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HOT DIP GALVANIZING TODAY 84

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CORROSION CONTROL OF STEEL

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THE ASSOCIATION IS AN INFORMATION CENTRE ESTABLISHED FOR THE BENEFIT OF SPECIFIERS, CONSULTANTS, END USERS AND ITS MEMBERS.

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EXECUTIVE DIRECTOR'S
Comment

As this issue of Hot Dip Galvanizing Today goes to press, the international standard ISO 1461:2022 is about to be adopted in its entirety as the South African standard for hot dip galvanized coatings on fabricated iron and steel articles – specifications and test methods. The document, SANS 121, Edition 3 will form the cornerstone of the contractual engagement between the galvanizer and the customer. The Association has played an active role on the technical committee that has assessed and ratified the amendments to the standard.

Knowledge of the standards, not only the test methods and specifications, but also the essence of the technology from which the standards are derived, is key to ensure that there is a meeting of minds related to the delivery of quality by the galvanizer. The operations team at our Association is updating all course material to reflect the amendments to the standard.

The Hot Dip Galvanizers Association has launched a direct marketing campaign on several media platforms to emphasis two key elements required for successful implementation and execution of the hot dip galvanizing technology for corrosion control. First is an understanding of the mechanism by which galvanizing provides corrosion control. The second is the methods and specification by which it is assessed. To achieve this, education of engineers and other specifiers as well as the fabricator of steel articles is imperative. The drive must extend to quality assurance practitioners to ensure that specifications have been met.

To give impetus to these initiatives, the aAssociation has run several internally developed courses, but also in 2024 placed renewed emphasis on training at a tertiary level. To this end several university and college interventions, reaching out to over 200 students engaged in studies related to the built environment have been successfully executed. The interventions have included lectures as well as plant tours.

Knowledge of standards is critical for the guarantee of design outcomes. The Association works hard to ensure that end users are protected in this way.

EDITORIAL COMMENT
in this issue

Einstein is often quoted as saying, *"Insanity is doing the same thing over and over and expecting different results."*

As we realize that change is the only constant it must follow that we adapt to these changes. In this issue we see how:

- Abeco and Aspen use limited space for critical installation of Fire Water Storage for a larger plant.
- Ensuring quality is a value stream activity – fabricators and galvanizers must understand and be able to deal with mill scale, what it is and how to deal with it for a quality outcome.
- Dealing with cracked welds and galvanizing is a notable aspect of design well worth reviewing and adjusting for future fabrication assemblies.
- The old aesthetic criteria of the quality of galvanizing is patently incorrect and this must not be a quality standard parameter that is consistently used to evaluate quality galvanizing.
- Change is inevitable, specifications, standards, and techniques are all areas of continuous innovation. Intergalva 2024 in Brussels will be a gathering of minds, attitudes, and innovation to drive galvanizing as a global industry into the future.

INTERGALVA 2024 update

INTERGALVA
10-14 June 2024 Bruges

The conference programme for Intergalva 2024 has now been announced. Sessions will take place on Monday 10, Tuesday 11 and Wednesday 12 June.

There is a wide range of sessions that reflect the current industry focuses, including *Meeting the Decarbonisation Challenge, Facilitating the Circular Economy, Zinc – the Healthy and Plentiful Raw Material, Improving Process Efficiency, Performance of Galvanized Steel*, and *Climate Resilient Concrete Infrastructure with Galvanized Reinforcement.* The majority of the programme is fixed, but we anticipate a few additions and adjustments – so check the event website for the latest programme. There will be simultaneous interpretations for German, Italian, French, Spanish, Chinese, Japanese and English.

The conference programme is augmented by optional masterclasses on key topics that are already proving popular with delegates. Topics include *Improving Energy Efficiency; Zinc Consumption and Kettle Maintenance; Optimising Pre-treatment; Improving Workplace Safety; Carbon Foot printing and EPDs for Galvanizing; Productivity and Jigging; Understanding ISO 1461 and Related Standards; LME Seminar: Zinc Trading, Pricing* and *Hedging.*

Optional visits to galvanizing plants in the Benelux are available on 13 and 14 June. Visits to Galvanizing Plants at Intergalva 2024 means that delegates can visit a wide variety of plants throughout Belgium and the Netherlands on Thursday 13 June and Friday 14 June. Registration for plant visits must be made during registration and the fees paid at the same time as the delegate registration fee. Groups 6 is a 2-day visit and must be booked by 10 May 2024 to ensure availability of hotel booking for the night of 13 June which is included in the price for the visit.

HOT DIP GALVANIZING – More than surface aesthetics

Hot dip galvanizing is primarily a means of corrosion control. The aesthetics of a hot dip galvanized coating is secondary. Yet, hot dip galvanized articles are frequently, subjectively judged on their aesthetics. Concerns arise from the variance in appearance between stakeholders' preconceptions of hot dip galvanizing producing a uniform bright lustered aesthetic and the mottled unweathered coating produced. Ultimately all zinc coatings, including hot dip galvanized coatings weather to a dull grey hue of the zinc carbonate patina.

Robin Clarke, Executive Director of the HDGASA points out that "International and local standards state that aesthetics is of lesser importance than corrosion control. Contrary to the standards, the common perception is that *'If it looks good, it must be of high quality.'*"

Preconceived expectations vs actual outcomes

It is best to ensure that customers understand that the definition of the quality of hot dip galvanizing is in line with it being a highly effective corrosion control coating. "Expectations in terms of the service life provided by the hot dip galvanizing's corrosion control to the steel rather than the coating's aesthetic appearance must be understood by all parties" advises Clarke.

"In a C3 (medium) corrosivity environment, carbon steel which is left unprotected has been determined to corrode at a rate of 25 to 50 microns a year. In contrast, the hot dip galvanized coating comprised of zinc and alloys of zinc corrodes at a much lower rate of 0.7 to 2.1 microns a year. As such, a hot dip galvanized steel article with a hot dip galvanized coating thickness measuring 200 microns, in a C3 environment, will provide corrosion control to the steel for more than 80 years – theoretically up to 200 years," Clarke explains.

In South Africa, a misconception often encountered and one that is frequently held as a customer expectation assumes that a hot dip galvanized coating can be applied to a predetermined and even thickness over the surfaces of the steel article, much like paint.

"One cannot apply a 120-micron hot dip galvanized coating to a steel article or in the same way apply a thicker 185-micron coating to the same article, to deliver *'good, better or best'* levels of corrosion control. The hot dip galvanized coating develops as a result of metallurgical diffusion between the steel and molten zinc. The level of such diffusion is driven predominantly by the steel chemistry namely the Silicon and Phosphorus content in the steel" he adds.

Quality links throughout the supply chain

The most important requirement for achieving a repeatable consistent and optimized hot dip galvanized coating is essentially due to the steel's chemistry, and homogeneity. Another significant factor is the close collaboration between the designer, fabricator and galvanizer: "Everyone must do their bit to optimize the outcome to achieve a suitable service life for the corrosion control of the article, with a high degree of confidence. The corollary is: poor steel selection and poor design will likely produce a poor coating"

"The best way for galvanizers to ensure quality outcomes and reduce costs is to educate customers to choose the best steel possible and ensure good project design while the galvanizer controls the galvanizing process as effectively as possible. These will support the galvanizing process to produce hot dip galvanized articles without the need for extensive fettling. By following this approach, the resulting benefits of net cost reduction and having achieved results in line with customer expectations have been successfully met. In Europe, the focus is on process control. However, historically in South Africa, labour was less expensive than technologically driven process control. As such it was considered prudent that galvanizers focus more of

their efforts on finishing. As galvanizing progresses in South Africa with the changing labour environment, local galvanizers have to look towards achieving a balance between improved process control technology and effective and efficient labour resources" Clarke advises.

Clarke concurs that nothing detracts more from high-quality galvanizing than an article having surface anomalies arising from poor welding seams, jagged pin holing, or the inevitable variation in aesthetics between mismatched steel. Clarke therefore supports the growing emphasis by galvanizers and their customers towards achieving attractive finishes. "With a collaborative approach between engineers, architects, fabricators, and galvanizers, we can achieve and ensure acceptable aesthetics consistently and repeatedly. However, this still requires the correct selection of good material, to enable the fabricator to include the correct vent and drain holes, and to design so that there is only one submergence in the galvanizing bath" he notes.

Challenges arising from the variation in steel

As local steel production falls and imports increase, quality issues predominate. While Clarke is not overly concerned that the finished product galvanized offshore will fail to meet the global standards, on which South African standards are also based, he is uneasy about the poor quality of the steel being imported for local consumption and specified for hot dip galvanizing showing poor or no regard for conformity to international grading and certification of such steel.

"If a merchant receives a mixed bag of steel, this will impact the entire supply chain. An architect may order the right quality steel and provide us with the certificates. However, when tested these steels, the provided certificates do not accurately represent the material," he notes.

Clarke has also encountered instances where reputable suppliers have 'mixed-up' varying lots having different metallurgical characteristics. When the HDGASA identifies a trend, this is traced back to the source for a solution to be found. This underscores the important industry monitoring role of the HDGASA together with the importance of ongoing education and training in hot dip galvanizing technology of all stakeholders.

Ensuring quality through ongoing training

To this end, Clarke calls on all hot dip galvanizers to tenaciously encourage designers, specifiers, and fabricators to attend HDGASA training courses to ensure their clear and informed understanding of hot dip galvanizing as a corrosion control technology to the benefit of all stakeholders.

"The HDGASA courses ensure delegates understand hot dip galvanizing from its ground rules. From ensuring participants understand why the standards are written, to providing clarity of metallurgy and mechanisms of corrosion control provided by hot dip galvanizing. The HDGASA follows basic science and first principles including the original concept of cathodic protection, and how hot dip galvanizing can provide high levels of corrosion control to carbon steel. Most importantly, however, our training courses help participants to understand how, by providing quality hot dip galvanizing, they can meet their customer's expectations by supporting their steel products with an extended service life. Doing this successfully is the embodiment and definition of hot dip galvanizing quality," Clarke concludes.

HOT DIP GALVANIZED coating thickness and Heat Affected Zone (HAZ)

Hot dip galvanized (HDG) coatings arise from the metallurgical reaction between perfectly clean steel and molten zinc at 450°C. Principally a hot dip galvanized coating develops in phases driven by the Silicon (Si) content of the steel.
An HDG coating provides two concurrent modes of corrosion control to the steel. Firstly, the coating encapsulates the steel in a barrier coating placing itself between the steel's surfaces and the corrosive environment. Secondly, the coating provides sacrificial corrosion control through a mechanism known as cathodic protection.

Cathodic protection transpires when two dissimilar metals conductively electrically connected react with the corrosive environment and while one of the metals corrodes the other metal remains undamaged. The metal that sacrifices itself is termed the anode (HDG) and the unaffected metal is titled the cathode (Steel).

The rate at which this occurs is proportional to the area of the cathode covered by the anode and varies according to the corrosivity of the environment in which the hot dip galvanized steel is employed. Thus, with HDG coatings, the area of the anode is the same as the area of the cathode.

The longevity of the protective life (service life of the coating) is directly proportional to the mass of the anode on the cathode. The more mass the anode has the longer it will be able to sacrifice itself thereby protecting the cathode.

Heat Affected Zones (HAZ)

The cause of the forming of the HAZ is heat. The width of the zone depends on several factors, largely thermal diffusivity and the choice of cutting methods.

Thermal diffusivity of a metal is the measure of how fast heat will be transmitted through its body. If the thermal diffusivity is high, such a metal can transmit heat quicker than a metal with lower thermal diffusivity. As such the metal having the higher thermal diffusivity will also be the faster cooling and the

HAZ will thus be narrower. On the other hand, low thermal diffusivity will keep heat in the metal for a longer duration and create a wider HAZ.

For example, the thermal diffusivity of stainless-steel grade 304 is 4.2mm^2/s, whereas for structural steel it is 11.72mm^2/s. This means that structural steel when subjected to heat, will create a smaller HAZ as it will cool down quickly.

The Silicon in steel is affected by heat. Silicon is driven away from the heat-affected area towards the more stable area unaffected by the applied heat. It follows that the reactivity between the steel and molten zinc is reduced in the HAZ region. The coating thickness is impacted across the zone and more so at the edge than inwardly.

HDG coat thickness measurement as applies to HAZ i.r.o ISO 1461 Standard

The mean average thickness of an HDG coating is in effect a means to determine the overall mass of the anode applied to the cathode in grams of anode per m^2. Coating longevity is relative to the amount of HDG on the Steel in grams/m^2. The HDG coating effectiveness is unaffected by the unevenness of the final HDG coating for as long as the coating provides a barrier i.e. no-uncoated areas corrosion control is in place.

ISO 1461 thickness readings

The ISO1461 Standard stipulates that coating thickness readings should:

1. Be taken so as to be as representative of the OVERALL coating as possible.
2. Not be taken along any edges and at a distance of at least 10mm from any edge and 100mm from any cut edge and not within any HAZ.
3. That no single-point reading is of any consequence.
4. That an average coating thickness be determined from a minimum of five (5) individual readings in any reference area.
5. That the final average coating thickness calculated from the averages of all reference areas is the single parameter that must equal or exceed the minimum average coating thickness stipulated in the relevant table of the standard viz. Table 3 or Table 4.
6. In cases of dispute a gravimetric test (ISO 1461) shall be the final determinant of the mass of the HDG coating per square metre. This is a destructive test and is not applied in the normal quality assurance procedures applicable to articles of steel that have been hot dip galvanized.

Should readings be taken along edges, cut edges and in a HAZ, the readings are expected to be on the lower end of thickness, however, the coating would have developed through all phases. Should chips or damage to the coating occur, renovation as per paragraph 6.3 of ISO 1460 applies.

‘GALVANIZE YOUR VARSITY’

Events 2024

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

UNIVERSITY OF JOHANNESBURG

Tshwane University of Technology
We empower people

The *Hot Dip Galvanizers Association Southern Africa (HDGASA)* will be visiting campuses across South Africa to interact with future mining engineers, mechanical engineers, and civil engineers as well as metallurgists about hot dip galvanized steel in 2024.

Through the ‘Galvanize Your Varsity’ events, students will learn about the hot-dip galvanizing process, design, sustainability, performance, standards and specifications, and inspection. The program is starting out in 2024 with on-campus presentations and engagements by the HDGASA at events where students can comfortably interact with our specialist advisors.

Educating specifiers and designers of the future is paramount to the HDGASA’s mission. The *Hot Dip Galvanizers Association Southern Africa (HDGASA)* is a non-profit trade organization committed to educating current and future engineers, owners, developers, fabricators, and specifiers about hot dip galvanizing for corrosion control.

The HDGASA is dedicated not only to educating current specifiers of the galvanizing industry but also future members. One of the biggest market limitations to the specification of hot dip galvanized steel is ignorance. The majority of architecture and engineering students are only exposed to the fundamentals of galvanized steel while studying at varsity. However, in the real-world hot dip galvanizing is extensively used to combat corrosion of iron and steel.

Thanks to University of Johannesburg, University of the Witwatersrand and Tshwane University of Technology, we are ready to forge the essential link between academic activity and industry.

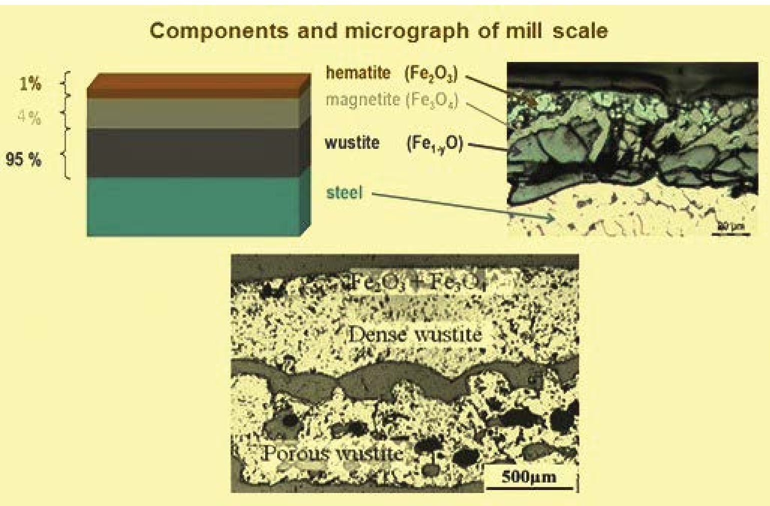
MILL SCALE IS NOT STEEL – it's an oxide

Mill scale is the product of oxidation which takes place during hot rolling. The oxidation and scale formation of steel is an unavoidable phenomenon during the process of hot rolling which involve reheating of steel in a reheating furnace, multi-pass hot rolling and air-cooling in the inter-pass delay times and after rolling. Mill scale is usually removed by process water used for descaling, roll and material cooling, and by other methods. It is subsequently separated by gravity separation techniques.

The formation of oxide scale not only results in a significant loss of yield of steel, but also deteriorates the surface quality of the steel product caused by rolled-in scale defects or roughened surface. In addition, the presence of a hard scale layer on the steel can have an adverse effect on roll wear and working life. The amount of mill scale generated in a rolling mill depends on the type of the reheating furnace and on the practice of rolling adopted in the mill. It is generally in the range of 1% to 3% of the weight of the steel rolled.

Mill scale mill scale is a layered and brittle material, composed of iron oxides with *Wustite* as a predominant phase. It is normally considered as waste material. Scale formed during the heating of steel to rolling temperatures in the reheating furnace is known as primary scale. This primary scale is removed generally by hydraulic descaling before hot rolling. The removal of the primary scale formed during the reheating operation before hot rolling is usually done for producing steel products with high surface quality and for reducing roll wear. However, secondary scale continues to form on the descaled steel surface during the inter-pass delay time in the roughing and intermediate rolling mills. The colour of primary mill scale is generally bluish black while that of the secondary scale is blue. The secondary scale gives the steel an appearance which is similar to that of a lacquer coating finish.

The iron in the primary mill scale is usually present in different chemical forms. The primary scale has three layers of iron oxides consisting of *Wustite* (mostly FeO), magnetite (Fe_3O_4), and hematite (Fe_2O_3) from the metal surface outwards.



1 Components and micrograph of mill scale.

Wustite is the inner most phase of the scale which forms next to the metal and is the Fe rich phase. It has the lowest O_2. It is represented as FeO.

The *Magnetite* phase, Fe_3O_4 is the intermediate phase of the scale. It is the main equilibrium constituent of scale below 500°C. It exists as a metal deficient oxide but at a much smaller level than *Wustite*. It has been shown from various studies that both cations and anions diffuse in Fe_3O_4, *Magnetite* occupies only around 4% of the total scale layer. *Magnetite* is harder and more abrasive than *Wustite*.

The *Hematite* phase, Fe_2O_3 is the outer most layer of the scale and has the highest oxygen content. *Hematite* occupies around 1% of the total scale layer at high temperatures. As with the *Magnetite* phase, *Hematite* is hard and abrasive.

The secondary mill scale is composed of iron oxides which predominantly consist of ferric oxide (Fe_2O_3). The thickness of this oxide layer is normally less than 0.1mm. It initially adheres to the steel surface and protects it from atmospheric corrosion provided no break occurs in this layer. Since secondary scale layer is electro-chemically cathodic to steel, any break in this scale layer causes accelerated corrosion of steel exposed at the break. The secondary scale layer is thus a boon for a while since it protects the steel against corrosion. However this protection disappears when the coating breaks due to handling of the steel product or due to any other mechanical cause. The size of Mill scale normally varies from dust size in microns up to usually 6mm.

Mill scale is a nuisance when the steel is to be processed. Any coating applied over it is wasted, since it comes off with the scale as moisture laden air gets under it. All mill scale needs to be removed to present a uniform and clean surface of the substrate steel for any application of any coating on the steel.

Removal of mill scale is virtually impossible by hand. It is extremely tedious and time consuming using power tool cleaning methods. Neither of these two methods gives a good base to start. Steel from the hot rolling mills has no surface profile, which is most important to the overall adhesion strength and integrity of the coating system. Mill scale is normally removed from steel surface by flame cleaning, pickling or abrasive blasting. These methods remove the mill scale and provide a surface profile that gives the coating system its design requirements. Coating over mill scale, however tempting, is a futile exercise, as the presence of mill scale on the steel surface accelerates the corrosion of the underlying steel.

ABECO BESPOKE DESIGN OF galvanized circular water storage tanks for Aspen

Port Elizabeth/Gqeberha based Aspen SA Operations needed to upgrade the Fire Protection System on the plant to complement the continued growth of its facilities. The need for a robust and sufficient supply of water is a necessity that Aspen has prioritized.

Aspen's Consulting Engineers, Clinkscales, Maughan-Brown (CMB) had extensive input in sourcing the best solution to the project's design options. The Increased storage tanks needed to be installed in a staged operation, without disrupting the supply of water from the existing water storage tank. The open tender required that the supplier provide Galvanized Water Storage Tanks in a limited space on an existing location to be completed within 12 months. The key consideration was achieving a water storage capacity of greater than 1 400 cubic metres which would be installed in the same available area located to the original 350 cubic metre water tank thereby increasing water storage to more than four times the original volume. The water is sourced from both municipal and borehole water which is pre-treated in an onsite reverse osmosis plant before being stored in the new Galvanized water storage tanks. The facility is to have an estimated service life of at least 20 years.

Abeco Tanks tendered a design using two circular storage tanks assembled on-site at Aspen. CMB evaluated and finalized the submitted design of the galvanized storage tanks in liaison with Abeco Tanks. The bespoke design met the requirements for not only water volume but also for the high wind load in the 'Windy City'. The two tanks have an installed base diameter of 7.33 metres and a height of 16.995 metres having a maximum storage capacity of 717.95 cubic metres each.

The hot dip galvanized panels were installed with the roof and top layer being bolted and secured then raised with a jacking system for each new level of panels until at final height. The installation required accuracy and a keen awareness of the area's turbulent winds before raising the tanks to the new level. Wind speed measurements were made continuously throughout the construction phase.

The Abeco team worked seamlessly with the Aspen team and achieved excellent results that will deliver safe water storage for the years to come. A successful project once again highlights the water storage needs increasing not only in the Eastern Cape but throughout Southern Africa.

HDGASA GOLF DAY 2023


TRANSVAAL
GALVANISERS