ArmorGalv® - THE ONLY TRULY "GREEN", HIGH PERFORMANCE, CORROSION PROTECTION FOR STEEL.

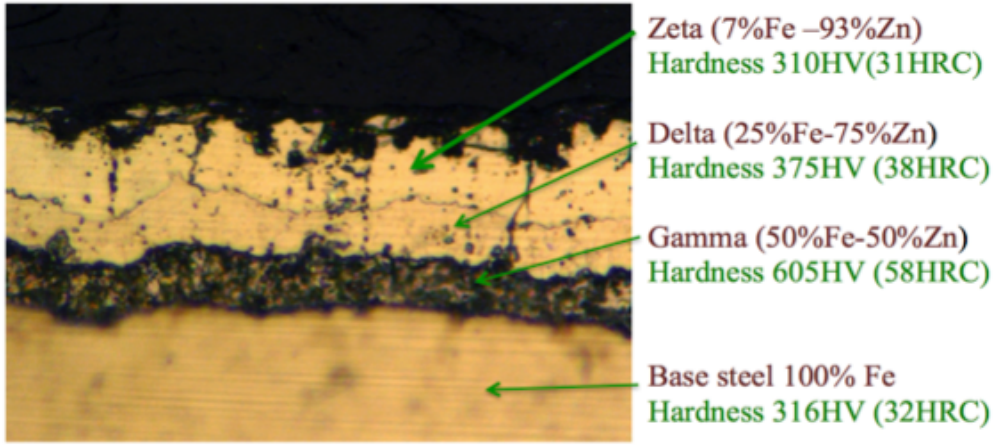
ArmorGalv® as a replacement to HDG and other coating systems

The **ArmorGalv®** technology is an environment-friendly process that offers superior corrosion protection and wear resistance as well as anti-galling properties. Following are some highlights of the **ArmorGalv®** technology which is, in fact, a modern, greatly improved, version of the well established Sherardizing zinc/iron diffusion process:
ArmorGalv® is not merely a sacrificial coating. By diffusing zinc atoms into steel, it creates layers of zinc/iron alloy on any steel part, including wrought and/or forged steel, castings, powdered metal (with no impregnation required!), and all grades of stainless steel.

The unique combination of properties offered by the **ArmorGalv®** technology, make it an excellent **replacement for cadmium, hex chromium and Hot Dip Galvanizing** as well as being very interesting for a multitude of Industrial applications, from construction in corrosive environments and components on Navy ships to mining applications, oil industry, automotive, power utility etc.
ArmorGalv® Thermal Diffusion Coating is covered by ASTM # A1059.

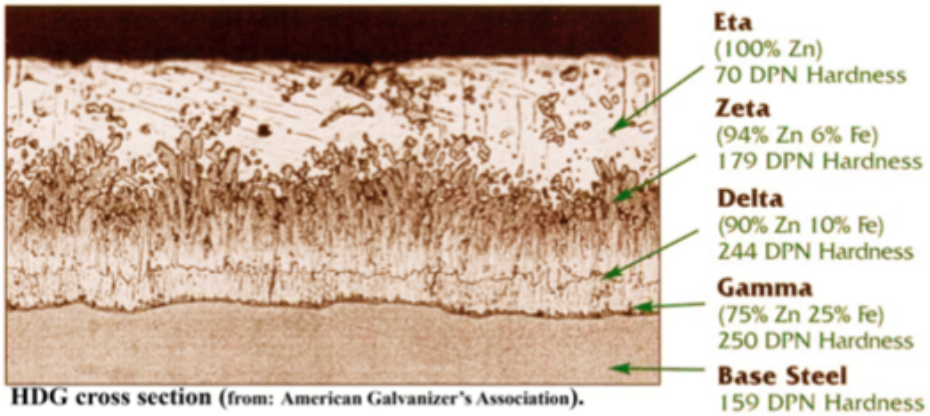
Hot Dip Galvanizing (HDG) has been the preferred zinc based solution for long term corrosion protection for over 100 years. Zinc, and even more so, the alloy of zinc and iron, offer a combination of galvanic protection (providing protection even to damaged areas in the coating, unlike paints), good wear and abrasion resistance and overall good durability in various climatic environments, including coastal areas. Much has been written about the process of Galvanic protection and Hot Dip Galvanizing, so most technical people are well acquainted with the basics of the process.
Here are the main reasons **ArmorGalv®** is displacing HDG in many applications:

Technical comparison of ArmorGalv® to HDG:



ArmorGalv® cross section

ArmorGalv® has a 100% intermetallic alloy structure, with a significant Gamma layer and a more iron rich structure than HDG. The **ArmorGalv®** layer is hard and abrasion resistant while the richer iron content also provides superior corrosion resistance.



HDG cross section (from: American Galvanizer's Association).

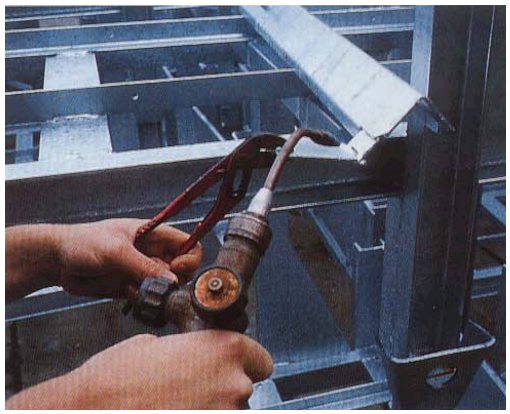
HDG, most of the time, has a pure zinc layer that is more than half of the coating. The intermetallic alloy layers are much thinner (particularly the very thin Gamma, which is the hardest and most corrosion resistant) and poorer in Iron content.

NOTE: DPN and HV hardness are identical, both are designations of the Vickers hardness test. From the above it is clear that **ArmorGalv®** is much harder than HDG and offers far superior abrasion and wear resistance.

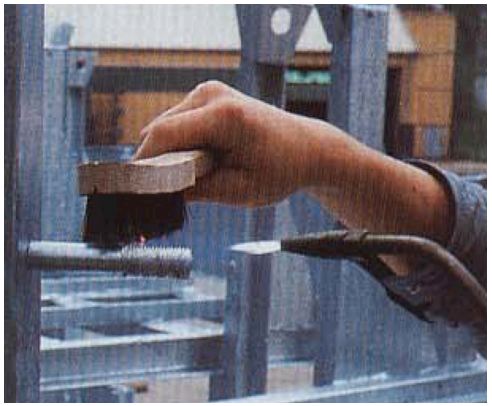
There are some additional technical differences that should be pointed out:

Problems and issues with HDG that do not occur with ArmorGalv®

Zinc runs need to be removed and cleaned up, manually, after HDG.

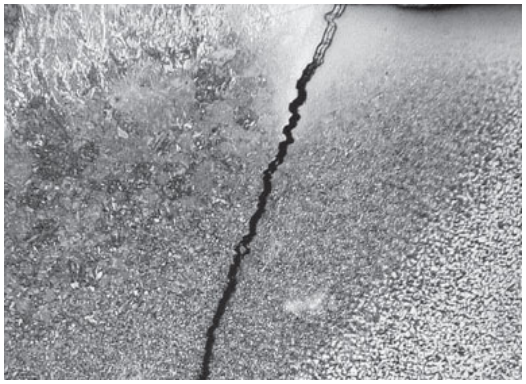


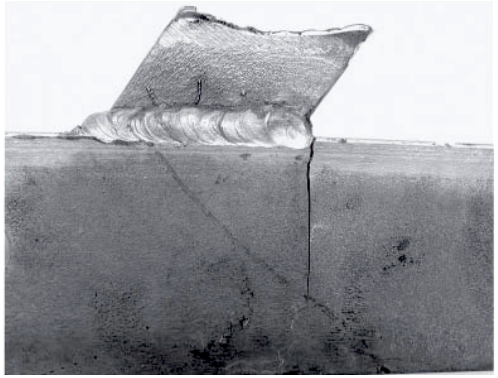
Moving parts and hinges need to be freed manually

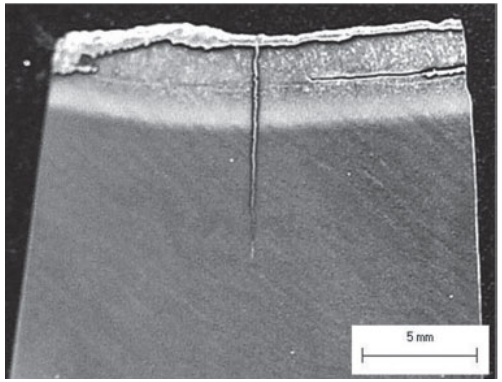


Threaded parts must be cleaned manually. Nuts are threaded after coating, so there is no protection on the inside thread.

Hydrogen and molten metal (liquid) embrittlement failures:



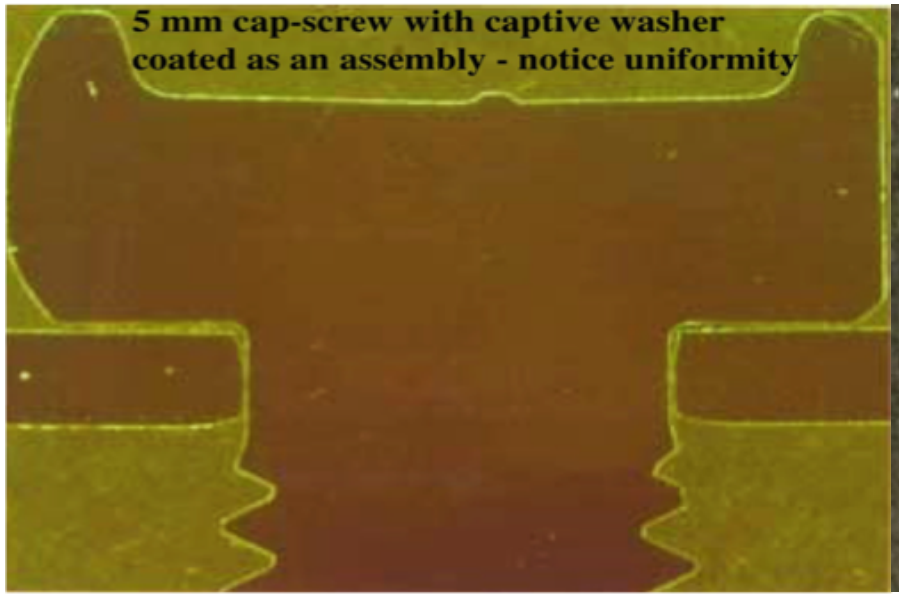


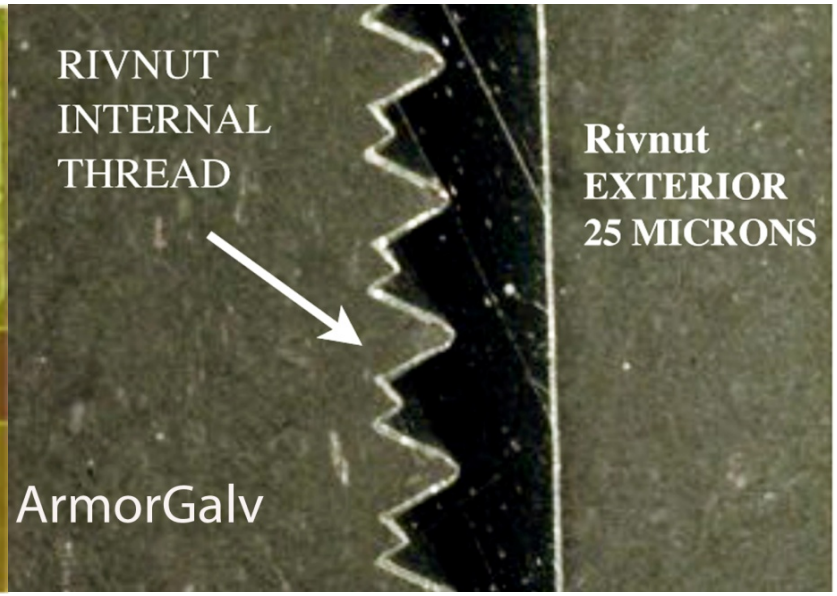


ArmorGalv® is entirely free from the above issues, and has the following additional advantages:

Precision and uniformity:

Unlike HDG, the **ArmorGalv®** technology creates an extremely uniform and controlled alloy layer. Due to the fact that we are dealing with zinc vapor (gas), which penetrates any open cavity in the part, **ArmorGalv®** is not sensitive to the geometry of the part and will coat internal surfaces of a part just like it does the external surface. This means, for instance, that unlike HDG nuts which get cut after galvanizing, leaving the inside thread unprotected, **ArmorGalv®** provides even and uniform protection to both the outside and inside threads.





As can be seen from the uniform coating even between the washer and body of the screw, **ArmorGalv® works well even on assemblies**.

Superior corrosion protection:

Florida Department of Transportation
RICK SCOTT
GOVERNOR
5007 NE 39th Avenue
Gainesville, FL 32609
ANANTH PRASAD, P.E.
SECRETARY

May 1, 2013

Evaluation of ArmorGalv® under Salt Fog Exposure and Partial Immersion in Saltwater

ArmorGalv® process showed limited visual signs of corrosion. (Figure 4.) There were a couple of rust colored spots that are most likely the result of surface contamination.

In addition to the visual observations, a specimen that was exposed to the salt fog environment

Figure 3 Traditional Hot Dipped galvanizing after 3000 hours in salt fog exposure

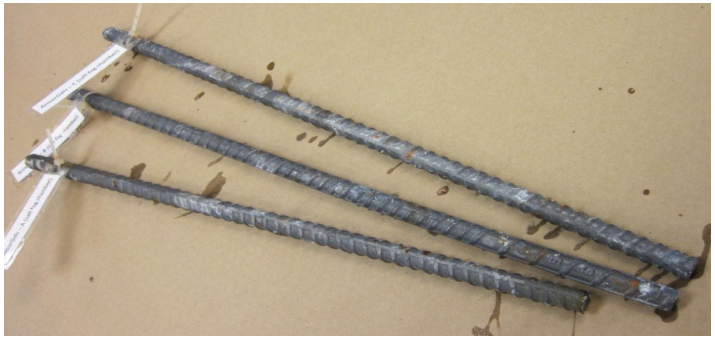


Figure 4 Armorgalv® process after 3000 hours in salt fog exposure

Part of a long-term corrosion test performed by the Florida Department Of Transportation, showing a side by side comparison of HDG and **ArmorGalv®**. While HDG coated rebar has completely failed after 3000Hrs (actually the failure started much earlier at around 600Hrs), the **ArmorGalv®** coated rebar showed no signs of corrosion at the end of the test. As can be seen from the cross section, after 3000hrs in the salt spray, the **ArmorGalv®** layer is still complete and intact.

Following above test, steel hardware on the San Pablo River Bridge in Jacksonville, FL. are protected with **ArmorGalv®**, as the first infrastructure project specifying **ArmorGalv®**.

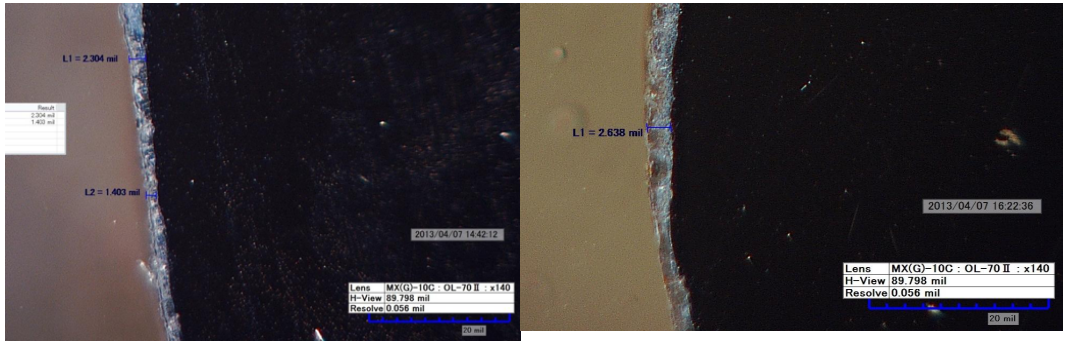
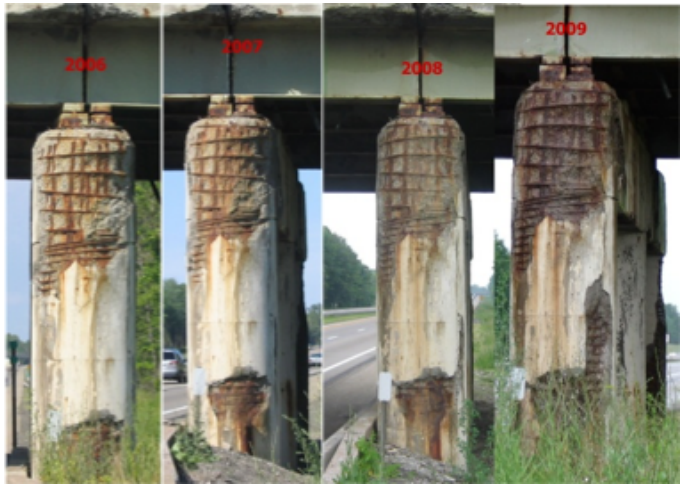


Figure 6 ArmorGalv® after 3000 hours in salt fog environment

Unexposed specimen ***Specimen after3000Hrs salt spray***

ArmorGalv® is the solution to corrosion of Rebar

The corrosion of rebar in concrete is estimated to cost the US economy between $50Bn and $100Bn per year.



The national Academy of science funded Test program for **ArmorGalv®** coated Rebar (NCHRP), following two years of testing, has concluded:

" Tests comparing the performance in severe salt environments with and without abrasion show a 5 to 10 times improvement in performance with the TZD-coated steel versus HDG steel."

and:

"TZD-coated reinforcement will have a significantly lower initial cost than stainless steel reinforcement, and can be applied to all strength grades of steel, allowing for potential additional savings where the designer can use higher tensile strengths to reduce the amount of reinforcing bars needed. When used with higher strength bars and lower permeability concrete, TZD could potentially lower the overall upfront and service life costs for bridges versus alternative reinforcing bar options."

ArmorGalv® coated rebar provides the most durable and flexible solution to rebar corrosion:

ArmorGalv® coated rebar can be bent and formed after coating, without losing corrosion performance.

Integrity of the ArmorGalv® coating is maintained on bent ArmorGalv® rebar

The ArmorGalv® process is extremely flexible and allows processing of rebar at a wide range of temperatures. This allows for treatment of high carbon rebar without fear of hydrogen embrittlement or loss of strength. It also helps improve elongation and flexibility for earthquake zones.

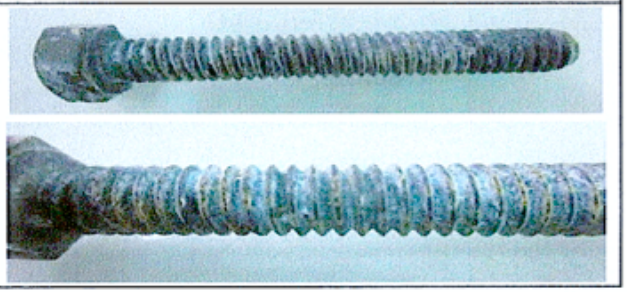
All @ 1500 Hrs

From left to right:
TDG (2), 316 SS (2), 304 SS (2), Silicate Coated HDG (2), HDG (2), Aluminum(1), electroplated (1), ERX TDG (1), ERX HDG (1)

KORTICK

From “normal” salt spray tests, to cyclic automotive industry tests and real life testing by the U.S Navy, **ArmorGalv®** has shown superior corrosion protection that was better than HDG by order of magnitude and has also out-performed Stainless Steels in some tests. Shown is a page from a side by side salt spray test, conducted for Kortick Mfg., showing **ArmorGalv®** out-performing both HDG and 316 Stainless Steel. Also, unlike HDG, **ArmorGalv®** exhibits excellent **anti-galling** protection.

SERCOVAM — RES 103448 .

Durée : 63 cycles *Duration :*	Exposition préliminaire : Aucun *Preliminary exposition: None*	Référence : VIS TH *Reference :*	
Dégradations *Damages*	**Rappel des exigences client** *Reminder of the customer's requirements*	**Conformité aux exigences client** *Compliance with the customer's requirements*	**Photographies** *Photographs*
Corrosion blanche sur la tête de vis et le filetage. Points de corrosion rouge sur le filetage. *White corrosion on the head of screw and the thread.* *Spots of red corrosion on the thread.* *"False" rusting or "Staining" per ASTM 1059*	Pas d'exigence. *No requirement.*	Sur demande du constructeur, la déclaration de conformité au cahier des charges des pièces testées relève de la seule responsabilité de notre client et/ou de RENAULT *Upon manufacturer's request, the conformity statement according to the specification of the tested parts comes under the exclusive responsibility of the automotive equipment supplier and/or RENAULT.*	

Above is part of a test by a French government institute that is testing for the automotive industry. This is a tough cyclic test, where the maximum specification for automotive parts is 42 cycles. Above, is the test report for **ArmorGalv®** coated fasteners, that has been stopped after 63 cycles with no sign of corrosion (the “white corrosion” is actually the silicate sealer).

REAL LIFE TEST

The inner pair of cargo lashings, manufactured by Spencer, were coated with **ArmorGalv®**. They exhibit no signs of rust after three years in the highly corrosive Gulf environment. The outer pair of legacy lashings, using standard materials and treatment, have significantly corroded over the same period.

Photo courtesy of Thomas Whelan, Mechanical Engineer, ACV Branch, NSWC-PCD thomas.whelan@navy.mil

After 3 years on the deck of an active U.S Navy hovercraft, HDG lashing is completely corroded while **ArmorGalv®** coated lashing, with grade 120 chain, shows no sign of wear or corrosion

No hydrogen or molten metal embrittlement and no strain aging

Grade8 automotive bolts (2040hrs salt spray ArmorGalv® provides corrosion protection

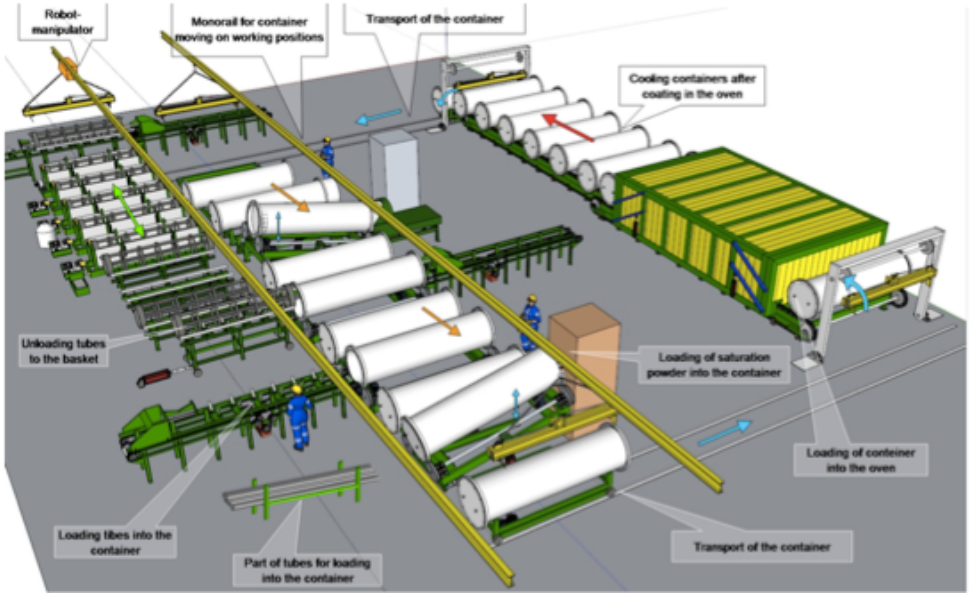
Springs on vibratory mine screen - and improves fatigue performance

The **ArmorGalv®** process, by it's nature, does not allow the hydrogen embrittlement process to occur. It does not involve acids and parts are processed at temperature for extended time, forcing hydrogen out. The natural micro-porosity of the **ArmorGalv®** coating allows hydrogen to escape. This has been proven through 100 years of field experience (including Sherardizing, which has a similar metallurgical structure) as well as laboratory testing. The **ArmorGalv®** process also provides **stress relief and improves fatigue performance**.

This allows for the protection, with **ArmorGalv®**, of high tensile, heat treated parts, without the fear of failure. Parts such as springs, high-grade fasteners, high-grade chains etc. greatly benefit from corrosion protection that HDG and most other coating technologies cannot provide.

Small **ArmorGalv®** system

Large system for parts to 40ft long (12m)

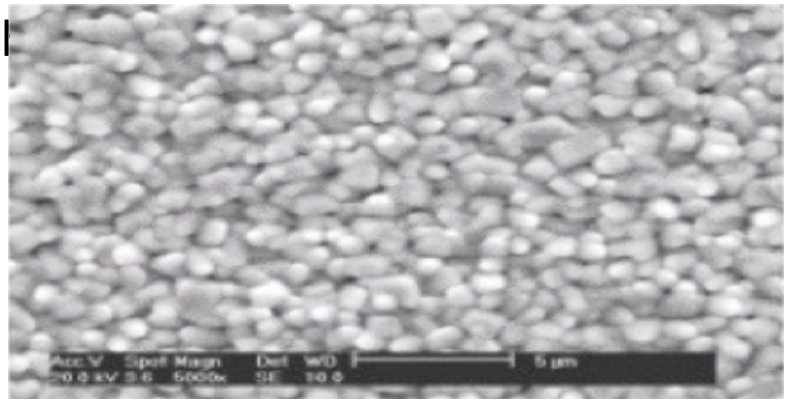


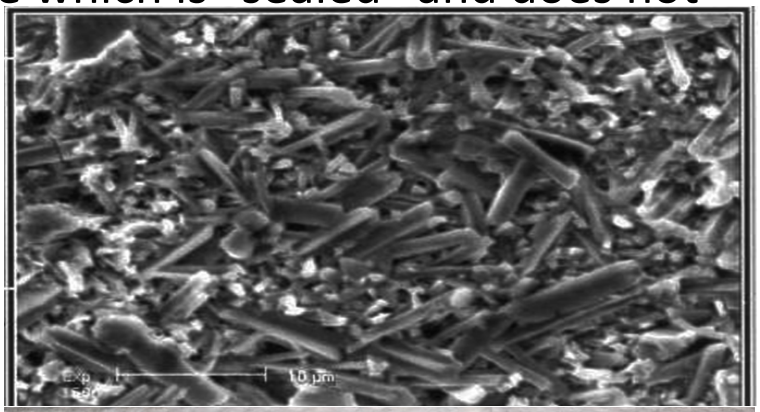
The **ArmorGalv®** process lends itself to highly automated facilities, as illustrated in the picture on the left, designed for automated processing of 3m (10ft) long tubes of various diameters. The tubes are evenly coated inside and out.

Energy efficiency -**ArmorGalv®** consumes **less than half the energy** of HDG

Paintability - It is a well known fact that HDG coated parts as well as zinc plated parts are difficult to paint and require special surface preparation such as mechanical or chemical etching to create a surface “profile” to get some minimal adhesion of paint to the surface. This is due to the fact that the HDG crystals create a “sealed” surface that does not hold paint or any other over-coating material.

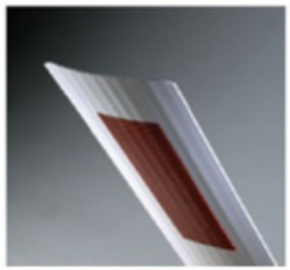
As illustrated in the following pictures, it can be seen that the **ArmorGalv®** surface (on the right) is dendritic in structure and acts as a “micro sponge”, absorbing any paint, rubber or over-coating and providing extremely good adhesion values. On the left is the HDG surface which is “sealed” and does not





Paint is absorbed deep into the **ArmorGalv®** surface of the hardened screws on the right, so It survived the drilling of the screws into concrete and removing them.

ArmorGalv® can be formed and bent after coating without loss of coating and corrosion performance



Delnorth Steel-Flex® roadside guide post is one of the most extreme examples of the ability of **ArmorGalv®** to withstand extreme deformation without loss of coating, or even paint adhesion. The **Steel-Flex®** spring steel roadside guide-posts, was developed by Delnorth International (Australia) and is being coated by the **ArmorGalv®** licensee ArmorGalv Aust. PTY Ltd. The post is made of a specialty spring steel and coated with **ArmorGalv®** and then powder coated. Testing the product entails 1500 cycles of a truck driving over the post, without it losing its flexibility, corrosion resistance and paint.

Some real life applications, projects and case studies using ArmorGalv® for protection

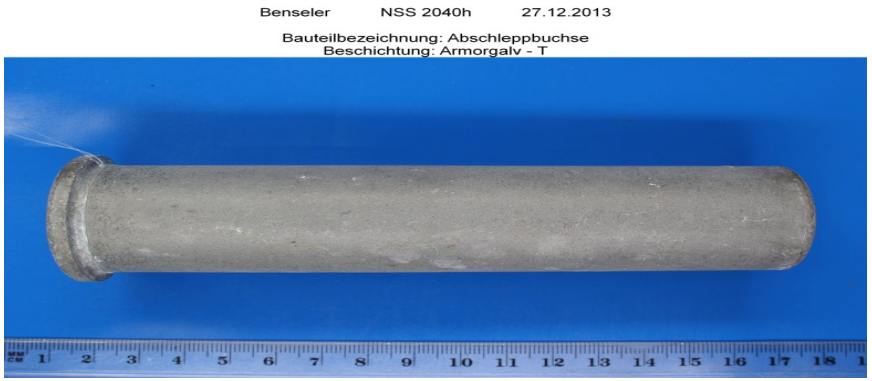
Marine applications.

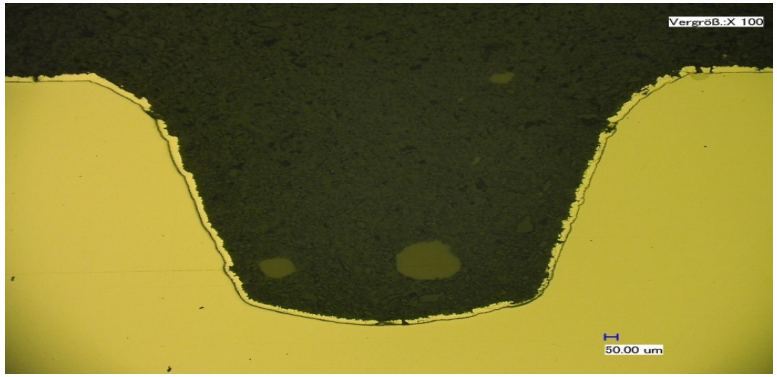
Barge towing chain in the north sea oil fields – a very critical application that involves protection from corrosion as well as wear and abrasion. A similar application is also chain used in fish farming.

The U.S Navy fleet of hovercraft (LCAC's) is equipped with lashings made of G120 high tensile chain, protected with **ArmorGalv®** . This light weight chain is long lasting and offers about 35% in weight reduction.

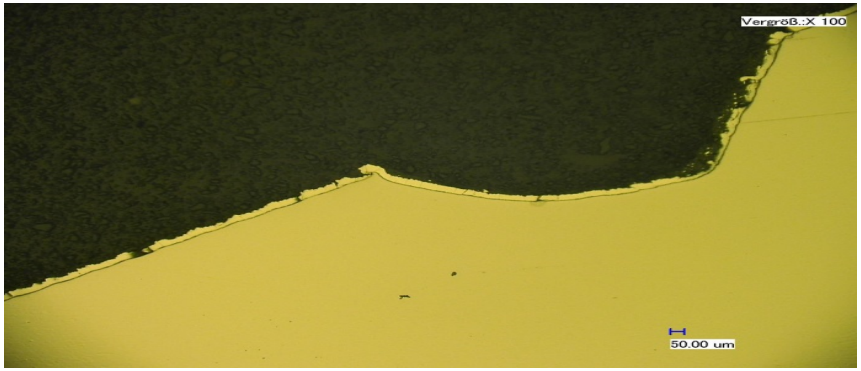
Automotive applications

ArmorGalv® use in the automotive industry is growing, having started with some of the toughest applications where other technologies do not work.





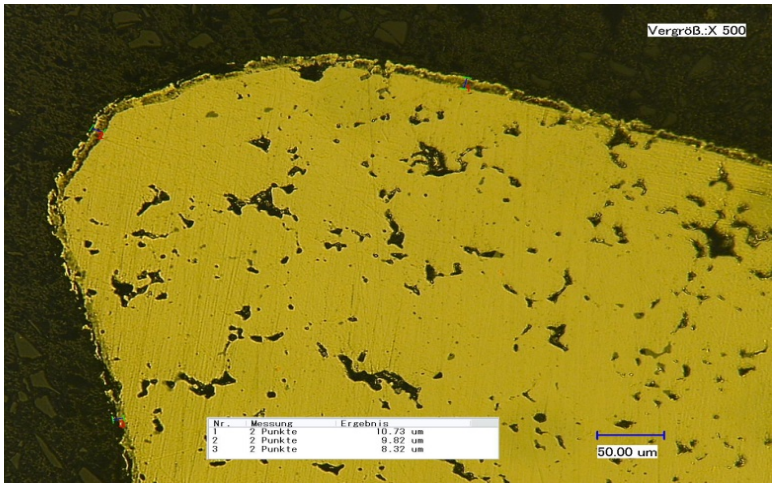
Cross section through the center of the thread



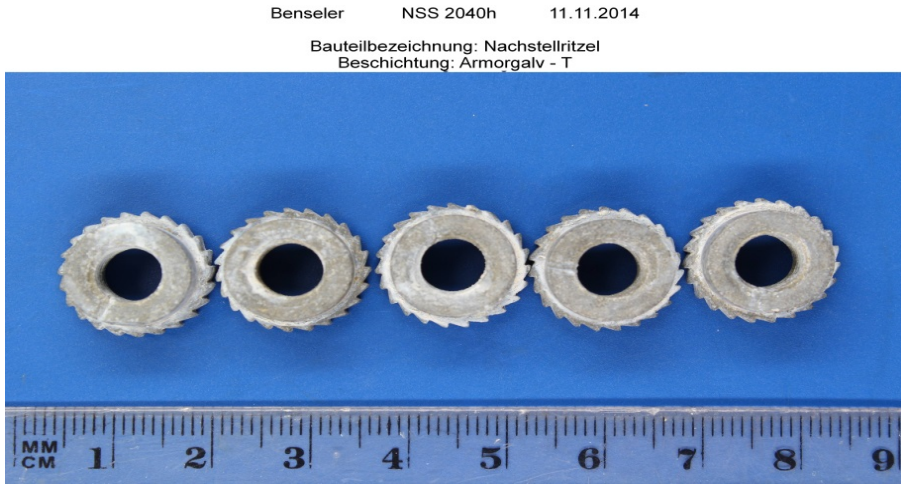
Cross section through the end of the thread

Above part is an **ArmorGalv®** protected tow bushing, which gets welded to the car frame and is used for towing the car in emergency applications. This part must be functional for the life of the car. Here **ArmorGalv®** replaces specialty stainless steel.

Sintered metal is the preferred, most cost effective method for manufacturing complex parts. **ArmorGalv®** helps expand the use of sintered metal by eliminating the need for polymer impregnation and greatly improving corrosion resistance and mechanical properties, as well as paint-ability.



Cross section through a tooth



Sintered steel ratchet wheels (2040 Hrs salt spray)

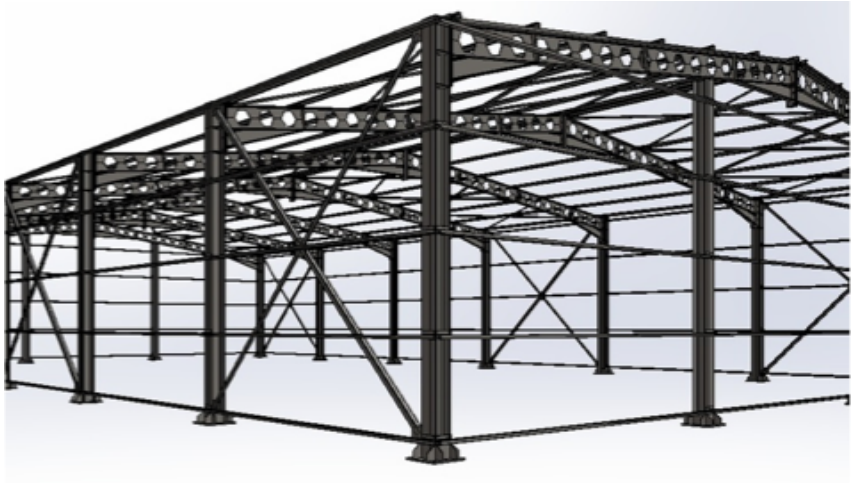
Car door hinge

Spring body clip

Trunk locking mechanism body

Infrastructure and construction

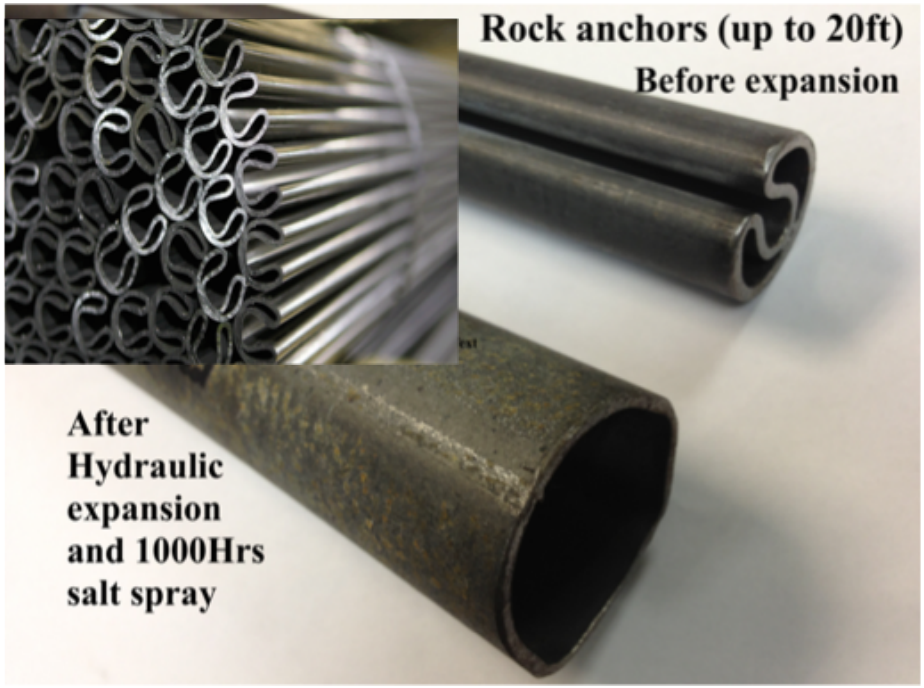
From bridges in coastal areas to modular steel buildings, **ArmorGalv®** provides steel structures with decades of maintenance free endurance, even in the most adverse conditions. The implications for greatly reduced maintenance costs for infrastructure are significant.



Railway fasteners across Europe and Australia are protected with **ArmorGalv®**.
The railway clips are made of spring steel. **ArmorGalv®** protects them against corrosion and prevents them from seizing.

Tough marine construction application

Dynamic Seawall Maintenance Systems provides a good example of using **ArmorGalv®** to protect steel in extreme marine environment, also involving high wear and abrasion resistance. After being drilled into the ground, the seawall anchor provides long term protection for the seawall from seawater and wave action. **ArmorGalv®** coated carbon steel has **replaced stainless** steel in this application. The shaft with the helix is drilled into the ground. The bolt holding the support plate gets threaded into the end of the tube to hold the concrete seawall plate. All parts are coated with **ArmorGalv®**



The rock anchor is one of the products that take advantage of the fact that **ArmorGalv®** coated steel can be formed after coating, without losing its corrosion protection.
The rock anchor is an extreme example of this. Having gone through severe deformation, it is expected to provide long-term corrosion protection in the corrosive environment of a mine.

ArmorGalv® coated nails and screws provide superior corrosion protection for construction, particularly in coastal zones and hurricane zones, where extremely long corrosion resistance is essential for wood structures.
ArmorGalv® coated screws also work well with sheet metal applications due to the ability of **ArmorGalv®** to retain its full protection even after self tapping into sheet metal.

Power utilities applications

High voltage switch. All steel parts are protected by ArmorGalv® , replacing Stainless Steel

Power utility companies are now specifying **ArmorGalv®** as the preferred coating for pole line hardware and other equipment, replacing HDG and stainless steel. Solar and wind power installations use **ArmorGalv®** protected hardware.

• Oil industry applications

- Thermal Diffusion has been used in the oil industry for superior corrosion protection for decades.
- The recent catastrophic spill in the Gulf of Mexico was found to have been caused by Hydrogen Embrittlement.
- **ArmorGalv®** is the only technology that combines the best corrosion protection, abrasion and wear resistance, anti galling properties, with a guaranteed freedom from Hydrogen Embrittlement.
- **ArmorGalv®** provides the oil industry with a solution that will greatly enhance safety and efficiency and generate significant cost savings in long term continuity of operations and maintenance.

Heavy construction, mining and agricultural equipment and hardware

In the extremely abrasive and corrosive environment of coal mining, equipment designers have taken advantage of the excellent abrasion and wear resistance of the **ArmorGalv®** technology, as well as the long term corrosion resistance. This is particularly true in critical applications, such as heavy equipment and the long-wall hinge pins that must guarantee no seizing of the hinges.

Military applications

ArmorGalv® provides military equipment the high performance combination of corrosion and wear resistance that helps make the equipment more reliable. It also significantly reduces maintenance and life cycle costs.

The U.S Army fleet of landing craft is being equipped with **ArmorGalv®** protected anchor chains and bow chains, drastically reducing operational issues and maintenance costs of these parts.

Conclusion

ArmorGalv® is the **"green"** answer to the high performance corrosion protection required across the economy, in most industries. **ArmorGalv®** is the future of corrosion protection solutions, in a world that is increasingly sensitive to protecting the environment and, at the same time, is in great need of a technology that will help reduce maintenance and life-cycle costs of infrastructure and equipment.

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Distek N.A LLC to its licensees.

Please see:
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