

Purlin and Girth Galvanized Coating for Corrosion Protection

(For ASHUGANJ 225MW Combined Cycle Power Plant)

July 11, 2014

This report shows that the galvanized coatings applied on girths and purlins(JIS G 3302 SGH490, equivalent with ASTM A 653 Gr 50) satisfy the requirements given in Owner's specification, applicable references or international codes.

1. Results of Performance

1.1 Requirements of Galvanized Coating

- 1) According to Section 14.14 of the Owner's specification, the steel surface shall be protected by either painting or galvanized coating.
- 2) According to Section 3.3 of the Owner's specification, the endurance period of coating shall be more than 20 years.
- 3) According to ASTM A1003, the Min galvanized coating weight Z180 (180 g/m²) is required.

1.2 Performance of Galvanized Coating

- 1) According to Attachment 3 "Mill Test Certificate of JIS G3302 SGH490", the metallic coating weight of approximately 290 g/m²(total both sides) are used on the steel sheets of girths or purlins. This value is much larger than Min. thickness (180 g/m²) in ASTM A1003.
- 2) The expected endurance period of the galvanized coating design is approximately 100years against the indoor environment condition of project site. The verification is shown in following section.

2. Verification of Performance

According to Technical Specification for Steel Works Section 4.5[FIGURE 1], purlin and girth are categorized as cold formed(fabricated through forming coils) secondary members complying with ASTM A653 Gr50 or equivalent. Actually JIS G 3302 SGH490 is equivalent to or more than ASTM A653 Gr50 based on values of yield, tensile test.

4.5 Cold Formed Secondary Members(Girth and Purlin)

Cold Formed Secondary Members shall conform to ASTM A653 Gr33 and Gr50 for Z Section with lips and C Section with lips respectively or Equivalent.

[FIGURE 1] Project Technical Specification for Steel Works

No Painting Work on Galvanized Area

Painting work is unnecessary on these galvanized members as per Section 10 of Technical Specification for Steel Works. [FIGURE 2]

10.0 PAINTING / GALVANIZING

All fabricated steel material, except those galvanized shall receive protective paint coating as specified in this specification.

Galvanizing of fabricated steel wherever specified, shall be as per relevant specification.

No paintings shall be applied for the around of bolt holes and structural surfaces

[FIGURE 2] Project Technical Specification for Steel Works

Applicable Standards

The applicable standards for steel sheet are the ASTM A653/653M and ASTM A1003/A1003M. According to ASTM A123/A123M Section 1.3, ASTM A123 specified on Section 11.5.4 of the Technical Specification is not applicable on steel sheet which galvanized on specialized or continuous lines.

Minimum Coating Weight

Purlin and girth (Type L, refer to Section 4.2 of ASTM A1003) have a minimum metallic coating weight of Z180 (180g/m² total both sides) as per Section 9.1 [FIGURE 3] and Table 1 [FIGURE 4] of ASTM A1003. Considering conversion factor in Section 8.1.3 of ASTM A653, approximate coating thickness is about 25µm (µm = 7.14g/m²).

9. Coating Properties

9.1 Metallic Coating—The minimum metallic coating weight [mass] requirements shall be as shown in **Table 1**.

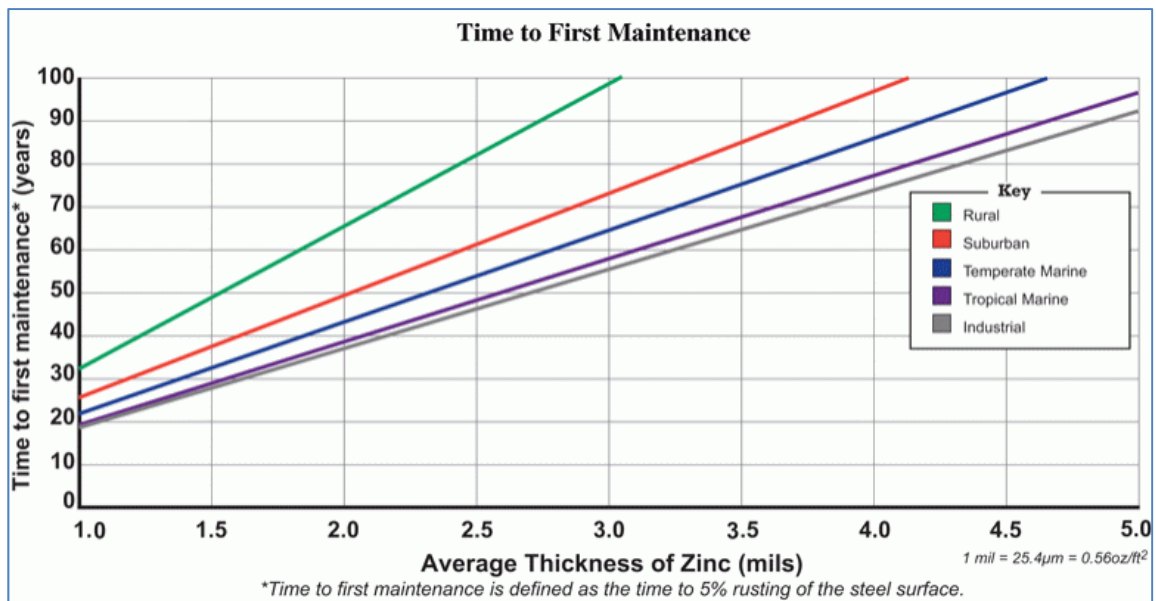
[FIGURE 3] ASTM A1003/A1003M

TABLE 1 Coating Weight [Mass] Requirements (Metallic Coatings)	
Product Designation	Coating Designation
Type H and Type L	G60 [Z180] ^A A60 [ZF180] ^B AZ50 [AZM150] ^C GF30 [ZGF90] ^D T1-25 [T1M 75] ^E T2-100 [T2M 300] ^E 30Z/30Z [90G/90G] ^F ZM20 [ZMM60] ^G
Type NS	G40 [Z120] ^A A40 [ZF120] ^B AZ50 [AZM150] ^C GF30 [ZGF90] ^D T1-25 [T1M 75] ^E T2-100 [T2M 300] ^E 20Z/20Z [60G/60G] ^F ZM20 [ZMM60] ^G
^A Zinc-coated steel sheet as described in Specifications A653/A653M A1063/A1063M .	
^B Zinc-iron alloy-coated steel sheet as described in Specification A653/A653M .	

[FIGURE 4] ASTM A1003/A1003M

Method for Corrosion Life

Galvanizing produces a zinc coating on the steel surface and is one of the effective methods for corrosion protection of steel. The proper selection of coating thickness requires knowledge of the corrosiveness of the environment in which the product will be used. The most commonly used method for corrosion life estimation of galvanized steels is the use of graph values for the different types of atmospheres as shown below: [FIGURE 5]

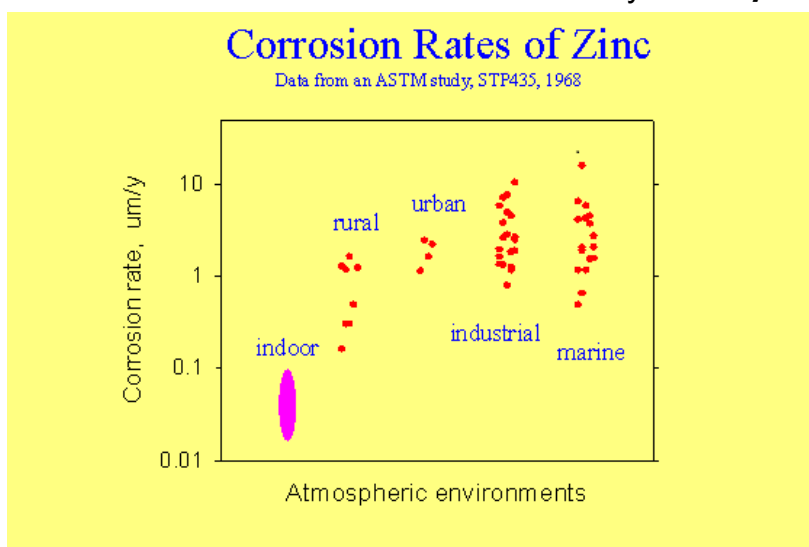


[FIGURE 5]

<http://www.galvanizeit.org/education-and-resources/resources/technical-faq-dr-galv/lifetime-vs-coating-thickness>

Another very useful tool for corrosion rate prediction (applicable to zinc-coated product by batch of continuous galvanizing) is the Zinc Coating Life Predictor (ZLCP) found at <http://www.galvinform.com:8080/zclp/index.html>. This is a program highly recommended by American Galvanizers Association to estimate the needed coating thickness with respect to lifespan by inputs of numerical values of parameters at a particular open air, rain sheltered or indoor condition.

The corrosion rate of zinc in atmospheric environments may vary from as low as about 0.1 $\mu\text{m}/\text{y}$ in indoor environments to as high as over 10 $\mu\text{m}/\text{y}$ in some industrial or marine environments as can be seen in ASTM study below. [FIGURE 6]



[FIGURE 6] ASTM Study, STP435, 1998

This means, Z180 galvanized steel (with about 13 μm coating thickness on each side) would have a corrosion life of about 100 years in an indoor environment but only for about 1 year in a marine environment. Description of atmospheric environments classification can be found in the attachment *Atmospheric Corrosion of Materials Section 1.2*.

Service Life of Purlin & Girth

Purlin and girth will be located in an indoor condition where the air is shielded from the outdoor air. Running the ZLCP program will estimate an average rate of $0.1\mu\text{m}/\text{year}$, a coating of $10\mu\text{m}$ with a 100 year service life. At this rate, a Z180 designation weighing about $180\text{g}/\text{m}^2$ total both sides will provide around 100 years life to first maintenance.

The supplied coating designation used for this project is an equivalent ASTM Z275 (weighing about $275\text{g}/\text{m}^2$ total both sides) which is of higher protection than Z180. [FIGURE 7]

Type	Coating Designation	SI Units		
		TST Total Both Sides, g/m^2	TST One Side, g/m^2	SST Total Both Sides, g/m^2
Zinc	Z001	no minimum	no minimum	no minimum
	Z90	90	30	75
	Z120	120	36	90
	Z180	180	60	150
	Z275	275	94	235

[FIGURE 7] ASTM A653/A653M Table 1

Therefore, the equivalent Z275 coating designation which is around $275\text{g}/\text{m}^2$ total both sides can already be considered adequate to be used for purlin & girth.

Reference

1. *Project Technical Specification for Steel Works*
2. *ASTM A1003M-13b Standard Specification for Steel Sheet, Metallic and Non-Metallic Coated for Cold Formed Framing Members*
3. *ASTM A653M-13 Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by Hot-Dip Process*
4. *ASTM A123M-13 Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products*

Attachment

1. *Atmospheric Corrosion of Materials (Emirates Journal for Engineering Research, Vol. 11, No.1, 2006 page 1-3)*
2. *Predict Hot-Dip Galvanized Steel's Service Life (The Specified Newsletter of the American Galvanizers Association)*
3. *Mill Test Certificate of JIS G 3302 SGH490*

ATMOSPHERIC CORROSION OF MATERIALS

S. SYED

Corrosion Research Group, Atomic Energy Research Institute, King Abdulaziz City for Science and Technology,
P.O. Box 6086, Riyadh-11442, Saudi Arabia. Email: sabirsyed2k@yahoo.com

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استحوذت مشكلة تآكل المواد الناجم عن الأحوال الجوية على أبحاث العاملين في ميدان المواد خلال السنوات الأخيرة حيث زاد معدل تآكل المواد على مستوي القياس بالطن أو التكلفة نتيجة للأحوال الجوية إذا ما قورن بالظروف البيئية الأخرى. حيث تتعرض كميات ضخمة من المواد بقطاعات الصناعة والسيارات والجسور والمباني للظروف الجوية وكذلك للمواد الملوثة والمياه. وتلقى ورقة البحث هذه الضوء على التآكل الناجم عن الأحوال الجوية لمختلف المواد وتأثير تعرض المعاملات ونظرية أسس التآكل الناجم عن الظروف الجوية.

In recent years, atmospheric corrosion of materials have attracted materials community for it accounts for more failures on both a tonnage basis and cost basis than any other type of environmental corrosion. Tremendous amounts of materials in industries, automobiles, bridges and buildings are exposed to the atmosphere and attacked by pollutant and water. In this review paper attention is paid to the atmospheric corrosion of various materials, influence of exposure parameters and basics theory of atmospheric corrosion.

Keywords: Materials, atmospheric corrosion, corrosion processes

1. INTRODUCTION

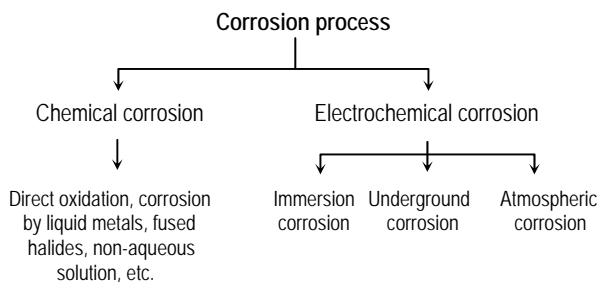
The word corrosion is derived from the latin *corrosus* which means eaten away or consumed by degrees; an unpleasant word for an unpleasant process^[1]. Corrosion is defined as the destruction of materials caused by chemical or electrochemical action of the surrounding environment. This phenomenon is experienced in day to day living. The most common examples of corrosion include rusting, discoloration and tarnishing^[2]. Corrosion is an ever occurring material disease. It can only be reduced it cannot be prevented because thermodynamically it is a spontaneous phenomena.

In fact, economy of any country would be drastically changed if there were no corrosion. For example, automobiles, ships, underground pipelines and house-hold appliances would not require coatings. The stainless steel industry would disappear and copper would be used for electrical applications. Although corrosion is inevitable, its cost could be reduced.

Corrosion can be fast or slow. Sensitized 18-8 stainless steel is badly attacked in hours by polythionic acid. Railroad tracks usually show slight rusting not sufficient to affect their performance over many years. The famous iron Delhi Pillar in India was made almost 2000 years ago and is almost as good as new. Its height is 32 feet and dia 2 feet. It should be noted however, that it has been exposed mostly to arid conditions^[3].

1.1. Classification of Corrosion Process

Corrosion process can be conveniently classified as follows^[4]:



Reaction of metals with dry air or oxygen is considered as a chemical corrosion. High temperature oxidation of metals and tarnishing of metals like copper, silver etc. fall in this category. Of late this is also considered to be an electrochemical process with the diffusion of oxygen (inwards) and metal ions (outwards) through the oxide layer, the electromotive force at metal-oxide interface being the driving force. Electrochemical corrosion occurs in the presence of electrolyte. The reaction is considered to take place at the metal-solution interface with the creation of local cathodic and anodic sides on the metal surface^[5].

1.2. Atmospheric Corrosion

The term “atmospheric corrosion” comprises the **attack on metal exposed to the air** as opposed to metal immersed in a liquid. Atmospheric corrosion is the most prevalent type of corrosion for common metals^[6]. Atmospheric corrosion is a subject of global concern because of its importance to the service life of equipment and durability of the structural materials. While there is a general agreement on the possible types of parameters that may lead to corrosion, these studies suffer severely from the lack of generality in the sense that their predictive capability is extremely poor.

Conventional atmospheric parameters that may lead to metal corrosion comprise of weathering factors such as temperature, moisture, rainfall, solar radiation, wind velocity, etc. Air pollutants such as sulphur dioxide, hydrogen sulphide, oxides of nitrogen, chlorides have also been found to contribute to atmospheric corrosion^[7].

The complexity and diverse nature of the atmospheric pollutants make the prediction of the atmospheric corrosion difficult. The synergistic interaction of the variables must also be considered in the model for arriving at a definite solution. A direct approach to the problem is to measure the observed corrosion rates and the participating atmospheric parameters and correlate them. The correlation equations, thus derived, are known as damage functions and they have been found to be extremely useful, though in a restricted manner, as the results are not easily transferable from one place to another^[8].

Predictability of atmospheric corrosion, in principle, should be based upon the complete understanding of the corrosion process and interdependence of the contributing parameters. Extensive data have been collected all over the world on atmospheric corrosion of metals exposed at different locations. Empirical and semi-empirical relationships have been developed to generalize these observations. Most prominent of these relationships have been the linear and exponential dependence of corrosion rate with relative humidity, pollutant levels and temperature^[9]. Grossman^[10] has investigated the atmospheric factors which determined the time of wetness of the outdoor structures. A thermodynamic perspective of copper tarnishing by SO₂ in the presence of moisture was reported by Chawla and Payer^[11]. Walters^[12-13] carried out some exhaustive studies on the laboratory simulation of atmospheric corrosion by SO₂ detailing the apparatus, electrochemical techniques and example results. The effect of pollutants such as SO₂, NaCl, dust, etc., on the critical humidity for the rusting to occur was well documented by Vassie^[14]. A statistical evaluation of the atmospheric corrosion of stainless steel was undertaken by Blank and Lherbier^[15]. The atmospheric corrosion rates of mild steel and low alloy cast steels were studied by Thomas and Alderson; Briggs^[16,17],

respectively. The damage function describing the atmospheric deterioration of materials due to acidic deposition was studied in detail by Lipfert^[18]. Stiles and Edney studied the potential damage to galvanized steel by the dissolution of zinc into thin aqueous films as a function of residence time, acidic species and pH^[19]. The corrosion product Zn²⁺ correlated linearly with incident H⁺ concentration. Some developments in the atmospheric corrosion testing were carried out by Pourbaix and Pourbaix^[20] and they assessed the corrosion behaviour of different types of steel in both natural and laboratory simulated conditions.

Atmospheric corrosion can further be conveniently classified into dry, damp and wet categories. Dry oxidation takes place in the atmosphere with all metals that have a negative free energy of oxide formation. The damp moisture films are created at a certain critical humidity level (largely by the adsorption of water molecules), while the wet films are associated with dew, ocean spray, rainwater, and other forms of water splashing. By its very nature, atmospheric corrosion has been reported to account for more failures in terms of cost and tonnage than any other form of corrosion.

The atmospheric environments are **classified as rural, urban, industrial, marine**, or combinations of these. These types of atmospheres have been described as follows^[21-23].

Rural: Rural environments are usually free of aggressive agents (deposition rate of SO₂ and NaCl lower than 15 mg m⁻² day⁻¹). Their principal corrosives consist of moisture, relatively small amounts of sulfur oxides (SO_x), and carbon dioxide (CO₂) from various combustion products. Ammonia (NH₃), resulting from the decomposition of farm fertilizers, may also be present. Rusting becomes pronounced when the relative humidity exceeds a certain value. For clean air this value is about 70 percent. Rural environments generally are not aggressive towards metals. This type of atmosphere is generally the least corrosive and normally does not contain chemical pollutants, but does contain organic and inorganic particulates. Arid and tropical types are especially extreme cases in the rural category.

Urban: Urban atmosphere is similar to rural atmosphere where there is little industrial activity, characterized by pollution composed mainly of SO_x and NO_x variety, from motor vehicles and domestic fuel emissions which, with the addition of dew or fog, generate a highly corrosive wet acid film on exposed surfaces (deposition rate of SO₂ higher than 15 mg m⁻² day⁻¹ and that of NaCl lower than this value).

Industrial: The most potent causes of corrosion in industrial environments are the sulfur oxides (SO_x) and nitrogen oxides (NO_x) produced by the burning of automotive fuels and fossil fuels in power stations. The critical relative humidity, above which metals corrode, drops to about 60 percent when these airborne pollutants are deposited on the metal surface.

These atmospheres are also associated with concentrations of chlorides, phosphates, hydrogen sulphate, ammonia and its salts.

Marine: The corrosiveness of a marine environment depends on the topography of the shore, wave action at the surf line, prevailing winds and relative humidity. While the corrosiveness decreases rapidly with increasing distance from the shore, severe storms can carry salt spray inland as much as 15 km. Salt is deposited on steel surfaces by marine fog and wind-blown spray droplets (deposition rate of NaCl higher than $15 \text{ mg m}^{-2} \text{ day}^{-1}$). This contamination induces severe corrosion at relative humidities exceeding about 55%. This environment is characterized by proximity to the ocean and salt-laden air that can produce very severe corrosion damage on many structural materials, enhance galvanic corrosion, and accelerate deterioration of protective coating systems. Marine atmospheres are usually highly corrosive. The principal culprit in marine atmospheres is the chloride (Cl^-) ion derived from sodium chloride.

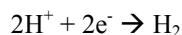
2. BASIC OF ATMOSPHERIC CORROSION

2.1. Theory of Atmospheric Corrosion

A fundamental requirement for electrochemical corrosion processes is the presence of an electrolyte. Thin-film “invisible” electrolytes tend to form on metallic surfaces under atmospheric exposure conditions after a certain critical humidity level is reached. It has been shown that for iron, the critical humidity is 60 percent in an atmosphere free of sulfur dioxide. The critical humidity level is not constant and depends on the corroding material, the tendency of corrosion products, surface deposits to absorb moisture and the presence of atmospheric pollutants.

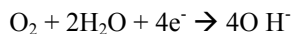
In the presence of thin-film electrolytes, atmospheric corrosion proceeds by balancing anodic and cathodic reactions. The anodic oxidation reaction involves the dissolution of the metal, while the cathodic reaction is often assumed to be the oxygen reduction reaction. It should be noted that corrosive contaminant concentrations can reach relatively high values in the thin electrolyte films, especially under conditions of alternate wetting and drying. Oxygen from the atmosphere is also readily supplied to the electrolyte under thin-film corrosion conditions.

The cathodic process: If it is assumed that the surface electrolyte in extremely thin layers is neutral or even slightly acidic, then the hydrogen production reaction (Eq.) can be ignored for atmospheric corrosion of most metals and alloys.

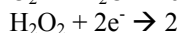
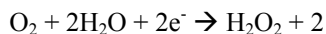


Exceptions to this assumption would include corrosive attack under coatings, when the production of hydrogen can cause blistering of the coating, and

other crevice corrosion conditions. The reduction of atmospheric oxygen is one of the most important reactions in which electrons are consumed. In the presence of gaseous air pollutants, other reduction reactions involving ozone and sulfur and nitrogen species have to be considered ^[24]. For atmospheric corrosion in near-neutral electrolyte solution, the oxygen reduction reaction is applicable (Eq.)



Two reaction steps may actually be involved, with hydrogen peroxide as an intermediate, in accordance with (Eqs).



If oxygen from the atmosphere diffuses through the electrolyte film to the metal surface, a diffusion-limited current density should apply. It has been shown that a diffusion transport mechanism for oxygen is applicable only to an electrolyte-layer thickness of approximately $30 \mu\text{m}$ and under strictly isothermal conditions ^[25]. The predicted theoretical limiting current density of oxygen reduction in an electrolyte-layer thickness of $30 \mu\text{m}$ significantly exceeds practical observations of atmospheric corrosion rates. It can be argued, therefore, that the over-all rates of atmospheric corrosion are likely to be controlled not by the cathodic oxygen reduction process, but rather by the anodic reaction(s).

The anodic process: Equation represents the generalized anodic reaction that corresponds to the rate-determining step of atmospheric corrosion.



The formation of corrosion products, the solubility of corrosion products in the surface electrolyte, and the formation of passive films affect the overall rate of the anodic metal dissolution process and cause deviations from sample rate equations. Passive films distinguish themselves from corrosion products, in the sense that these films tend to be more tightly adherent, are of lower thickness, and provide a higher degree of protection from corrosive attack. Atmospheric corrosive attack on a surface protected by a passive film tends to be of a localized nature. Surface pitting and stress corrosion cracking in aluminum and stainless alloys are examples of such attack.

Relatively complex reaction sequences have been proposed for the corrosion product formation and breakdown processes to explain observed atmospheric corrosion rates for different classes of metals. Fundamentally, kinetic modeling rather than equilibrium assessments appears to be appropriate for the dynamic conditions of alternate wetting and drying of surfaces corroding in the atmosphere. A framework for treating atmospheric corrosion phenomena on a theoretical basis, based on six different regimes, has been presented by Graedel ^[26]. The regimes in this so-

Dr. Galv

PREDICT HOT-DIP GALVANIZED STEEL'S SERVICE LIFE

How can I predict the service life of galvanized steel in a specific environment?

For the past 80 years, galvanized steel samples have been tested in a variety of environments around the world to determine the corrosion rate of zinc. These known rates were used to develop a performance chart that was linear to the zinc coating thickness of the galvanized steel.

Although an accurate method of determining field performance at particular sites, the service-life chart the American Galvanizers Association has been using for the past 20 years has changed - for the better!

Strict environmental regulations imposed over the past 10 to 15 years have improved the quality of air to the point where galvanized steel lasts much longer. So, in order to have a contemporary method of predicting the zinc corrosion rate (hot-dip galvanized steel's performance) for any project throughout the world, the *Zinc Coating Life Predictor* software was developed.

Funded by the International Lead & Zinc Research Organization, designed and built primarily by Gregory Zhang of Teck Cominco Metals, Ltd., the *Predictor* performs calculations based on models that were developed using statistical methods, neural network technology, and an extensive worldwide corrosion database.

The environmental data input required to estimate a corrosion rate for any location includes: temperature, annual precipitation, relative humidity, sulfur dioxide concentration, and airborne salinity. Once these values are input, the software calculates and reports a corrosion rate, and gives the option to either calculate the predicted life given the zinc coating thickness, or the coating thickness required to achieve a specified life. (Note: zinc coating thickness can only be specified for continuously galvanized steel [sheet], not after-fabrication hot-dip galvanized steel.)

This software was used to develop a chart that predicts the service life of hot-dip galvanized steel of varying coat-

ing thicknesses in a wide variety of environments. This chart provides a general idea of the performance expected from galvanized steel in any of five environments as defined by the American Society of Testing and Materials. (The new service-life chart is on page 4 of this newsletter.)

To predict the performance of galvanized steel in your location, visit the American Galvanizers Association's Web site at www.galvanizeit.org and click on "Service Life" to access the *Zinc Coating Life Predictor*. Following are explanations of how to collect the open atmosphere data for the five environmental parameters for your particular location:

1) & 2) Temperatures and annual precipitation (or rainfall) information can be gathered from www.weather.com, The Weather Channel's site.

3) Relative humidity data can be gathered from the National Weather Service at www.nws.mbay.net/rh.html.

4) Sulfur dioxide concentrations can be obtained from an EPA report that lists the peak air quality statistics for major pollutants. This file can be found at www.epa.gov/oar/aqtrnd00/pdf/files/factbook.pdf.

Some cities, particularly rural, do not monitor their levels of sulfur dioxide due to their low concentration. These areas can be estimated to have the lowest of all the concentrations.

5) Air salinity data for numerous environments does not readily exist. Some data exists for areas close to the sea; therefore, for inland areas, these values can be estimated from any other known data and their distance from the ocean. Some examples of airborne salinity data can be found in the *Zinc Coating Life Predictor*, as can examples of the other four environmental parameters.

Questions about the *Zinc Coating Life Predictor* may be directed to AGA: aga@galvanizeit.org or 800-468-7732.

New Software Improves Service Life Prediction for Zinc Coatings

Since the 1960s, the service life chart for hot-dip galvanized steel has been a staple of AGA publications. The ultimate factor in choosing a corrosion protection system is always “how long will it protect?” This is the question on the minds of every specifier, engineer, and architect. The ability to provide these people with an accurate tool to predict the corrosion rate of galvanized steel is essential in marketing galvanized steel products. However, the curve that is currently distributed to the public (Figure 1) was developed some time ago. The changing atmospheric conditions warrant a new tool that will improve the prediction of the service life of hot-dip galvanized steel.

The International Lead/Zinc Research Organization (ILZRO) has recently developed internet-based software to predict the service life of zinc coatings. This software, developed by Gregory Zhang of TeckCominco Metals Ltd., allows users to input environmental parameters, which affect the corrosion rate of zinc, and then calculates an anticipated corrosion rate based on the particular environment. The program performs calculations based on models that were developed using statistical methods, neural network technology and an extensive worldwide corrosion database.

The environmental input data required to estimate a corrosion rate for zinc includes temperature, airborne salinity, sulfur dioxide concentration, relative humidity, rainfall, and sheltering condition (indoor, rain-sheltered, or outdoor). Once these values are known, the program calculates and reports a corrosion rate and also gives the option to either calculate the predicted life, given the coating thickness, or the coating thickness required to achieve a specified life. The AGA Technical Department used this program to produce a current anticipated service life chart for hot-dip galvanized steel (Figure 2).

The original curve was developed from corrosion data from 1900 to 1960. The atmospheric conditions of these years were at an all-time low in terms of pollution. In this time period the birth of environmental policies and industrial improvements occurred resulting in a cleaner environment. Restrictions on the exhaustion of harmful chemicals and improvements in fume capture and exhaust air controls as well as fuel changes have significantly improved the air quality and reduced the pollution levels. By reducing the pollution level, or corrosive elements, in the air the corrosion rate of metals, particularly zinc, also decreased.

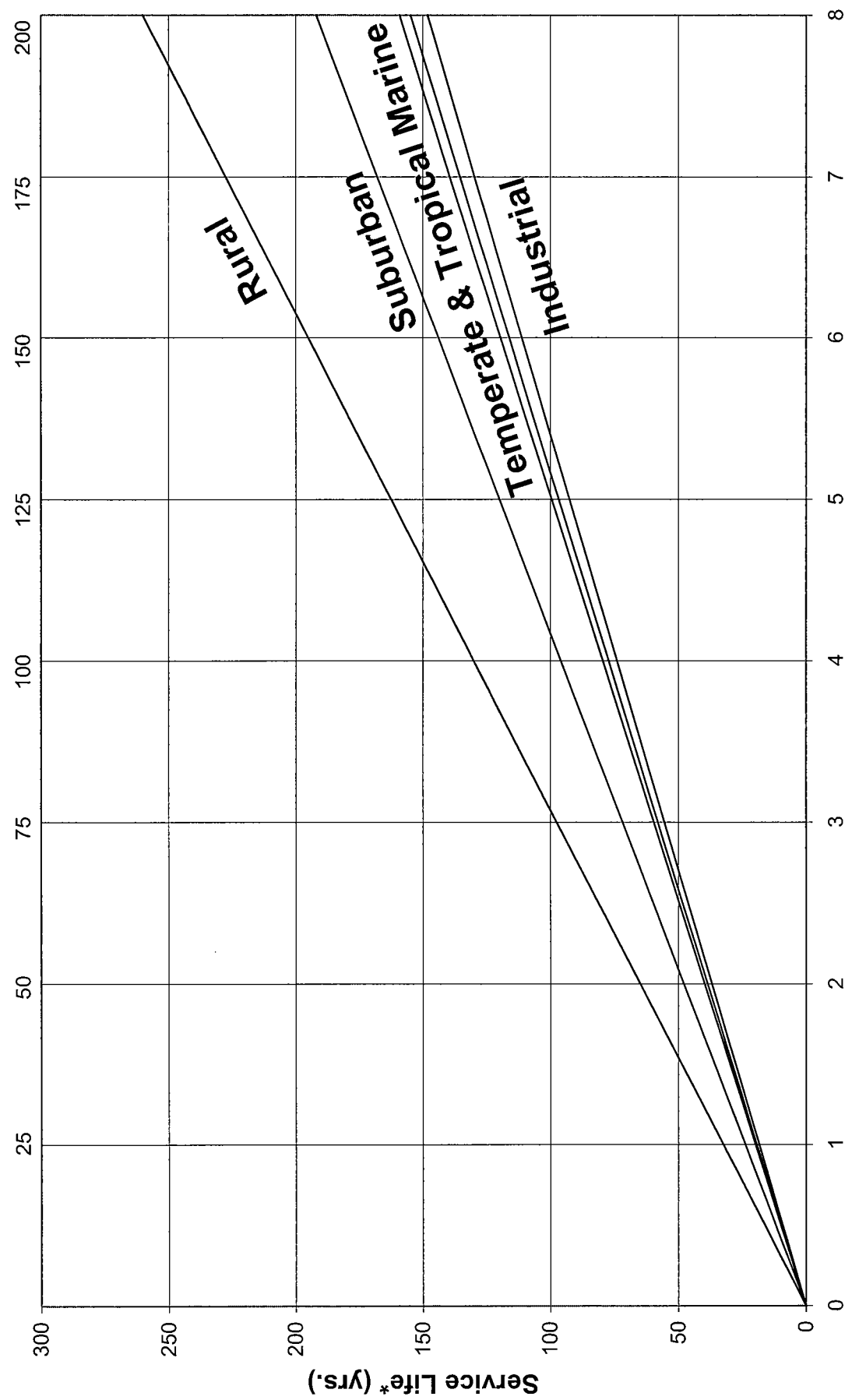
The recent advent of the Internet has made a vast informational resource available to anybody who owns a computer and has access to a phone line. Almost every major company, agency, and government has a web site that users can access to obtain information. Through the use of the World Wide Web, one can obtain environmental data for a variety of locations and regions. The easy accessibility to this information allows anyone find the correct parameters to use the Zinc Coating Life Predictor.

The resources used to construct the latest service life chart were taken from a variety of websites. The temperatures and annual precipitation (or rainfall) were gathered from www.weather.com, which is the Weather Channel's site. The relative humidity data was gathered from the National Weather Service (www.nws.mbay.net/rh.html), which had annual relative humidity data for numerous cities throughout the U.S. The sulfur dioxide concentrations were determined from a report produced by EPA that lists the peak air quality statistics for the major pollutants. This file can be found online at www.epa.gov/oar/aqtrnd00/pdf/files/factbook.pdf. Some cities, particularly rural, do not monitor their levels of sulfur dioxide due to their low concentration. The input values for rural cities were estimated to be the low end of the sulfur dioxide concentrations. Air salinity data for numerous environments does not readily exist. Some data exists for areas close to the sea; therefore, for inland areas, these values were estimated based on their distance from the ocean and from any other known data. Some examples of airborne salinity data can be found on the Zinc Coating Life Predictor Web site (fortjava.com:8080/zclp/index.html), as can world wide examples of the other four environmental parameters.

The Zinc Coating Life predictor is slated to become a part of the AGA's web site (www.galvanizeit.org) in the near future. Directing potential customers to this site will allow them to find out for themselves that hot-dip galvanized steel provides the best corrosion protection system for their project.

Service Life Chart for Hot-Dip Galvanized Coatings

Derived from The Zinc Coating Life Predictor



Average Thickness of Zinc (microns top line, mils bottom line)

*Service Life is defined as the time to 5% rusting of the steel surface

Note: 1 oz./ft² ~ 1.8 mils

POSCO Mill Test Certificate / 검사증명서

Certificate No./증명서번호 :120329-KLNE-042-001
Date of Issue/발행일자: Sep., 04, 2012
Surface Treatment: NH (Cr-Free Coating)

Order No./계약번호:0005145212

PO No./주문번호:HHMLA12022801

Supplier/주문자:DAEHYUB STEEL CO.,LTD

Commodity/품명:HOT ROLLED GALVANIZED COIL

Customer/고객사:HANMAEK INDUSTRY CO.

Spec & Type/규격:JIS G 3302 SGH490

Size/치수	Product No. 제품번호	Quantity 수량	Weight 중량 (kg)	Heat No. 제강번호	POSITION	Tensile/인장시험			Coating Weight (g/m ²)		DIVISION	Chemical Composition/화합성분(%)				
						YP	TS	EL	Zn	Zn		C	Si	Mn	P	S
						(MPa)		(%)	Upper	Lower		-4	-3	-3	-4	-4
3.2x1078xC	CVC2349B	1	13,480	SQ67891	B	485	554	27	144.7	145.3	L	1324	10	870	117	45
3.2x1078xC	CVC2350A	1	13,540	SQ67891	B	485	554	27	144.7	145.3	L	1324	10	870	117	45
3.2x1078xC	CVC2351B	1	13,470	SQ67891	B	480	554	25	146.0	146.0	L	1324	10	870	117	45
3.2x1078xC	CVC2352A	1	13,540	SQ67891	B	480	554	25	146.0	146.0	L	1324	10	870	117	45
3.2x1078xC	CVC2352B	1	13,510	SQ67891	B	480	554	25	146.0	146.0	L	1324	10	870	117	45
3.2x1078xC	CVC2353A	1	13,520	SQ67891	B	475	551	27	144.3	148.3	L	1324	10	870	117	45
3.2x1078xC	CVC2353B	1	13,480	SQ67891	B	475	551	27	144.3	148.3	L	1324	10	870	117	45
3.2x1078xC	CVC2356A	1	13,530	SQ67891	B	489	573	24	144.7	146.7	L	1324	10	870	117	45
3.2x1078xC	CVC2356B	1	13,360	SQ67891	B	489	573	24	144.7	146.7	L	1324	10	870	117	45
*** Sub Total	(010) ***	9	121,430 (kg)	< Not Welded >												

* Position - T : Top, M : Middle, B : Bottom
* Tensile Test. Direction : Longitudinal, Gauge Length : 50mm(Rectangular),
* Division - L:Ladle Analysis
* Chemical Composition Unit: -2:x1/100, -3:x1/1000, -4:x1/10000, -5:x1/100000

We hereby certify that the material herein has been made in accordance with the order and above specification.

* 본 검사증명서에 명기된 규격용도와 사용시 안전상 문제가 발생할 수 있으며,
검사증명서 위·변조시 사문서 위조(형법231조)로 불이익을 당하실 수 있습니다.

Surveyor To:

Kang Y. S.

POSCO Gwangyang Works, 700 Geumho-dong, Gwangyang-si, Jeollanam-do, 545-711, Korea

Chief of material testing section Kang. Y. S

