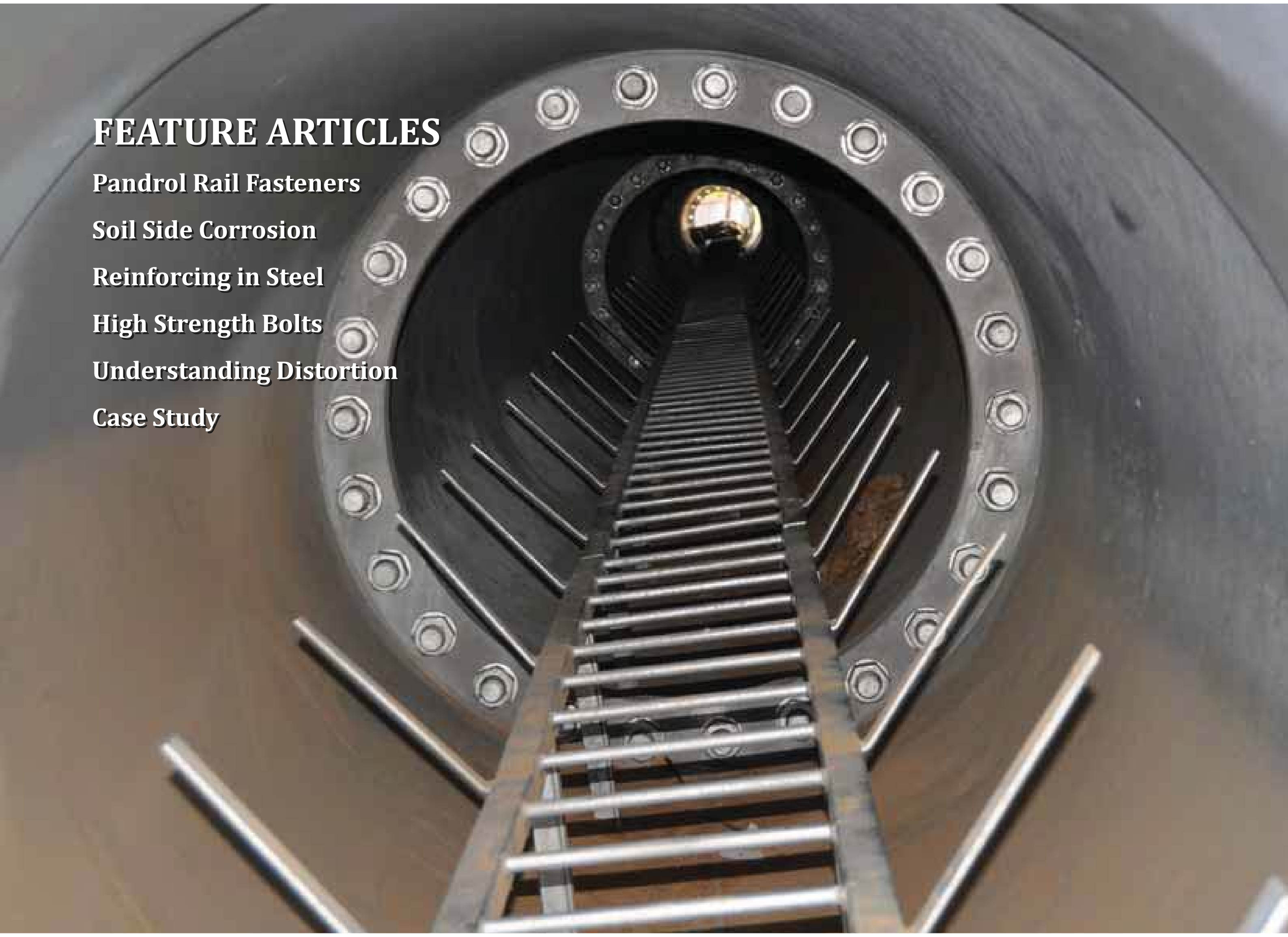
HOT DIP

Galvanizing TODAY

60

Hot Dip Galvanizers Association Southern Africa

2015 Volume 12 Issue 1



FEATURE ARTICLES

Pandrol Rail Fasteners

Soil Side Corrosion

Reinforcing in Steel

High Strength Bolts

Understanding Distortion

Case Study

ADDING VALUE TO STEEL

HOT DIP Galvanizing TODAY

Hot Dip Galvanizers Association Southern Africa 2015 Volume 12 Issue 1

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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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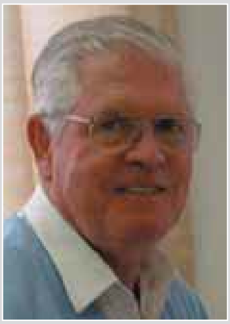
Executive Director's Comment



They say that "change can be as good as a holiday". We were all able to have a holiday during the Christmas break; however all the changes that have taken place at the Association over the past six months have been far from a holiday.

Following a serious slow-down in the economy and the knock on effect within the hot dip galvanizing industry, we were required to embark on a cost saving exercise. This process included a range of cost saving issues, including the unfortunate process of rationalising costs of a Cape Town operation that was well away from our primary market centred in Gauteng.

Additional savings were generated by a change of auditor, relocation of the offices and greater controls relating to all forms of expenditure.

Staff changes also contributed to the need for adjustments within the office. Shaun Amos resigned and left the Association in December and I returned to the role of Executive Director. This change called for a delay in my retirement date and a return to finding a suitable replacement.

To this end we were fortunate to identify Robin Clarke who joined our staff at the beginning of March.

Robin is a qualified mechanical engineer with extensive experience in manufacturing and specifically within the casting industry. Due to his technical ability, practical experience and his demonstrated willingness to acquire hot dip galvanizing experience, I am most excited about the future of the Association.

To support Robin during a hand over period, I will continue at the Association for at least a further six months. Following my retirement I shall remain available on a consulting basis.

On behalf of the Executive Committee and our wider membership, I welcome Robin to the Association and trust that he will serve the interest of the members and just as importantly, that of the wider corrosion protection industry.

Bob Wilmot

Hot dip galvanizing training for inspectors

The Association's three day Inspector's courses continue to be well attended and are attracting international interest.

During February and March two courses were presented, both at our new Bedfordview offices. Of the fifteen candidates that attended, seven achieved over 75% with the remaining eight passing with scores greater than 50%.

The objective of our three day Inspector's course is to provide delegates with the necessary skills to assess the quality and conformance of hot dip galvanized coatings and Duplex systems, in terms of applicable specifications.

The specifications used in our region are; SANS121 (ISO 1461:2009) for 'batch type hot dip galvanizing' and SANS32 (En10240:1997) as used for 'automatic or semi-automatic hot dip galvanizing for tube and pipe'.

Interpretation of specifications is reviewed with an emphasis attached to the value of a visual inspection and procedures for determining zinc coating thicknesses.

Candidates are introduced to how steel chemistry affects the quality of a hot dip galvanized coating; followed by corrosive environments and what constitutes a corrosion cell. Forms of corrosion are briefly reviewed and how metallic coatings are applied where corrosion control and the ultimate service life of a carbon steel structure is being specified.

On course No.2 we were able to welcome Mr Javier Sabadell *Director General Asciación Techica Española De Galvanización* and an Association colleague. Javier attended our course in order to review our course material and adapting it for use in Spain. Our colleagues in Brazil have implemented a similar programme that uses a number of aspects from our local Inspector's course.

We are available to run the Inspector's course anywhere in the country on the basis that we have 6 or more candidates. It is also advisable that a hot dip galvanizing plant is available in the area for conducting the practical phases of the course.

Above right:
Course No. 1 - February 2015.

Below right:
Course No. 2 - March 2015.

Full course details and application forms together with costs are available on our web site www.hdgasa.org.za

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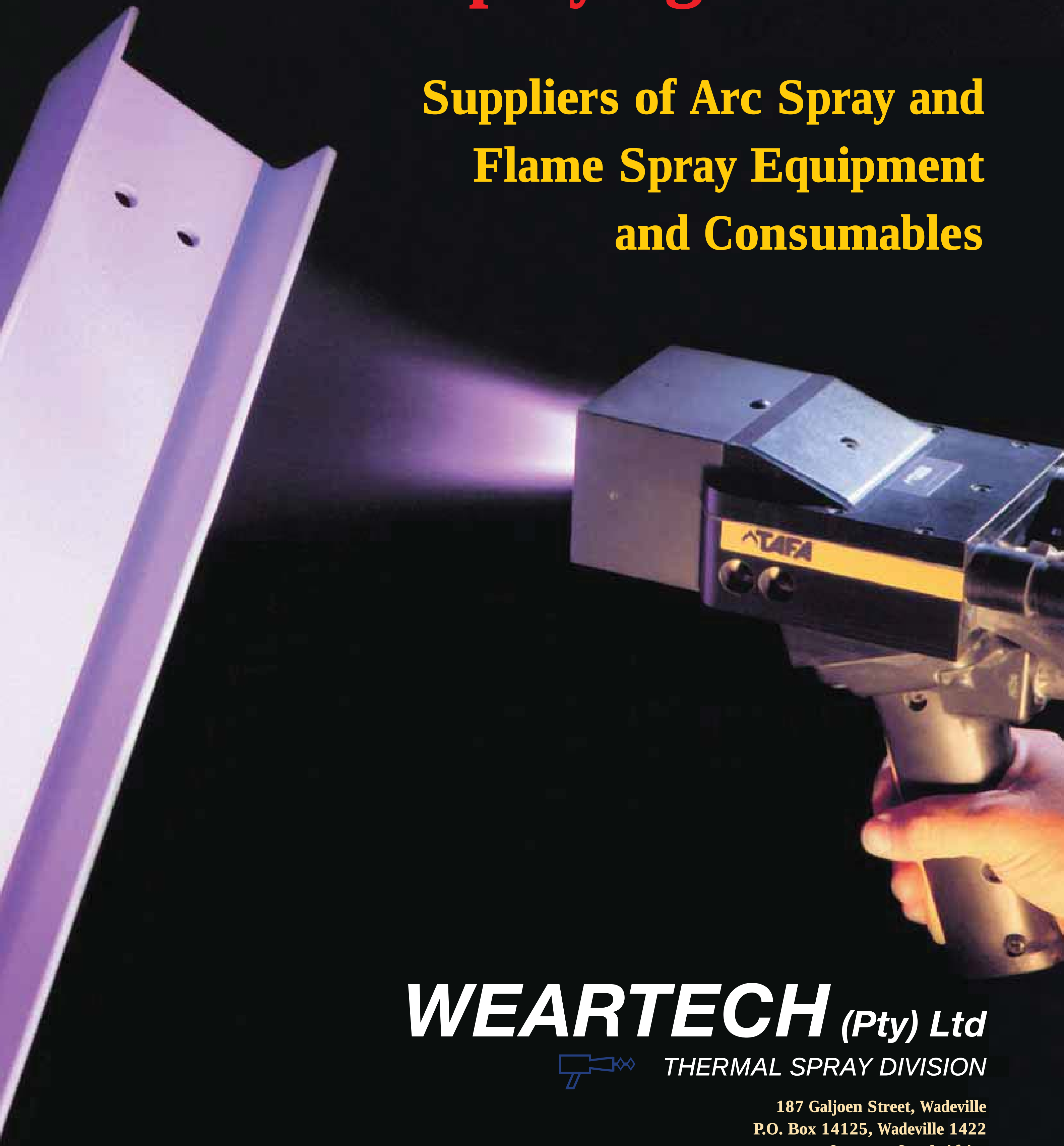

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HOT DIP GALVANIZING: A cost effective protection system

When comparing hot dip galvanizing with other protection systems, two elements have to be taken into consideration: the initial costs of applying the protection system and the life-cycle costs, including maintenance, to ensure the steelwork is protected against corrosion throughout the entire lifetime of the mine project. Whereas initial costs are typically a small fraction of the total lifetime costs, life-cycle costs, especially if frequent maintenance is required, can be several times the initial costs.

Initial costs of applying a zinc coating through hot dip galvanizing are comparable to those of a quality paint-only protection system. However, hot dip galvanizing's major advantage is its maintenance-free longevity. Once applied, no further costs occur throughout the project life. Paint-only systems show failure after a few years, requiring regular maintenance thereafter; making maintenance costs a major expenditure. Hot dip galvanizing as a protection system for steelwork in mines can save 50% or more in total steel protection costs over a 30-year project lifetime. No other protection system provides a better return on investment.

A Sustainable Choice

Zinc is an integral part of the environment, naturally present in rock, soil, water and air. It is an essential micronutrient for humans, animals and plants. Zinc coatings greatly improve the durability and life cycle of steel products and, like steel, zinc is 100% recyclable, thus conserving valuable resources and providing economic savings for future generations.

Conclusion

Hot dip galvanizing provides superior corrosion protection to steel. It is easily and swiftly applied and covers the entire surface of the steel article, even in inaccessible areas, provided the article is properly designed. Hot dip galvanized coatings provide a unique dual protection that prevents corrosion even if the coating is damaged. Maintenance painting is often impossible in mining environments, so the only option with paint-only structures is complete replacement. Hot dip galvanized coatings are hard and chip-resistant. They provide long lasting and maintenance-free corrosion protection to steel even in aggressive mine environments and provide significant savings compared with other protection systems that require maintenance.

Hot dip galvanized shaft guides prior to installation into a deep level gold mine.

Hot dip galvanized high pressure service pipes waiting to be moved underground.

Hot dip galvanized cross shaft steel "Buntons" used together with the shaft guides to equip the shaft on a gold mine.

Typical example of hot dip galvanized shaft station steel structure, beginning check assembled followed by dis-assembly to be transported underground to be re-erected.


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How to achieve savings and a better galvanizing finish with nickel tablets

The addition of nickel tablets into the zinc kettle is a proven way to reduce the coating thickness of items being hot dip galvanized and increase the shine and overall appearance. Nickel tablets have been successfully used locally and internationally for many years. They provide a unique, easy and cost effective way to introduce and maintain nickel in the zinc kettle at an optimum of 0.05%.

Nickel tablets.

Main advantages of adding nickel tablets into the zinc kettle:

1. Reduces pick up by inhibiting the growth of the alloying layers beneath the surface of the zinc, this results in drastic cost savings especially when a great deal of high silicone work is processed, as the nickel tablets reduce the Sandelin curve.
2. They provide a brighter and smoother finished product. This is achieved across the board but especially with highly reactive / high silicone steels. By lowering the Sandelin curve the addition of the nickel tablets helps to transform thick, dull and patchy coatings to an impressive thinner, smooth and high shine finish.
3. Galvanizers have also found reduced levels of floating dross in their kettles as well as less or no dusting required as the work is coming out the kettle.

Thickness test done before the conversion to nickel tablets.

Drastic reduction achieved on an identical item dipped after the conversion with nickel tablets. Coating still within ISO specification.

Traditionally there have been three options for the galvanizer to consider when adding nickel to the kettle:

1. Adding raw nickel powder can be hugely inefficient and costly if not done correctly.
2. Zinc/nickel alloy, while effective, cannot be controlled easily should the nickel balance need to be altered and generally works out more expensive.
3. Nickel tablets: this option works out to be the easiest and most cost effective way to add and maintain the correct levels of nickel in the kettle.

Left: Before nickel tablets.
Right: Chrome like finish achieved after the addition of nickel tablet.

The tablet method requires no specialized machinery or training, and takes only minutes to be incorporated into the zinc before dipping can resume (hence no downtime). The soy wax sealed tablets are simply placed on top of the surface of the molten zinc where they burn off, the bath is skimmed and dipping continues as normal.

After the initial conversion is done three tablets are added per ton of zinc. This maintains the level perfectly and makes it incredibly easy for the galvanizer to see an immediate improvement in the finish and reap the benefits of significant cost savings.

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Performance of hot dip galvanized resilient rail fasteners exposed in a severe marine environment

Modern railway systems are designed for high-speed traffic and extremely heavy axle loadings, particularly in the case of trains transporting cargo. Examples in South Africa are the Richards Bay coal line (200 cars) and the Sishen to Saldana iron ore line. This has necessitated the development of sophisticated railway track design in order to prevent rail creep at steep gradients, gauge widening on tight curves as well as relaxation of the fastening devices between rails and sleepers over a period of time.

The introduction some decades ago of the resilient rail fastener, which is manufactured from tempered spring steel, has contributed substantially to the provision of reliable and safe railway track systems throughout the world.

A problem that remained was that of atmospheric corrosion, which can cause the premature fatigue, fracture of stressed high strength steel, particularly when it is constantly flexed.

Despite initial negative opinions expressed to the contrary by technical experts, hot dip galvanizing has been demonstrated to provide the most cost effective method of corrosion control for resilient rail fasteners.

This article discusses the laboratory and practical tests, which showed conclusively that the hot dip galvanizing process has no deleterious impact on the metallurgical properties of the spring steel from which rail fasteners are manufactured. Recommended hot dip galvanizing procedures and controls are also considered.

Introduction

Apart from the limited use of steel sleepers, wood was for many years the preferred material, with hardwood timber favoured for heavy duty mainline track. This led to the decimation of vast indigenous forests where trees were felled to produce railway sleepers that were exported from the country of origin to various destinations throughout the world.

The concept of resilient rail fastener assemblies was first developed in the form of square laminated spikes similar in shape to a shepherds crook. These spikes were driven into pre-drilled holes in wooden sleepers. Millions of these so-called Elastic Rail Spikes were successfully installed throughout the world, frequently in the galvanized condition, since the metallurgical properties and hardness levels were within what was then considered to be the acceptable range for hot dip galvanizing.

As the pending shortage of timber and inevitable cost increase became apparent, the use of alternative sleeper material was researched. This led to the development of the high-density concrete sleeper that is in general use today.

Meanwhile, an astute Norwegian railway engineer by the name of Pandrol had designed a resilient spring clip, which he patented in his own name. The UK manufacturers of the Elastic Rail Spike, who were quick to perceive the significance of this design, acquired the manufacturing rights. Thus the well-known Pandrol Rail Fastener was born.

Plainly, the elastic rail spike was not suitable for use with concrete sleepers while at the same time, track technology had advanced to such an extent that a more sophisticated fastener design had become essential.

In time, other effective resilient fastener designs were introduced but the question of corrosion control in corrosive environments needed re-addressing, since the hardness properties and clamping force applied by the new generation of resilient fasteners was substantially greater than that of the first generation elastic rail spike. This raised concerns regarding the suitability of hot dip galvanizing.

The South African scene

The South African railway system operates on narrow 3ft 6inch (1.05m) gauge track. Due to the undulating nature of the terrain, steep gradients and tight curves are required to be negotiated by heavily loaded goods trains, up to 1km in length. These trains transport coal and iron ore from mines situated in the interior at altitudes of up to 1 500m, down to the ports at sea level. In order to prevent serious problems such as rail creep and gauge widening – which can result in disastrous derailments – track technology and construction in South Africa is of necessity equal to the best worldwide.

In contrast, many other rail routes have been constructed along the coastline in order to avoid costly civil works. Frequently, the track is situated within the ocean spray zone where aggressive corrosion is encountered to the extent that in some instances, unprotected fasteners needed replacing every two to three years. Corrosion is a well-documented cause of the premature fracture of tensioned spring steel, particularly in circumstances where cyclical flexing is encountered as in the case of rail fasteners when trains are travelling along the track.

Metallurgical properties of resilient rail fasteners

Fasteners are manufactured from grade En45 silicon, manganese spring steel for oil hardening and tempering, the chemical analysis of which is as follows.

C %	Mn %	Si %	S, P % max.
0.55 – 0.60	0.70 – 1.00	1.50 – 2.00	0.05

Table 1: Chemical Analysis of En45 Steel.

Fasteners are forged at a temperature of 950°C and then quenched in oil. The required hardness level is achieved by tempering in a furnace for

30 minutes at 550°C. In this way a spring is produced with a hardness level of 45RC (Rockwell C scale). The clamping force provided by each fastening device is normally in excess of 900kg.

The influence of hot dip galvanizing on the performance of resilient rail

Research and development

During the 1970s, numerous laboratory and practical studies were undertaken in South Africa to determine to what extent, if any, hot dip galvanizing impacts adversely on the integrity of resilient rail fasteners.

A vibrating test was carried out on several galvanized fasteners and the results compared with those obtained for ungalvanized components. This severe test entails suspending a heavy concrete sleeper by means of a rail fastener, which is connected to a vibrator designed specifically for this purpose. This so called "Vibrogir" equipment induces high frequency vibrations into both the fastener and the sleeper. Results are gauged by the number of test hours obtained before fatigue failure of the fastener occurs.

Discussion of test results

- *Hydrogen embrittlement*

  High strength hardened steels, which are exposed to acids, have a propensity to absorb liberated nascent hydrogen. These hydrogen atoms accumulate along the steel grain boundaries where after a few hours they accumulate to form molecules of hydrogen that could result in hydrogen embrittlement.

It is possible to diffuse hydrogen atoms by mild heat treatment when it is still in the nascent stage, but once molecules have formed, heat treatment has no effect. It is for this reason that high strength bolts are heated to a temperature of about 200°C immediately after the electro-deposition of zinc coatings in the electroplating industry, where hydrogen absorption can occur both by way of acid pickling as well as the actual plating process. Whether such heat treatment would be effective in the case of substantially thicker hot dip galvanized coatings is doubtful since hydrogen does not readily diffuse through solid zinc.

Opinion has been expressed by metallurgical authorities that absorbed hydrogen is liberated at the substantially higher molten zinc galvanizing temperature of 450°C despite the brief exposure of about four to five minutes at this elevated temperature.

In all the laboratory tests undertaken on our behalf by the metallurgical department of the University of the Witwatersrand, no evidence could be found of damage to hot dip galvanized components that could be attributed to hydrogen absorption.

In one incident, galvanized resilient fasteners of a more recent design, fractured in large numbers on a track along the Atlantic Coastline (Sishen Saldana Iron Ore Line), shortly after installation. The immediate reaction from sceptics and critics was to attribute such failures to hydrogen embrittlement, due to the fact that the fasteners were hot dip galvanized. The actual cause was

continued on page 10...

inadequate heat treatment during manufacture, which resulted in inordinately hard and brittle material.

- *Material hardness properties after hot dip galvanizing*

  Hardness measurements taken both before and after hot dip galvanizing, confirmed that exposure to the molten zinc had no significant influence on steel hardness. If anything, the effect was to marginally soften the material.

- *Metal fatigue tests*

  Several hot dip galvanized resilient fasteners were subjected to the same vibrating test as applied to ungalvanized fasteners. The results obtained were similar for both the hot dip galvanized and uncoated components.

- *Steel surface defects*

  Occasionally, an installed fastener was found to have fractured for no apparent reason. It was eventually observed that these failures occurred at rolling defects on the steel surface, which would constitute stress raisers. At the same time it was established that such steel surface defects would not necessarily result in the fracture of ungalvanized components. The most feasible explanation is the formation of micro-cracks in the Fe/Zn alloy phases of the coating, due to fastener flexing in service. In the event that a micro-crack is situated directly over a rolling defect, it would be possible for the crack to propagate into the steel at such a stress raiser.

  By selecting material relatively free from surface defects and avoiding excessively thick galvanized coatings where Fe/Zn alloys predominate, this phenomenon is controlled and very rarely encountered.

The hot dip galvanizing process

It will be seen from the chemical composition of En45 spring steel in *Table 1* that the carbon, silicon and manganese contents are extremely high. At 1.50 – 2%, silicon is higher than the maximum level as normally depicted on the Sandelin Curve while the carbon and, to a lesser degree the manganese; also contribute to increased Fe/Zn alloy formation when steel is immersed in molten zinc. Despite this, the galvanized coating properties of En45 steel are equivalent to those achieved on normal carbon steels where the silicon content is <0.04% and the phosphorus level <0.01%. This is provided that the immersion cycle in molten zinc is not extended unduly, ideally less than four minutes.

It would seem that there is an initial incubation period during which the diffusion reaction is parabolic with time, after which the reaction becomes linear with time. For this reason extended immersion times in the molten zinc must be avoided.

By adhering to good galvanizing procedures, the results obtained when galvanizing En45 spring steel will be entirely satisfactory.

Acid cleaning

Exposure to acid containing an inhibitor should be limited to the shortest time possible. A period of less than 20 minutes in unheated hydrochloric acid is normally adequate to ensure satisfactory cleanliness. Acid stripping and re-galvanizing is not acceptable.

Hot dip galvanizing

Immersion in the molten zinc at a maximum temperature of 450°C for less than 4 minutes will ensure an acceptable degree of zinc / iron formation. Extended immersion times resulting in excessively thick zinc / iron layers must be avoided.

Quenching in water

Water quenching should take place immediately after centrifuging in order to prevent unnecessary continued alloy layer growth after withdrawal from the molten zinc. The mild thermal shock induced by water quenching will not alter the hardness properties of fasteners.

Conclusion

Extensive laboratory, practical studies and site experience has shown conclusively that the hot dip galvanizing of resilient rail fasteners manufactured from hardened spring steel has no adverse influence on the mechanical properties of these components. There are no special requirements other than adherence to good hot dip galvanizing practice.

The millions of hot dip galvanized resilient rail fastening devices now in service in railway systems throughout the world, provide conclusive evidence that, for cost effective corrosion control, hot dip galvanizing is the preferred method.

This has also led to the acceptance of hot dip galvanizing as a means of corrosion control for grade 10.9 high strength bolts in some national specifications. Arguably, the propensity for hydrogen embrittlement to occur is far greater when a less durable zinc electroplated coating is applied, despite the fact that electroplating is a generally accepted coating for high strength bolts.

Resilient rail fasteners can and are hot dip galvanized without the risk of hydrogen embrittlement and fatigue failures. Reasonable "best practice" hot dip galvanizing procedures need to be implemented and adhered to.

Substantial increases, three to four times the service life of unprotected rail fasteners can and are achieved by the application of hot dip galvanized coatings, to provide corrosion control in aggressive environments.

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Shouldn't more rebar be galvanized?

Corrosion of the steel reinforcing component (rebar) within concrete structures can lead to expensive repairs or, in rare and extreme cases, catastrophic results such as a structural collapse.

Whilst the risk of rebar corrosion is more prevalent in coastal regions, no reinforced concrete structure is immune. And assuming that inland locations have a lower corrosion risk does not necessarily hold true; areas where acid rain occurs or where there is a risk of acid mine drainage are cases in point.

It is also important to bear in mind that environments may change. For example, it is entirely possible that a structure built today in a low risk region may in future be surrounded by a potentially corrosive environment due to say, the construction of a nearby power station or other industrial development.

Suffice to say, corrosion can strike anywhere. There are several methods used to mitigate steel corrosion in concrete. These include:

- Coating the concrete with a membrane or paint.
- Mixing corrosion inhibitors into the concrete during batching.
- Replacing conventional rebar with stainless or 3CR12 steel.
- Introducing an electrochemical method (cathodic protection).
- Coating the rebar itself, either with an epoxy or zinc (hot dip galvanizing).

However the focus of this article is the very last method mentioned namely, hot dip galvanizing of rebar.

What is rebar corrosion?

Before introducing the benefits of hot dip galvanizing rebar, it would be helpful to understand the main causes of corrosion and simultaneously clear up some associated misunderstandings. When applied to steel exposed to the atmosphere, the terms corrosion, oxidation and rusting are much the same thing. When steel (an alloy of iron and carbon) comes into contact with air, depending on the prevailing conditions, it has a tendency to revert back to its natural state (iron ore) by the commonly known process called oxidation, or more colloquially, rusting.

Catastrophic structural failure example, attributed to corrosion of reinforcement.

Corrosion sequence

The environment contains corrosive inducing elements and compounds such as oxygen, chlorides, sulphur dioxide and water and, in time, these substances penetrate the concrete, triggering the corrosion sequence.

Unprotected rebar corrodes in the following sequence.

1. Once these corrosive elements have penetrated through to the rebar, corrosion (rust) will begin and progressively intensify.
2. During this process various ferrous compounds are formed and they will come to occupy a volume 2.5 times that of the parent steel from which they originate.
3. This expansion stresses the concrete surrounding the rebar leading to a condition known as concrete spalling, where the protective concrete layer covering the rebar breaks away, leaving it exposed and even more vulnerable to the environment.

continued on page 14...

Ingress of corrosive substances is first indicated on the concrete surface by rust stains, followed by cracks.

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Primary advantages of galvanizing

1. Prevents concrete spalling: Hot dip galvanizing of the rebar substantially reduces the risk of concrete spalling. Studies, done mostly along the coast but inland as well, have shown that necessary remedial work to attend to rebar corrosion is usually required about 10 years after construction. Hot dip galvanizing of the rebar extends that period to 30 years. Accordingly, it is cost effective as the cost of galvanizing the rebar is much less than the cost to repair concrete spalling, caused by corroding, uncoated rebar.

2. Combats carbonation: Carbonation is a process whereby carbon dioxide in a moist environment reacts with hydrated cement paste to form an acid aqueous solution that tends to reduce the concrete's alkalinity. This reduction is ideal for zinc's corrosion protective properties as it is amphoteric (i.e. having both acidic and base characteristics). Conversely there is no similar advantage in the case of uncoated steel.

3. Resists chlorine-contamination corrosion: Chloride contamination of concrete is a major reason for steel corrosion, thereby adversely affecting the service life of reinforced concrete. Penetrating chloride ions can depassivate steel, promoting active metal dissolution. Hot dip galvanizing reduces or even prevents rust staining, provides a greater tolerance to construction imperfections and resists chloride attack. This improved resistance to chloride attack is due, for a large part, to the lower value of free corrosion potential of hot dip galvanized steel.

Spalling concrete indicates a potential for structural failure. Once spalling has occurred, it becomes very difficult and expensive to repair.

However, it must be stressed that the introduction of hot dip galvanized rebar is not intended as a substitute for poor concrete. Concrete quality remains the most important factor when corrosion protection of a structure is considered. Having said that, it is generally accepted that such concrete quality as well as correct site placement may present practical difficulties that cannot always be avoided and accordingly, and under these specific circumstances, the additional protection afforded by hot dip galvanizing may prove to be critical.

Some misconceptions de-bunked

Despite the obvious advantages that galvanizing provides, misconceptions still exist from a lack of knowledge of the hot dip galvanizing process and its corrosion control characteristics. Should these misconceptions persist, opportunities to improve structural integrity and service life may well be overlooked and lost.

Misconception 1

The high alkalinity of freshly poured "wet" concrete causes it to react with the galvanizing zinc coating, therefore damaging it. In practice, although limited reaction does occur, the concrete's alkalinity reduces during the curing process resulting in this reaction ceasing and the negative effects are negligible.

Misconception 2

That chemical elements produced during the pour compromises the bond between the concrete and the rebar. "Pull-out" tests conducted by researches around the world, as well as the latest series of tests done locally by Dr.R.G.D. Rankine, Construction Materials Consultant with specific knowhow relating to Concrete Technology, shows no reduction in bond strength compared with black rebar. Conversely, an increase in the bond strength was observed.

Misconception 3

A further misconception is that, due to the hot dip galvanizing temperature of 450ºC, the reinforcement will lose structural strength and its tensile integrity. This is not so in that the transformation ranges of steel occurs between 700º to 900ºC, well above the hot dip galvanizing temperature. This fact has been confirmed by laboratory tests as well as practical case studies on hot dip galvanized fasteners and structural steel components.

Economic considerations

As mentioned above, the preventative cost of using hot dip galvanized rebar is more than offset by the savings enjoyed later, when avoiding expensive remedial costs that may well be required to repair spalling concrete, caused by onset of corrosion of uncoated rebar.

Although costs vary due to geographical and other factors, it is still a reasonable assumption that, by using galvanized rebar, the corresponding increase in cost of reinforced concrete would be in a range of 5 – 10%. However, if the galvanized rebar was restricted to strategic locations (where the risk of corrosion is high such as exterior walls) the overall cost increase for a project could be as little as 0.5 – 3%.

When compared to many other methods of corrosion protection, hot dip galvanizing of rebar is more economical. However, and perhaps more importantly for the project owner, the full benefits will only be experienced over the life of the project in the form of reduced maintenance and remedial costs.

Sydney Opera House.

Examples

Hot dip galvanized rebar has been successfully employed for over 50 years, with excellent results. There are many examples around the world and here are three:

1. Sydney Opera House, one of the world's most recognizable and iconic buildings
2. Johannesburg Civic Centre
3. New Groote Schuur Hospital, Cape Town.

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Johannesburg Civic Centre.

New Groote Schuur Hospital, Cape Town.

Conclusion

To summarise, employing hot dip galvanizing to protect rebar benefits the long term durability of reinforced concrete structures in a number of convincing ways, namely:

- Significantly extends the life of the structure.
- Substantially reduces long term maintenance costs.
- Convenience of manufacture.
- Ease of handling, transportation and installation.
- No special design requirements are necessary.
- Protects the structural integrity against both existing and future corrosive atmospheric conditions.
- A proven product boasting an outstanding track record that extends for over half a century and is arguably without peer.

All things being considered, the question that we perhaps should ask our legislators, architects and engineers is, "Shouldn't more rebar be galvanized?"

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Soil side corrosion

When one considers the service life of steel structures it is incumbent upon the designer to consider the application and the environment/s to be encountered. Three fundamental environments are considered, being atmospheric, water and soil and usually all three in combination. In this article we consider that of soil side corrosion.

There are many applications where steel structures are used in buried or partially buried applications, such as water pipes, roadside poles, fencing posts, steel utility structures, culverts and piling and borehole casings.

In atmospheric environments, most materials have predictable modes of corrosion that are a function of pollution levels, time of wetness, temperature, rainfall, prevailing winds, relative humidity and even the topography of the land.

The durability of steel and steel coated structures buried in soil is a function of several interacting parameters including soil resistivity, acidity (pH), moisture content, soluble salts and oxygen content (aeration). However, all these corrosion processes involve the flow of current (electrons) from one locality to another. It follows that the higher the resistivity value, the greater the steel's durability against corrosive attack. A list of typical values for a range of soil types and corresponding resistivity values are given in *Tables 2 and 3.*

Most soils fall in a pH range of 6 to 8, which is favourable for corrosion control and durability when using hot dip galvanizing. Soils with lower pH values (acidic soils) are found in areas of high rain fall and marsh lands, which tend to be more corrosive, particularly where zinc is the primary coating material.

Soil side corrosion is extremely variable and given such a complex environment, it is difficult, but possible to draw some conclusions about soil type and corrosive conditions. *Table 1* gives some guidance on the evaluation of soils in terms of type and corrosivity.

Soils may appear to be a heterogeneous electrolyte, but can be divided into three identifiable phases.

1. The solid phase made up of soil particles which will vary in size and in chemical composition and levels of entrained organic matter.

Two examples of hot dip galvanized steel structures buried in soil. In both cases a neutral backfill (less corrosive) is the first step of providing an envelope around the structure as part of combating soil side corrosion.

2. The aqueous phase which is soil moisture content. Water is the carrier of the chemical elements that facilitates corrosion.
3. The gaseous phase which consists of air contained in the soil voids. Some of this air may dissolve in the aqueous phase.

The solid phase

Soils are commonly classified according to the general size range of their particulate component. Sandy, silt and clay soils are thus identified from the predominant size range of their inorganic particles. Soils rarely exist with only one of these components present. The various groups of sand, silt and clay make up the soil classifications on the basis of their particle size.

Clay soils are characterised by their ability to absorb water readily, the level of which is determined by the nature of the clay. For this reason, clay soils present a significantly higher corrosion risk than sandy soils. For this reason also, the nature of the soil on the surface may not reflect its nature below the ground.

The aqueous phase

Corrosion will only occur in the presence of moisture that contains ions that will transmit the electric current maintaining corrosion activity. There are several types of soil moisture.

These are free ground water, gravitational water and capillary water.

Free ground water is determined by the water table, which may range from near ground level to many metres below the surface. This is the least important factor in determining corrosion of buried steel as most installations are above normal water tables. Where high water tables bring ground water in contact with embedded steel, corrosion will progress as if the steel were in an immersed environment.

Gravitational water arises from rainfall or man¬made irrigation and will soak into the soil at a rate determined by its permeability. This will increase the period of wetness of the steel's surface and this in turn will impact on the soil's corrosive effects, depending on the conductivity of the gravitational water. Where regular rainfall occurs, most soluble salts may be leached from the soil over time, which will reduce the corrosive effects of gravitational water. Gravitational water will ultimately end up in the water table.

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Soil Type	Description of Soil	Aeration	Drainage	Colour	Water Table
1. Lightly corrosive	1. Sands and sandy loams 2. Light textured silt loam 3. Porous loam or clay loams thoroughly oxidized to great depths	Good	Good	Uniform colour	Very Low
2. Moderately corrosive	1. Sandy loams 2. Silt loams 3. Clay loams	Fair	Fair	Slight mottling	Low
3. Badly corrosive	1. Clay loams 2. Clays	Poor	Poor	Heavy texture and moderate mottling	0.6 to 0.9m below the surface
4. Unusually corrosive	1. Muck 2. Peat 3. Tidal marsh 4. Clays and organic soils	Very poor	Very poor	Bluish-grey mottling	At surface or extreme impermeability

Table 1: Visual ratings of corrosiveness of soil.

Soil Type	Degree of Corrosiveness	Electrical Resistivity (ohm-cm = 1S/cm)
1	Very Low	10 000 to 6 000
2	Low	6 000 to 4 500
3	Moderate	4 500 to 2 000
4	Severe	2 000 to 0

Table 2: Relationship of soil corrosion to electrical resistivity.

Classification	Resistivity Ohm-cm
Clay	750 to 2 000
Loam	3 000 to 10 000
Gravel	10 000 to 30 000
Sand	30 000 to 50 000
Rock	50 000 to infinity

Table 3: Typical soil resistivity values.

Capillary water is entrained in the pores and on the surfaces of the soil particles. The ability of soil to retain moisture is obviously important to plant growth. It is the capillary water that is the prime source of moisture in determining corrosion rates of steel in soil.

Item	Measured value	Rating
Soil composition	Calcareous, marl limestone, sandy, but not stratified sand Loam, sandy loam (content 755 or less) clay (silt content 75% or less) Clay, marl clay, humus	+2 0 -2
Ground water	None Existing Vary	0 -1 -2
Resistivity	10.000 ohms-cm or more 10 000 to 5 000 5 000 to 2 300 2 399 to 1 000 1 000 or less	0 -1 -2 -3 -4
pH	6 or more 6 or less	0 -2
Carbonate	5% or more 5 to 1% 1% or less	+2 +1 0
Sulphates	200mg/kg or less 200 to 500mg/kg 500 to 1 000mg/kg 1 000mg/kg or more	0 -1 -2 -3

Table 4: Soil corrosivity assessment technique.

The fluctuations in water content in soil due to precipitation and evaporation cause a variation in oxygen content; as drier soils allow more oxygen access and oxygen concentration cell formation may be enhanced.

Soil chemistry

Acid or alkaline conditions develop in the soils depending on their parent rock and the geological or man-made activity that may impact on them over time. Most soils are in the pH range of pH 6 to 8. Highly acidic soils are relatively rare, and generally occur in swamp soils or areas subjected to high accumulations of acidic plant material such as pine needles.

Soluble salts are essential to plant growth and are a major factor in corrosion. These salts may include salts of potassium, sodium, calcium

Armco Superspan arch as an underpass on the horse race track.

and magnesium. Salts such as calcium and magnesium, while initially promoting corrosion, frequently act beneficially as their insoluble oxides and carbonates become corrosion inhibitors over time.

Bacteria in soil are another factor that is important in corrosion activity. Sulphates can promote rapid bacteriological corrosion of steel because of sulphate reducing bacteria. Hydrocarbon-using bacteria can also accelerate failure of organic coatings used underground.

Soil has to be able to conduct electricity to participate in the corrosion of buried steel. The resistivity of the soil is used as an important measure of soil corrosivity. The higher the resistivity, the greater the resistance to current (electron) flow moving between anodic (zinc) and cathodic (carbon steel) of a zinc coated steel.

Regions of moderate or high rainfall will commonly have low levels of soluble salts in the soil, while desert soils may have very high salt levels. Some of the most aggressive soils in Southern Africa are located in desert areas like the Namibia and the Kalahari Desert, which has higher corrosion rates, particularly for hot dip galvanized coatings.

Estimating soil corrosivity

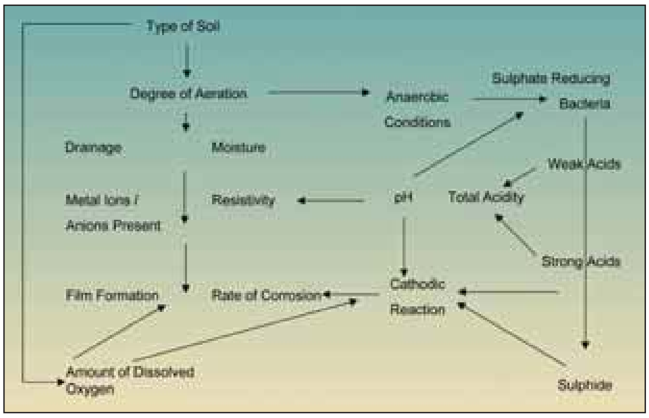
A great deal of case study data and specific research has been accumulated and this is invaluable in evaluating the potential for corrosion for various types of buried structures. While there are no easy answers, the German Gas and Water Works Engineers Association has developed a standard soil corrosivity assessment technique which rates the various factors that influence corrosion of steel in the ground detrimentally or beneficially. The sum of these factors gives an approximate corrosion rating.

Soil rating

Using the rating figures from *Table 4* the following is used to assess the soil corrosivity:

0 or above	Non-corrosive
0 to -4	Mildly corrosive
-5 to -10	Corrosive
-10 or less	Highly corrosive

General considerations



Relationship of environmental factors to the corrosive nature of a soil

The Association has ten Sponsorship packages available for the Awards evening scheduled to be held on Friday the 21st of August 2015

Recipients of WGS Barnett Trophy, Awards 2013: HA Mofutho Pedestrian Bridge

Each package will cost R22 500.00 (excluding Vat) and will provide the following promotional opportunities:

- ❖ Your logo will appear on all promotional items relating to the Awards Evening. These include: the HDGASA website (your name will appear as a sponsor, with a link provided to your website or contact details); the menus and Order of Ceremony; wine labels for the 3 bottles of wine on each table.
- ❖ Your logo and/or company name will be featured in our Awards issue of Hot Dip Galvanizing Today. The magazine is distributed to approximately 4 000 contacts in South Africa, Namibia, Botswana and internationally.
- ❖ Two free tickets to attend the Awards evening
- ❖ Your company name will be listed as a sponsor in press releases and publicity material.

We are only able to make ten of these fantastic opportunities available. These will be awarded on a first-come-first-served basis, so do not delay in booking your slot!

New equipment gives quality a boost at Impala Bolt & Nut

Driven by quality and innovation local bolt and nut manufacturer, Impala Bolt & Nut recently announced the addition of new optical equipment to the already comprehensive manufacturing and testing capabilities. The importance of quality in the manufacturing of a bolt or nut is critical to the longevity and application of the product explains Impala Bolt & Nut Managing Director Derek Cohen.

As a long standing manufacturer and supplier Impala understands the importance of stringent quality control prompting the purchase of this new equipment which will prove advantageous in ensuring enhanced visual and precision measurement abilities. Armed with this new equipment Impala will reaffirm their position as leaders by guaranteeing superior quality control and more efficient and effective testing systems.

This new and advanced optical equipment is earmarked by its market leading characteristics which set it apart from its competitors. Some of the unique characteristics include:

- Transmission illumination: with two high-and-low shifts to fit in with the measurement demand of different work pieces
- Non-spherical collector lighting system: allows the visual field of the projector screen to be brighter and more homogenous, reducing measurement errors and further securing the accuracy
- Imported Philips long-life halogen tungsten lamps: able to handle long-time use of the projector
- Axial flow blower fans: allows the bilateral heat radiation to provide super-strong radiating power
- Built-in feeder box, RS232 interface and 2-coordinate measuring software.

Boasting these unique characteristics this new piece of equipment is set to change the way quality and precision is measured. "The fastener industry is often under fire for quality standards and we are confident this new equipment will be instrumental in manufacturing superior quality products for a number of applications", added Cohen.

About Impala Bolt & Nut

Impala Bolt & Nut's complement of quality manufactured products encompasses a comprehensive range of standard and specialised bolts, nuts, washers and fasteners to provide the full solution for your requirements. With a vast warehouse of finished products available ex-stock off the shelf, we are able to deliver standard products quickly and efficiently. Impala also has the flexibility, capacity and expertise to manufacture fully customised fasteners specific to your application.

The use of high strength bolting assemblies for pre-loading

Rob Pietersma, Managing Director, CBC Fasteners.

Spencer Erling, Education Director, SAISC.

Historically in South Africa these bolts were commonly known as High Strength Friction Grip (HSFG) bolts.

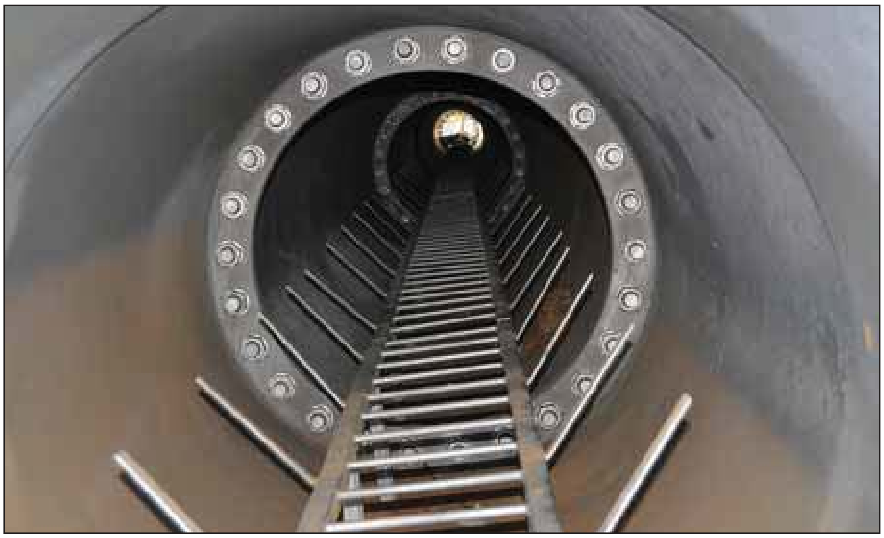
HSFG bolts were manufactured under SABS 1282 in grade 8.8 and 10.9. The 'S' on the head of the bolt indicated that it was a HSFG bolt for structural use. These bolts were used for non-slip applications (HSFG applications) as well as preloaded applications i.e. important joints, crane structures, cyclically loaded structures such as supports for vibrating equipment and for impact loaded structures.

Why we were able to have only one standard is explained below.

This standard has now been replaced in South Africa with EN 14399-3, also in grades 8.8 and 10.9 and with a head marking HR. We have not established what HR stands for.

What has commonly been requested in South Africa over the last 5 years, particularly where there has been a European design influence for important structures such as power stations, has been the EN 14399-4 bolt: this comes in grade 10.9 only and replaces old standard of DIN 6914, which was rarely, if ever, used in South Africa. Based on European design philosophy the strength of the bolt is taken as being in the shear plane in the unthreaded stronger part of the bolt.

To ensure this happens these bolts typically have a shorter threaded part than the HR bolts.



An unusual bolted connection.

The EN14399-4 standard bolt has the HV mark on the head. The V is associated with the symbol v used for shear in engineering calculations as these bolts are typically used in shear/bearing type connections, hence the need for two standards i.e. HV and HR in the European environment.

In South Africa we assume that the shear plane of our bolts is in the weaker threaded parts. This assumption allows us to use friction grip bolts for all preloaded applications i.e. non-slip as in HSFG and also for those important connections mentioned above.

The EN14399-4 has a lower nut height than EN14399-3 and the proof loads are according to ISO 20898-2 and are only slightly above the ultimate strength of the bolt. The reason for this is that for the 14399-4 (HV shear) connections, it is the shear strength of the bolt that is important. For the 14399-3 (HR=HSFG equivalent) the clamping force and the friction between the plates transfers the load.

EN14399-3 nuts have a 9% higher proof load than EN 14399-4. In the event of over tensioning EN 14399-3, the bolt will definitely break without the threads stripping whereas in the case of 14399-4, stripped nut threads could occur and a failed assembly will not have become evident.

A common complaint from the field, particularly from the 'old timers' who remember, is that the new EN 14399-3 nuts heights have been reduced. 'Dis nie soos die ou ding nie'. This reduction in height is as much as 2.7mm on a M24 nut, or 12%.

An assembly, as mentioned in the heading, is a new term which has been introduced into the equation. This relates to the requirement that bolt, nut and washers are to be supplied by one manufacturer as a complete assembly guaranteed suitable for use in pre-loaded connections.

The manufacturer has the obligation to perform certain testing on the assemblies to underwrite this guarantee. The first test involves determining the required torque to obtain the required tension (force) in the bolt.

The influence of lubrication between the threads of the nut and the bolt needs to be known to determine the torque. The manufacturer may supply pre lubricated nuts or if not, the nature of lubrication required to be used by the customer must be indicated and be in accordance with testing undertaken by the manufacturer.

The second test performed by the manufacturer is to ensure the performance of the assembly from the recommended pre load through additional tightening, until pre-determined angle turns have been achieved, thereby proving suitability to use for pre-loaded applications.

Certification on this front is required. This certification needs to be traceable, from the original wire used to manufacture the components, through the testing regime and right up to where the bolts have been used in the structures.

To this end identification numbers are marked on the components.

Hot dip galvanizing of grade 10.9 product

This has become a contentious issue, quite unnecessarily. The first risk is hydrogen embrittlement. This is overcome by shot blast cleaning which avoids acid contact.

Alternatively bolts can be cleaned in inhibited acid with specific time limits. Manufacturers have tended towards the shot blasting route and most reputable galvanizers have excellent systems in place to ensure no acid contact. The second risk is the not too well known or understood: one of hydrogen induced stress corrosion cracking (HiSCC). The hydrogen comes from the localised corrosion at the break in the galvanized layer, where the steel is exposed. This can come from white or red rust or any other corrosion process. A corrosion reaction taking place will also result in hydrogen being released at and into the breaks in the galvanized layer. White rust is a good example of a source of hydrogen and is simply the corrosion

The nut is pre lubricated thus giving it an apparent different finish to the traditional hot dip galvanized finish which is on the bolt and washer.

reaction which most readily takes place in the bolt holes' closed environment.

It is a known fact that steel and hydrogen are 'mortal enemies'. Exposure to hydrogen can lead to cracking of what was otherwise crack-free steel. The development of the cracks is thought to be further promoted in hard steel such as 10.9 bolts by being subjected to enough hydrogen entering cracks at high enough stress intensities.

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Bolted connection at Bakubung Platinum Mine Headgear.

Quality checks on a connection.

CBC follows the German guideline on galvanizing which requires that surface hardness is limited to maximum HV375 and bolt tensile strengths are held below 1140Mpa. This reduces the susceptibility of the steel to the influence of HiSCC. CBC Fasteners' bolts manufactured under these guidelines were tested at Darmstadt University last year. The bolts were subjected to a mixture of diluted acid in the thread area and tensioned to above 90% of the ultimate strength of the bolts. The bolts all passed the minimum required period of 48 hours (some 60 hours) without breaking and subsequently passed tensile tests.

Whilst at CBC we are confident of our hot dipped galvanizing grade 10.9 bolts, which we manufacture to German galvanizing guideline standards, it is noted that the Southern African Institute of Steel Construction (SAISC) remains silent on the hot dipping of grade 10.9 bolts. The American Institute of Steel Construction prohibits the hot dip galvanizing of grade 10.9 bolts, their reasoning being that whilst it is possible to galvanize the 10.9 bolts correctly, there are many ways in which the process can go wrong and they decided not to expose their engineers to this risk.

It has been suggested that the German approach to the HiSCC problem was that in Germany and other parts of Europe, they were locked into grade 10.9 (EN 14399-4) with no grade 8.8 alternative and therefore had to find a solution to HiSCC. It is noteworthy to mention that in South Africa where we have had an incident of HiSCC, two factors were present; surface hardness above HV 375 and extremely poor installation practice. Where installation practice improved, no subsequent failures were experienced. Total failure rate was a mere 0.000225%. The sample size was in the order of 258 000 bolts. The concept of HiSCC is unfortunately being used as an excuse to focus negatively on bolt manufacturers whereas the causes are in reality probably design faults and/or installation errors.

Site related issues

It is our experience that there is a general lack of understanding by so many construction businesses regarding correct installation and tensioning of construction bolts. This results in, inter alia, the use of impact wrenches where torque/tension cannot be verified; not using washers where required; no lubrication of hot dip galvanized assemblies; incorrect torque being applied; and not maintaining batch control. In many instances there is a rush to take short cuts only to find out later when things go wrong that replacement of bolts is required by the main contractor.

Problems identified with poor site procedures include, but are not limited to, the following:

1. Thick end plates in heavy connections are sometimes not straight when they come out of the workshops. Site personnel then over tighten the bolts to pull the plates straight. They do not replace the bolts used for this process.
2. From a safety point of view it is common to assemble a group of steel components into a large sub-assembly. A big crane is then used to hoist the assembly.

In order to assist making the connections between the assembly and the previously erected elements, bolts are often left loose and tightened once the connections have been mated. We do not know that the bolts have been damaged because they have been loaded in unexpected ways.

Bolt availability issues

A common mistake made by end users is to assume that construction bolts will come straight off the shelf. Bolts are a lot easier but may still require a manufacturing lead time of six to eight weeks. Nuts are more difficult as certain of these have to be imported and if there is a pre lubrication requirement, this will always be the case.

Because of the concept of these bolts being supplied as assemblies, it will be unacceptable for bolt distributors to have nuts galvanized and to supply them with other manufacturers' bolts as conforming assemblies or vice versa. It will not help the contractor who did not order his bolts timeously to the correct specification.

CBC Fasteners has acquired a huge amount of experience over the last six years, including some scars. We are willing to share our experience by offering installation training and are always willing to offer solutions to user requirements.

Understanding distortion

What is distortion?

Distortion is the unwanted warpage that is occasionally evident after hot dip galvanizing. Considering the amount of steel that is hot dip galvanized daily, the frequency of distortion is relatively low. However, when it does occur it is a serious concern for both the fabricator and galvanizer.

What causes a product to distort?

Hot dip galvanizing takes place at a temperature of about 450°C, which is at the lower end of the stress relieving range for treating steel. Thus the hot dip galvanizing process tends to release any inherent stresses that are contained in the steel, resulting in a dimensional change, commonly called distortion.

Why does it only happen sometimes?

When steel fabrications distort during hot dip galvanizing, the reasons have usually been built in at an earlier stage. Internal stresses to some degree are present in most steel structures and as a rule, are not a problem when hot dip galvanized.

Some sources of these internal stresses can be:

- Residual stresses induced at the mill during rolling of structural sections or plate.
- Residual stresses created by bending or welding.
- Lack of symmetry in simple sections such as channels or built-up sections.
- Combination of thick and thin material in the same assembly.
- Assemblies made too large that they require double end dipping to successfully coat the entire surface.

Can I tell if a product will distort during hot dip galvanizing?

Internal stresses are often in equilibrium with each other and will not result in distortion, however, due to the wide range of sources identified above, it is difficult to accurately predict whether distortion will occur or not.

Is welding a potential source of distortion?

When welding structures are fabricated, it is impossible to avoid the introduction of some stress especially during welding. It can be said that internal stresses due to welding play the greatest part in creating distortion.

What else can lead to distortion?

Distortion can also occur if steels of significantly different thicknesses are joined in an assembly. Symmetrical sections are less likely to distort than asymmetrical sections.

Preventing distortion

Products shaped by bending

Consider a plate rolled to form part of a circle. During hot dip galvanizing, the release of stress will cause the radius of the circle to increase, ensuring that the final fabricated circle of pieces do not meet up.

These difficulties can be overcome by installing temporary braces across the section to ensure that the object retains its desired shape. Braces can be either welded or bolted in position, with size and thickness proportional to the plate being retained.

Braces should be located at quarter points of the structure. Similar results can be obtained with bent troughs, angle frames, cylinders and back to back channels. It will, however, be necessary to touch up the area where the braces have been removed, with an approved repair material.

Welding or fabrication induced stresses

Welding plays an essential part in fabricating objects that are to be hot dip galvanized. It is therefore important to understand how welding stresses are generated, in order to minimise them during fabrication.

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By following a few basic rules, the incidence of distortion can be considerably reduced.

- Avoid over welding, welds should be no larger than is essential for the structural integrity of the fabrication.
- Welding should be as symmetrical as possible, in order to ensure the stresses are balanced. This can be done by placing welds near the neutral axis or by balancing them around this axis.
- Use a well planned balanced welding sequence. Extra care should be taken to minimise stresses by preparing and working to a welding plan, with large structures.
- Weld seams that significantly reinforce the structural strength should as far as possible be welded last so that they do not hinder the contraction of other welds.
- Use as few weld passes as possible and reduce the welding time to control the heat input.
- Make weld shrinkage forces work in the desired direction or balance shrinkage forces with opposing forces.
- Use backstop welding or staggered welding to minimise stresses.

Should a fabrication distort either after welding and before, or after hot dip galvanizing due to these stresses, it is possible to re-straighten the item. Best results are obtained by hot straightening before hot dip galvanizing as this will take less time and will not damage the zinc coating. Tests carried out prove that hot straightened components, which are within tolerance before hot dip galvanizing will not distort again after hot dip galvanizing.

Fabrications that lack symmetry

When fabrications are substantially symmetrical in both the horizontal and vertical planes, they have a much lower potential to distort at hot dip galvanizing temperatures. Under these conditions, the expansion forces are balanced and the product does not suffer any distortion. This condition exists with tubes, I-beams, rectangular hollow sections and other similar sections. When these sections are combined in a fabrication, it is possible to remove this symmetry.

Consider the case where a length of thin walled rectangular hollow section is welded to the top of an I-beam section. The geometric shape is no longer symmetrical, even though the two individual components are. The thinner walled tubing will reach the temperature of the molten zinc sooner than the thicker flange at the bottom. As a result, the RHS will expand faster than the bottom flange, causing the section to bow upwards.

Sections, which are not symmetrical, such as channels and angles will experience similar problems due to their in-built asymmetry. In the case of channels, the section will bow with the toes pointing outwards.

There are three recommended methods to overcome this type of situation.

- Redesign the fabrication as a symmetrical member. This will enable the forces to balance one another, preventing distortion.
- Fabricate and hot dip galvanize the components as individual pieces, and then weld together after galvanizing. The welds can be touched up using an approved repair material.
- Using bolts and pipe spacers to separate, assemble two asymmetrical pieces back to back. Hot dip galvanize and then separate after cooling - all contact surfaces can now be touched up using an approved repair material.

Combining thick and thin material in an assembly

When thin material is heated during hot dip galvanizing, it expands faster than a thicker material, heated for the same length of time. The thinner material will therefore distort if the thicker material restrains its expansion.

Consider a common trailer, where a thin plate is welded to a heavier frame: the sheet is generally attached to the frame by

welding. If the sheet is only half as thick as the frame, it will reach the temperature of the molten zinc twice as fast as the frame. As the sheet is restrained by the welds to the frame, the subsequent increase in sheet size will cause buckling to the sheet surface.

Two methods are recommended to overcome this problem:

- Hot dip galvanize the sheet and frame separately and then join together. Use hot dip galvanized bolts or screws, or if welding, repair with an approved repair material.
- Use a similar frame and sheet material thickness.

As the component is still fully protected against corrosion, it might be acceptable in some instances. When this type of distortion occurs, it is not readily corrected after hot dip galvanizing.

Hot dip galvanizing oversize objects.

When a fabrication is too large for a single immersion in the largest bath, double end dipping or progressive galvanizing can be used.

These processes increase the potential for distortion as it introduces uneven heating into the object. The one end is heated to the galvanizing temperature and therefore expands, whereas the opposite end is still at ambient temperature. Dipping the second part of the fabrication will not remove any distortion that has already occurred.

This is amplified when the fill and vent holes are undersized, requiring longer immersion times. Similarly, incorrect drain holes will retard the drainage of molten zinc, increasing the mass and possibility of distortion.

Distortion as a result of the above can be overcome or reduced by:

- Designing the components in modular lengths to suit a bath size so that a single immersion can be achieved.
- Ensuring that the vent fill and drain holes of a fabrication are adequately sized to enable rapid immersion and withdrawal from the bath.

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- Allowing for linear expansion in the design so that any distortion is elastic and is not constrained by any cross bracing.

Distortion as a result of double end dipping is rarely seen in simple pipes and poles due to their symmetry and simple design.

Long thin objects

Generally, long thin poles and pipes will not necessarily distort due to their symmetrical design. Should they be lifted at both ends, however, they may take on a characteristically bowed shape following the hot dip galvanizing process. Distortion is aggravated if fill and drain holes are insufficient in size, allowing the object to retain molten zinc when being lifted from the galvanizing bath. Bowing of this nature becomes permanent when the steel cools.

The following three methods are suggested to avoid or reduce distortion arising from the above:

- Lifting lugs or holes should be provided at quarter points.
- Vent and drain holes should be located and sized to maximise the rate of drainage and minimise the retention of molten zinc inside the section.
- The vent holes are to be located on the same side as the lifting lugs and the drain holes on the opposite side.

Designing to avoid distortion

During the design stages of large and complicated structures it is important to review the question of distortion with the hot dip galvanizer and/or the Association. In this way controls are introduced at the design stage taking into account the fabricating process and ensuring that the components are suitable for hot dip galvanizing to avoid potential distortion.

Reference: Association's Information Sheet No 10 "Avoid Distortion".

The performance of Pandrol rail fasteners in a marine environment on the Natal South Coast

Two sites were selected on the Natal South Coast for this study, viz, Park Rynie some 65kms south of Durban and Port Shepstone, 115kms south of Durban. Both areas were selected on the basis of their proximity to the sea being within 100 to 200 metres of the high water tide level. Surrounding corrosive conditions were observed by the review of other steel components in the area.

Park Rynie

- The Park Rynie site *(figure 1)*, visited on 19 May 2004, is located approximately 65kms south of Durban. Zinc coating thicknesses measured as follows: minimum 83µm, mean 121µm and maximum 150µm.
- Coating thickness measurements were taken on a Pandrol rail fastener and cast iron shoulder, both components having being hot dip galvanized. The hot dip galvanized coating on the Pandrol rail fastener measures 143µm *(figure 2)*.
- Coating thickness of the hot dip galvanized cast-iron shoulder measured 134µm *(figure 3)*. It is estimated that these components have been in service for between 18 to 20 years. By providing the same degree of corrosion protection to the shoulder clip assembly, a balanced design is achieved without the potential for a galvanic couple.
- A painted steel mast at the Park Rynie rail crossing illustrates the severity of the corrosive environment experienced at this particular site *(figure 4)*. It is believed, subject to confirmation, that this mast was coated with an epoxy tar.

Port Shepstone

- The sea is approximately 200 metres to the left of the Port Shepstone site and the town some 6kms further south *(figure 5)*. Zinc coating thicknesses measured as follows: 136µm minimum, 154µm mean and 197µm maximum.
- The seaside (using an ungalvanized cast iron) shoulder had corroded away exposing the hot dip galvanized Pandrol *(figure 6)*. The holding capacity of this particular fastener has become totally ineffective. Note the condition of the "land (lee) side" of the rail, where the system is intact and operative.
- *Figure 7* shows an example of a missing fastener, where the "ungalvanized" cast-iron shoulder is presumed to have

Figure 1.

Figure 2.

Figure 3.

Figure 4.

corroded away, allowing release and removal of the hot dip galvanized Pandrol fastener. No trace of the Pandrol rail fastener was found.

- *Figure 8* is a general view across the rail track illustrating the location of the site relative to the sea and the resultant marine environment. Note the severe corrosion of the steel fence post in the foreground.
- *Figure 9* indicates the condition of an un-galvanized rail fastener, which is obviously a replacement as it has been installed in the reverse direction to all the other hot dip galvanized fasteners. Note the severe corrosion of the un-galvanized cast-in shoulder and the "pitting type" corrosion that has developed on the un-galvanized Pandrol rail fastener.

From our observations it was clearly established that the side of the rail, together with the fasteners that face the sea were affected to a greater extent than those on the lea side of the track. It can be concluded that the rail provides a degree of "shielding" from the sea spray. This is a subjective observation as it is clear that the severe corrosive environment is attacking both sides of the rail.

The majority of Pandrol rail fasteners were hot dip galvanized, but one or two un-galvanized rail fasteners were found and assumed to be replacement items. In some positions the un-galvanized cast-in shoulder had corroded away and was no longer operative. In four instances the Pandrol rail fastener together with its cast-iron (un-galvanized) shoulder had completely disappeared. This is attributed to the fact that these shoulders were initially installed un-galvanized.

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Figure 5.

In general, all the hot dip galvanized Pandrol fasteners were in very good condition while the occasional un-galvanized Pandrol fastener and many of the un-galvanized cast-iron shoulders were exhibiting severe and advanced state of corrosion.

It could not be determined exactly how long these components have been in service other than the date embossed on the concrete sleeper, which is June 1971. The web of the rail was likewise exhibiting corrosion with the sea side face corroded to a far greater extent than the lee side.

Both the Pandrol rail fastener and the cast iron shoulders were hot dip galvanized, measuring a minium of 87µm, a mean of 108µm and a maximum of 134µm. Minimum deterioration, due to corrosion, was found on these components.

An example of the aggressively corrosive environment along the South East Coast

Figures 10 and 11 are an indication of the corrosive conditions that can be determined from the state of mast 108/14 together with its base. These "ungalvanized" components would appear to have been coated with an epoxy tar or a bitumastic compound. Where the protective coating had been penetrated, corrosion of the steel is at an advanced state.

Figure 6.

Figure 7.

Figure 8:

Figure 9.

Figures 10.

Figures 11.

Doublespeak

The well-known writer George Orwell is believed to have been the first to coin the phrase 'Doublespeak'. The prime purpose of doublespeak is to make the truth sound more palatable by euphemism, distortion, ambiguity or obfuscation. It is language which pretends to communicate but doesn't. It is language which makes the bad seem good, the negative seem positive and the unpleasant attractive. It is language which avoids or denies responsibility and conceals or prevents the truth or reality.

Doublespeak was very popular with the apartheid regime, with terms like 'good neighbourliness', 'separate development', 'plural society', 'homelands', being used to describe the implementation of the apartheid system. The words 'terrorist', 'communist' and 'traitor' were also forms of doublespeak to denote anyone who protested against the apartheid policies. There were also a whole host of government and military agencies whose doublespeak names did not truthfully indicate what their true function was, like BOSS (The Bureau for State Security), CCB (Civil Cooperation Bureau), Project Coast (chemical and biological warfare) and Project Duel (elimination of SWAPO prisoners of war), whose main function was to disrupt anti-apartheid activities in South Africa and abroad by assassinating oppositional leaders and destroying ANC facilities.

Doublespeak is well known in defence, intelligence and state security circles in many countries. The USA Department of Defence has been well known for its use of doublespeak with euphemisms like 'servicing the target' (bombing), 'force packages' (warplanes), 'rendition' (the practice of sending a foreign criminal or terrorist suspect covertly to be interrogated in a country with less rigorous regulations for the humane treatment of prisoners) and 'waterboarding' (a form of torture in which water is poured over a cloth covering the prisoner's face and breathing passages. Extreme forms of torture are called 'enhanced interrogation'. Military drones are called 'unmanned aerial vehicle predator and reapers'. G.W. Bush's rush to attack Iraq after 9/11 was termed the 'war on terrorism', without any reference to the groups behind the WTC attacks being associated with Iraq. At this time, G.W. Bush reminded the soldiers and their families that the war in Iraq is "really about peace." (President George W. Bush, April 2003)

Our South Africa government too has its very full share of doublespeak; in fact it is a feature of many government officials in their attempt to explain private expenditure, unlisted gifts and, dare we say it, bribes and corruption. Our former Communications Minister was a great exponent of doublespeak. Some examples: damage to a rented car amounting to R425 000 was written off because "nobody could be held responsible", R325 000 for recruitment drives went down the drain because of "organisational realignment" and R1, 27m on fraudulent international calls was because of unidentified perpetrators.

There are wonderful examples of doublespeak in business and commerce, with some examples being "staff are our greatest assets" (truth: they're the easiest cost to eliminate), "downsizing" or "re-engineering" (truth: laying off staff), "difficult exercise in labour relations" (truth: strikes), company 'Vision and Mission Statements' (truth: looks good in the entrance foyer and impresses clients), "we need a new paradigm" (truth: we actually don't know what to do), a "temporary cash flow" (truth: our cost management is poor), "nonperforming assets" or "nonperforming credits" which are "rolled over" or "rescheduled" (truth: bad loans or bad debts) and "meaningful downturn in aggregate output" (truth: recession).

Enhanced language proficiency, greater general knowledge and critical thinking are probably the best ways to learn how to resist doublespeak. In many cases, we don't know enough about the subject so are not able to recognise that the language being used is concealing, distorting or misleading the reality. There seems also to be a need to be aware of the peculiar 'vulnerability' of the linguistics of the English language. Linguistically, words are not things, but verbal tokens or signs of things that should be related back to the things that they stand for so that they can be verified. Being sceptical about what is being spoken about, especially by politicians, can reveal if the language is being abused and, if so, we should not hesitate to question the speaker to try and reveal the reality.

The Association wishes to thank Bob Andrew who is a consulting value engineer and honourary member of the Association for his article. He can be contacted on anneve@iafrica.com or boband@mweb.co.za.

The Association's annual Golf Day

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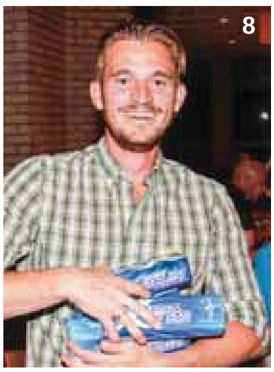
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The annual Golf Day of the Association was held at the Germiston Golf Club on Thursday the 19th March 2015.

The **winners** of this year's Golf Day *(photos 1 and 2)*, with a score of 65, were the team from O-line (who have been chasing the trophy since 2009). Well done to Steve Endley, Mark Matthews, Ryan Liebenberg and Richard De Sousa.

Well done to the Metsep team consisting of Jason Bawden, Renier Rabie, Shaun Gray and Lucian Pistritto for persevering and winning the **Pink Lady** *(photo 3)*, which was sponsored by Transvaal Galvanisers. Incidentally; only four teams brought the pink ball home!

Second place *(photo 4)* was awarded to Louis le Roux, Stephen van Zyl, Adriaan Louw and Gareth Hannaway of SA Galvanizing Services. Their score was 64.

With a score of 63, **third place** *(photo 5)* was awarded to Duncan Baldie, Danie Pretorius, Frikkie Erasmus and Albert Holt of Macsteel Tube and Pipe.

Nearest the Pin *(photo 6)* was awarded to Jan Steyn and Steven van Zyl *(photo 7)* hit the **Longest Drive** (again)!

Since bad shots come in groups of three, a fourth bad shot is actually the beginning of the next group of three, the **Longest Day** *(photo 8)*, with a score of 40, went to Graeme Kirby, Ryan Hines, Vincent van Niekerk and Ross Taylor, of Transvaal Galvanisers.

Thank you to our sponsors for their contributions, without which we would not be able to hold a Golf Day. The sponsors are: Armco Galvanizers, Lianru Galvanisers, Macsteel Tube and Pipe, Robor (Pty) Ltd – Galvanizers and Transvaal Galvanisers.

Consistently delivering superior quality galvanized products to all our customers

Armco Galvanizers Isando has been operating since 1989. Geared up to accommodate heavy structural steel up and till 13m in length. Isando has an average output of plus minus 2000 tons per month. With an improved lay down area and increased loading capacity by addition of a tower crane we strive to give "A" class service to all our customers big or small.

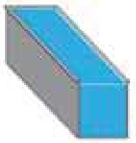
Armco Galvanizers Dunswart is a second facility based in the Boksburg area. Dunswart has an average output of plus minus 900 tons per month. This branch specializes in small structural components and is geared up to accommodate items up and till 5m length.

Armco Galvanizers Randfontein is a third facility based in the Randfontein area. Randfontein has an average output of plus minus 800 tons per month and is geared up to handle light to medium structural steel up and till 6.2 m in length.

The company has it's own SANS 121 2000 ISO 1461 accredited Hot Dip Galvanizing plants. And is listed under the SABS ISO 9001 scheme.

GALVANIZING BATH SIZE

ISANDO



13m (l) x 1.45m (w) x 2m (d)
(effective size)
13.2m (l) x 1.5m (w) x 2.2m (d)
(actual size)

DUNSWART

5m (l) x 1.18m (w) x 1.8m (d)
(effective size)
5.2m (l) x 1.2m (w) x 2m (d)
(actual size)

RANDFONTEIN

6.25m (l) x 1.25m (w) x 1.8m (d)
(effective size)
6.5m (l) x 1.3m (w) x 2m (d)
(actual size)

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