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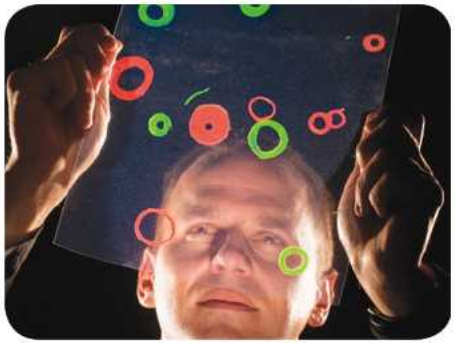

Arc Fault Risk Assessment and Degradation Model Development for Photovoltaic Connectors

Benjamin B. Yang, Kenneth M. Armijo, Richard K. Harrison, Jay Johnson, Jason M. Taylor, N. Robert Sorensen

U.S. DEPARTMENT OF ENERGY

National Nuclear Security Administration

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Project Goal and Findings

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Project Goal

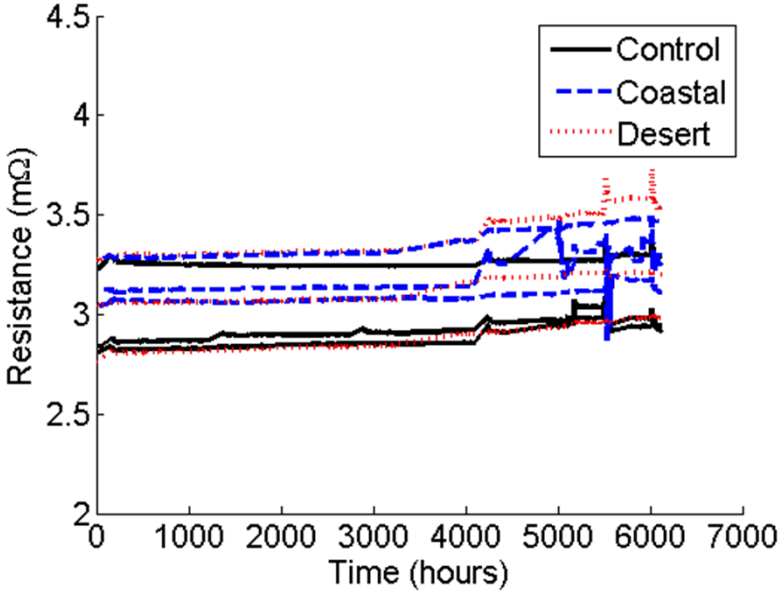
- Accelerated lab test of connectors
- Characterize connectors for arc fault risk

Primary Findings

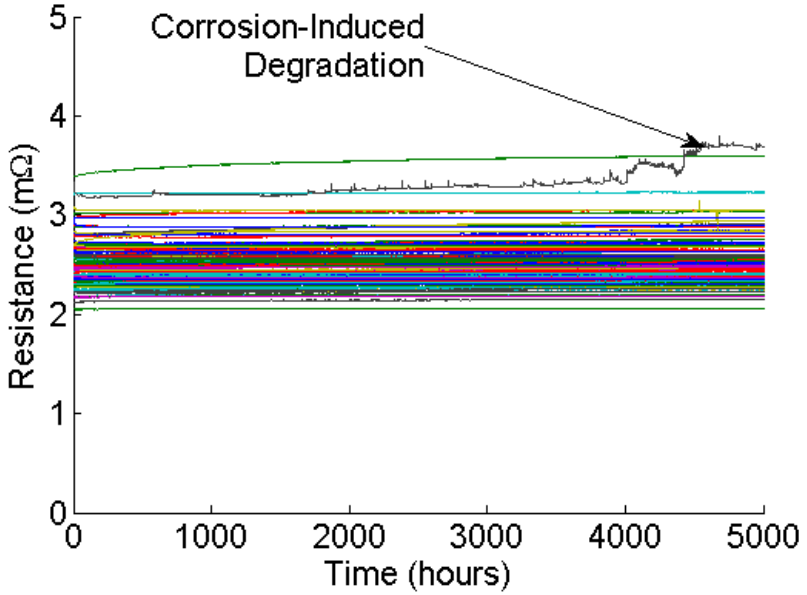
- BOS connectors are robust to corrosion.
- Arc fault risk of connectors depends on a combination of materials and connector design.

Connectors are Robust to Damp Heat and Corrosion

85°C/85% RH Damp Heat

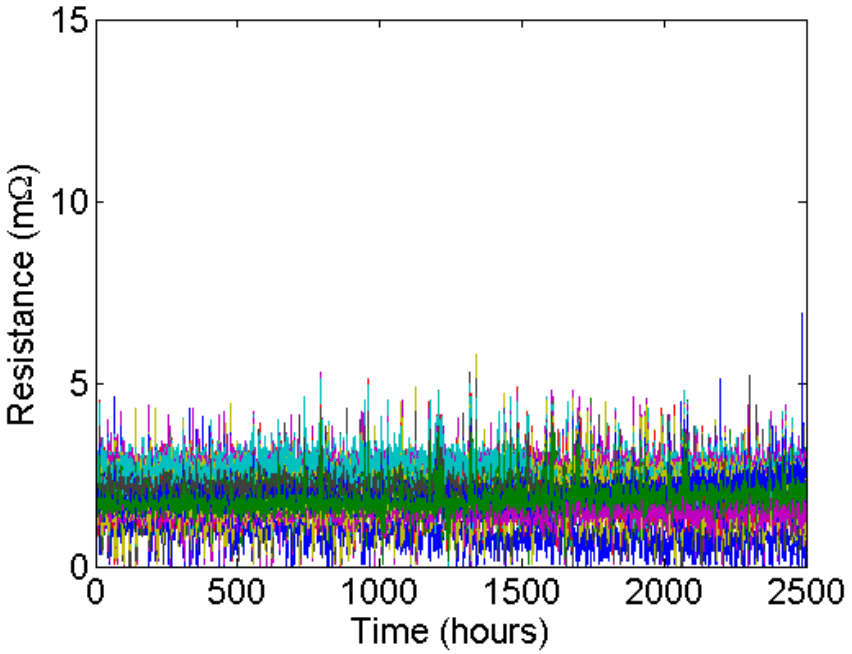


Class II Corrosion Chamber



- While some degradation was observed, connectors were overall robust to corrosion and damp heat.
- No discernable difference between control and coastal- or desert-simulating grime.

No Degradation Among Connectors Undergoing Over 2500 Hours of Outdoor Exposure



- No failures observed in 2500 hours of long-term passive outdoor exposure test involving 51 connectors.
- Design and fabrication of new outdoor test with added current stress in progress.

Arc Fault Testing Translates Degradation into Arc Fault Risk

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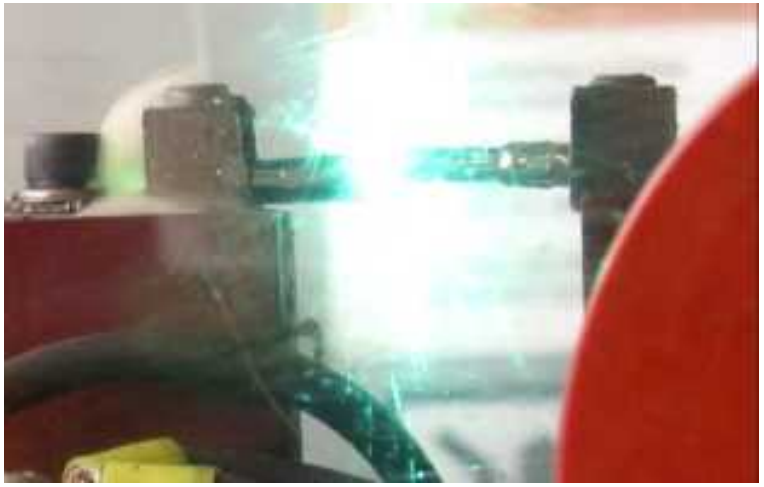
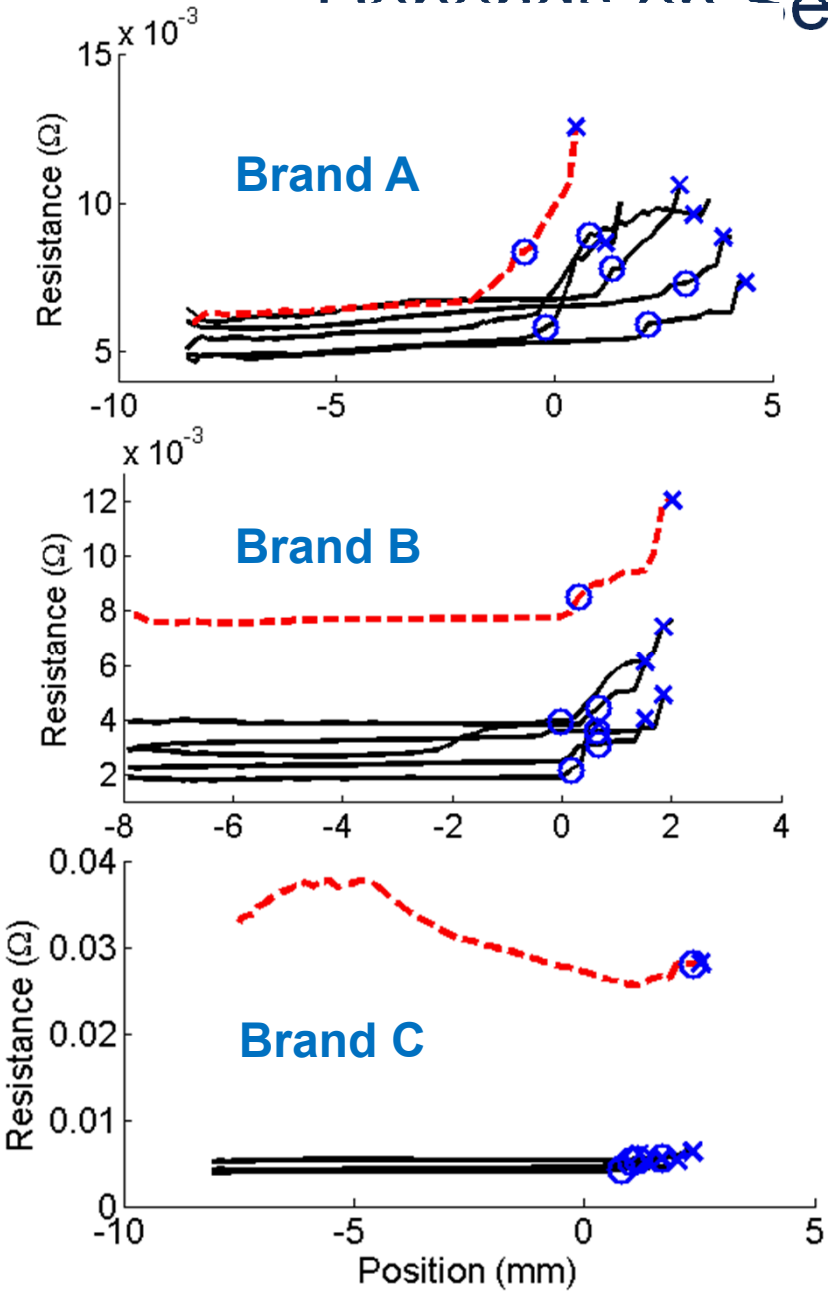
Connector separation distance necessary for arc ⟷ Resistance increase necessary for arc ⟷ Arc fault risk

- Connector separation distance prior to arc serves as a proxy for arc fault risk.
- Temperature can potentially be a method for arc fault prognostics.
- Arc fault spectrum can also be used as a material analysis tool.



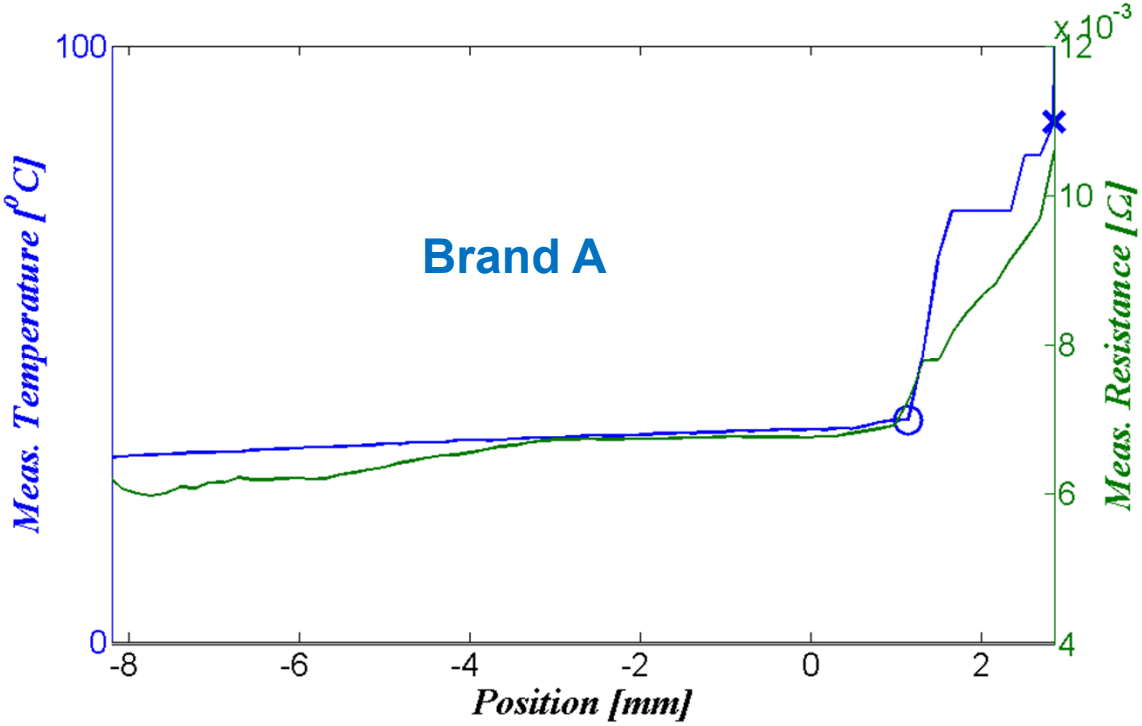
Effect of Corrosion On Arc Fault Risk Depends on Several Factors



Legend:
- : degraded connector
- : fresh connector
- o : First observed spark
- x : Sustained arc

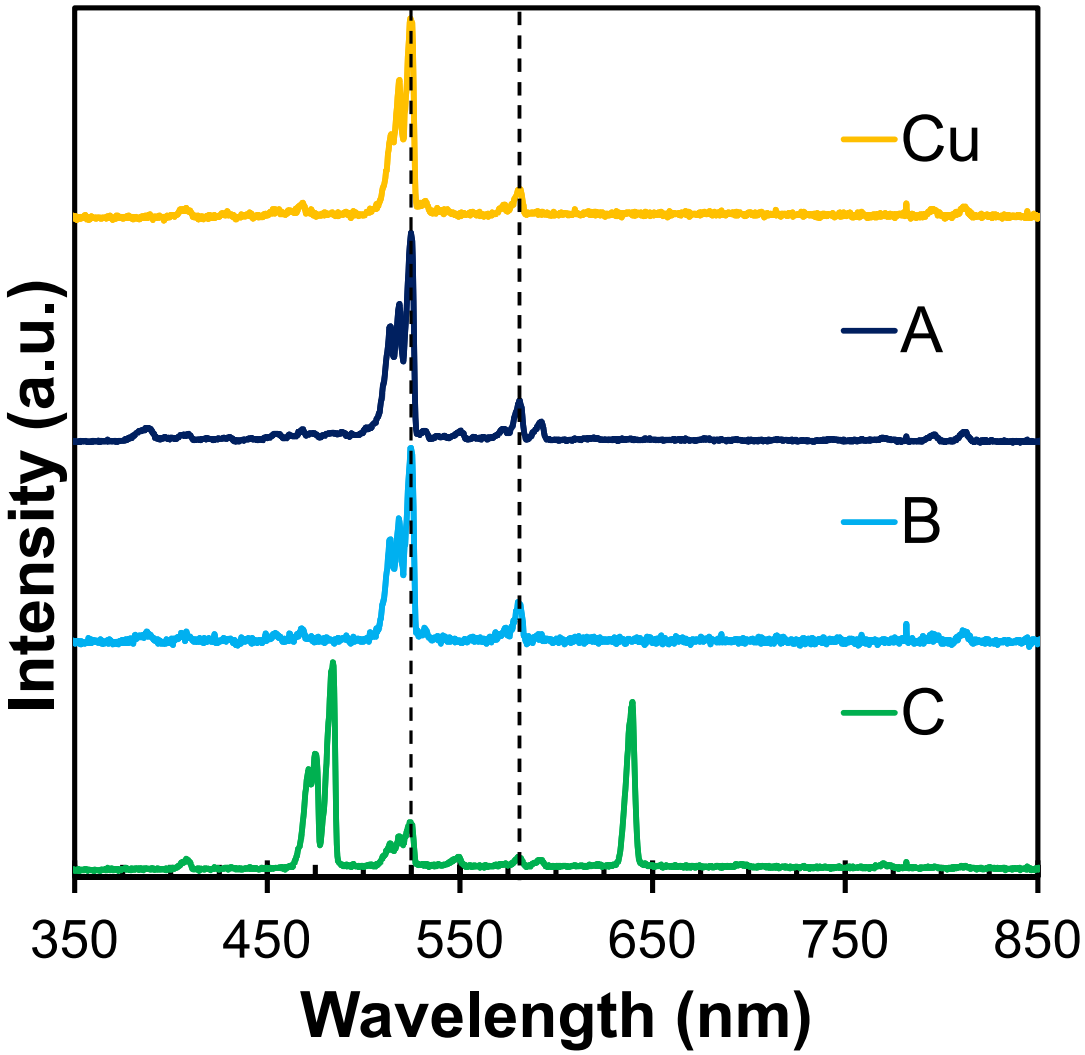
- Arc fault risk likely depends on materials and geometry:
  - **A:** Corrosion results in similar resistance but higher arc fault risk.
  - **B:** Corrosion results in higher resistance but minimal effect on arc fault risk.
  - **C:** Corrosion results in much higher resistance but lower arc fault risk.

Arc Fault Temperatures



- Temperature increases measurably between first spark and sustained arc.
- This phenomenon could be used for arc fault prognostic applications.

Arc Fault Spectra Can Provide Additional Useful Data



- Optical emission spectroscopy was used to evaluate the arc fault.
- Spectrum can identify connectors with similar composition (A and B) and those that don't (C).
- Can potentially measure material vs. depth and temperature.

Conclusions

- BOS connectors were found to be robust to corrosion-related accelerated tests.
- A procedure to evaluate arc fault risk of new and degraded connectors was established.
- BPS connector arc fault risk is likely dependent on several factors, such as composition and structure.
- Temperature and emission spectrum analysis can reveal additional information about the underlying degradation and arc fault processes.