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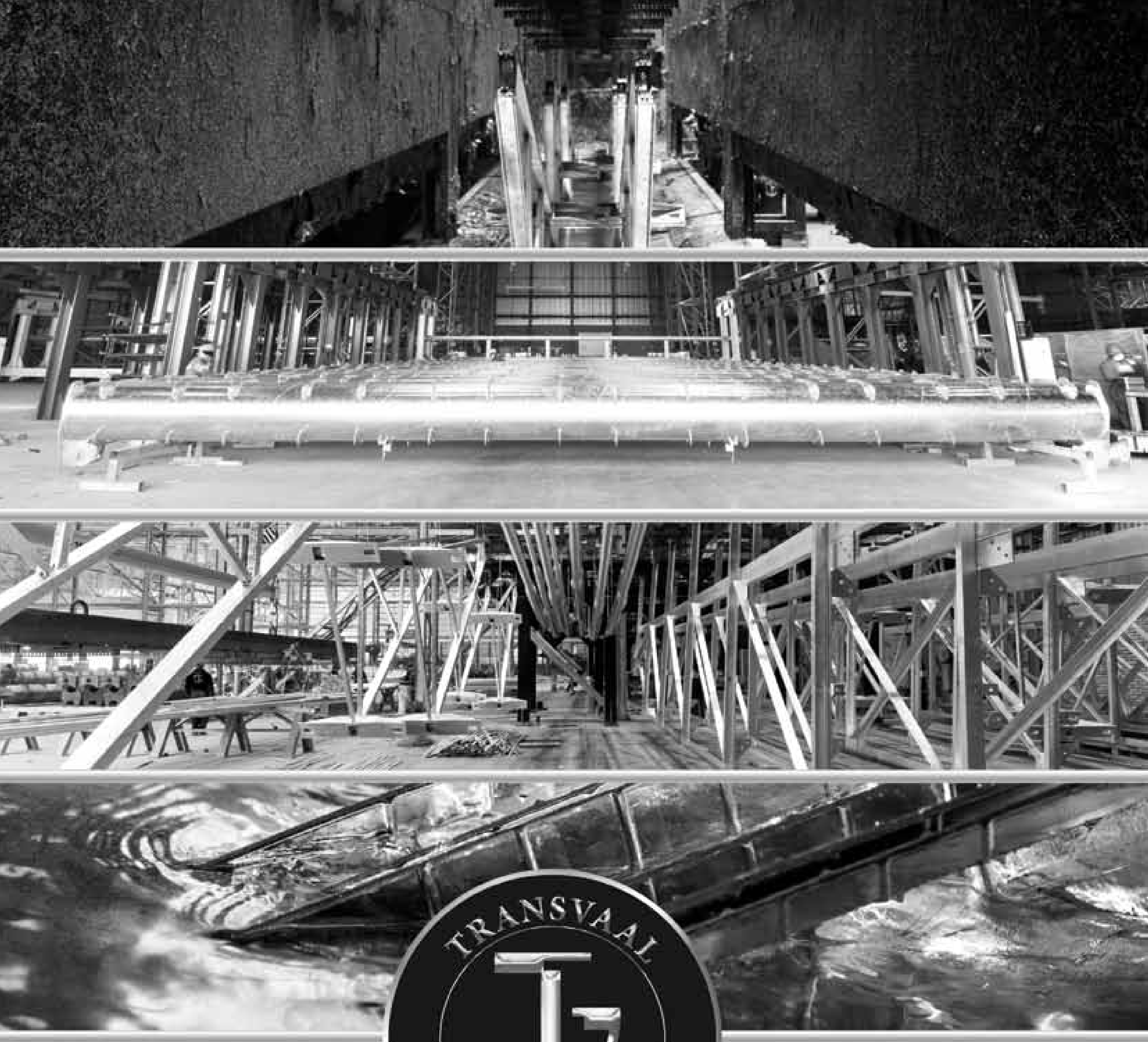
HOT DIP GALVANIZING TODAY 75

The Official Publication of the Hot Dip Galvanizers Association Southern Africa

CORROSION CONTROL OF STEEL



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EXECUTIVE DIRECTOR'S Comment

Some weeks have passed since I wrote this from home during the state ordered Covid-19 lock-down. What a tumultuous time for our country and indeed the world, as we face the stark challenges of preventing or containing the damage from a socio-economic crisis that our generation has never before experienced. The Covid 19 pandemic struck us, like a lightning bolt, at a time when our country could least afford it.

Historically mankind has always risen to challenges when faced with such dire situations Epidemics, wars and financial meltdowns are not new. So why do we unite at such times? I guess that the answer lay in the behaviour of the majority of humanity. Mankind has repeatedly shown itself to rally and be carried forward by the majority, intent on doing "the right thing" when it counts. My hope is that history will again repeat itself and over time we will emerge stronger, wiser and kinder to the planet and to each other.

In my view, part of "doing the right thing" is to continue to plan and strategize for the future. The nuts and bolts of daily life must be attended to. In this context it remains important that strategic initiatives to stimulate the revival of the South African steel industry and its downstream industries must be attended to.

One initiative in this regard is the Steel Industry Master Plan. This plan is to be drafted based on input from all role players across the domestic steel value chain and presented to the Department of Trade and Industry. From this draft it is intended that Government, Labour and Business will actively engage to set out fixed actions and secure the required commitments needed to stimulate the growth of the industry in a unified and structured manner. It is furthermore planned that an oversight committee will be established to co-ordinate the implementation of the required commitments and action programs.

As with any initiative, some scepticism exists regarding the realization of such a plan. There are concerns related to the "role players" and the availability of Governmental resources. It is also uncertain as to whether the diverse commercial goals of businesses, throughout the value chain, can be channelled into a single vision. Notwithstanding such, it is clear that unified action is needed to ensure the continued viability of this critical South African economic sector.

Job creation is vital in the rebuilding of our economy. It is widely acknowledged that manufacturing and fabrication activities are very powerful job multipliers in an economy. The production of steel, fabrication of steel components and structures, as well as the essential need for steel corrosion control provides an existing means, while also promising further opportunities, for job creation and upskilling of labour in South Africa.

Other key issues to be addressed are the proposed pricing of steel in the South African and continental African markets. The stimulation of demand for locally produced components and structures through infrastructure projects and designation of local materials for SOE projects. Critically we need security of South Africa's energy resources, electricity in particular and greater alignment between employer and employee in the wages versus productivity debate. Should decisive strategic actions addressing these matters be addressed by such a plan, the potential for reigniting investment in South Africa is likely to become a greater reality. Urgent action is needed.

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EDITORIAL COMMENT

in this issue

In Shakespeare's play, Julius Caesar was warned: "Beware the ides of March!" It is often said that life has an odd way of mirroring art. In South Africa, on the Ides of March, we were all warned of the Covid-19 pandemic and measures to flatten the curve of the scythe of the reaper. I hope that we heed the warning and so avoid the fate to which Julius, by not responding appropriately, did succumb.

We have much to do in this time of many challenges, most of all we need to act together in ensuring that our beloved country survives and thereafter flourishes through our combined efforts and disciplines. In this issue:

- The Hot Dip Galvanizers Association Southern Africa (HDGASA) has been allied to the South African Institute of Mining & Metallurgy (SAIMM) for decades. The SAIMM celebrated 125 years of existence in 2019, no small feat by any measure. The HDGASA are accredited through the SAIMM for 3 CDP (continuous development points) on the Level II Hot Dip Galvanizers Inspectors course. In February 2020 we were offered pride of place on both the outside and inside of the front cover of their journal. Thus we proclaimed our continued allegiance and garner strength from our fellow mining and metallurgical peers as we head into the challenges of the future in South Africa.
- Wire and fences, expectations and standards. Fences are installed to provide us with the peace of mind that our assets are being guarded by an untiring sentry. As we have expectations so too should we have a better understanding of how the strength of the sentry is itself protected. We look at the standards and discuss some pertinent details for our readers to consider when planning this key aspect of any project.
- Training through the HDGASA and our fellow institute of corrosion CorrISA await our reader's attention. We continue to encourage all stakeholders who rely on steel and iron to learn more about maintaining their designs, investments and assets through appropriate corrosion control.
- In this issue's personality profile, Chantell Aucamp who joined the HDGASA team as our Office Manager shares details and thoughts about being part of the association's service delivery team.

The difference between growth and stagnation is activity. Our chosen future lies within each one of us. Anything worthwhile achieving requires persistent focussed dedication and effort. Let us move forward together on our journey to strengthening South Africa for a future of growth and development by being unwavering in our resolve to strengthening our beloved country and the continent of Africa.

ZINC COATED STEEL FENCING – considerations in design and specification

FROM DOMESTIC, COMMERCIAL AND FARMING REQUIREMENTS, THE FENCING OF LAND IS AND WILL CONTINUE TO BE A SIGNIFICANT MARKET FOR THE SOUTH AFRICAN WIRE INDUSTRY.

Choosing an appropriate type of fence and its constituent materials is essential for the increase in the service life of fences. Use of appropriate specifications will result in long term savings.

The intention of this article is to provide designers, specifiers, or consumers with an oversight of the design considerations, material selection and corrosion control options that are available when specifying or purchasing a fencing solution across a variety of applications

Foremost, the duty or functional requirements of the fence must be considered. These requirements should drive the parameters for the design or layout of the fence.

Typical types and applications

- Smooth wire fences – electrical fencing, property boundaries, vineyard trellises, etc
- Woven fences – diamond mesh for property boundaries of enclosure of domestic animals or small livestock
- Barbed wire fences – single or double strand for property or larger livestock.
- Mesh panel type fences – designs for a variety of applications, from property boundary to high security requirements.

Irrespective of fence type the choice of wire is an important consideration.

Wire or rod of varying chemical composition may be used to produce soft or plain wire or high strain steel wire. Over and above wire composition, wire diameters will also determine ultimate breaking loads and elastic limits. For

pre-tensioned line fencing, temperature variations are important. As a rule of thumb, data from the Hot dip Galvanizers Association of Southern Africa – Steel Protection Guide, provides the following – for each 5° above or below 15°C, subtract or add a tension of 100 N for a 3.15mm fence.

The potential for exposure to fire damage may also be a consideration. International studies reveal that temperature of the fire, wire tension and diameter are the main considerations in predicting levels of damage that may be suffered by a fence subjected to a fire. Again, a rule of thumb is that fires at temperatures of less than 400°C are unlikely to affect the performance of any wire. Also, high strain steel wire generally thinner in diameter, requires less heat than thicker, softer wires to get to critical stress levels for wire integrity. Maintenance becomes important in high risk areas since low grass density (particularly dry grass) in and around zinc coated wires will minimize temperatures in the event of fires.

Table 1

Corrosivity category	Units	Rate of zinc corrosion
C1	µm/a	Less than 0.1
C2	µm/a	0.1 up to 0.7
C3	µm/a	0.7 up to 2.1
C4	µm/a	2.1 up to 4.2
C5	µm/a	4.2 up to 8.4
CX	µm/a	8.4 up to 25

Coupled to the materials selected for each application, the strength of fences is also determined by the number of wires per fence height as well as spacing of posts.

Over and above the functional elements discussed above, some considerations may be given to aesthetic requirements of a fence, particularly for domestic and commercial applications.

Developments in fence and fence construction methods have led to mesh panel type fencing gaining traction, particularly in the domestic and commercial property fencing marketing. This brings another derivative into play.

Irrespective of the fence type – from simple line type fencing and it's derivatives to mesh panel type – very serious consideration needs to be given to the correct corrosion control system that is required to optimise the return on investment in the fence.

The first consideration must be the environment into which the fence will be placed. ISO 9223 provides guidelines for the corrosivity of various atmosphere. There are six main classifications ranging from a low corrosivity environment designated C1, to an extremely corrosive environment designated CX.

These environmental classifications are derived at by the considerations and mathematical weighting of critical factors such as, time of wetness and pollution levels based on levels of salinity (chlorides) and sulphur dioxide

As a typical example:

C4 – high corrosivity index – Typically Temperate, subtropical to tropical, low to high pollution (SO2 30 to ≤90µg/m^3) or substantial chloride effects, e.g. one kilometre of the ocean or within one hundred metres of sheltered coastal areas but outside the splash zone of sea water.

In the 1980's, the CSIR did research on the topic of environmental classifications for the regions across South Africa. The map of South Africa was drawn to illustrate very broadly designating environmental corrosivity zones. This may well be used as a starting point for determination of levels of corrosivity. However, field experience by the HDGASA does require that an accurate assessment of the micro- environment for each actual site is required to ensure sound decision making on probable rates of corrosion. As an example, structures in False Bay and Table Bay, despite both locations within the Cape Peninsula often display marked variations in the rates of corrosion despite being coastal zones less than 40km apart.

Having identified the environmental site conditions through use of the ISO 9223 guidelines, an estimate of rates of corrosion of various metals is also given by the ISO 9233 standard for each environmental corrosivity category.

Since a hot dip galvanized coating comprises zinc and zinc/iron alloys, we consider the typical rates of corrosion of zinc. *Table 1*, extracted from the ISO 9223 standards, provides rates of corrosion for each category. A more precise rate is be determined from an understanding of actual site conditions.

Zinc is electronegative relative to carbon steels and the development of a zinc and zinc/iron alloy coating during the galvanizing process provides corrosion control to the steel through both barrier protection as well as cathodic protection, should the barrier become damaged. This has an advantage over painted surfaces which provide only barrier protection, which when breached will allow under corrosion creep to occur.

It is in this context that a full understanding of the advantages of the hot dip galvanizing process of wire and its ability to provide corrosion control is required. The life span of zinc coated steel is directly related to the thickness of the protective zinc coating.

As a summary of the wire galvanizing process:

Wire may be galvanized on a continuous coating line. The process includes annealing, acid cleaning, fluxing, galvanizing and then a narrowly controlled wiping process to remove excess zinc and produce a very defined coating thickness aligned with several wire coating thickness standards. Once wires exit the wiping stage, unless specifically excluded from the order, it is passed through a passivation phase. This is necessary to prevent wet storage staining on the galvanized wire.

Examples of the standards alluded to for the wire production and the coating of wire includes:

SANS 675 – This standard specifies the characteristics of drawn steel wire, zinc coated by the hot dip process, to be used for line fencing wire or barbed fencing wire or for fencing general purposes.

Table 3 of the standard specifies two classes of coating:

- Class A - thick coating and
- Class D - standard coating

SANS 935, a standard which specified the characteristics of zinc coatings, applied by the hot dip process to steel wire of round or oval sections and intended to be used for general purposes. Here Table 1 of the standard defines 3 grades of coating, Grade 1 being a heavy mass coating, Grade 2 being a medium duty and Grade 3 being light mass per unit area.

However, SANS 935 was replaced in 2007 by **SANS 10244** – the latest version of this standard is Edition 2:2011. The scope of the standard is to cover the requirements for coating mass, other properties and testing of zinc and zinc alloy coatings on steel wire products of circular or other sections. The standard covers coating applied by both the hot dipping in a bath as well as a coating by means of an aqueous solution of suitable electrolyte.

Considering smooth wire, woven or barbed wire fences results from a study performed as a joint venture between the IZA, SAWA, ARC and Standards – South Africa suggest that even for rural areas, only SANS 675, class A wire would be suitable for fencing applications in the South African environment. Alternatively, wire hot dip galvanized to SANS 10244 – Part 2 standards to Grade 1 is approximately equivalent to the SANS 675 class A coating specification.

An overview of the grades or classes of wire coatings is useful at this juncture.

Each standard provides tables defining the minimum mass per area of zinc (or zinc alloy in the case of SANS 10244-2) for wires of varying diameter. It is however possible to determine an approximation of the coating mass by converting the mass per m² by the SG of Zinc at 7.2 kg/m³. This calculation will provide an indicator of coating thickness which should be easily measurable. In turn this thickness can be used as a first indication of coating mass when field evaluations are undertaken.

In the event of a dispute regarding type or class of coating, the definitive test for coating mass is a gravimetric test. Here a strict procedure is followed in which accurate weighing before and after acid stripping of the coating allows for the determination of coating mass. The HDGASA undertakes such testing on request.

From SANS 675, Table 3, for Class A coatings, as an example for common wire sizes, we have

Wire diameter	Mass of zinc (min)	Approx. coating thickness
2.15mm up to 2.5mm	230g/m²	32µm
2.5mm up to 2.8mm	245g/m²	34µm
2.8mm up to 3.2mm	255g/m²	35µm

By contrast, from SANS 675, Table 3 for Class D coatings, wire ranging in diameters 2.8mm to 3.2mm are specified with a minimum coating mass of 50g/m². This

Wire diameter	Class A Mass of zinc (g/m²)	Class B Mass of zinc (g/m²)	Class C Mass of zinc (g/m²)	Class D Mass of zinc (g/m²)
2.15mm up to 2.5mm	230	125	85	45
2.5mm up to 2.8mm	245	125	95	45
2.8mm up to 3.2mm	255	135	100	50

Table 2

equates to an approximate thickness of 7µm only and can be considered to offer about one fifth the service life of a Class A coating in any given environment.

The exercise may be repeated by drawing data from the SANS 10244-2 standards, in this instance illustrating the significant variation in coating masses for each grade. Classes A and B coated wire is usually obtained by zinc coating and then drawing. Class C and D are standards for low mass coatings. *(Table 2)*

It is apparent that Class A coating thicknesses per the SANS 10244-2 specifications are closely aligned to that of SANS 675, Class A. It is recognized that SANS 675 is specific to a Zinc coating only and the SANS 10244-2 specification may include a coating of some zinc alloy applied by means of an aqueous solution of suitable electrolyte. Again, field experience suggests that zinc alloy coatings, when employed are often of class C or D level weights.

Mesh panel style fences are constructed by fusion welding of wire "droppers and stringers" using either uncoated wire or galvanized wire. The required level of security against penetration for such fences will determine the wire diameters, spacing and possible need for reinforcing bars. Different manufacturers of panel type fences have unique design characteristics or variations in material selection, post design and panel fixing

systems to differentiate their product in the marketplace.

An array of corrosion control systems of is also used for mesh panel type fences.

Should galvanized wire be used, the welds strip this area of zinc or zinc alloys at the points of intersection. This needs to be compensated for by a coating aimed at protecting the bare wire against the environment to prevent the onset of corrosion. Often the choice is to apply a paint system to the entire panel. Such systems may range from wet paint applications of any number of paint types to powder coating applications to epoxy bonded resin type coatings. In some instances, zinc rich paints are used and marketed through word association techniques as providing equivalent corrosion protection to full zinc coatings which are attained through the various hot dip galvanizing processes. Each of the various paint systems provide a barrier against the atmosphere and may be chosen on a cost versus application basis. A paint systems also supply an opportunity to provide a matching aesthetic to the environment. However, surface preparation is critical. If wire is to be painted and especially, should galvanized wire be overcoated, proper preparation becomes important since some paints are not compatible with the passivation products that may be present after galvanizing.

Any failure of a paint system through incorrect choice of paint type, ineffective cleaning or application techniques can result in cracking of the paint. Several outcomes, all effecting the fence aesthetics as well as the ultimate service life of the fence are possible when the corrosion control system fails.

Significant voids in a paint system results in direct contact of the zinc coating with the prevailing atmospheric conditions. In some instances, the voids may host moisture from condensation, leading to a phenomenon called white rust in which an unstable reaction is triggered between the zinc and the water. Evidence of this is the appearance of a white powdery residue evident on the fence.

Of greater consequence for service life of a fence is the event in which paint failures occur on panels produced from fusion welding of lightly galvanized wire. This is of heightened relevance when fences are placed into service in corrosive environments.

Should paint failures occurs in a coastal or high pollution environments, moisture with enriched chloride and/or sulphur concentrations will lead to an accelerated consumption of zinc. Initially only the white rust is evident but ceases to form once all the zinc is depleted. Once the zinc is depleted the onset of corrosion of the steel wire is imminent. The evidence is red rust staining and indicative that the carbon steel wire is now being consumed through corrosion.

This returns the designer or specifier to the application of standards for hot dip galvanized wire. It is possible to predict from known environmental conditions the rates at which zinc will be consumed. Couple this to known zinc coating thicknesses for various grades of wire and the service life to full depletion of zinc may be estimated. As an example therefore a 3mm wire coated to SANS675, with a 255g/m² coating (at approximately 35μm average thickness) is likely to deliver in any given environment in the order of five times more service life than a 3mm wire

coated to SANS10244-2 class D, which has a 50g/m² coating.

A third corrosion control option exists. In this instance black or uncoated wire is welded into a panel configuration per the panel design. Panels may then be hot dip galvanized to SANS121:2011 specifications. Several advantages accrue to the purchaser of such a fence.

In the first instance the concern related to protection in and around the weld area is dealt with since the coating is developed post the welding operation.

Importantly also, is that the hot dip galvanizing process differs from the wiped galvanizing process in that the coating develops over a longer period of submergence in the zinc. This results in thicker coatings. Minimum coating thicknesses extracted from Table 3 of the standards for SANS 121:2011, illustrates the point. In considering wires of nominal diameter 3mm, the minimum allowable coating standards are shown in *Table 3*.

It is therefore apparent that hot dip galvanizing to SANS 121:2011 will produce coatings in the order of magnitude of twice that of wire wiped to comply with SANS 675, Grade A or indeed 10 times the order of magnitude of SANS 675 class D or SANS 10244 -2 Grade 3.

Table 3

Thickness of wire	Minimum average mass g/m²	Minimum average thickness (µm)
1.5 up to and less than 3mm	395	55
3mm up to and less than 6mm	505	70

It is important to note that in the SANS121:2011 standards, the scope excludes sheet, wire and mesh panels fabricated from a continuously galvanized and wiping process. On occasions this creates confusion around the standard applicable to mesh panels. For clarity, mesh panels that are batch dipped must be evaluated against the SANS 121:2011 standard.

Hot dip galvanized mesh panels may also be painted for purposes of additional corrosion protection or to meet specific aesthetic or colour coding requirements. Again, appropriate preparation regimes are required to achieve successful painting over hot dip galvanized articles.

Under a wide range of environmental conditions, unpainted hot dip galvanized mesh panel fences have provided excellent duty and service life.

It is evident that careful consideration must be given to an appropriate corrosion control system

In conclusion

The selection of a fencing system and its components may appear, at face value, to be a simple matter.

A fence should always be considered an asset to a property owner and be given the same level of consideration as other assets when considering life cycle and maintenance costing.

The creation of specifications and standards have been written to place at the disposal of South African consumers, checks and balances to assist with the identification and understanding of fencing components and their properties. South African manufacturers producing to these standards utilize appropriate machinery and quality systems to provide products that comply to the standards. This is important, since approximately 10 000 t/pa of imported wire finds its way onto S.A. shores, the standard of manufacture of which may not be clearly determinable, other than through laboratory testing.

Knowledge of the standards and confidence in compliance ensures that the designer, specifier and fabricator can select the best option available.

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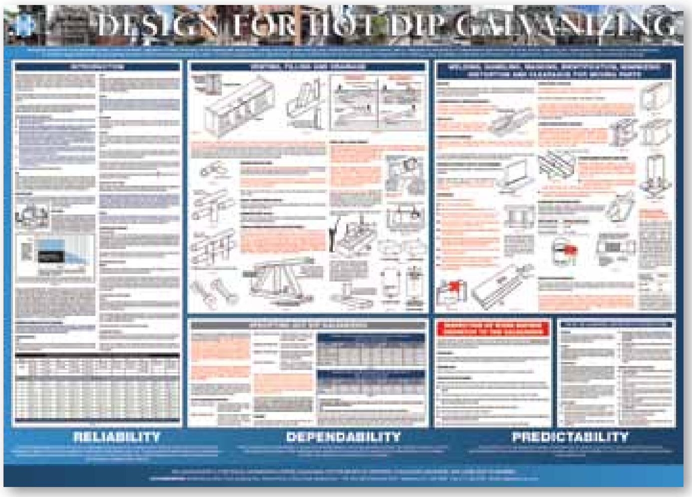
DESIGN FOR HOT DIP GALVANIZING WALL CHART

The **wallchart** is an invaluable reference chart for fabricators and specifiers. Key information is readily available to allow for best engineering practice for galvanizing.



TECHNICAL GUIDES

The HDGASA **Steel Protection Guide** and **Facts about Hot Dip Galvanizing** are available in high-gloss printed material for reference and guidance.

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Over the past decades, the company has established itself as one of the world's market leaders and a reliable partner with our transport technology for hot-dip galvanizing plants. With references plants in more than 25 countries on 5 continents Scheffer proved that we always deliver customized solutions beginning with systems for single operation areas of the facilities up to whole automated material handling systems from jigging over pretreatment and galvanizing to digging.

During planning and development of solutions for transport technology in hot-dip galvanizing systems, we consistently trust in both many years of experience as well as new technologies. The reliability of Scheffer products is guaranteed by the company's investment in continuous development. It therefore comes as no surprise that Scheffer is time and again launching highly innovative products. All the components - from a conventional overhead bridge crane to the automatic acting drive units - are designed for the rough and challenging working conditions within a hot-dip galvanizing plant and tailor-made solutions for the customer's individual demands.

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Together with our customers, we find this kind solutions for everyday problems and for all kind of galvanizing plants. For example, with a customer we were able to optimize pickling cranes with a wide variety of materials and designs so that they are prepared for the harsh environmental conditions above the acid and the risk of unplanned system failures was significantly minimized. This is a win-win situation for us and our customers because it supports us to increase the efficiency and reliability of all components and our automatic systems and therefore helps us to be leading in the galvanizing technology.

HDGASA – SAIMM
and mining in South Africa

SOUTH AFRICAN MINING ENGINEERS ARE AMONGST THE MOST INNOVATIVE IN THE WORLD, NOTABLY IN THE SPHERE OF DEEP-LEVEL MINING. FROM BOTH A LIFE OF MINE AND SAFETY IN OPERATION PERSPECTIVE, EFFECTIVE CORROSION CONTROL IS A CRITICAL ELEMENT OF DESIGN AND OPERATIONS IN MINING ENVIRONMENTS.

The Hot Dip Galvanizing Association (HDGASA) teamed up with engineers from a number of mines including Anglo America's President Brand and Kinross Shaft 2 more than 40 years ago, to perform trials and assess the effectiveness of hot dip galvanizing coatings as corrosion control medium in underground mining applications. The variations in micro-climatic conditions from the top of a headgear to the bottom of a 1 500m deep shaft are increasing corrosive to an extreme degree. Successful trials, coupled with periodic follow-ups to assess coating performance and recording of these results and case studies saw the widespread acceptance of hot dip galvanizing being accepted as the preferred corrosion control technology employed by the mining industry. The results of the trials and monitoring of performance also culminated in a seminar, held in Johannesburg on hot dip galvanizing in the mining industry. These case studies can be retrieved and reviewed, free of charge, from our website at *www.hdgasa.org.za /technical/case-studies/*

The HDGASA recently published, in the association's HOT DIP GALVANIZING Today magazine (volume 16, Issue 1), an article giving readers a clear overview of where hot dip galvanizing can be successfully used in mining. In all of the applications shown, hot dip galvanizing has repeatedly demonstrated its advantages as a corrosion control technology for mining applications.

The HDGASA's ongoing relationship with the mining industry is extended to the training sphere and requests for assistance at mines in Limpopo Province and Mpumalanga. The South African Institute of Mining and Metallurgy (SAIMM) after reviewing the level II course material authorized the granting of 3 CPD points to professionals who have completed the course and are registered with the Engineering Council of South Africa (ECSA).

In light of the continued collaboration between the HDGASA, SAIMM, ECSA and the mining industry, the HDGASA was proud to grace the cover page of the volume 20, number 2 – February 2020 edition of the technical journal of the SAIMM once again bolstering the significant role hot dip galvanizing provides to the mining industry.

"Knowledge is the only instrument of production that is not subject to diminishing returns" John Maurice Clark

Level I: Introduction to Hot Dip Galvanizing

The HDGASA one day INTRODUCTION TO HOT DIP GALVANIZING course is designed to provide an initial understanding of the concepts relating to hot dip galvanized coatings applied for corrosion control of steel components. The course comprises six modules. In order for the course to be viable we require six or more candidates to attend. Arrangements can also be made for this course to be held at a venue of your choosing for more than six candidates. In addition to the course, a special visit to a hot dip galvanizing plant may be arranged on a separate date, should six or more candidates be interested and able to attend.

Level II: Certified Galvanizing Inspectors

The HDGASA advanced Level II course provides the necessary skills to assess the quality and conformance of Hot Dip Galvanized coatings and Duplex Systems to the applicable specification. Delegates are introduced to other metallic type coating specifications and their application for corrosion control design.

The course provides an in-depth interpretation of the specifications and accepted best practice procedures for determining coating thickness, visual inspection of surface finishes as well as the evaluation of these coatings for corrosion control of steel components. The course includes a visit to a hot dip galvanizing plant where delegates will have an opportunity to assess finished product against the relevant quality standards on a real time first hand basis.

Three Continuous Professional Development (CPD) points are awarded to delegates attending the entire course. Bookings are limited to a maximum of 10 people, with applications treated on a first-come-first-serve basis. In order for the course to be viable we require 6 or more candidates to attend. Arrangements can also be made for the course to be held at a venue of your choice for more than 6 candidates.

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THE HDGASA WEBSITE HOSTS A PLETHORA OF INFORMATION AND DATA. OF PARTICULAR INTEREST ARE THE CASE STUDIES. THESE REAL-WORLD CASES ARE AVAILABLE AS SUPPORT RESOURCES FOR THE REVIEW AND INVESTIGATION OF THE PRACTICAL EFFECTS AND OUTCOMES THAT DATA PRODUCES THEORETICALLY.

Two case studies from our files are of current importance as we face the renewal phase post Covid-19. Firstly the use of Hot Dip Galvanized Rebar is shown to be a key element in ensuring the longest service life i.e. prior to first maintenance when used in the construction of public infrastructure. The less we spend on initial maintenance the larger the number of projects can be expanded.

The second case study selected is focussed on cable ladders. With the need to draw down both the cost and frequency of maintenance of electrical infrastructure we look at past successful approaches to meet this challenge. Cable support systems need to provide the longest possible service life as refitting is a highly disruptive, labour intensive and hazardous process.

In both of these cases the use og hot dip galvanized steel is shown to reduce the total cost of ownership of steel and concrete assets currently available.

CASE STUDY 4: Reinforcement in concrete

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1 The site of an old pedestrian bridge (No. B776) that was demolished in April 2005.

The Application

Hot dip galvanized reinforcement for additional corrosion protection of reinforced concrete structures. The use of hot dip galvanized reinforcement is not a replacement for good quality concrete, but as additional corrosion control, which is estimated to extend the service life of concrete structures by between 3 and 4 times. The quality of concrete is subject to many variables, not least being practical site conditions, installation and placement supervision, compaction of the concrete; cement water ratio, curing, depth of concrete cover over and ultimately environmental conditions.

Environmental conditions

The environmental conditions are described as severe marine, (class C5 in terms of ISO 9223), subjected to sea spray, chloride attack, carbonation, and quality of the concrete, i.e. durability (oxygen permeability and sorptivity).

The site

This case study is the result of a detailed investigation of a pedestrian bridge situated along the foreshore of Algoa bay. The stairway was rebuilt in 1980 using galvanized reinforcement due to spalling concrete.

Hot dip galvanized reinforcement was used in the sea side (left hand side) approach stairway that was re-built 25 years earlier than the demolishment date.

The surf was 50 meters to the left of the bridge shown in the photograph.

Sample concrete cores were extracted from the sea facing side, top slab and landside of the structure. These samples were sent to an independent concrete diagnostic and durability laboratory with instructions to establish the ingress of chlorides, carbonation and quality of the concrete.

Depth of concrete cover over the reinforcement confirmed as 45 to 60mm. Samples of hot dip galvanized reinforcement was retrieved for examination.

Findings

Chloride concentrations (% as mass of cement) at a depth of 45 to 60mm ranged between 0.15 & 0.65% on side facing inland, and 0.27 & 1.26% on the sea facing side. At a depth of 30 to 45mm the chloride concentrations ranged between 0.19 and 2.6%. Chloride levels at a depth of 15 to 30mm rose to between 0.49 to 8.8% of cement mass.

Accepting that the typical limit is 0.1% chloride for uncoated reinforcement, it should be totally unacceptable to use plain reinforcing without additional corrosion protection in this environment.

2 – 3 Core Samples from the side facing inland.

4 Isolated red rust was found, usually associated with minimum concrete cover and/or mechanical damage to the concrete cover.

5 The condition of exposed hot dip galvanized reinforcement found during the demolition of the 40 year old bridge was, with isolated exceptions, found to be exceptional condition.

6 Typically 98% of that inspected was similar to that shown in the photographs.

Carbonation was found to be more severe on the landside of the structure, with penetration depths of 18 to 22mm.

Concrete durability index testing results of oxygen permeability was as follows: – 1 sample "very good", 1 sample "good", 4 were "poor" and 1 "very poor". Sorptivity of 2 samples were excellent, 2 good and 2 were poor.

In certain isolated cases where the corrosive conditions had penetrated to the steel, due to very limited cover, the zinc had been sacrificed and some attack was evident on the carbon steel.

Condition of the reinforcement

Micrographs from sample reinforcement bars were developed and are shown in *Figures 7 and 8*. The depths of cover of these samples were selected at 45mm and 60mm respectively.

The outer appearance of the bar section demonstrated a dull grey colouration with no significant zinc layer degradation.

A transverse cross section through the bar revealed a 'normal' galvanized zinc and inter-metallic layers, clearly delineated in *Figures 7 and 8*. The galvanized coating thickness was between 240 and 260µm.

Conclusion

Examination of the stairway hot dip galvanized reinforcing, after 25 years in service in a severe marine environment, revealed conclusive evidence that the zinc coating was providing excellent corrosion control of the carbon steel reinforcement.

While other forms and methods of reinforcement protection are available, it can be shown that hot dip galvanizing of reinforcing is a preventative process that must be applied as part of the construction process. It is a system of "prevention is far better than cure"

Economics and extra costs are best described in terms of a quotation taken from *"Corrosion of Steel in Concrete"* by Bertolini, Elsener, Pedeferri and Polder.


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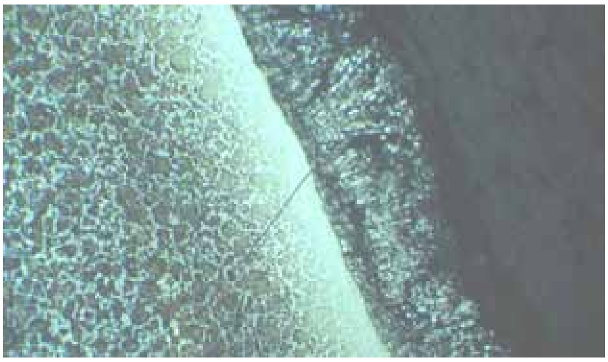
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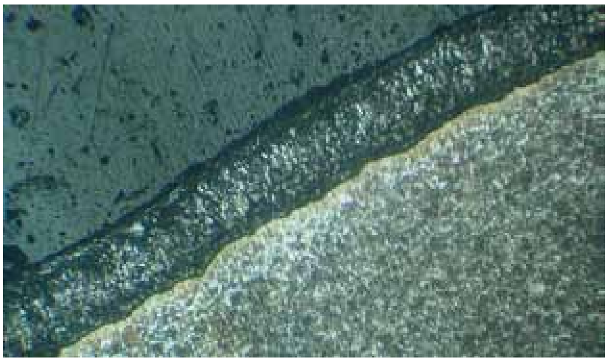
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7 Hot dip galvanized coating on the reinforcement bar. Coating thickness of 70 to 90µm (magnification100X).

8 Hot dip galvanized reinforcement at a depth of cover measured in a range from 45 to 50mm. All test samples were recovered from the demolished bridge.

"The cost of adequate corrosion prevention carried out during the stages of design and execution are minimal compared to the savings they make possible during the service life and even more so, compared to the cost of rehabilitation, which might be required at later dates.

The so-called De Sitter's "law of five" can be stated as follows:

One dollar (R18.86) spent in getting the structure designed and built correctly is as effective as spending $5 (R94.30) when the structure has been constructed but corrosion has yet to start, $25 (R471.50) when corrosion has started at some points, $125 (R2357.50) when corrosion has become widespread".

Exchange rate at time of publishing in April 2020 : USD1 = ZAR18.86.

CASE STUDY 18: Cape Town petro-chemical plant cable ladders

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9 General view of the petro-chemical plant at Milnerton Cape Town. 25 year old duplex coated cable ladders were used as the bases of the case study.

10 Zinc electro-plated fasteners were used for slice plates, with coating thicknesses normally less than 10μm. Many of the fasteners were found to be corroding and in need of maintenance.

11 A&S Cable ladder and a more modern edge mounted cable ladder in the background.

12 Close up view of the A&S Cable ladder.

The Application

The original petro-chemical plant in Cape Town was established in 1966. The subject case study cable ladders were installed in about 1984 and therefore have an estimated service life of approximately 25 years.

At the time when these cable ladders were installed, the plant electrical engineer had specified hot dip galvanizing for corrosion control and long term sustainability and service life performance. In 2009 an evaluation of the cable ladders installed in 1984 was undertaken to establish the corrosion control performance of hot dip galvanized steel, as a stand-alone system, before considering specifying a duplex system for future applications.

A number of cable ladders were selected for evaluation of the corrosion control performance after 25 year of service.

At the time and as a result of abnormal heights of cable ladder side rails (140mm), top-hat type cross rung configuration were specified for use in most of the petro-chemical plants throughout South Africa.

The cable ladder side rail and top-hat type cross rungs were manufactured from 2.0mm mild steel. The splice plates were made as a flat plate bolted together using M6 fasteners uniquely spaced on either side of the junction. The cable ladders and splices were hot dip galvanized in accordance with the previous national standard, SABS 763, which has been super ceded in 2000 by SANS121 (ISO 1461:2009). All cable ladder fasteners were either mechanically or zinc electro-plated.

Environmental conditions

The location being relatively close to the sea would generally be categorized as marine atmosphere. In reviewing the ISO 9223 – Corrosion of Metals and Alloys – Corrosivity of Atmospheres it is possible to categorise this part of Milnerton as a C3 or worst case scenario C4 environment.

Environmental conditions of the area are influenced by the prevailing winds. The corrosion rate of zinc experienced at the site are reduced by the rain bearing North Westley and Westley winds that wash the corrosive chloride salts from the hot dip galvanized steel improving service life of structures.

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13 – 14 Examples of hot dip galvanized cable ladder being measured at 89μm and 82μm respectively.

For a fully detailed review of the ISO 9223 specification a review of Information sheet No.8 from the Association web site www.hdgasa.org.za is required.

The site

The plant is situated in the Milnerton area and within approximately three and a half kilometres off the Atlantic Coast line. Note the influence of prevailing winds relating the corrosion rates and the removal of the corrosive chloride salts from structures.

Findings

Hot dip galvanized steel is specified primarily for corrosion control of carbon steel structures. For this reason three factors must be considered when galvanizing (zinc) and/or duplex corrosion control systems, i.e. coating thickness, continuity and environmental conditions.

SANS 121 (ISO 1461) specification requires that for steel thicknesses equal or greater than 1.5mm, but less than 3mm, must have a minimum local coating thickness of 45μm and a mean of 55μm. The coating thickness readings taken on both the side rail and cross rung of the cable ladder in question remain well in excess of this specification. Coating thicknesses on all the cable ladders inspected and measured were found to exceed 80μm.

Unfortunately the mechanical and electro-plated fasteners were found to be corroded and require corrective action in order to extend the service life of these items.

Conclusion

After 25 years of service life the cable ladders were in excellent conditions. Measurements take from which it can be assumed that the components can be expected to continue in service for a further 25 years.

As indicated the fasteners require maintenance and to this end it is recommended that the corroded components be replaced or thoroughly cleaned and generously over coated with an appropriate zinc rich epoxy, such as "Galvpatch" or "Zincfix".

Resources at no cost

There are voluminous case studies, technical papers and FAQ available free of charge on our website at *www.hdgasa.org.za*. Please feel free to contact us for any further information or clarification.

PERSONALITY PROFILE

CHANTÉLL AUCAMP

As a newcomer to the industry what were your initial experiences over the first weeks?

As a newcomer to the industry my first weeks were interesting and informative, as I came from a plastic industry background. It took some time to find my feet, but with no time wasted I joined the first training group in February for the Galvanizers Inspectors Course Level II. I really enjoyed the course and found it quite informative. I also enjoy working with a smaller group, instead of a big corporate company where you can hardly remember everyone's names.

Tell us a little about yourself, your home life, your hobbies and passions.

A little about myself, well I am married with four kids. So you can well imagine that we have a busy home life. We are a close family, so most of the time is spent at home with the kids. I love to bake and cook, so if I have a moment to myself I am baking up a storm in my kitchen. I am currently studying, so at this point in time that is my hobby and passion. If all goes well, I will be completing my studies soon and will have time to take on a real hobby.

Who has had the biggest influence in your life?

My husband is the biggest influence in my life.

What is your favourite reading?

If reading to my kids counts – then children books. But to be honest I don't read much, I am more a movie person. So I would rather spend my spare time watching a movie with my husband.

Do you have any dislikes?

Yes, dark chocolate!

Finish the sentence: "On a Friday afternoon at five o'clock, I... would kick off my shoes and relax with my family around the braai.

THE ASSOCIATION WOULD LIKE TO ACKNOWLEDGE THE ADVERTISERS AND THANK THEM FOR THEIR SUPPORT

HOT DIP GALVANIZING MEMBERS

GALVANIZER	LOCATION	TEL. NO	SPIN	NO. OF LINES	BATH SIZES (L x W x D) (m)
GAUTENG					
ArcelorMittal South Africa	Vanderbijlpark	016 889 9111		3	Sheet galvanizer
Armco Galvanizers	Isando	011 974 8511		1	13.2 x 1.5 x 2.2
Armco Galvanizers - Randfontein	Randfontein	011 693 5825		1	6.5 x 1.3 x 2.0
Galferro Galvanisers In-line and general	Springs	011 817 3667		4	13.5 x 1.65 x 2.5 6.8 x 0.9 x 1.4 6.5 x 0.9 x 1.5 6.45 x 0.755 x 0.9
Lianru Galvanisers cc	Nigel	011 814 8658		2	7.2 x 1.3 x 1.6 4.5 x 1.3 x 1.6
Pro-Tech Galvanizers (Pty) Ltd	Nigel	011 814 4292	•	2	3.2 x 1.1 x 1.5 3.0 x 1.1 x 1.2
Silverton Engineering	Silverton	012 843 8000		1	7.0 x 1.7 x 2.0
SMT Galvanizers	Benoni South	011 421 1495	•	2	2.6 x 1.0 x 1.5 2.0 x 1.0 x 1.5
Transvaal Galvanisers In-line and general	Nigel	011 814 1113		4	15.5 x 2.0 x 3.2 – 1 of 12.5 x 1.2 x 1.8 – 1 of 8.0 x 1.2 x 1.5 – 2 of
WESTERN CAPE					
Advanced Galvanising (Pty) Ltd	Bellville	021 951 6242		1	14.0 x 1.4 x 3.0
South Cape Galvanizing (Pty) Ltd	George Industria	044 884 0882		2	3.7 x 0.94 x 2.3
EASTERN CAPE					
Galvanising Techniques cc	Port Elizabeth	041 486 1432		1	12.0 x 1.3 x 2.3
Morhot (Pty) Ltd	East London	043 763 1143		1	7.0 x 2.5 x 1.5
KWAZULU/NATAL					
A&A Galvanisers	Pietermaritzburg	033 387 5783	•	1	3.8 x 0.9 x 1.8
Bay Galvanisers	Richards Bay	035 751 1942		1	5.0 x 1.2 x 2.5
Durban Galvanizing (Pty) Ltd	Briardene	031 563 7032		1	9.5 x 1.3 x 3.0
Phoenix Galvanizing (Pty) Ltd	Phoenix	031 500 1607	•	2	14.0 x 1.4 x 2.5 3.0 x 1.2 x 1.2
Pinetown Galvanizing	Pinetown	031 700 5599		1	9.0 x 1.2 x 3.0
INTERNATIONAL					
MAURITIUS					
Galvanising Co Ltd	Port Louis	+230 234 5118		1	7.0 x 0.75 x 1.68
ZIMBABWE					
Essar Tubes	Graniteside	+263772833477		1	10.0 x 1.1 x 1.0

- Sheet, wire, pipe and other in-line galvanizing members dedicate their plants to the galvanizing of their own products. The bath sizes are inside dimensions and not maximum component size. Kindly take note of the expansion of the component when dipped into molten zinc or discuss with relevant galvanizer.

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.

Armco Galvanizers Randfontein is our second 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 6m in length.

Armco Superlite is listed in accordance with the BSI ISO 9001:2015 quality scheme which ensures the quality of all products and services produced by **Armco Superlite**. Specific customer quality plans are drawn up where required for any of our operations.

Armco holds the SATAS mark for Hot Dipped Galvanized steel and all products galvanized at our premises are according to the SANS 121 / ISO 1461 specification. Galvanizing certificates are supplied on request.

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Web. www.armco.co.za

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