Thermal Spray Coating
for Corrosion Protection

What You Need To Know

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PRESENTATION TOPICS

• Corrosion Basics
• Thermal Spray Coating-What It Is & What It Does
• Advantages & Disadvantages
• Basics for Good Application
• Steel Bridge Metallizing Case Studies
• Metallizing of Concrete Substructures
CORROSION BASICS
“The destruction of a material by chemical or more specifically, electrochemical reaction with its environment.”

FOR OUR PURPOSES:
The destruction of steel resulting in the formation of rust
NATURAL CYCLE OF CORROSION

Iron Ore

Blast Furnace

Exposure

Steel (Iron) Plate

Corrosion/Rust

THERMAL SPRAY COATING FOR CORROSION PROTECTION
FOUR CONDITIONS NECESSARY FOR CORROSION (ACME)

- Anode
- Cathode
- Metallic Pathway
- Electrolyte
COATINGS DECISIONS BASED ON CORROSION CYCLE

% Corrosion

- >20%
- 6-10%
- 3-5%

Time

Complete Replacement
Repair w/Overcoat
Touch-up / Spot
METHODS OF PROTECTION
METHODS OF PROTECTION

• PROTECTIVE COATINGS
  • Conventional Liquid Coatings:
    • Barrier
    • Inhibitive
    • Sacrificial

• CATHODIC PROTECTION
  • Impressed Current
  • Sacrificial Galvanic

• ALTERNATIVE MATERIALS
  • Alloys (Stainless Steel, Brass)
  • Composites
  • Aluminum
HOW PROTECTIVE COATINGS WORK

• Barrier Coatings
  • Most liquid coatings work this way. They provide a semi-permeable barrier to air and moisture that provides a barrier to environmental exposure.

• Inhibitive Coatings
  • Some coatings passivate the steel to prevent corrosion.
  • Conversion coatings (phosphoric acid and chromate washes) and calcium sulfonates work this way.

• Galvanic (Sacrificial) Coatings
  • Coatings give off electrons and sacrifice themselves for the substrate. Zinc and lead based coatings work this way.
Galvanizing works primarily as a sacrificial coating. As it does its job, the zinc coating gives up electrons which react with the environment leaving the characteristic white powder, which is actually zinc salts.

Galvanizing also works as a barrier coating.
WEATHERING STEEL

• Weathering steel is actually steel which is specially formulated to corrode SLOWLY. In ideal situations this corrosion is imperceptible, however it forms a protective “patina”.

• In environments where weathering steel is subject to frequent wetting, it will corrode quickly. In applications like Interstate overpasses, this frequent wetting and chlorides will accelerate corrosion, ultimately leading to section loss, and premature failure.
Metallizing is the application of molten metal to a prepared steel surface for the purposes of cathodic corrosion protection. It is a sacrificial galvanic coating.

Metallizing is also used as a form of cathodic protection on concrete structures, when connected to the reinforcing steel.
• Unlike most organic liquid coating systems, which primarily provide barrier protection; metallizing provides corrosion protection through sacrificial galvanic action. Metallizing provides protection to the steel, and will act as a sacrificial anode, similar to that in a water heater or outboard motor.

• Galvanizing utilizes the same primary corrosion protection mechanism. Unlike galvanizing, metallizing is porous in nature, and should be sealed to provide maximum service life.
METALLIZING – HOW IT IS APPLIED

• During metallizing operations, a wire is fed through a gun which melts the wire and propels it onto the surface utilizing compressed air.

• Metallizing can be applied by flame spray or electric arc methods.

• The most common Metallizing wires consist of either pure Zinc (Zn), pure Aluminum (Al) or a 85/15 Zn/Al mix.

• The use of 85/15 Zn/Al is most common due to it’s workability and higher adhesion capabilities than pure zinc.
METALLIZING – HOW IT IS APPLIED

THERMAL SPRAY COATING FOR CORROSION PROTECTION

Arc-spray system

Flame spray system

Powder spray system
METALLIZING – HOW IT IS APPLIED

ARC–SPRAY SYSTEM

Principle of wire arc spraying according to DIN EN 657
METALLIZING – HOW IT IS APPLIED

Typical Metallizing Operation
ADVANTAGES OF METALLIZING

• Long Service Life
  o Some applications have been in service 50+ years.

• Superior Life Cycle Cost
  o Due to the long service life and reduced interim maintenance.

• Cold Weather Friendly
  o Unlike most coating systems, metallizing can be applied at any temperature.

• No curing period
  o Metallizing does not require any time to cure or recoat, allowing the entire thickness to be placed in a single work shift.
DISADVANTAGES OF METALLIZING

- Higher initial cost.
- Requires higher degree of surface preparation.
- Requires removal of flame hardening and other surface defects for good success.
- Less user friendly and requires highly trained and experienced operators.
- Requires a sealer for maximum performance.
- May incorporate the use of an aesthetic overcoat.
- May be affected by some liquid deicing compounds.
BASICS FOR GOOD APPLICATION
SURFACE PREPARATION

• SURFACE PREPARATION – SSPC-SP5, “White Metal Blast”

• CHLORIDES - Remediate to less than 5 μg/cm²

• SURFACE PROFILE - 2.5 to 4.5 mils

• ABRASIVE - Use expendable abrasive to avoid peening, and produce a sharp, angular profile

• FLAME CUT EDGES - Remove flame hardening through grinding prior to abrasive blasting
THERMAL SPRAY APPLICATION

- **APPLICATORS** - Use trained & experienced operators. Consider daily bend tests. Standoff distance and angle of application are critical.

- **APPLICATION** - Should be made as soon after blast as possible to avoid flash rusting and/or rustback.

- **BUILD** - Apply full 8 to 12 mils in a single shift to avoid intercoat cleanliness & adhesion problems. Apply in multiple passes of 2 mils each.

- **ADHESION** - Should be a minimum of 700 psi for 85/15 Zinc/Aluminum metallizing.
SEALER APPLICATION

• USE - Sealer should be applied to 100% of the metallized area.

• THICKNESS - Sealer is meant to fill voids in metallizing, and not intended as a barrier coat. Application thickness 0.5 to 1.5 mils.

• TIME - Sealer should be applied within 8 hours of thermal spray application to ensure good penetration into metallizing.
STEEL BRIDGE METALLIZING CASE STUDIES
CASE STUDY NO. 1

Cleaning and metallizing of the Rainbow Bridge, Niagara Falls, NY
• The project involved complete coatings removal and metallizing of the Rainbow Bridge, crossing the Niagara River Gorge from Niagara Falls, US to Niagara Falls, Canada.

• Tourism and pedestrian use dictated coatings work to progress during winter months.

• Aesthetic moisture cure polyurethane (MCU) overcoat applied due to highly visible nature of the structure.

• Specified 85/15 ZN/AL metallizing, at 8 to 12 mils thickness.

• SSPC-SP5, “White Metal Blast” was specified - expendable abrasive was required.

• Chloride remediation was 5 µg/cm².

• Metallizing was applied in a single shift.

• An MCU Sealer was specified, and applied within 8 hours of metallizing application.

• Minimum adhesion allowed was 700 psi.
IN SERVICE PERFORMANCE

- Metallizing is performing as well as anticipated after a 15 year evaluation.
- Problem areas were limited to isolated areas of deck/joint leakage.
- MCU overcoat may be needed in visible areas.
• Metallizing can be cost effective (life cycle cost) in large applications, when properly performed.

• MCU sealers and overcoats work well.

• Metallizing was successfully applied in winter months under the appropriate conditions.

• Access to properly trained and qualified metallizing applicators is key.
CASE STUDY NO. 2

Rehabilitation and Recoating of the Stickney Point Bridge, Sarasota, FL

THERMAL SPRAY COATING FOR CORROSION PROTECTION
THE PROJECT

• Project involved rehabilitation, steel repair and recoating of Stickney Point Bridge (SR 72), the main route into Siesta Key.

• Adjacent residences and tourism drove project schedule.

• Metallizing chosen to prolong coating life and maximize time to future repainting.

• First metallizing project on FL’s West Coast.
COATING SELECTION CRITERIA

• Metallizing:
  • 50+ Years of corrosion protection
  • Advances in portable metallizing equipment
  • Decrease in future maintenance painting projects
  • Ability to blast, metallize and seal in one shift
  • Less restrictive ambient condition requirements
• Specifications Utilized:
  • Florida DOT, Section 561, “Coating Existing Structural Steel”
  • SSPC-CS 23.00/AWS C.2.23/NACE No. 12, “Application of Thermal Spray Coatings (Metallizing) of Aluminum, Zinc, and Their Alloys and Composites for the Corrosion Protection of Structural Steel.”

Note: TSP referenced CS-23 in its entirety, and only discussed those items that changed from joint standard.
SPECIFICATION ISSUES

• Key Requirements/Issues
  • Soluble salts
  • Edges, connections, fasteners
  • Blasting, metallizing, sealing and adhesion testing must be done in one shift
  • Caulking
  • Anchor profile
  • Clear coat – after repairs, degradable dye
  • Dry film thickness measurements – SSPC PA-2
  • Removing hardened surfaces
REQUIREMENTS FOR GOOD METALLIZING

• NACE No. 1 / SSPC-SP5, “White Metal Blast”
• Deeper Anchor Profile – Minimum 2.5 mils
• Contractor / Applicator Pre-Qualifications
• Adhesion Testing – ASTM D4541
• Flexibility – Mandrel Testing
• 8-12 Mils DFT, Multiple Passes, 3’ x 3’ Work Area
• Distance from the Substrate

THERMAL SPRAY COATING FOR CORROSION PROTECTION
LESSONS LEARNED

- Not recommended for incentive/disincentive contracts, as changes are under restraint.
- Flame cut edges were an issue, even though addressed in Section 561.
  - Need to specifically identify in future.
- Limited number of contractors in FL became a potential issue when metallizer was removed by FDOT.
- Areas with limited access where metallizing may not be practical need to be identified and addressed in the contract.
METALLIZING OF CONCRETE SUBSTRUCTURES
In other areas of the country, metallizing is used as a form of passive Cathodic Protection (CP) for concrete structures.

Florida DOT uses this process extensively for their numerous coastal substructures. These methods may be applicable in LA.

Acknowledgement goes to Ivan Lasa, of FDOT Corrosion Research Laboratory for the use of the following slides:
• A thermal sprayed zinc anode applied can be used for steel or concrete.
• Provides corrosion protection on steel surfaces and corrosion control (CP) on concrete.
• Zinc, aluminum, 85/15 alloy is the most commonly used.
TYPICAL CORROSION OF REINFORCED CONCRETE
• Why Cathodic Protection?
  o Good patches promote accelerated corrosion in the concrete surrounding the patch and new spalls develop in a few years.
  o Corrosion develops around the repair due to the characteristic change of the repaired rebar.
HOW IT WORKS

• Direct Connection
  • An electrical circuit is established such that current flows from the external metallizing to the rebar.
SACRIFICIAL CATHODIC PROTECTION

• Arc-Sprayed Metallizing
  - Requires an electrical connection to the steel reinforcement, but can be used without concrete restoration by application directly to the steel reinforcement.
CHANNEL FIVE BRIDGE

• Connection plates placed above the splash zone.
• Typical service life of the system is 10 to 12 years.
• 16 – 20 mils thickness (typical).
HOWARD FRANKLAND BRIDGE

• Typically applied to caps and beams (most common use).
BRIDGE DECK APPLICATION

- Metallizing on bridge underdecks provides a service life of 8 to 10 years depending on elevation of the underdeck (may be less).
- A top coat to reduce atmospheric corrosion is sometimes used.
THANK YOU!!!

Questions?

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