Thermal Spray Aluminum for Aluminum Corrosion Prevention

Ship Design and Materials Technologies
Panel Meeting

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Problem:

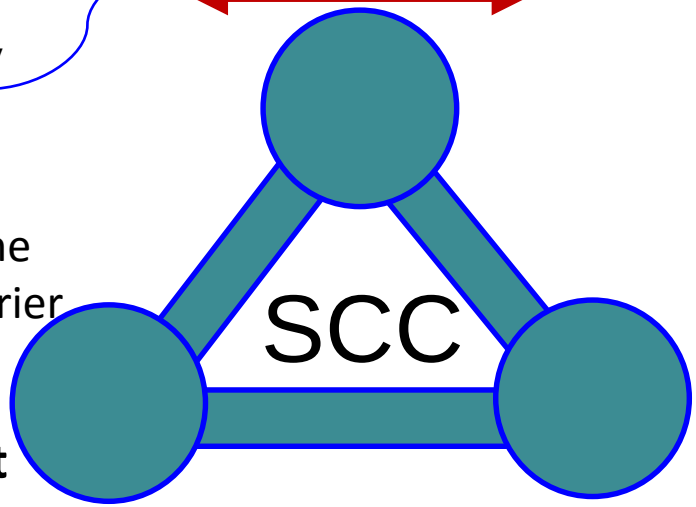
- Aluminum is part of the Navy's $3B ship corrosion problem
  - Mg-Al 5000 series (5086, 5083, 5059, 5456) alloys will sensitize over time, which becomes exfoliation or worse, stress corrosion cracking (SCC)
- Sensitization and SCC are already a huge repair problems on CG 47 superstructure, and are already emerging on LCS
- 50% of USN ships under contract or construction use aluminum significantly – LCS, LHA, JHSV, SSC, CVN
  - It's not limited to an in-service repair problem
- Aside from Low Solar Absorption (LSA) paint, there is **no preventative treatment** for 5xxx alloys short of replacement!

Sensitization and SCC- A Materials Problem

Sensitization: Mg_2Al_3 'β phase' forms at higher temp and migrates to grain boundary

Residual stress from forming or welding, or applied stress (e.g. ship motion in a seaway)- very difficult to avoid

Tensile Stress At Surface



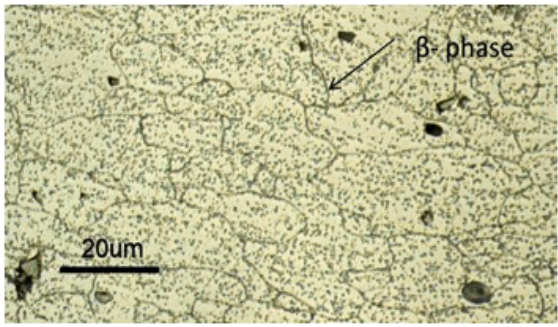
Painted aluminum alone is NOT an effective barrier

Corrosive Environment

Objective: Break one or more legs of the triangle to avoid SCC

Even strain-hardened tempers H116 and H321 will form β phase after years of exposure at in-service temperatures <150F

Susceptible Material



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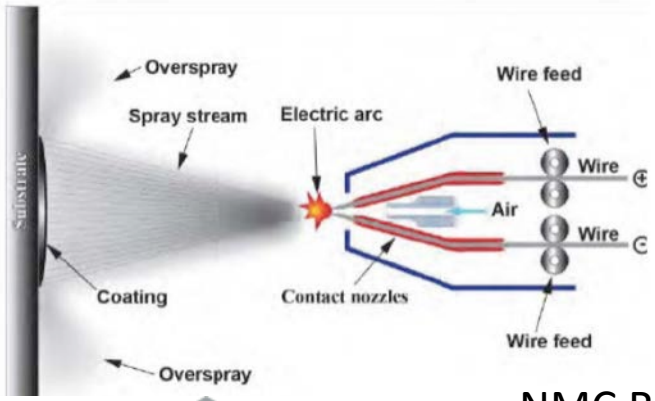
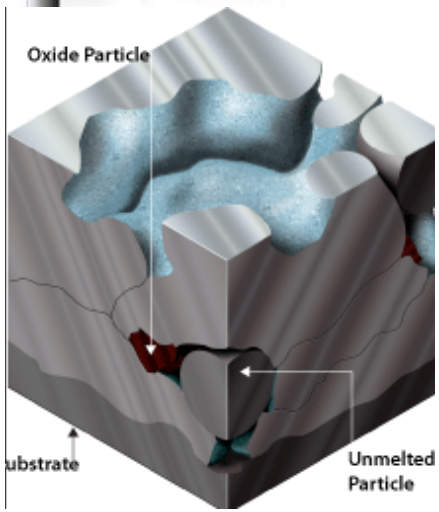
Electric Arc Thermal Spray



- Two wires are melted in arc, and propelled onto surface by compressed air
- Particles 'pancake' onto surface, solidify, and contract
- Subsequent passes build additional thickness at ~90% densification, 10% voids, typ. to 0.010 inch thickness
- A mature, fairly cheap and quick* metallic coating, but voids are a concern

*NSRP NASSCO/DTRC "Procedure Handbook for Shipboard Thermal Sprayed Coating Applications" 3/92



<u>NMC R2519 Rapid Response project</u>

- For CVN application, Thermal Sprayed Commercially Pure (CP) aluminum was applied to sensitized Al substrate
- Worst case: NO paint was applied
- While untreated samples failed, Thermal Spray passed both 1000 hour scribed, acidified salt fog test (no indications) and 6 month SCC U-bend tests (no failures)

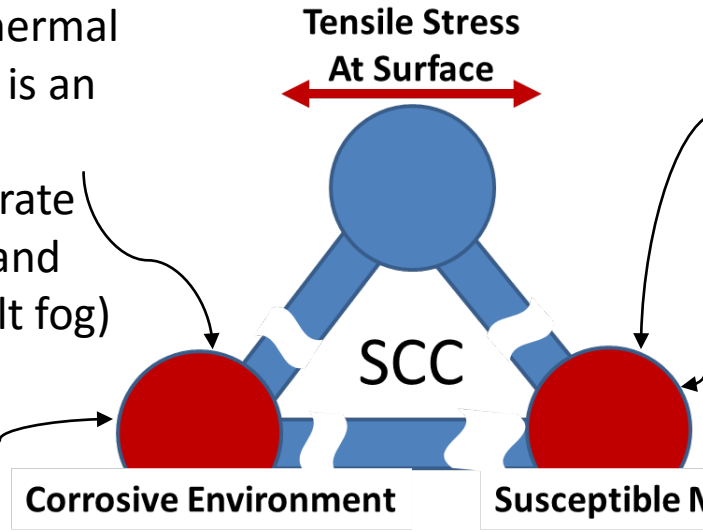
-Voids are STILL a concern for 35 yr life

Concurrent Technologies Corporation

Thermal Spray + Paint Can Work – As a System

Even without paint, Thermal Sprayed CP Aluminum is an effective barrier to environment for substrate (R2519, 6 month SCC and 1000 hour acidified salt fog)

WITH paint, the combination should provide an extremely durable composite environmental barrier



With no magnesium in the alloy, CP Aluminum coating is NOT SUSCEPTIBLE to sensitization

Combined with an LSA paint, this will also preclude further sensitization of the substrate

Questions to be answered

- What is the targeted treatment area size and configuration?
- Among Electric Arc Thermal Spray, HVOF, or Cold Spray- which is most appropriate for the targeted treatment area?
- What is the bond strength of Thermal Spray Aluminum + Paint on Aluminum plate substrate?
- Is thermal spray coating a suitable substrate for non-skid?
- Is CP aluminum the ideal substrate- or are there others (perhaps anodic to surface) which could perform better?
- The combination of paint + Thermal Spray essentially creates a composite coating layer. What types of material performs best here?
- Combined with Ultrasonic Impact Treatment (UIT)- or in lieu of UIT?
- What is the minimum thermal spray thickness required? What is the maximum?
- How sensitive is this system to surface preparation and environment during application?
- What are the cost and weight impacts?
- What else not included on this list?

Questions and Comments?

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