Air Force Research Laboratory

AFRL Corrosion Integrated Product Team Update

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Integrity ★ Service ★ Excellence

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Outline

- AFRL Corrosion IPT update
  - Organizational Overview
  - CIPT Mission
  - Demand signals
  - Corrosion IPT Activities
  - TCC Student Development
- Air Force Corrosion S&T Needs

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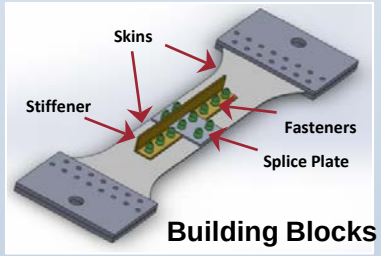
Mission of the AFRL CIPT

"The AFRL Corrosion IPT (CIPT) provides continuity of science and engineering-based corrosion expertise for <u>quick reaction</u> and rapid response; plans and executes <u>corrosion-centric R&D</u>; and facilitates introduction of new and improved corrosion-fighting technologies, from any source, into Air Force weapon system <u>acquisition and sustainment</u> processes."

Find ⇄ **Fix**

MIC picture?

Prevent



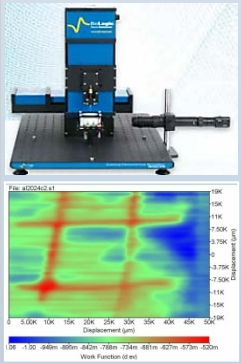
Building Blocks

Advanced Protocols Development

ACES Chamber

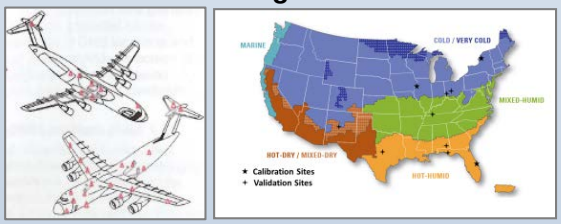
Detect

NDI Tools

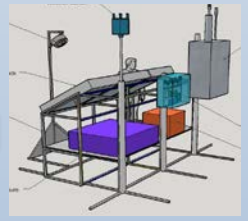


Predict & Manage

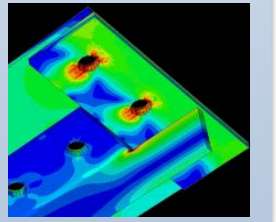
Fleet Management Tools



Corrosion Modeling



Instrumented Outdoor Exposure Rack



Galvanic Corrosion

International

NATO OTAN

THE TECHNICAL COOPERATION PROGRAM TTCP

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Demand Signals

- Air Force Life Cycle Management Center , Product Support Engineering (AFLCMC/EZP)
- Aircraft Structural Integrity Program (ASIP)
- Air Force Customers – program offices (weapon systems and support equipment), repair depots, field level

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Technical Challenges

- New accelerated test methods for corrosion protection schemes
  - Exposure conditions (with combined effects)
  - Representative test specimens
- Comprehensive characterization of service environment corrosivity
- Understanding degradation mechanisms
- Techniques to quantitatively detect and characterize corrosion
- Specifications and Standards

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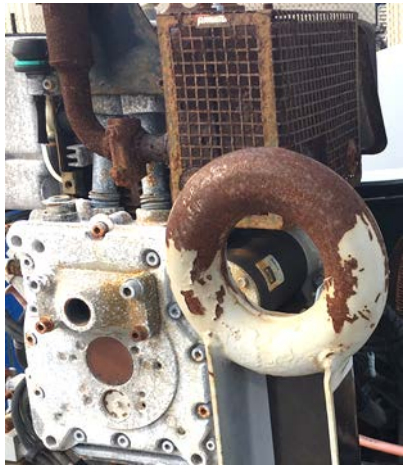
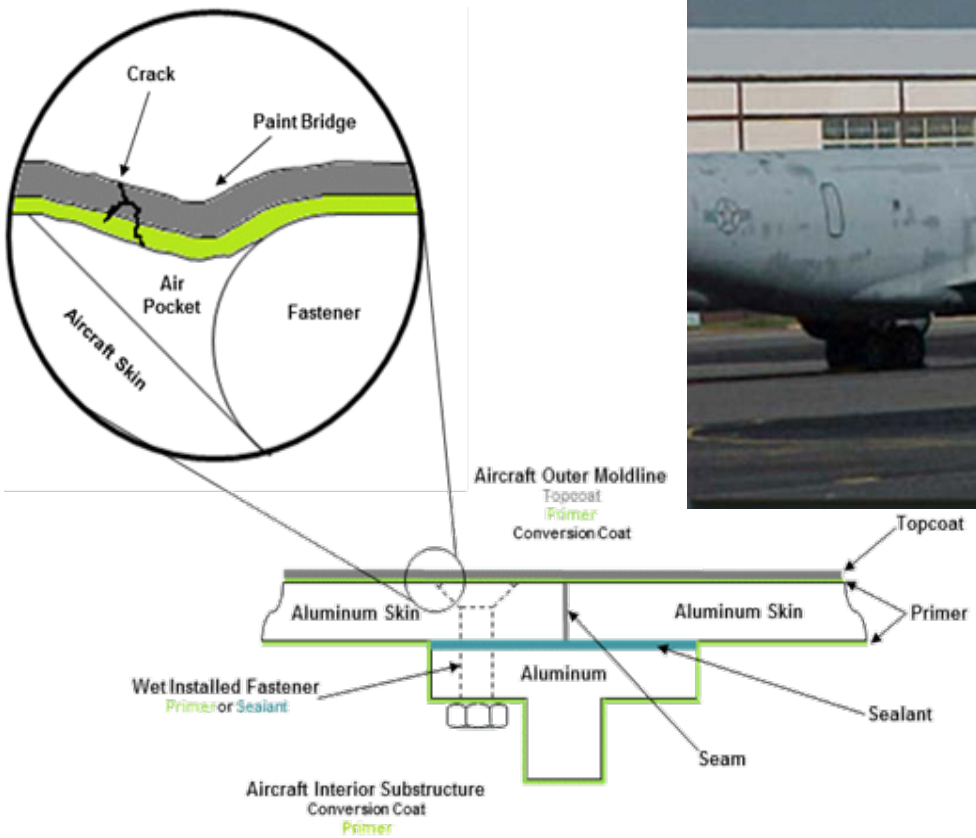
Quick Reaction S&T - Example

- AFRL Corrosion IPT and Air Force Life Cycle Management Center Support Equipment and Vehicles Program Office (AFLCMC/WNZ) are conducting a corrosion survey of aerospace ground equipment for Pacific Air Forces Command (PACAF)
- Purpose is to assess corrosion materials and processes and provide recommendations for Air Force Technical Order 35-1-3
- Evaluation team includes AFRL personnel (Gov. and Contractor) and faculty and students from Mercer University

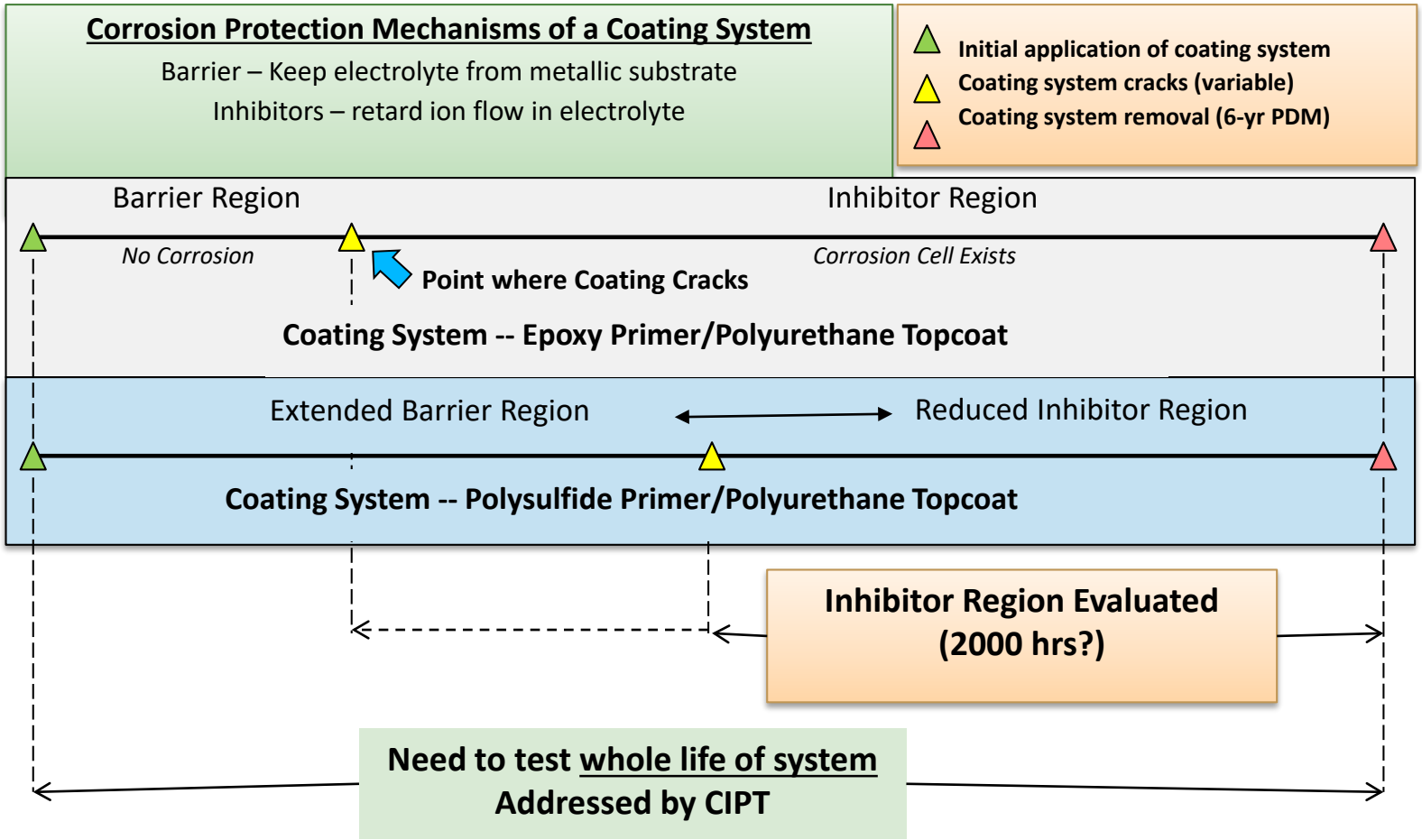


Coating Failure

Purpose of Flexibility Testing:
To Evaluate Performance of Paint Bridge



Life of a Coating System



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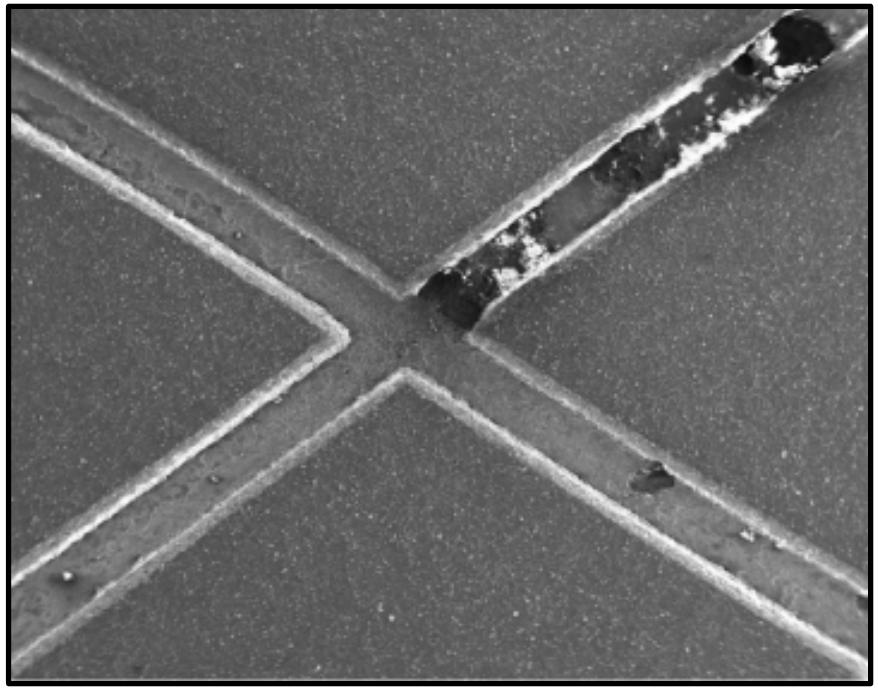
Laboratory vs. Outdoor Corrosion Mechanisms



ASTM B117 Salt Fog Test

Corrosion occurs as pits in the scribe

Outdoor Exposure Testing

Corrosion occurs under the coating, originating at edges and scribe

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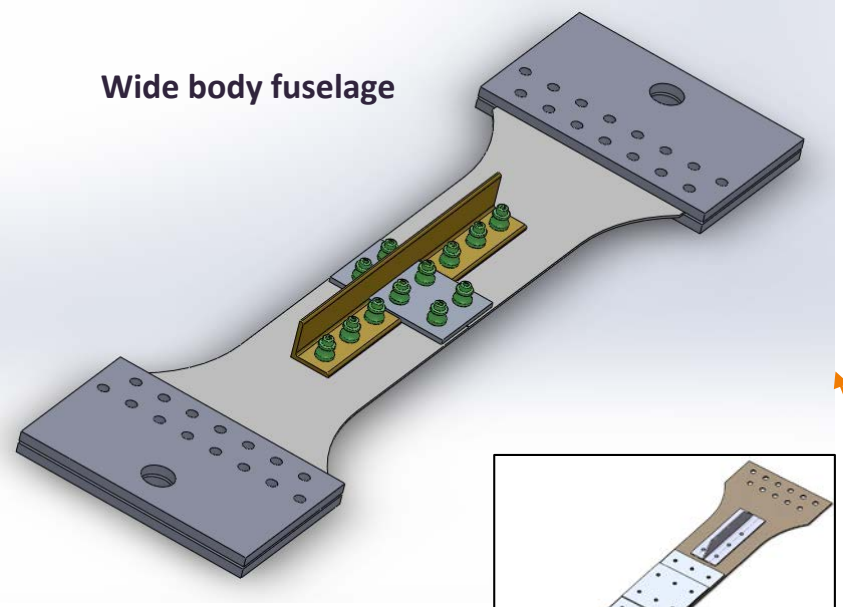
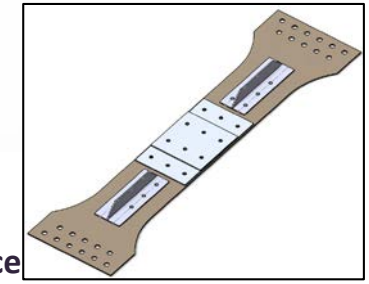
New Test Specimens





Fighter wing splice

Design of Experiments

- Skin alloys
- Stiffener alloys
- Splice plate alloys
- Fastener type
- Fastener alloy
- Corrosion protection scheme
- Loads
- Environments
- Maintenance procedures

Designed to exercise *corrosion protection schemes*

- Other specimen configurations are possible
- Potential for a “library” of generic configurations
- Test protocol to assess corrosion effects on realistic structural details in realistic environments

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AFRL 1st Generation Combined Effects Chamber

- SERDP Project WP-1674 “Dynamic Multivariate Accelerated Corrosion Test Protocol”
- Salt fog chamber with ozone and UV exposure
- Significant increase in aluminum corrosion

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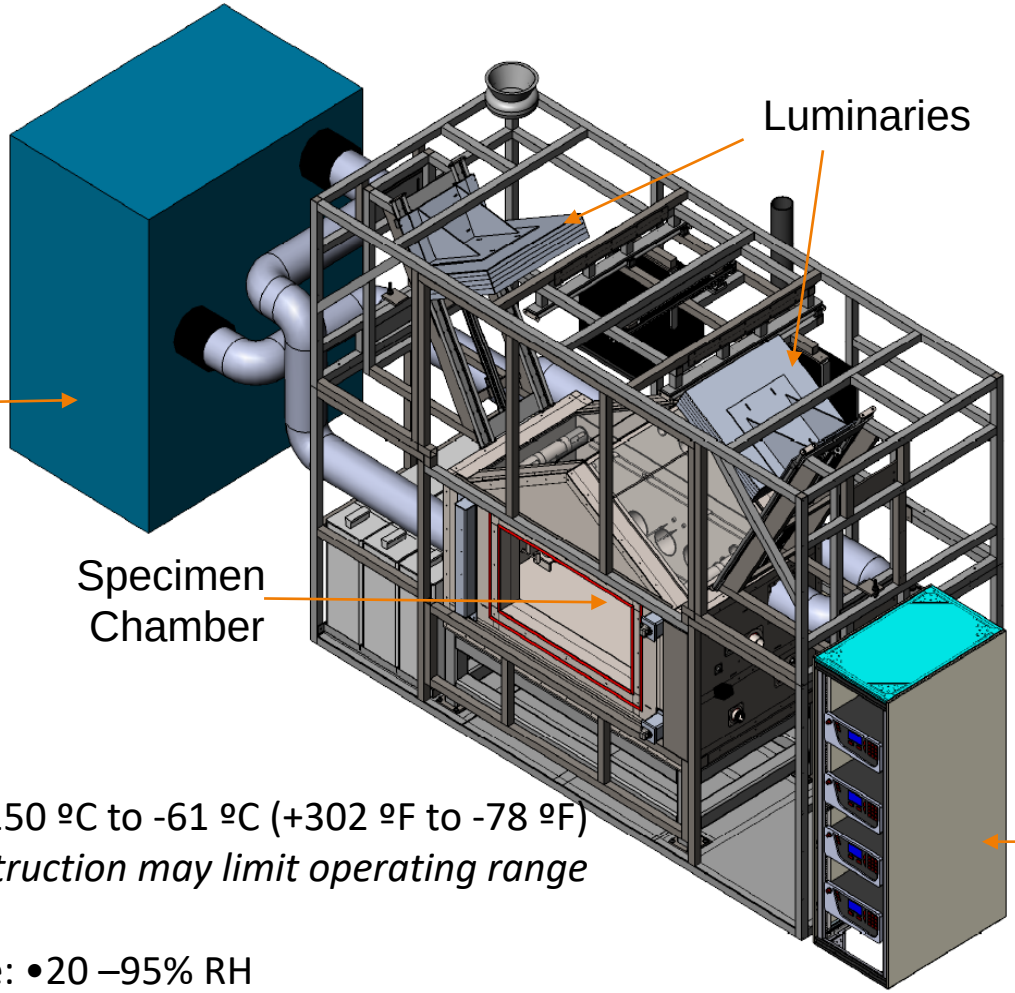
Accelerated Combined Effects Simulation (ACES) Test Apparatus



- Metal halide luminary system
  - UVB (290 –315 nm)
  - UVA (315 –400 nm)
  - Visible (400 –700 nm)

<u>Background gas analyzer</u>
Ozone
CO/CO_2
SO2
NO_x

- Temp range: +150 ºC to -61 ºC (+302 ºF to -78 ºF)

** Chamber construction may limit operating range*

- Humidity range: •20 –95% RH
- Limited by a 4°C dew point and 85°C max dry bulb
- 100% RH boosted by corrosion cabinet bubble towers

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Accelerated Combined Effects Simulation (ACES) Chamber

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Weather Instrumentation and Specialized Environmental Monitoring Platform (WISE-MP)

Purpose of the WISE-MP:

1) Validation of ACES: quantify environmental conditions at a specific location, recreate in ACES, compare
2) Measure environmental parameters and correlate to corrosivity of operating locations

1. Multi-functional gas monitor (O_3, NO_x, and SO_2)
2. Weather monitor
3. Particulate Chloride Monitor
4. Control Box
5. Support Frame and Sample Rack

Environmental Severity Assessment

- Current severity ranking per TO 1-1-691 only differentiates between mild, moderate, or severe
  - Based on a mass loss measurement averaged over a whole year
  - Must take into account diurnal and seasonal variations
- The interaction between the emerging coatings and the environments is critical
- The current state of the art is inadequate to properly manage corrosion maintenance and more accurate, real time data is needed

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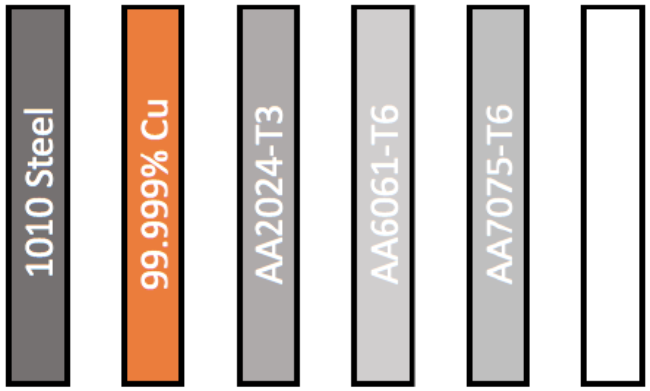
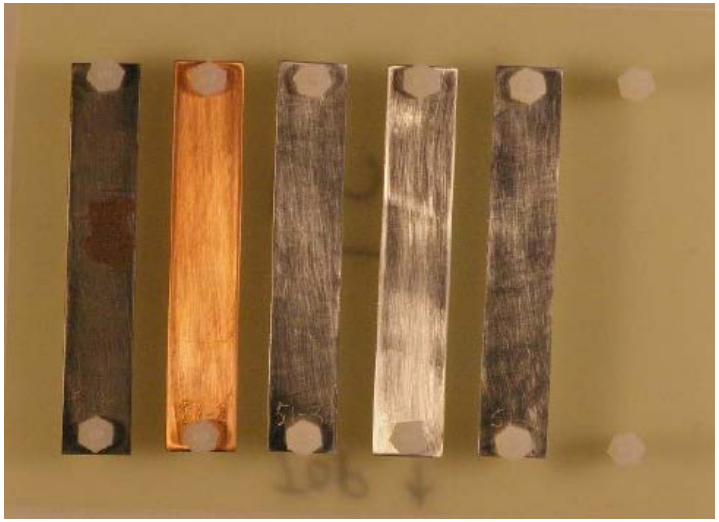
Environmental Severity Assessment

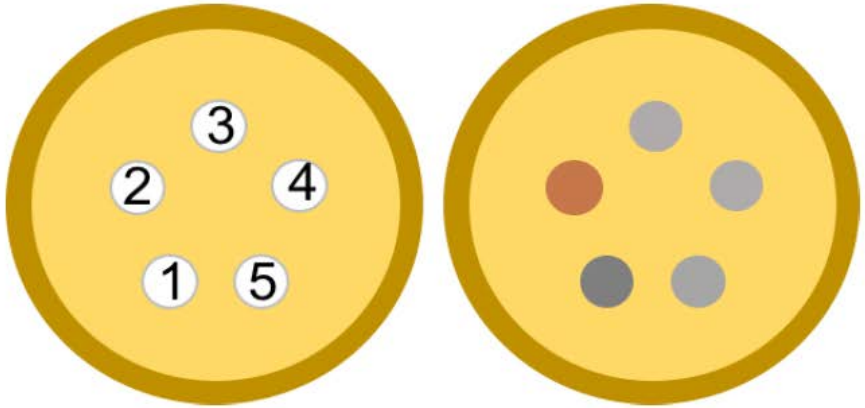
- Mass loss panels similar to those used to generate TO 1-1-691 Table 3.1
- Triplicate measurements will be used for each time interval





Environmental Severity Assessment

- Pitting morphology
- Corrosion product chemistry



Metal Classification	
1	AA2024
2	99.999 Copper
3	1010 Steel
4	AA7075
5	AA6061

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Environmental Severity Assessment

- Adirondack Analytics, Cumulative Corrosion Damage Methodology (AFRL/RX-funded)
  - Predict variable increments of damage based on:
    - Diurnal and seasonal temperature/humidity cycles
    - Atmospheric contaminant levels
- Corrosion Prognostics LLC, "Computational Corrosion Modeling for CBM+/Aircraft Environment Tracking" (SBIR Phase II)
  - Development of mechanistic aluminum pitting models based on surface wetness and ground-based station data

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Corrosion S&T - Summary

- AFRL Corrosion IPT mission focused on quick reaction engineering and corrosion technology R&D
- Develop accelerated test capabilities
- Environmental severity assessment

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