

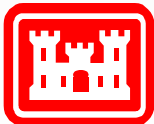
Novel Corrosion Control Coating Utilizing Carbon Nanotechnology

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US Army Corps
of Engineers

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Construction Engineering Research Laboratory

Report Documentation Page

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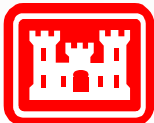
R&D Goal

Develop best available & user-friendly coating systems for protecting steel infrastructure from corrosion:

System #1 3-Coat system \geq best 3-coat Zn rich system

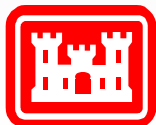
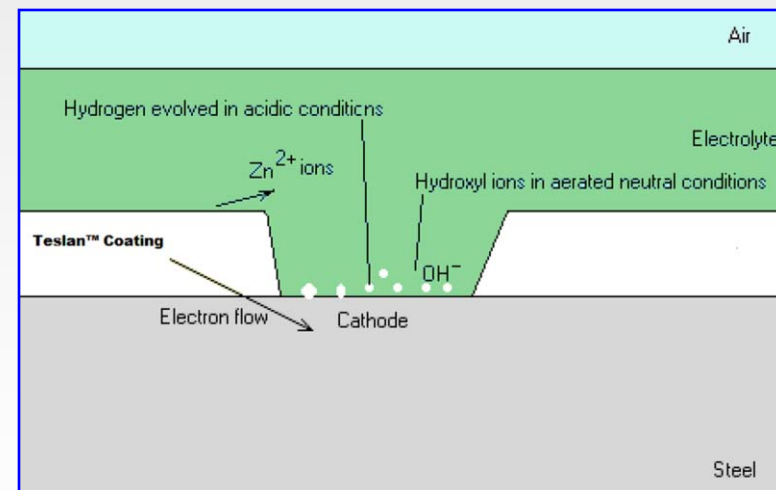
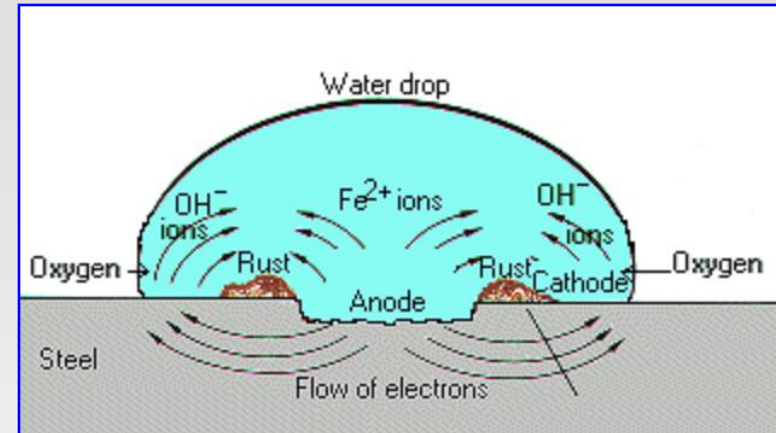
System #2 2-Coat system = best 3-coat Zn rich system

System #3 1-Coat DTM $>$ best 1-Coat DTM alternative



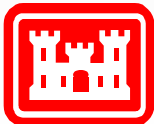
Novel Epoxy Paint System

- 3-Coat Epoxy Paint System
 - Epoxy primer formulated with
 - Zinc dust
 - Single Wall Carbon Nanotubes (SWNT)
 - Epoxy Intermediate Coat
 - Polyurethane topcoat
- Dual barrier coating and cathodic coating protection for steel
- Shifts the potential to cathodic potential in the event of a coating defect
- Aluminum can be used in place of the zinc



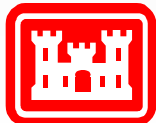
Dual Purpose Technology

- First, produce the toughest most resilient barrier coating
- Second, shift the potential of the environment to a less corrosive cathodic potential
- Outperforms barrier coating only technology



Function of Single Wall Carbon Nanotubes (SWNT)

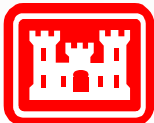
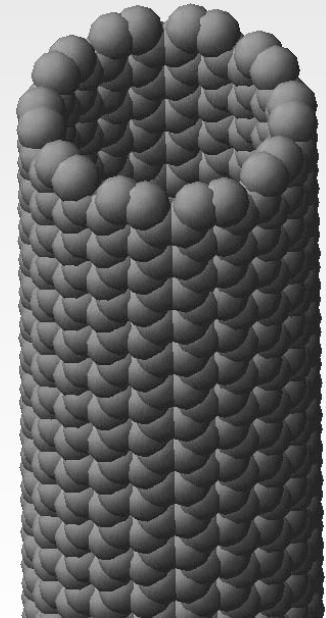
- Produce galvanic reactivity of the substrate
- Facilitate electron transfer through the binder
- Reinforce / Toughen Binder



How ?

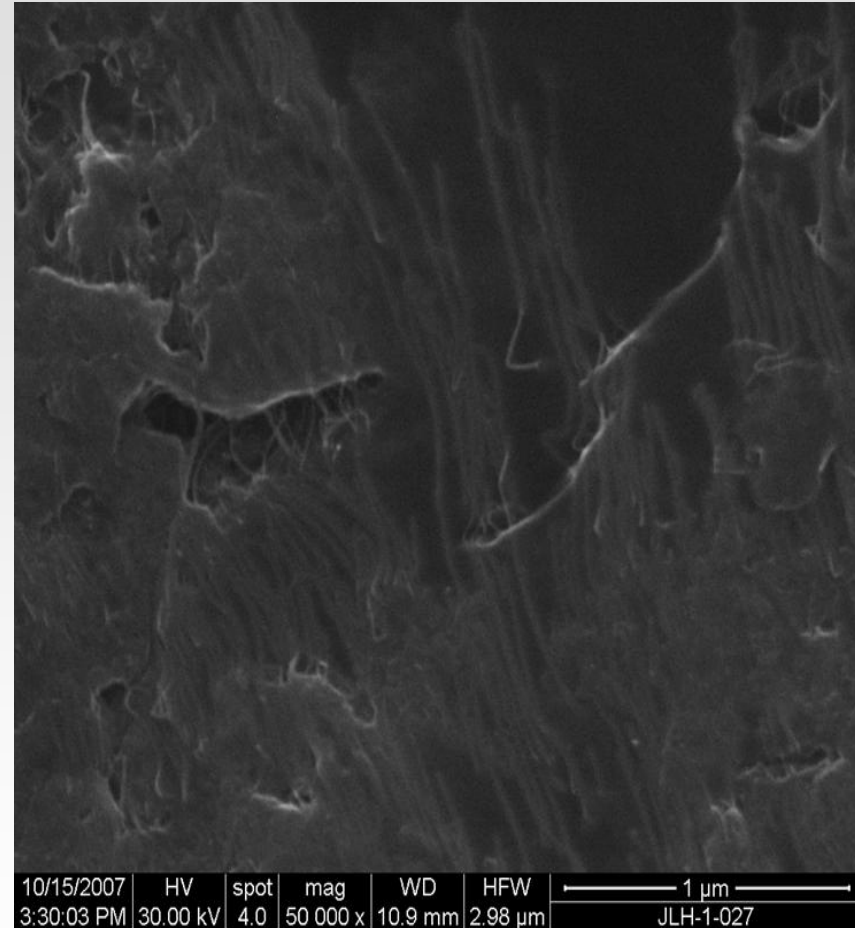
- Pioneered by Nobel Laureate Richard Smalley
- Structure
 - electrical
 - mechanical properties
- Current-carrying capacity
 - 1,000x greater than copper
- Tensile strength
 - 50x greater than steel

Single Walled
Carbon Nanotube

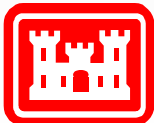


Barrier / Electrical Properties

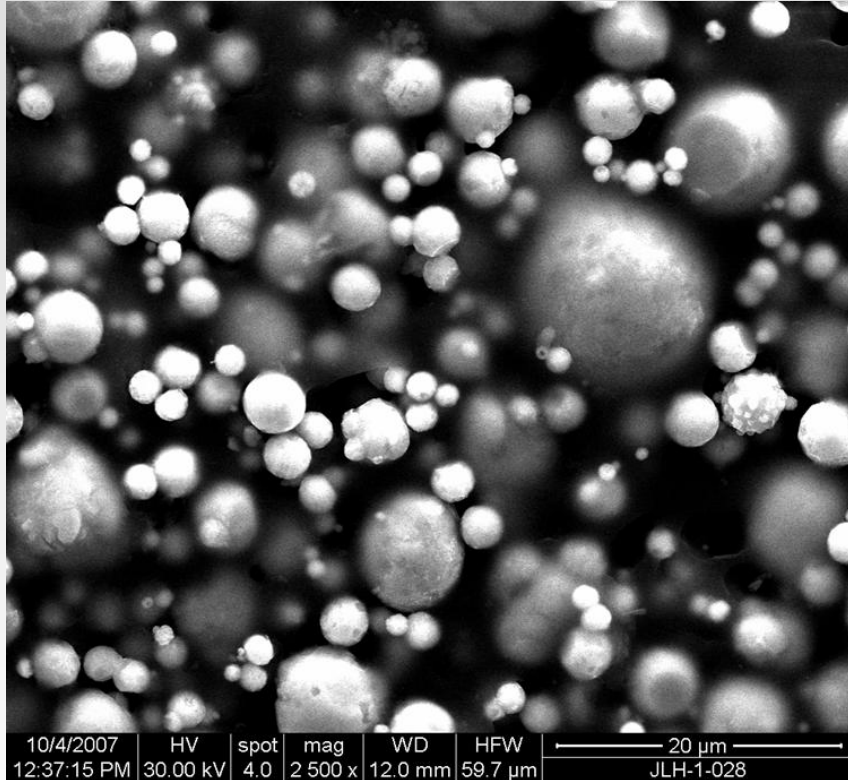
- Carbon Nanotube Ropes
 - strength of the carbon-carbon bonds builds an extended network of Carbon Nanotube Ropes
- Reinforce / Stiffen / Toughen
- Electron Path
 - through the binder
 - between the cathodic substrate and anodic sacrificial metals



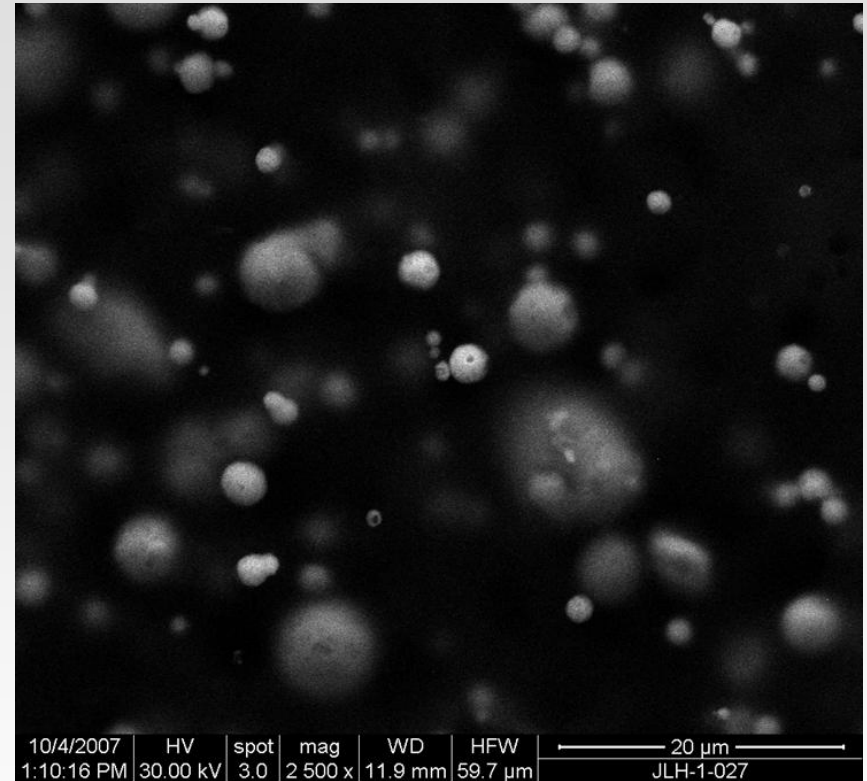
SEM Micrographs courtesy of Unidym, Inc., Houston, Texas



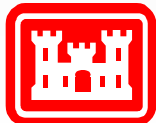
Barrier Properties



Traditional Zinc-Rich Primer



TESLAN™ Primer



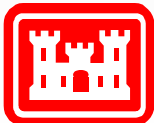
Lower Pigment Loading = Better Adhesion & Stronger Film

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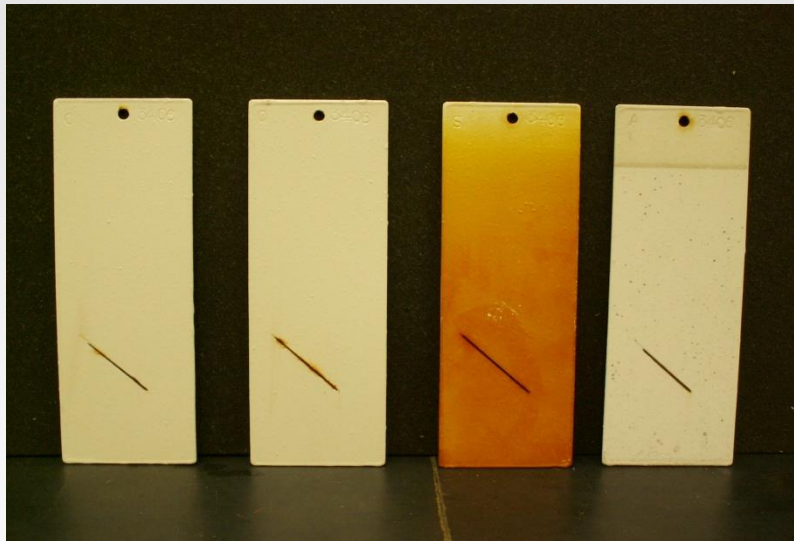
Corrosion Testing

- Outdoor exposure and weathering - ASTM D1014
- Fresh water immersion testing - ASTM D870
- Salt water immersion testing – ASTM D870

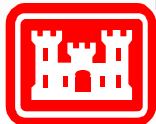


3-coat Epoxy System

- Graded “10” of “10” after 3-
years of testing (25,000+ hours)
 - No undercutting
 - evaluation criterion in accordance with ASTM D1654

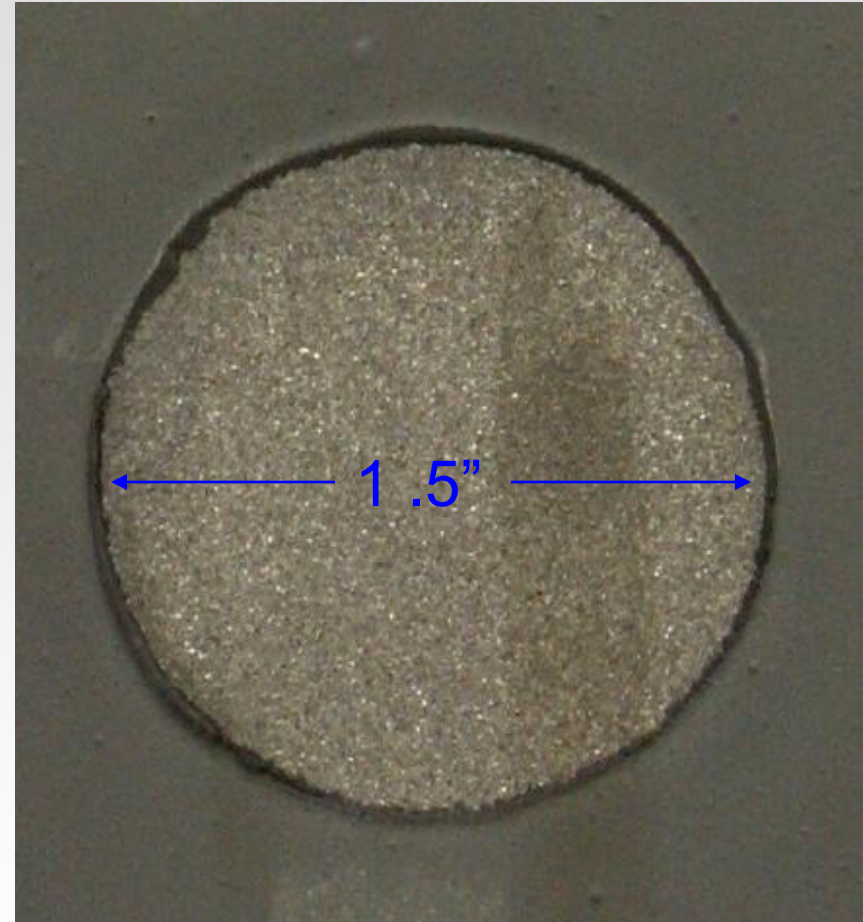


Fresh Water Salt Water Outdoor

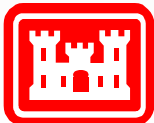


Epoxy Primer

- **Bullet-Hole Testing** iaw AASHTO M-300
 - White metal blasted 1 ½ - inch diameter
 - Immersed in 5% Salt Water Solution
 - Demonstrates Cathodic Potential
 - Cathodic Throwing Power



500+ Hours

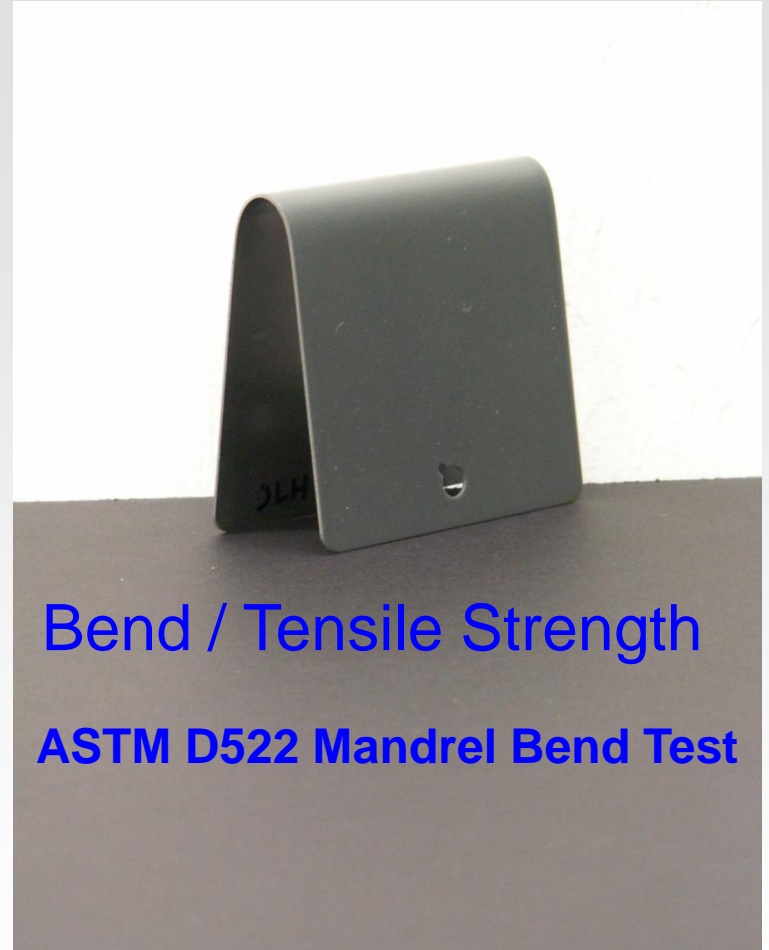


Durability

Impact Resistance



ASTM G14 Falling Weight



Bend / Tensile Strength

ASTM D522 Mandrel Bend Test



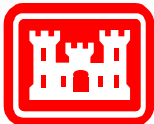
Benefits

- Improved integrity of barrier films due to
 - lower pigment loading
 - SWNT reinforcement
- Improved durability and modulus under stress; impact, abrasion and flexing
- Cathodic corrosion protection in the event of a coating defect



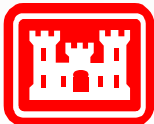
Benefits (cont.)

- More resistant to heat and UV
- Weight reduction via
 - lower metal content
 - reduced film thickness
- Better aesthetics, color and gloss with lower loadings and ability to pigment
- Less vulnerable to pore, coating break, and other coating defects
- Less susceptible to poor adhesion due to inadequate surface preparation



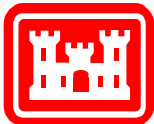
Benefits (cont.)

- 3- coat performance with a 2-coats
 - Structural integrity with lower metal loading
 - Eliminate intermediate coat build
 - Compatibility with high performance topcoat
- Reduction of film thickness
- Potential of single coat direct to metal system outperforming traditional 2 and 3 coat systems
- Longer service life
- Lower overall costs



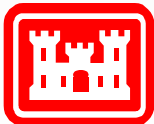
Environmental Benefits

- Lower zinc and associated lead levels (approximately 50% reduction) with zinc system
- Total elimination of heavy metals using the aluminum system
- Easy to formulate high-solids coating systems
- Longer service life and waste reduction



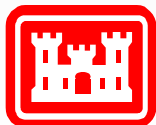
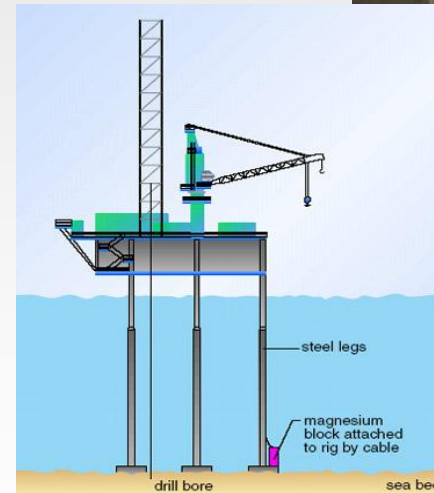
Application Methods

- All conventional wet coating methods
 - Spraying
 - Brushing
 - Rolling
 - Coil coating
- Powder Coating (under development)



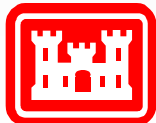
Fields of Use

- Aerospace and Defense
 - Marine coatings
 - Lightweight performance coatings
 - Zinc-chromate alternative
 - Plating alternative
 - Steel hardware & structures
- Petrochemical Industry
 - Offshore rigs
 - Oil tankers
 - Pipelines / transmission lines
 - Drilling / refinery / plant maintenance coatings
- Locks & Dams



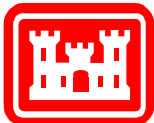
Current Project

- Title: *“Inherently Conductive Additives for Reducing the Zinc Dust Content In Corrosion–Inhibiting Primers for Steel”*
- 3-Coat epoxy/polyurethane system applied December 2008 to a fuel tank at Ft. Bragg, NC
- Corrosion coupon test rack in place
- Coating and coupons will be monitored for 2 years +



Project Outcomes

- DOD Specification & Standard Development
- Implementation Army – wide
- Expand to other services

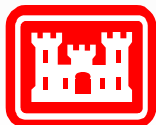
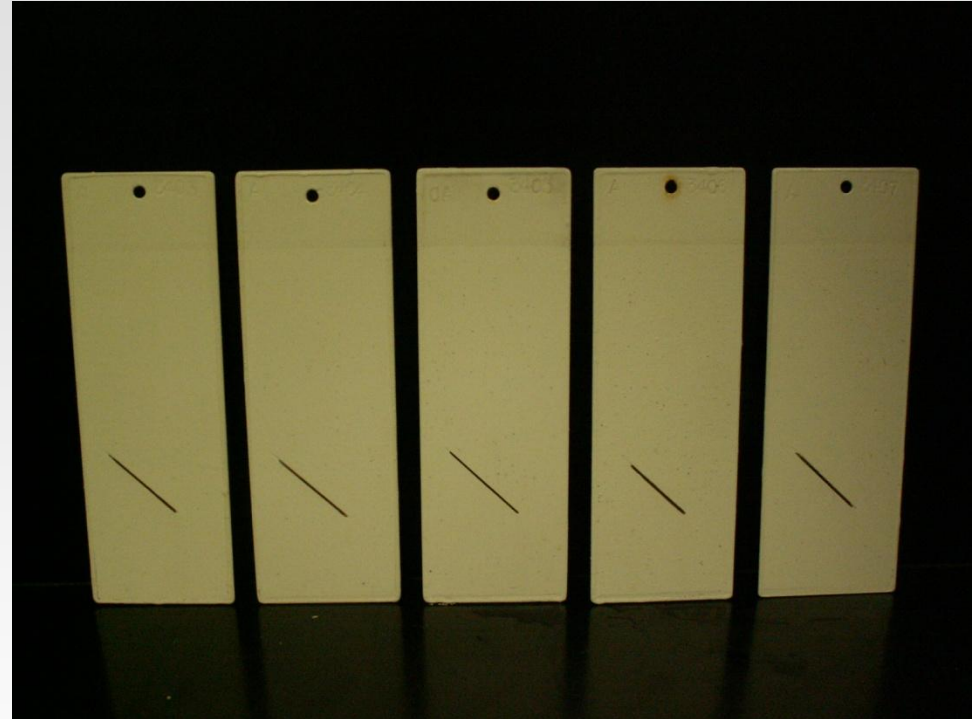


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Conclusion

- INNOVATIVE EPOXY/POLYURETHANE SYSTEM USING SWNT UNDER EVALUATION
- Characteristics
 - Toughness & durability
 - Corrosion protection
- Benefits vs. traditional system
 - Lower metal content
 - Lower pigment loading
 - Lower weight



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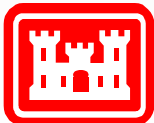
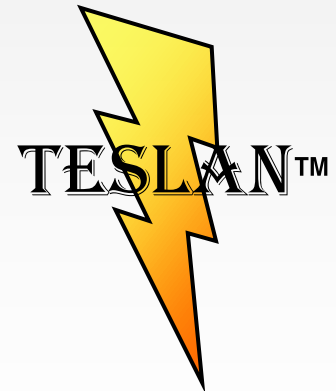
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