METALIZING - LONG TERM CORROSION CONTROL

SAVINGS IN MATERIAL, LABOR, AND MAINTENANCE COSTS

Protecting valuable assets around the world
Quality assurance measures are taken in accordance with SSPC-CS23.00 / AWS C2.23M / NACE No. 12 Joint Standards – “Specifications for the Application of Aluminum, Zinc, and Their Alloys and Composites for the Corrosion Protection of Steel” – approved July 2003. This specification is issued to meet a critical industry and government need. Thermal spray coatings are used extensively for the corrosion protection of steel and iron in a wide range of environments.

SURFACE PREPARATION FOR METALIZING

• THE MOST CRITICAL PART OF ANY COATING PROJECT IS THE SURFACE PREPARATION

• 3-5 MIL ROUGH SURFACE ANCHOR TOOTH PROFILE

• UTILIZE STEEL GRIT MEETING SSPC AB3 STANDARDS

• UTILIZE BLACK BEAUTY 1240 MEDIUM GRIT FOR FIELD PREPARATION – BLACK BEAUTY MEETS SSPC AB1 STANDARDS
POSITEST PULL OFF ADHESION TESTING IN ACCORDANCE WITH ASTM D 4541

Aluminum – Adhesion test
Minimum 1000 psi

Zinc – Adhesion test
Minimum 500 psi

ANCHOR PROFILE IS DETERMINED BY REPLICA TAPE & RECORDED IN ACCORDANCE WITH ASTM D 4417 STANDARDS
THICKNESS IS MEASURED AND RECORDED FOR EACH COATED COMPONENT USING CERTIFIED COATING THICKNESS CALIBRATION MEETING SSPC PA 2 STANDARDS

SAFETY/HEALTH: ARC THERMAL SPRAY TREATED AS A WELDING PROCESS

- FULL RESPIRATOR HELMET WITH NEGATIVE PRESSURE, FRESH AIR SUPPLY RECOMMENDED FOR INDOOR AND OUTDOOR USE
- UV RADIATION PRODUCED BY ARC
- EYE/BODY PROTECTION REQUIRED FOR MANUAL APPLICATION
- PROTECTIVE CLOTHING, GLOVES, SUNSCREEN
- HIGH NOISE LEVEL AT GUN HEAD
- EAR PROTECTION (EAR MUFFS AND/OR EAR PLUGS)
WIRE ARC SPRAY PROCESS DESCRIPTION

• ELECTRICALLY ISOLATED METALIZING WIRES OPPOSITELY CHARGED UTILIZING A LINCOLN DC 1000 AMP RECTIFIER
• DUAL WIRE CONTROL FEED
• CONTINUOUS ARC IS STRUCK TO WIRES
• MOLTEN ALLOY IS PROPELLED AND SLAMMED TO SUBSTRATE USING 375 CFM COMPRESSED AIR
• MOLTEN ALLOY RAPIDLY COOLS ON CONTACT WITH SUBSTRATE TO FORM NON-POROUS PROTECTIVE SACRIFICIAL COATING
• NO COOLING OR CURING OF COATING REQUIRED (READY FOR IMMEDIATE SERVICE)
"Red Devil 888"
Technical Aspects of the Machine

• Soft knee current limiting
• SCR phase rectification allows user programmed voltage manipulation.
• SCR snubber for clean rectified DC power devoid of high order harmonics.
• High current linear supply capable of large current transients for flawless machine start up.
• High feed rates 0.45 meters per second or higher dependent on gear ratio.
• 1000 amps continuous @ 100% duty cycle. Larger currents possible through power supply slaving (2000, 3000, 4000, etc)
• Superior line/load regulation.
• Pulse width modulation /SCR phase control allows user flexibility over varying voltage conditions.
• Variable start/stop speed control, variable current limiting, over/voltage short circuit protection, and remote control capabilities (wired/wireless).
• Rugged and dependable, permanent magnet DC washdown motor meets NEMA specs.
• Industrial waterproof process control interconnects and busses
• Exclusive use of oxygen/phosphorous free virgin copper.
• The ultra high molecular weight polyethylene utilized in building the machine reduces machine weight, while making it single operator friendly. Additional mechanical properties include the internal mechanisms to be dust resistant and non-conductive.
• Parts are manufactured to withstand extreme temps and conditions.
• For operation in field conditions from -30F to +155F
<table>
<thead>
<tr>
<th>Feature</th>
<th>IMC -Red Devil 888</th>
<th>Thermion</th>
<th>TAFA</th>
<th>OSU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field portability</td>
<td>Yes</td>
<td>Limited</td>
<td>Limited</td>
<td>Limited</td>
</tr>
<tr>
<td>Capable of spraying any metal in wire form</td>
<td>Yes</td>
<td>Limited by melting pt &amp; hardness of alloy</td>
<td>Limited by melting pt &amp; hardness of alloy</td>
<td>Limited by melting pt &amp; hardness of alloy</td>
</tr>
<tr>
<td>Sealed, dust proof, waterproof solid state electronic controls</td>
<td>Yes</td>
<td>Sealed</td>
<td>Sealed</td>
<td>Sealed</td>
</tr>
<tr>
<td>Self-lubricating, waterproof motor</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Brushless motor</td>
</tr>
<tr>
<td>Adjustable airflow for varied textures of application</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Airflow controlled at gun by applicator</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Capable of operating 1,000 feet away from DC power source</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Can form &quot;instant&quot; alloys</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Can operate from High lifts and scaffolding</td>
<td>Yes</td>
<td>Limited</td>
<td>Very Limited</td>
<td>Very Limited</td>
</tr>
<tr>
<td>Deposition rates of 1,200 square feet per hour at 10 mils can be achieved</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>DC Power source separate from controls and wire feed unit</td>
<td>Yes</td>
<td>Yes</td>
<td>One model</td>
<td>No</td>
</tr>
<tr>
<td>Meets OSHA requirements for confined space applications</td>
<td>Yes</td>
<td>Limited by distance capability</td>
<td>Limited by distance capability</td>
<td>No</td>
</tr>
<tr>
<td>Air is directly fed through gun head</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Enclosed wire feed unit</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Can operate in various positions and heights</td>
<td>Yes</td>
<td>Limited by distance capability</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Oxide knurled wheels to eliminate slippage of wire at high velocity</td>
<td>Yes</td>
<td>6 gear feed system, separate</td>
<td>Push/pull wire system in gun head</td>
<td>Wire push system, separate</td>
</tr>
<tr>
<td>Can operate in extreme temperatures and conditions (-30F - 155F)</td>
<td>Yes</td>
<td>Limited</td>
<td>Limited</td>
<td>Limited</td>
</tr>
<tr>
<td>Produces less than 1% porosity</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Deposit efficiency of 90% or higher for Zinc</td>
<td>Yes</td>
<td>60%</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Creates surface roughness less than 2 mils</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>
The microstructures of thermally sprayed deposits are ultimately based on the solidification of many individual molten droplets. A splat results when a droplet of molten material, tens of micrometers in diameter, melted in the arc, strikes a surface, flattens out and solidifies. The collection of these splats forms the deposit. There are numerous considerations relative to the dynamics of deposit evolution during thermal spraying. The physical aspects of splat formation deals with the spreading of the molten droplet, interactions with the substrate, etc. These characteristics are affected by the temperature of the splat, the splat viscosity, surface tension, as well as other considerations. Splat morphology will depend on a variety of things, the most important of which are particle velocity, temperature, diameter and substrate surface profile. Further considerations involve the physical properties of the splat, which deal with cooling rate, solidification criteria, nucleation and growth of crystals, phase formation, etc. The above aspects of splat formation and solidification are complex and interrelated. Generally it can be said that when the parameters are such that as the particle velocity increases, the porosity decreases. IMC’s metalizing process has achieved these parameters.
Velocity forces the molten particles into the valleys of the prepared steel. The particles are locked into the ridges of the peaks upon cooling.
If the particles don’t penetrate these valleys, the result will be poor adhesion and possible delamination of the coating.
EXXONMOBIL COMPARES TSA APPLICATIONS

Flame sprayed coupon from unknown applicator (provided by Bob Kay/BRCP)

The substrate has insufficient profile for good adhesion. The first pass of flame spray aluminum formed a carbon deposit from the process and was made on top of the cooled, then the second pass deposit. This is a weak point in the coating.

Thermal Arc Sprayed coupon from standard thermal spray equipment (provided by Bob Kay/BRCP)

This application has through porosity, a weak bond at the interface. The arc has not achieved sufficient temperatures, so incomplete melting of the alloy has occurred.

Thermal sprayed TSA coupon from IMC (provided by Bob Webber/BTCP)

IMC TSA process has a better bond at the interface. The TSA has penetrated the anchor tooth profile for superior adhesion. The molten alloy splats have been deposited at such a rapid rate, proper angle, & high temp that 3-4 mils were accomplished at one pass.
AMERICAN BUREAU OF SHIPPING PERFORMED ALUMINUM & ZINC MICROGRAPH STUDIES THAT DEMONSTRATE EXCELLENT INTERFACE BONDING
Adhesion testing performed on aluminum in accordance with ASTM C633-01 & D897-01 standards

<table>
<thead>
<tr>
<th>MATERIAL/DESCRIPTION:</th>
<th>One (1) set of bond caps</th>
</tr>
</thead>
<tbody>
<tr>
<td>IDENTIFICATION:</td>
<td>102</td>
</tr>
<tr>
<td>DATE RECEIVED:</td>
<td>10/2/03</td>
</tr>
<tr>
<td>SPECIFICATIONS:</td>
<td>Client Instructions</td>
</tr>
<tr>
<td>TEST EQUIPMENT:</td>
<td>T.O. S/N 120990-1</td>
</tr>
<tr>
<td>TECHNICIAN:</td>
<td>Ronald R. Richter</td>
</tr>
<tr>
<td>PROCEDURE:</td>
<td>HML-T7M-1-94 Rev. 1</td>
</tr>
<tr>
<td>COMPLIANCE:</td>
<td></td>
</tr>
</tbody>
</table>

**BOND SHEAR TEST RESULTS**

<table>
<thead>
<tr>
<th>SPECIMEN NO.</th>
<th>DIAMETER INCHES</th>
<th>SQ. AREA INCHES</th>
<th>TOTAL LOAD LBS.</th>
<th>TENSILE PSI</th>
<th>FAILURE MODE</th>
</tr>
</thead>
<tbody>
<tr>
<td>769-03</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>#2 (10/2)</td>
<td>1.000&quot;</td>
<td>.7854</td>
<td>5,190</td>
<td>6,608</td>
<td>Split coating</td>
</tr>
</tbody>
</table>

WITNESSED BY: Tommie Kallet

REVIEWED BY: Brenda K. Any

HML Letters/Reports are for the exclusive use of the client to whom they are addressed and apply only to the sample tested and/or inspected. Letters/Reports are not necessarily indicative of the qualities of apparently identical or similar products.
Why IMC?

- ZERO porosity
- Outstanding adhesion
- Equipment portability
- Cradle to grave service
- Experience
Tank From Guam
Sealing the chine by metalizing prevents multiple systems from being employed. Exxon used a polymer in addition to the specified paint system.
This deck exemplifies the durability and protective quality of metalizing in any environment.
EXAMPLE OF CORRODED REBAR IN THE BROOKLYN BATTERY TUNNEL

ZINC BEING DEPOSITED ON THE REPAIRED AREAS OF THE VENTILATION SHAFT

OUR RECTIFIER, 375CFM COMPRESSOR, & 100 kw GENERATOR WERE TOPSIDE IN THE TUNNEL APPROX. 150 FT AWAY
This study is a continuing evaluation of the "in field" performance of various structural coatings that were originally evaluated in order to select a replacement coating system for the (Lead Paint), Basic Lead Silico Chromate (BLSC) alkyd paint system, specified by the Department prior to 1989.

This 1994 evaluation did not include a life cycle cost analysis, however based on the performance ratings, the following conclusions are made:

- The zinc metalizing systems (100% solids, no VOCs) are out performing all other generic systems.

- Zinc rich primers (inorganic and organic) continue as the best performing primers.

In 1990, environmental regulations were revised limiting architectural coatings to a maximum 3.8 lbs. pr gal. VOC (volatile organic compounds). However, metallic primers (i.e. zinc primers) have a limit of 4.2 lbs. per gal. VOC. Therefore, most of the coatings included in this study fail to meet current VOC regulations. Many of the inorganic zinc primers, most of the urethane and all of the vinyls, as manufactured for study, are now obsolete.

FULL DETAILS CAN BE FOUND AT: http://www.tfhrc.gov/hnr20/bridge/metal.htm
NEW JERSEY DOT METALIZING PROJECT - ROUTE 33

- Length: 145 feet - Approx. Tons: 121 of Steel
- Coating Thickness: .008” to .012” - Coating Material: Pure Zinc
- Area Metalized: Approximately 153,231 square feet on entire project
- No top coat was applied to the zinc metalizing
The New York Thruway Authority rehabilitated **Seven** Bridges between Milepost 424.3 and Milepost 428.7, Buffalo Division, Erie County.

- Coating Thickness:.008” to.012”–Coating Material: Zinc/Aluminum alloy
- Area Metalized: Approximately 121,890 square feet of steel
- A seal top coat was applied to the Zinc/Aluminum metalizing
In 1995, the rehabilitation of Staten Island Ferry commenced. A deposition of 8-10 mils of pure zinc metalizing was utilized on the following components:

- Vehicle Ramps * Pedestrian Railings * Ramp Barriers * Hand Rails
- A paint top coat was applied to the metalizing
NYCTA ENGINEERS STATE “NO CORROSION ON ANY OF THE METALIZED & COATED SURFACES!”
How does a Metalized Coating out-perform Paint?

**Adhesion Strength:** While a metalized coating and paint both form a mechanical bond with a blast steel surface, typical adhesion strength for metalized coatings is much stronger than prime paints. Unlike paint, the adhesion strength does not degrade when exposed to thermal cycling.

**Dry film properties:** A metalized coating is harder and stronger than paint. Combined with the bond properties, this makes a metalized coating more resistant to impact, abrasion and wear than paint. A metalized coating is not affected by UV exposure.

**Anodic Protection:** A zinc or aluminum metalized coating anodically protects the underlying steel by sacrificial mechanisms. Protection is more effective and more efficient than zinc paint because the metalized coating is in direct contact with the steel without “interference” from the paint binder.

**Chemical Resistance:** Metalized coatings (particularly Aluminum) achieve some measure of resistance due to formation of a tightly adherent oxide layer. A topcoat may be applied to improve protection or provide desired appearance.
Metalizing costs can start at $4.80 and go up to approximately $15.00 per square foot. Each project has variables and some of them are specified above.

Zinc, Aluminum, and other alloys are a commodity and can vary in price weekly. Some alloys can have a lead time of 2 weeks or more.

Projects that call for metalizing, require communication between the project managers, general managers, fabricators, project engineers, metalizing field supervisors, etc. This communication will assure that the project is successful and achieves the most durable long term corrosion protection system available in the marketplace. Remember, metalizing has been proven to last up to 40 times longer than paint and other coatings, which equates to significant cost-savings in maintenance, labor, and materials.

### METALIZING COST FACTORS

<table>
<thead>
<tr>
<th>Cost Savings</th>
<th>Cost Additions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Performing job in fabricators facility</td>
<td>Metalizer has to supply scaffolding</td>
</tr>
<tr>
<td>Surface preparation performed by fabricator</td>
<td>If project is over water</td>
</tr>
<tr>
<td>Fabricator supplies air</td>
<td>Containment</td>
</tr>
<tr>
<td>Fabricator supplies power</td>
<td>Dust collection required onsite</td>
</tr>
<tr>
<td>Fabricator supplies special equipment - cranes/man lifts etc</td>
<td>Lead Paint removal job – Hazardous Waste Disposal *</td>
</tr>
<tr>
<td>Disposal of spent abrasives</td>
<td>Disposal of spent abrasives</td>
</tr>
<tr>
<td>Supplies scaffolding</td>
<td>Project consists of complex &amp; intricate components</td>
</tr>
<tr>
<td></td>
<td>If several Mobilize/Demobilize charges can incur due to the lack of fabricators planning</td>
</tr>
</tbody>
</table>

* Very High Cost
Cost Comparison of Painting to Metalizing
Study done by FHWA

Cost per ft²
Average Shop Metalizing $  5.50       Paint     $  3.50
Average Field Metalizing       $15.00       Paint     $10.00

Total cost         $606,128             $2,610,858

Cost Metalizing/ft²/year         $.121         Paint     $.522

Figures provided by Mr. Robert Kogler, Corrosion & Coatings Engineer, FHWA
NASA
Radar System
20 Year Relative Cost Comparison

Conventional Coating Cost $447,675
Metalized Coating Cost $134,329
Life Cycle Cost Savings $313,346

Actual cost of metalization vs. estimated cost of in-house corrosion control efforts.
IMC METALIZING FOR VARIOUS INDUSTRIES

OFF SHORE
- Atwood Oceanics

TANKS
- Maritrans

POWER GENERATION
- N.C. Power

DAM GATES
- Panama Canal

SHIPPING
- Maritrans – non skid application

RADAR
- NASA

ARCHITECTURAL
- Oklahoma City Federal Bldg. Blast Wall

BARGE
- MTA

RAIL CARS
WHY SHOULD METALIZING BE UTILIZED AS A CORROSION CONTROL METHOD?

• Life cycle cost savings
• A metalized coating is harder and stronger than paint
• No volatile organic compounds
• No cure time, no mixing, no hazardous waste, no shelf life limitations
• If a paint coating is required, it will adhere to the thermal spray without any surface preparation
• Metalizing is not affected by UV exposure
• Zinc or aluminum metalized coatings anodically protect the underlying steel by sacrificial mechanisms

Our process uses electricity, air, and pure alloys

THAT’S IT….NOTHING ELSE!
IMC’s metalizing process has been tested and proven effective by:

- The United States Navy
- The United States Army Corps of Engineers
- The Federal Highway Administration
- American Water Works
- The American Bureau of Shipping
- Major Corporations
“Society of Protective Coatings, SSPC-CS 23.00 / American Welding Society C2.23M / National Association of Corrosion Engineers, NACE No. 12, Specification for the Application of Thermal Spray Coatings (Metallizing) of Aluminum, Zinc, and Their Alloys and Composites for the Corrosion Protection of Steel”

“Metal Sprayed Coatings for Corrosion Protection Aboard Naval Ships”: MIL-STD-2138A


“Thermal Spraying -Practice, Theory, and Application”: American Welding Society


Canadian/British Specifications: CSA Standard G189-1966; British Standard 2569, Part 1
Our references include ExxonMobil, Chevron, Williams, Mobil Dredge, Maritrans Shipping, DOT’s, MTA, Department of the Interior, Army Corp of Engineers, and many others. (Commendation Letters Available)

If you have any questions please contact us at 1-888-INT-METL (468-6385)

or visit our website @ metalize.net