NASA Corrosion Technology Laboratory

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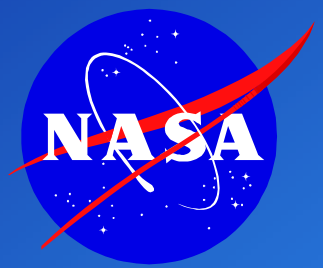
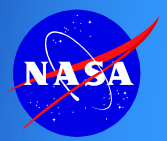


Kennedy Space Center

NASA CORROSION TECHNOLOGY LABORATORY

Multifaceted capability that

- **Conducts applied research**
- **Develops new corrosion detection and control technologies**
- **Investigates, evaluates, and determines materials performance and degradation in different environments in support of NASA, other government organizations, industry, and educational institutions**
- **Provides consulting and testing services**
- **Represents NASA at the DoD Corrosion Exchange**
- **Member of the National Corrosion Technology Alliance between NASA and DoD**
- **Participates in educational outreach activities**



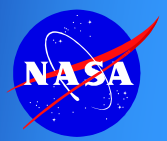
NASA CORROSION TECHNOLOGY LABORATORY

MISSION

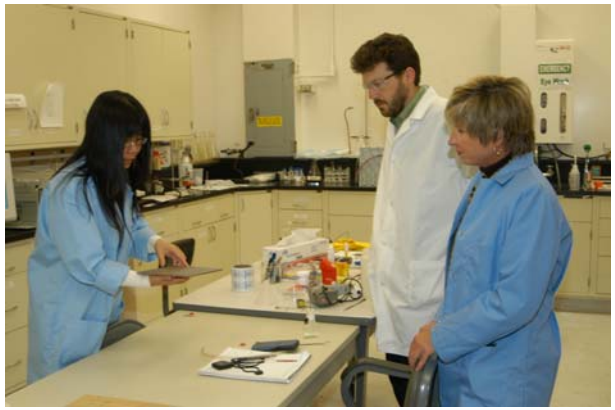
To develop corrosion control and detection technologies and to investigate, evaluate, & determine material behavior in various corrosive environments

FACILITIES

- Atmospheric Exposure Site
  - Cathodic Protection Compatibility Tank
  - Seawater Immersion
  - On-Site Laboratory
- Electrochemistry Laboratory
- Accelerated Corrosion Laboratory
- Coatings Application Laboratory
- Photodocumentation Laboratory



People



Wendy Li, Paul Hintze, Jan Lomness

Amanda Napier

Rubie Vinje

Jerry Curran

Mark Kolody

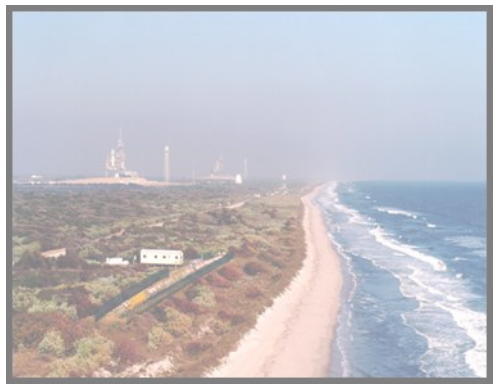
Bill Dearing

Luz Marina Calle

Dave McLaughlin

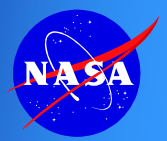
KSC Atmospheric Corrosion Test Site

- Documented by ASM as one of the most corrosive naturally occurring environments.
- Actively maintained for over 35 years.
- Historical database for evaluation of new materials.
- On-site laboratory for real time atmospheric and seawater immersion corrosion investigations.
- Remote access network connectivity for data acquisition and real time video by the Internet.
- Instrumented for complete weather information.



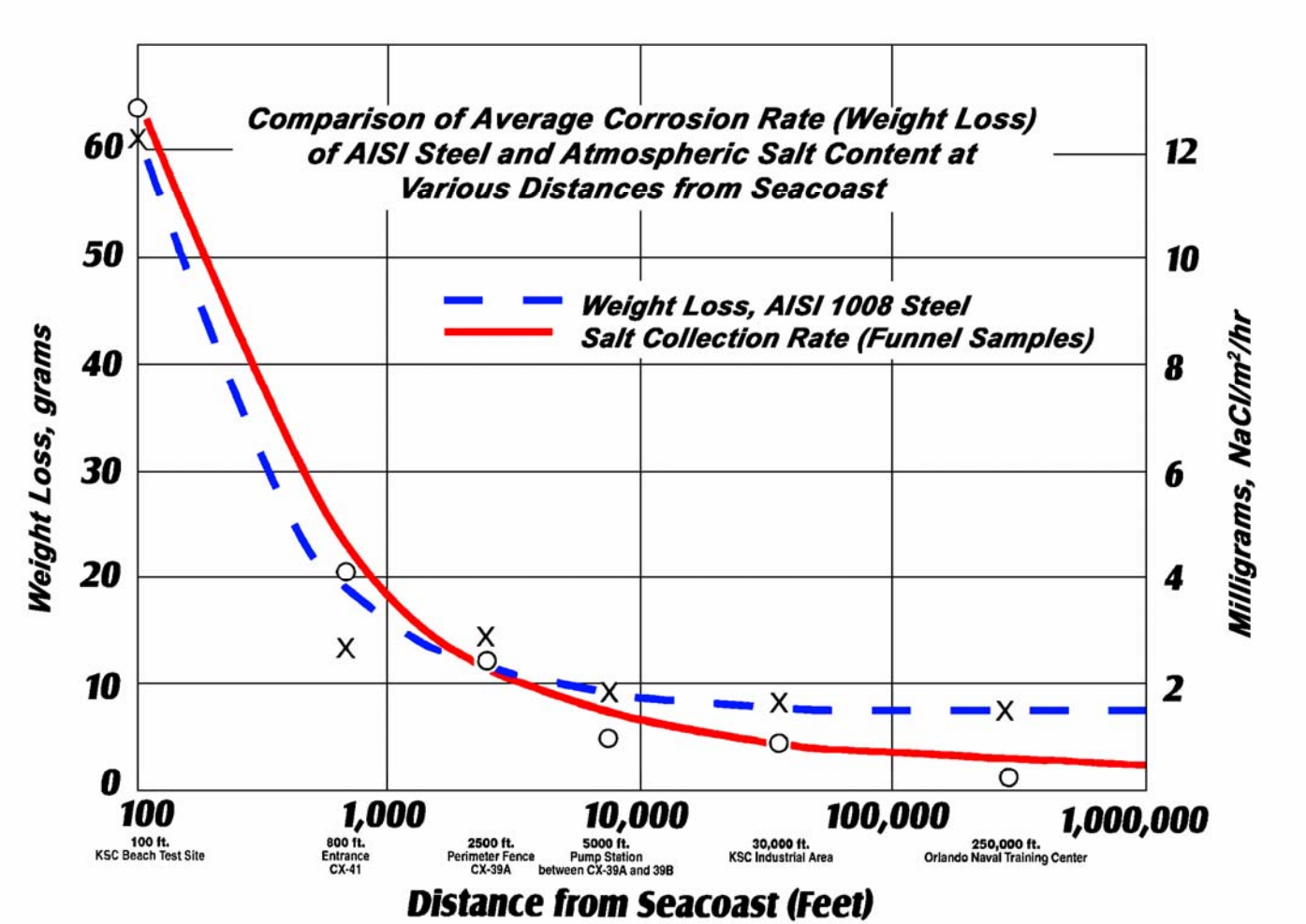
Corrosion Rates

Location	Type Of Environment	µm/yr	Corrosion rate (a) mils/yr
Esquimalt, Vancouver Island, BC, Canada	Rural marine	13	0.5
Pittsburgh, PA	Industrial	30	1.2
Cleveland, OH	Industrial	38	1.5
Limon Bay, Panama, CZ	Tropical marine	61	2.4
East Chicago, IL	Industrial	84	3.3
Brazos River, TX	Industrial marine	94	3.7
Daytona Beach, FL	Marine	295	11.6
Pont Reyes, CA	Marine	500	19.7
Kure Beach, NC (80 ft. from ocean)	Marine	533	21
Galeta Point Beach, Panama CZ	Marine	686	27
Kennedy Space Center, FL (beach)	Marine	1070	42



S. Coburn, Atmospheric Corrosion, in Metals Handbook, 9th ed., Vol. 1, Properties and Selection, Carbon Steels, American Society for Metals, Metals Park, Ohio, p.720 (1978)

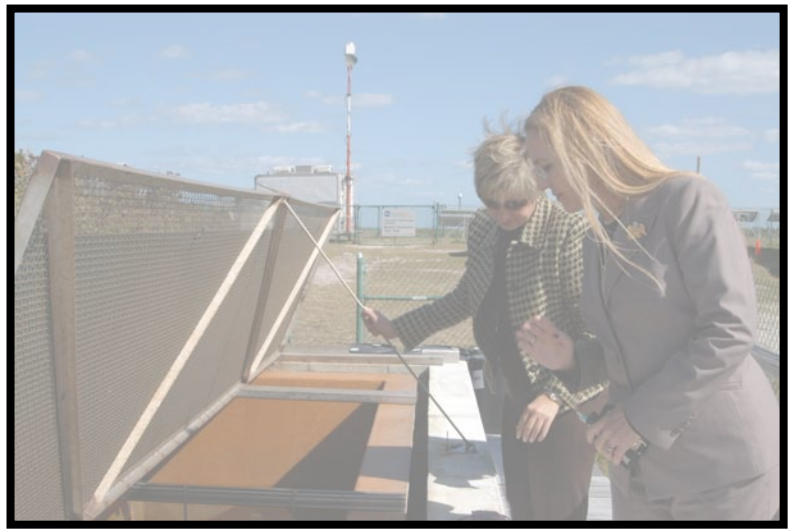
Corrosion Rate as a Function of Distance from KSC Corrosion Test Site



J.D. Morrison, Report on the Relative Corrosivity of Atmospheres at Various Distances from the Seacoast, NASA-Kennedy Space Center, Report MTB 099-74, January 1980

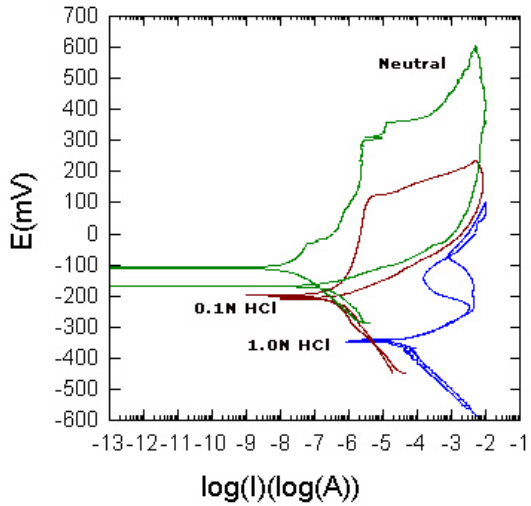
Seawater Immersion System

- Two immersion tanks with a continuous once-through, filtered supply of seawater is used to evaluate test coupons, component hardware, or full scale test articles.
- Temperature, salinity, dissolved oxygen, conductivity and pH are closely monitored.
- Can be utilized for the evaluation of protective coatings, metal alloys, reinforced concrete, composites and other materials in a seawater environment.
- Specialized tests can be designed to study impingement-corrosion, erosion-corrosion, cavitation and other velocity effects.



Electrochemistry Laboratory

- State-of-the-art instrumentation and equipment for corrosion measurements including direct current (DC) and alternating (AC) current methods.
  - Polarization resistance
  - Tafel extrapolation
  - Potentiodynamic scanning
  - Cyclic polarization
  - Electrochemical impedance spectroscopy



Novel Electrochemical Test Cells

Micro-Electrochemical Cell

- The cell can measure the corrosion properties of areas between 1 mm and 1 µm in diameter
- Ideal for measuring properties of welded samples or studies of localized corrosion

Crevice Free Corrosion Cell

- Minimizes crevice corrosion during electrochemical testing
- Controlled atmosphere for use under a variety of conditions

Coatings Application Lab

- Equipped with state-of-the-art coating application equipment with conventional, airless, and plural component spray capabilities.
- Maintains an inventory of standard steel and aluminum test panels.
- Ensures that coatings are applied in a prescribed and consistent manner to SSPC, NACE International and military specifications.

Accelerated Corrosion Laboratory

- Salt fog testing to study the ability of a material to resist corrosion.
- Capabilities include traditional salt spray techniques, as well as advanced cyclic and acidic methods.

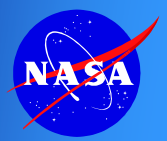
Surface Analysis

State of the art electron microscopes and experienced staff study corrosion mechanisms through surface chemistry, depth profiling, and composition mapping. Techniques available for surface analysis include:

- TEM (Transmission Electron Microscopy)
- SEM (Scanning Electron Microscopy)
- XPS (X-Ray Photoelectron Spectroscopy)
- AES (Auger Electron Spectroscopy)
- Rutherford Backscattering Spectroscopy
- SIMS (Secondary Ion Mass Spectrometry)

Representative Projects

- Smart Coating Development (NASA)
- Self-cleaning coatings (NASA)
- Corrosion Resistant Tubing for Shuttle Launch Sites (NASA)
- Polysiloxane Coating Development (NASA)
- Galvanic Coatings for Protection of Steel in Concrete (NASA)
- Non-chrome Conversion Coating Evaluation (Navy)
- Airplane Wing Study (Air Force)
- Seawater Immersion Studies of Welds for Military Applications (Navy)
- Launch Site Coating Development and Evaluation (Air Force)
- Single Coat/Rapid Cure Marine Tank Lining Evaluation (Navy)
- Antifouling Coating Test and Evaluation (Navy)
- Chloride Rinse Agent Investigation (Army)
- Support Equipment Paint Replacement Project (NASA)
- Electrochemical Evaluation of Coatings for Solid Rocket Motors (Thiokol)
- VAB/LCC Roof (Reinforced Concrete) Corrosion Study (NASA)
- Refractory Concrete Study (NASA)
- Urethane Replacement Study (NASA)
- Depainting/Surface Preparation Study (NASA)
- Cryogenic Storage Corrosion Study (NASA)



Project Highlights

Performance of Chemical Rinse Agents on Aircraft Alloys Exposed to a Seacoast Environment

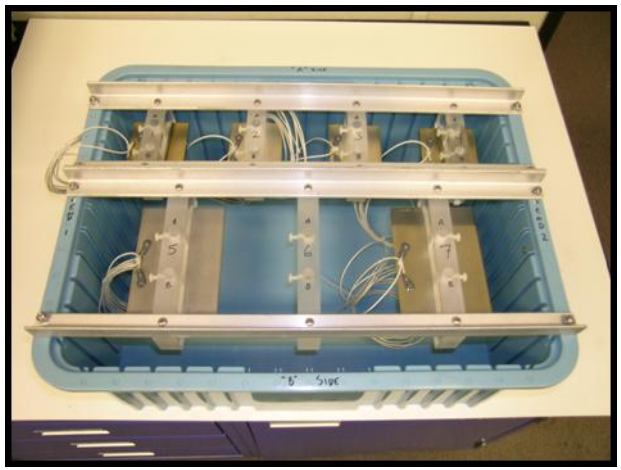
Four chloride rinse agents (CRAs) were evaluated for use on military aircraft, missiles, and various components.

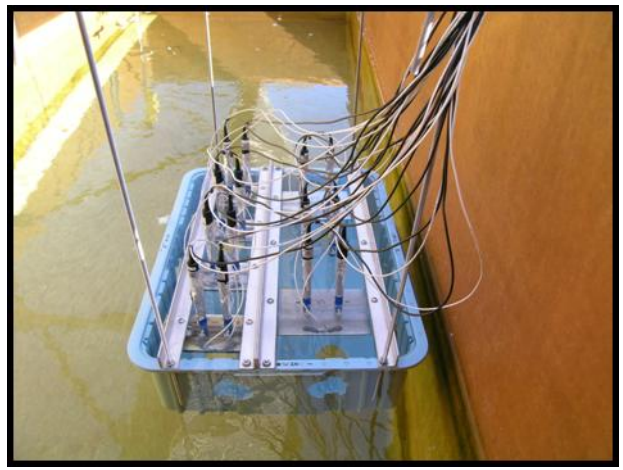
Corrosion Resistant Tubing for Space Shuttle Launch Sites

- The performance of a series of corrosion-resistant tubing materials were investigated under simulated launch site environment conditions.
  - Long-term atmospheric exposure
  - Electrochemical methods
  - Surface analysis techniques
- The investigation resulted in the selection of a material which requires little maintenance.

Corrosion Resistance of Welds for Military Applications

- Welded samples were exposed to fresh Atlantic flowing seawater.
- The galvanic effect between the welded material and base alloy was investigated.
- Pitting of welds and base materials was investigated and characterized.





Support Equipment Coating Study

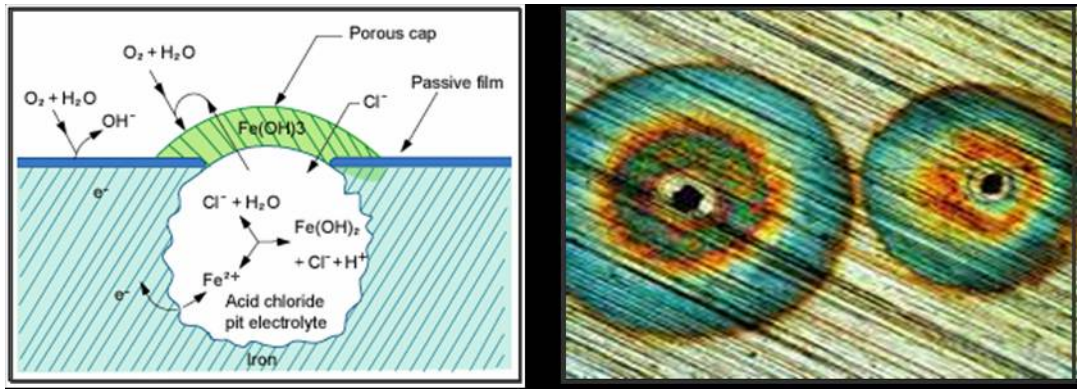
- Coating systems are evaluated for use on support equipment at the KSC launch sites.
- Composite test panels are used to investigate the performance of:
  - Zinc primer systems
  - Powder coat systems

Chromate Coating Replacements for Military Aircraft

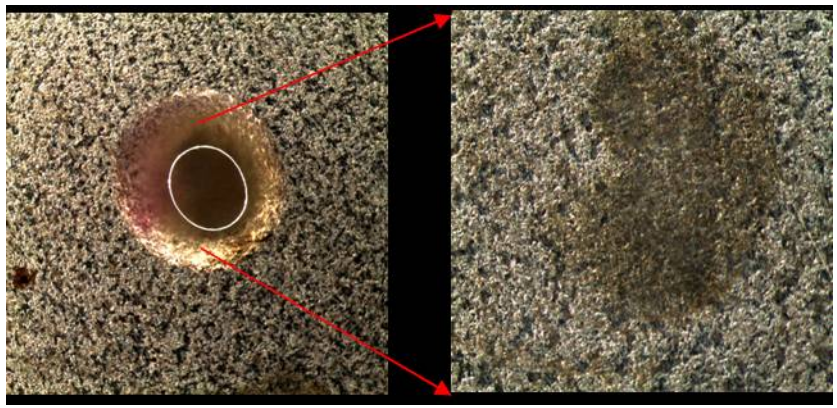
- The effectiveness of replacements to currently used chromate conversion coatings is being investigated.

- The coating system matrix utilizes:
  - Four aluminum substrates
  - Nine pretreatments
  - Five primers
  - Two topcoats

Smart Coating for Corrosion Sensing and Protection



basic pH conditions at localized corrosion cathodic sites



Microcapsules indicating localized corrosion

Corrosion Performance of a 30 Year Old Chromated Primer

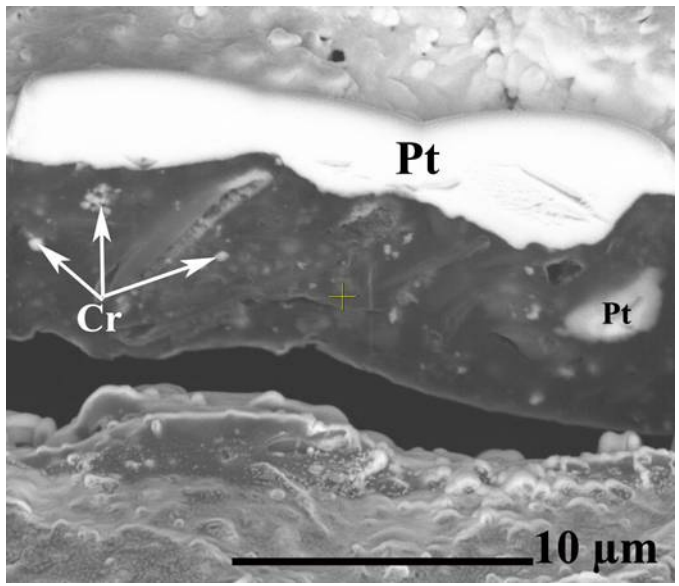
Orbiter Enterprise

Steven F. Udvar-Hazy Center at Dulles International Airport

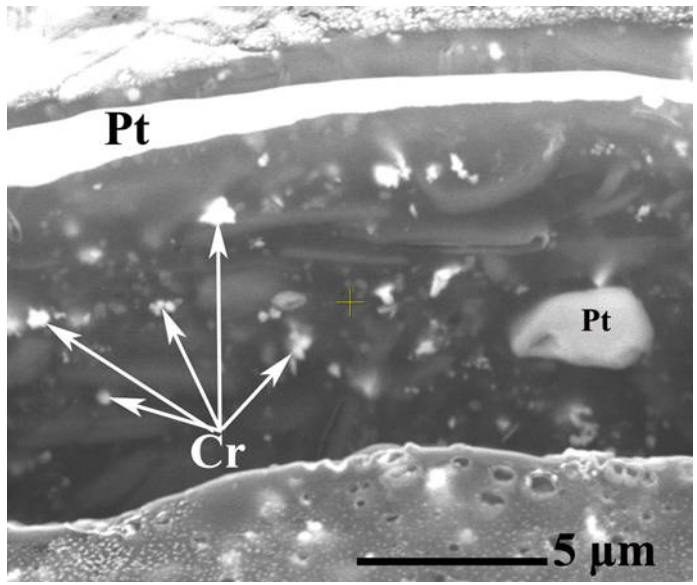
Smithsonian's New National Air and Space Museum

Corrosion Performance of a 30 Year Old Chromated Primer

- The Orbiter Program heavily relies upon the corrosion protective ability of PRC-Desoto's Super Koropon Primer, MB0125-055
- Covers most structure, bonding surface for thermal protection, protects critical components

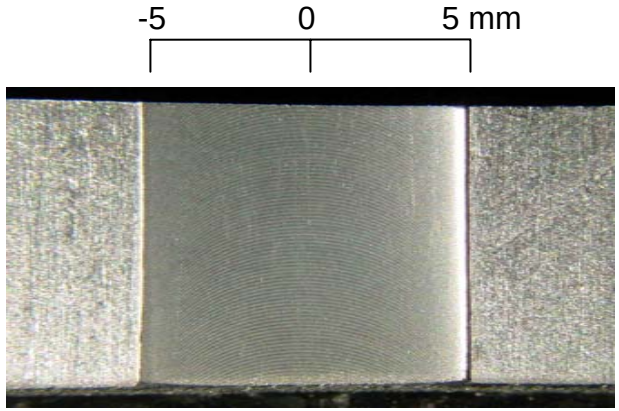


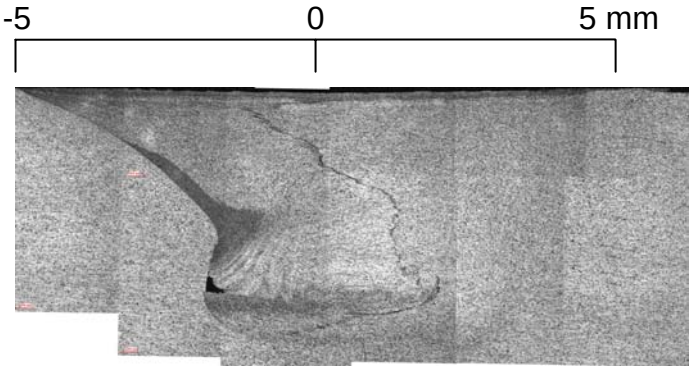
Enterprise Cross Section

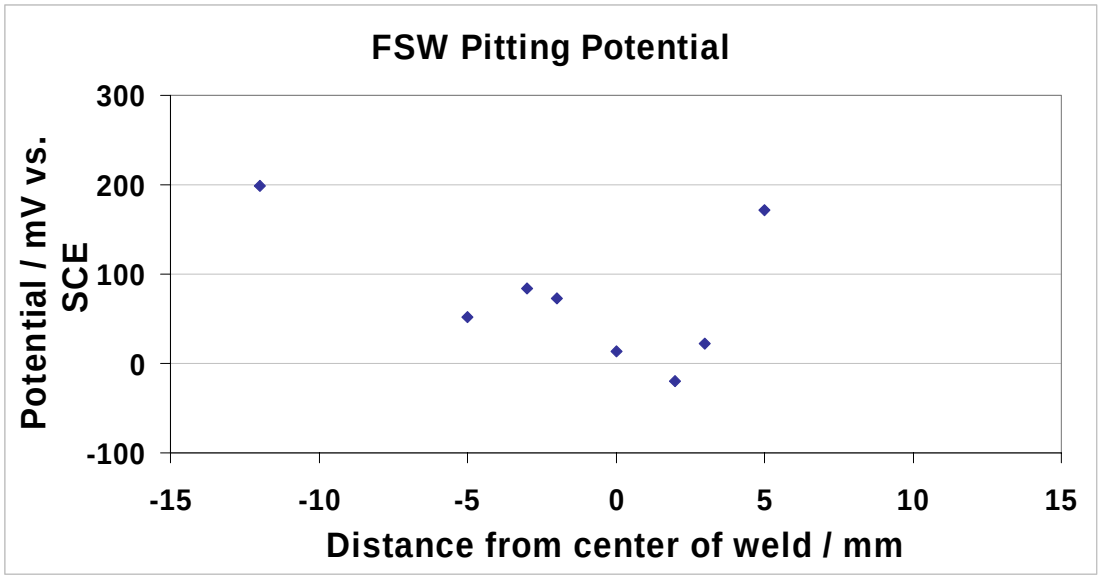


Control Cross Section

Micro-electrochemical Study of Corrosion of a Friction Stir Weld

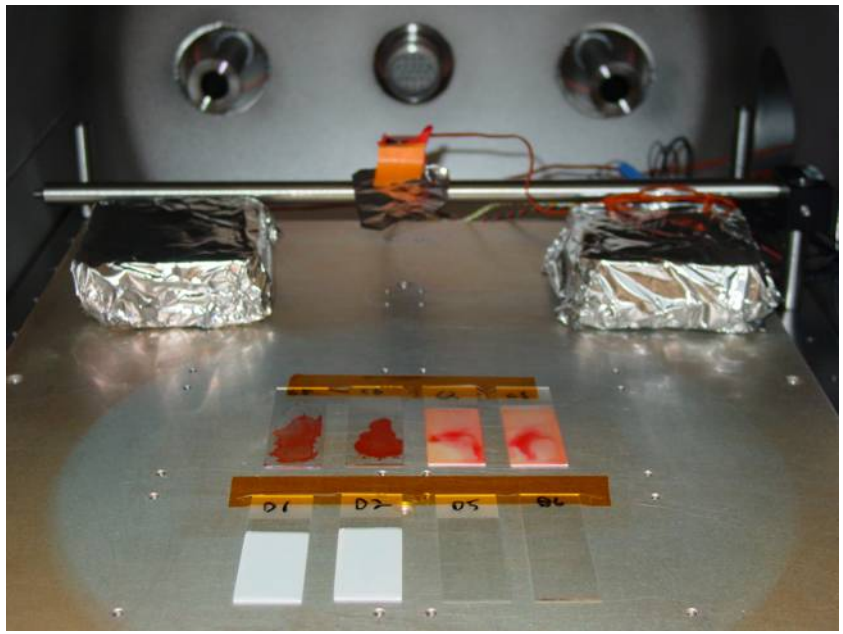






Self Cleaning Coatings

- Spacecraft, spacecraft assembly areas and crew quarters in Space Station, Shuttle, and CEV are susceptible to contamination from industrial and biological contaminants
- Develop self-cleaning coatings that can either be applied directly to metal surfaces with little affect to the other properties of the metal or be incorporated into current paints.



Affiliations

- **Academic**

  University of Central Florida
  Florida Institute of Technology
  Texas A&M
  Louisiana Tech
  North Dakota State University
  University of Mississippi Medical Center
  University of Florida
  University of Texas
  Lehigh University
  The Ohio State University
  Northern Illinois University

- **The NASA Corrosion Technology Laboratory also works with federal organizations, industry, and commercial laboratories**