Thermal Diffusion Galvanizing

Kortick Manufacturing Company TDG Findings

Thermal diffusion galvanizing (TDG) is a method of applying a uniform, sacrificial, zinc-iron or zinc aluminum alloy coating using a metallurgical vapor diffusion process. TDG brings multiple benefits to the utility industry: **Improved corrosion resistance, coating consistency, penetration of previously uncoated areas, anti-galling properties, and environmental efficiencies.**

Kortick Manufacturing is a Pole Line Hardware Manufacturer in Hayward, California serving the utility industry. The current plant equipment and materials for this project are manufactured by the Distek Group, trademarked “ArmorGalv”. Distek began working on this technology in 1993, building upon the early foundation of thermal diffusion dating back to the early 1900’s. TDG adheres to ASTM 1059 and surpasses the performance requirements of ASTM 123 and 153.

**Improved Corrosion Resistance**

At 25 microns of coating, versus 55 microns of Hot Dip Galvanizing, TDG outperforms HDG on flat, shaped, and threaded product.

Further lab test results reflecting TDG performance comparative to HDG are available in the appendix. The data include Salt Fog tests from accredited labs, UL Certification, and a Power Tech labs Inertia Engineering switch test. Additional results from a wide variety of automotive, farming equipment, mining, and oceanic industries are also available via request from Kortick Manufacturing and Distek.
Results from a 5,000 hour salt spray test in 2010 and a recent 1000 hour PowerTech Labs test present findings that TDG is exceeding HDG, 304 stainless, and equaling 316 stainless corrosion performance. More data is needed in regards to stainless equivalence with Kortick testing planned for fall of 2013.

Real world tests have also proven TDG corrosion resistance superiority to HDG. These live deployments have proven TDG’s flexibility.
The real world data includes U.S. Navy testing (see above), comparative three year test in the high salinity of the Dead Sea marine environment and a Florida Department of Transportation rebar test. TDG applications are currently active in: farming equipment, automotive applications (Daimler Benz, VW/Audi), Kansai Airport Roof pivot pins, Honk Kong New underwater tunnel, mining roof supports, North Sea Oil rigs, and German railway systems.

Of course corrosion performance in the real world is highly dependent upon the ability of the galvanizing to stay bonded to the base material. The thermal process creates a new iron-zinc alloy that is a metallurgical conversion - the Thermally Diffused layer is an integral part of the surface, not a coating.

The bond makes the galvanizing chip proof, multi layered, and high strength, this allows for corrosion resistance even if the surface layer is compromised through tough field use. In contrast, the HDG surface layer and alloy
layers are softer than TDG\textsuperscript{10}, leaving them susceptible to abrasion and chipping, which over time will degrade the corrosion resistance of HDG. The TDG onion layering stands in stark contrast to other coatings, which are subject to flaking, chipping, and corrosion bleed. Thermal galvanizing bakes the proprietary zinc solution into the base material at a temperature between 650-814 degrees Fahrenheit. (Dependent on base material) The process ensures a chemical bond for corrosion resistance while the TDG alloy layer has microscopic porosity which allows any hydrogen to escape, preventing hydrogen embrittlement. This is in stark contrast to HDG, which traps hydrogen inside allowing for the possibility of creep and eventual stress cracking. The Audi automotive spec, available upon request, supports these findings. The new Bay Bridge is a good local example of hydrogen embrittlement issues in Northern California. Furthermore, The TDG coating structure is malleable which makes it amenable to bending, crimping, and forming, creating excellent field uses and real world corrosion performance. Painting over TDG is also allowable.

Coating Consistency and penetration of previously uncoated areas.

Attached is a picture of a captive washer and rivnut coated by Chem-Plate Industries in Chicago Illinois. Chem-plate was the first U.S. TDG manufacturer and has done 7 years of quality research on TDG. The coating thickness is consistent at 25 microns throughout the threaded fastener, which maintains the original internal thread structure.

Since TDG applies at an even 25 microns throughout the product, threading tolerances are tightened, thread “gunking” is eliminated, and clean-up is no longer needed. Every portion of a threaded fastener is crucial and must be coated. The current specification practice of deeming certain portions of a fastener “significant” and others insignificant, one example being ASTM F1941, is a concept the utility industry should leave behind. In the utility world, every aspect of a bolts’ corrosion resistance is significant:

Since TDG goes directly from a solid to a vapor, the coating is also effective at coating inside pipe and other hard to reach areas that either remain uncoated or inconsistently coated with current processes, many of these areas are corrosive break down points. Examples specific to the utility industry include Alley Arm braces, tubular cross arms, and eye nut ridges.
Anti-Gallling and Low Friction

TDG also has strong anti-galling properties, replaces cadmium (along with the environmental health safety issues), and performs well in metal to metal applications. The zinc/iron alloy has a self-lubricity that can be enhanced by soaking dry lubricant into the surface. The Osaka Airport uses TDG coating on roof hinge joints, an application where galling could lead to a catastrophic roof failure. A major construction and farming equipment manufacturer uses TDG as a bearing surface on steel hinges and sliding parts, and Audi uses TDG components in engine compartments in part due to its high heat resistance, with a working temp up to 1200 Fahrenheit.

Environmental Efficiencies and Local Grid Support

TDG dramatically reduces waste streams, approaching near zero discharge numbers, while eliminating the use of Cadmium and other toxic coatings. The process is RoHS compliant, totally nontoxic, and heavy metal free. In 2006 the EPA presented Distek and the TDG technology with the 2006 MVP2 award “Most Valuable Pollution Prevention award”.

Below is a chart showing the dramatic reduction in waste stream for a TDG plant in comparison to a zinc electroplating plant.

The primary TDG plant for utility coatings is located at Kortick Manufacturing in Hayward California, a Certified Bay Area Green Manufacturing Business.
Thermal Diffusion Galvanizing

It is Kortick Manufacturing’s findings that TDG is a cost effective solution to improving length of service for grid components encompassing any grade of steel, aluminum, forgings, and castings. The improved length of service and performance will reduce total cost of ownership for the utility.

For Further Information

Gavin Frase-Kortick Manufacturing- gfrase@Kortick.com

End Notes
Some of the original Properties of TDG are based in Sherardizing. A process invented by British metallurgist Sheard Cowper Coles in 1901

ASTM 1059
<table>
<thead>
<tr>
<th>Test Description</th>
<th>Test Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horizontal Combustion</td>
<td>ASTM D2863</td>
</tr>
<tr>
<td>Vertical Combustion</td>
<td>UL 94 V-0</td>
</tr>
<tr>
<td>Heat Distortion</td>
<td>NEH 30, 60, 90</td>
</tr>
<tr>
<td>Smoke Density</td>
<td>UL 94 HB, V-0</td>
</tr>
<tr>
<td>Burning Rate</td>
<td>UL 94 HB, V-0</td>
</tr>
<tr>
<td>Spread of Flame</td>
<td>UL 94 HB, V-0</td>
</tr>
</tbody>
</table>

**UL certification Documentation**
5 Powertech Labs HDG switch and TDG switch with 304 SS collar after 1000 hr B117 Salt Spray

6 5000 hr salt spray
Navy Test Results

NAVSEA WARFARE CENTERS
ARMORALV Cargo Lashings

- Zinc powder coating is thermally diffused (heated to 600-750°F) into base metal to alloy the zinc to the steel, providing a superior corrosion-proof coating.
- Evaluation ongoing under NAVSEA PWS377J Tasking
  - Bulk Testing to 35,000 Pounds
  - ACU-4 / ACU-5 to evaluate during 6-month deployment
- Side By Side Comparison with Legacy Cargo Lashings
- Meets ASTM Standard A 185WA 169M – 86 for Zinc Alloy Thermo Diffusion Coatings (TDC) on Steel Fasteners, Hardware and other Products
- Approved by NAVSEA 039, Tech Warrant Holder, Coatings & Corrosion Control, 02/AUG/2011

FOR OFFICIAL USE ONLY
Expeditionary and Maritime Systems Department
ArmorGalv® at the Dead Sea!
Dead Sea 350 g/l salinity
North Sea 35 g/l salinity

No Corrosion
1 mil of ArmorGalv® after 3 years in the aggressive Dead Sea atmosphere. Please note white salt encrustation. Fasteners still have original gray color

Badly Corroded
2 mils of Hot-Dip Galvanized bolts after 3 years in the aggressive Dead Sea atmosphere. Fasteners are corroded to base metal.

9 FDOT Letter

Florida Department of Transportation
1000 S.W. 1st Ave
Miami, FL 33130

March 7, 2015
Neal E. Brotke, Ph.D.
Vice President, Research
Trinity Consulting Group, Ltd.
3981 North Devon Avenue
Kahului, HI 96732

Dear Dr. Brotke,

I am pleased to offer the collaboration of the Corrosion and Durability Research Laboratory at the State Materials Office of the Florida Department of Transportation for fabrication of the project, “Residual Diffusional Zone (RDZ) HDG.” I am also pleased to report that you are preparing to conduct work in support of the NCHRP 23-96 program. The proposed technology would provide necessary characterization in the areas of an added corrosion resistant finish for examination of bridge decks, walls, pilings, beams, and columns.

We have been looking to this work for close to 5 months without concrete in both ambient and tank and partially submerged test conditions. The performance compares to hot dip galvanized(HDG) in all test conditions. The HDG has failed in both conditions with tremendous amount of corrosion while the zinc diffused zinc has not shown a lot of corrosion. We offer in collaboration by accepting the zinc diffused zinc test however we could be used in experimental projects in highly aggressive marine environments.

In addition, we can provide pictures of the failures in our lab to confirm the performance of the zinc diffused zinc which was similar in cost to HDG, but questions still remain as to how it will behave in a high test environment like concrete.

Looking forward to successful implementation of your projects.

Mark A. Pandale
305-299-0990

www.dor.state.fl.us

10 HDG and TDG microscopic hardness summary. Full report available upon request.
11 Large farming equipment manufacturer TDG parts

12 Audi TDG spec available upon request


14 Kortick Green Certification renewed in 2013 for another 3 years