-85285 Type IV CL H, FED STD 595 Color 36173	99GY001

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Test Results

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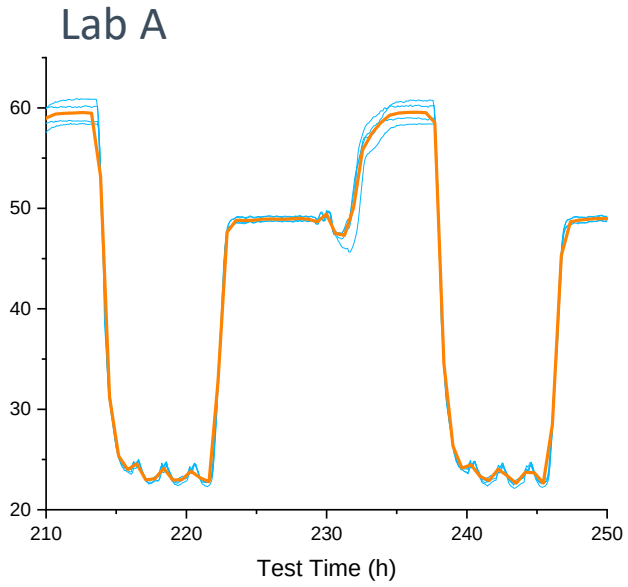
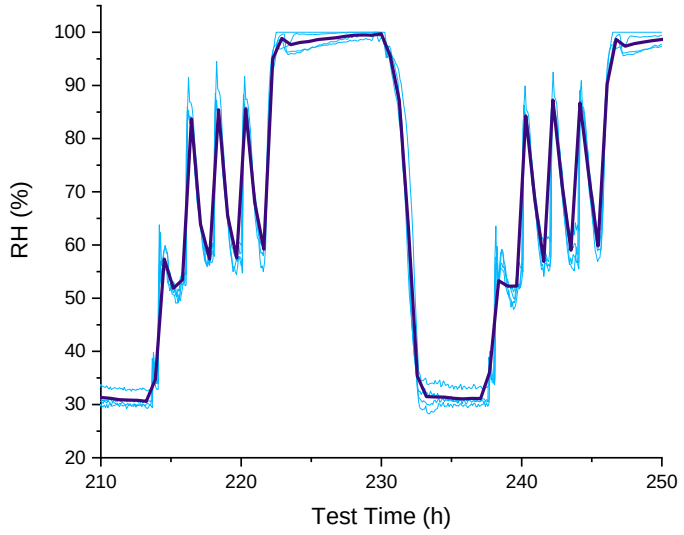
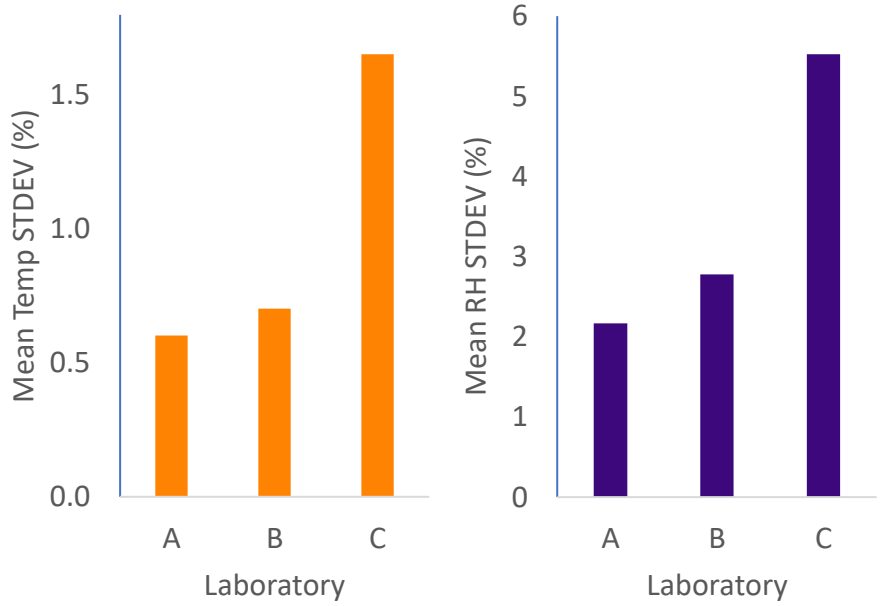
Accelerated Corrosion Testing

- Four docking platforms were used to test four coatings at three laboratories
- Variation of the time dependent temperature and relative humidity was quantified for each laboratory test chamber
- Laboratory A had more consistent chamber temperature and RH compared to labs B and C

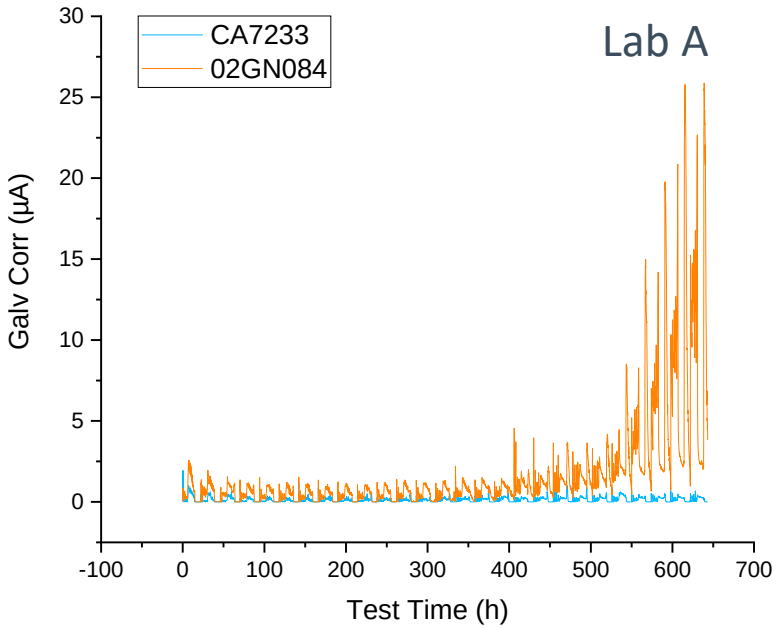


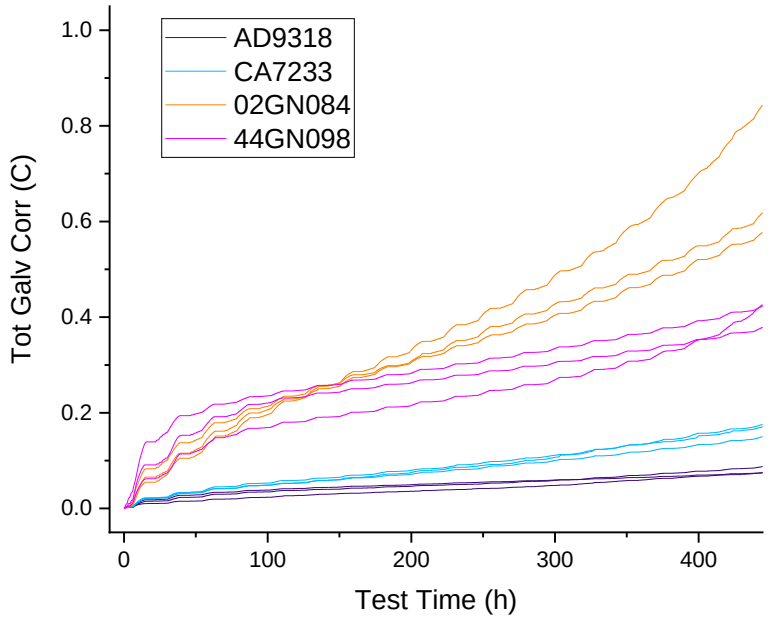




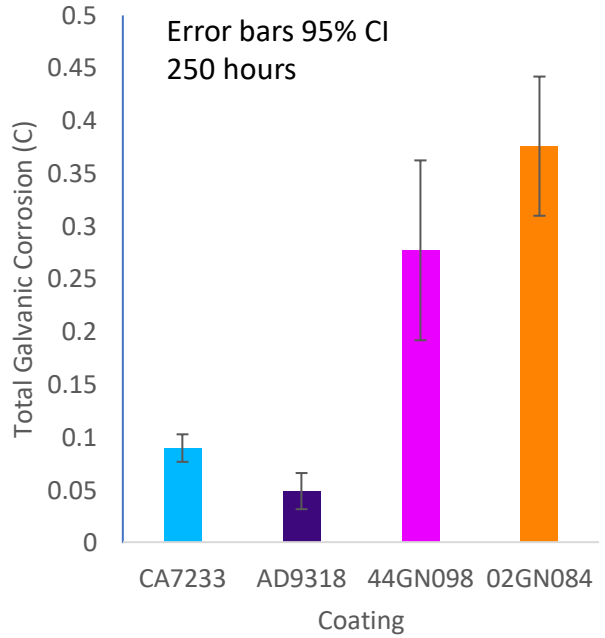
Accelerated Corrosion Testing

- The time dependent corrosion response to the environment is integrated to obtain total corrosion at any point in time
- There is clear separation between the two qualified chromate primers
- Almost immediate differentiation between chromate and non-chromate primers



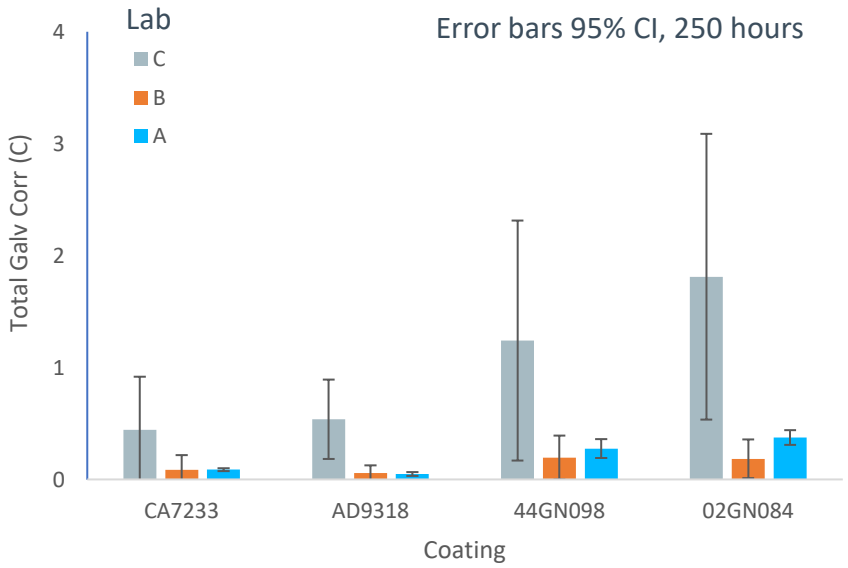


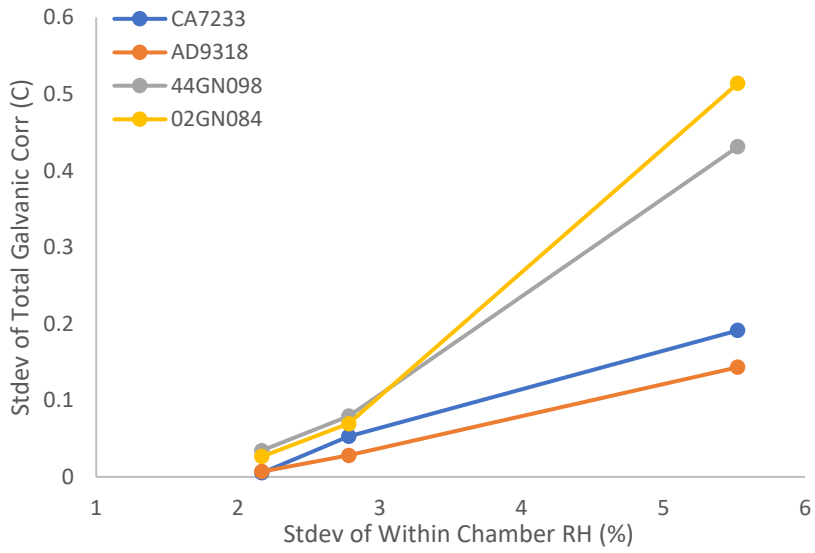
SS316 / AA7075-T6



Test Chamber Performance

- Variability of corrosion test results are associated with consistency of temperature and RH within the chamber
- Performance differentiation is dependent on chamber performance
- Given measurement system resolution, high severity may not be as important as chamber control for performance testing

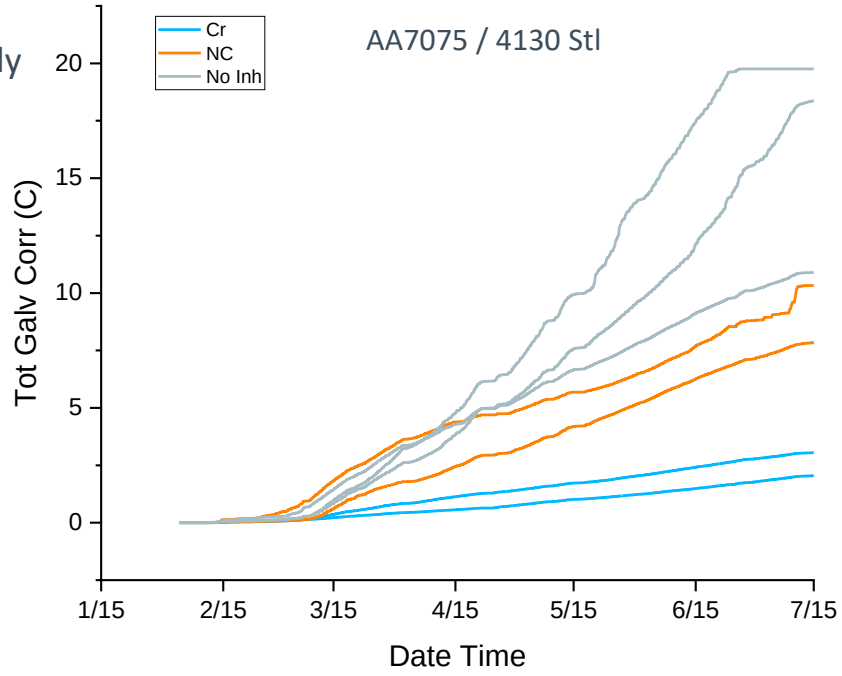


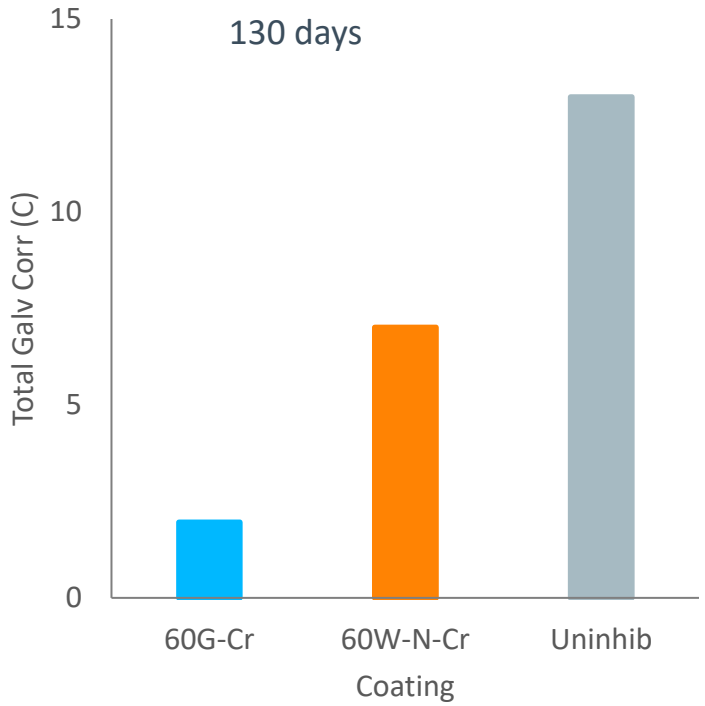


Outdoor Exposure Results

- A chromate primer provided the best protection in outdoor testing (Battelle)
- Separation in performance was evident within a few days of test initiation

Primer only tests





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Coating Performance Measurements

Summary and Conclusions

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Observations

- Electrochemical sensors can be used to continuously assess coating performance throughout a laboratory test, at an outdoor exposure site, and on an asset
- Rank order coating performance can be rapidly determined in laboratory and outdoor tests
- The capacity to discriminate coating performance within a test is dependent on achieving uniform conditions within a chamber
  - The environmental monitoring can be used to quantify the chamber variability

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Thank You

Questions?

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