GUIDELINES FOR THE ADDITIONAL PROTECTION OF GALVANISED STEEL COLUMNS

INSTITUTION OF LIGHTING PROFESSIONALS

LCTF

HEA
Highway Electrical Association

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Contents

1. Introduction

This document is intended to provide guidance to all those who have responsibility for the specification of steel lighting columns. Its primary aim is to provide a basis for defining the severity of the environment into which any steel lighting column will be located. Taking into account environmental conditions both above and below ground and the expected performance in terms of protection life, it goes on to offer guidance in the selection of appropriate protection systems.

Two classes of protection are defined for low to moderate atmospheric corrosivity, and moderate to high atmospheric corrosivity respectively. Within each class, three levels of root protection have been defined to take into account differing underground conditions within any given atmospheric environment.

The document firstly, defines levels of performance required, secondly, goes on to set out a basis for defining the atmospheric environment in terms of geographical location, and thirdly, suggests protection systems appropriate to Group I and Group II.

It is not the purpose of this document, at present, to define in detail for Group II protections, specific systems for over painting the basic protections given as Group I.

Instead, the purpose is to indicate the need for further protection in moderate to high atmospheric corrosivity environments. The Group II protections introduce a two-coat paint system. It should be noted that further paint coats or systems may be applied to extend the column life or the period between maintenance. Equally, it may be possible to apply a single specialised coat under certain circumstances.

N.B.: *For further information relating to the requirements for hot dip galvanised steel lighting columns and corrosion protection can be found in the ILP Technical Report 26 – Painting of Lighting Columns.*

For other lighting related enquiries please contact the LCTF Secretary contact details can be found on the back of this document.

2. Scope

The document refers to the protection of mild steel lighting columns with a metallic coating, namely hot-dip galvanizing. This protection and additional protective coats are defined within two groups of atmospheric corrosivity; low to moderate and moderate to high. Specific protection systems are defined for the two classes together with a selection of root protections dependent on the severity of any given set of ground conditions.

3. Performance

The minimum level of performance around which this document is written is based on a coating life of 20 years. The standard (Group I) protection must be capable of achieving this in what may be regarded as low to moderate atmospheric corrosivity. An enhanced (Group II) protection should be capable of achieving this in severely polluted atmospheres as well as achieving a life considerably longer in less onerous conditions. The performance in terms of-underground conditions should be such that the coating life is not reduced from what it would be with respect to atmospheric conditions. The relationship between expected coating life and environmental conditions is shown in Appendix 1 for the two groups of protections.

4. Environmental Conditions

4.1 Atmospheric environments have been defined to some degree in BS EN ISO 12944.

A more qualitative approach is given in the 'Relative Values of Acid Deposition in the UK' published by the Galvanizers Association. The Millennium map, reproduced in this document and the information which can be found on the Galvanizers Association web site offers relative levels of acid deposition which are based on certain major pollutants including sulphur dioxide, oxides of nitrogen, hydrogen sulphide and chlorides and relates directly to the corrosivity of the atmosphere. These levels of acid deposition are derived from, and correlate extremely well with, the corrosion rates of zinc. From this information it is fairly straightforward to estimate which of these environments give galvanized coatings an expected life of 20 years and which will not. This gives a reasonable and generally acceptable basis from which to define whether in any given location a Group I or Group II protection is required.

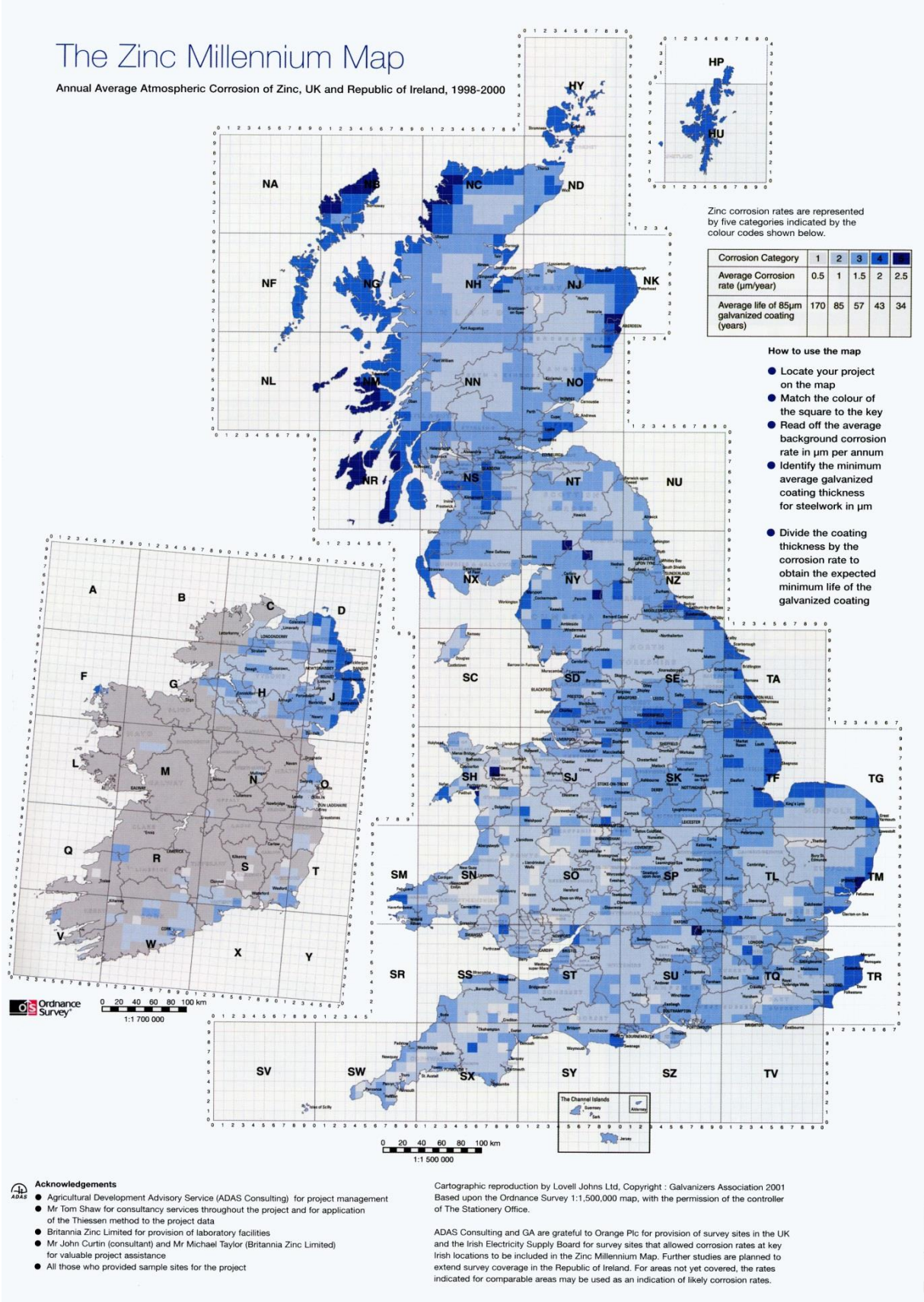
4.2 Underground conditions are more prone to localised variations and do not lend themselves to a general designation by area. Where factors which effect corrosivity are known or ground surveys are undertaken, some estimate can be put on the performance of the metallic coating, ie., acidity, alkalinity, ground water, or the presence of foreign materials. For the considerable number of occasions where data is not available, past experience must be used to some degree. For the purpose of this specification three levels of ground aggressivity have been used. These levels have been designated; non-aggressive or passive (**P**), moderately aggressive (**M**) and aggressive (**A**). The aggressive nature of the ground conditions refers to corrosivity with respect to the two types of metallic coatings. A more quantitative evaluation can be made by ranking all known factors which contribute to the aggressive or non-aggressive nature of the soil.

N.B.: *Further reading and updates to 1900 Series painting documents can be found at:*

- Manual of Contract Documents for Highway Works Series NG 1900 Protection of Steelwork Against Corrosion (Amendment – August 2014)
  http://dft.gov.uk/ha/standards/mchw/vol1/index.htm

- Manual of Contract Documents for Highway Works Volume 2 Notes for Guidance on the Specification for Highway Works Series NG1800 Structural Steelwork
  http://dft.gov.uk/ha/standards/mchw/vol2/index.htm

Acid Deposition in the United Kingdom



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5. Group I Protection System

(For low to moderate atmospheric corrosivity)

5.1 Hot-dip Galvanized Systems

5.1.1. System IGP

(i) Hot-dip galvanized on the external and internal surfaces of the column in accordance with BS EN ISO 1461. This shall be a coating of zinc and zinc-iron alloy layers obtained by dipping in a molten zinc bath with not less than 98.5 by weight of zinc.

(ii) The thicknesses obtained shall be in accordance with the following table:

Table 3 – **Minimum Coating thickness and mass on samples that are not centrifuged**

Article and its thickness	Local coating thickness (minimum) µm	Local coating mass (minimum) g/m²	Mean coating Thickness (minimum) µm	Mean coating mass (minimum) g/m²
Steel > 6mm	70	505	85	610
Steel > 3mm to < 6mm	55	395	70	505
Steel > 1.5mm to < 3mm	45	325	55	395
Steel > 1.5mm	35	250	45	325
Castings > 6mm	70	505	80	575
Castings < 6mm	60	430	70	505

Note: This table is for general use, individual product standards may include different requirements including different categories of thickness. Local coating mass and mean coating mass requirements are set out in this table for reference in such cases of dispute.

(iii) The requirements of BS EN ISO 1461 ensure that the zinc coating is continuous, of the required thickness and sufficiently adherent to withstand normal handling conditions without peeling or flaking. Variations in the finish can occur during galvanizing and these are often outside the control of the galvanizer. The acceptability of the coating should be based primarily on its performance and corrosion resistance. Variations in appearance such as dull grey coatings, stains, roughness and runs are generally acceptable unless otherwise agreed.

5.1.2 System IGM

(i) Columns galvanized as for System IGP but with additional protection to the vulnerable root area. This additional protection can be offered using either Highways England Item 121 applied at a nominal thickness of 100 microns minimum dry film, a 2PK Pitch Epoxy/2PK Coal Tar free Epoxy applied at a nominal thickness of 100 microns minimum dry film build or using a 2PK Glass Reinforced Epoxy applied at a nominal thickness of 200 microns minimum dry film build to the external root section to a distance of 250mm above ground level.

5.1.3 System IGA

(i) Columns galvanized as for System IGP but with an additional protection to the external surface of the root section to 250mm above ground level. This additional protection can be offered using a Highways England Series 1900 2PK Epoxy MIO Item121 applied at a nominal total dry film thickness of 300 microns or Highways England Series 1900 2PK Epoxy MIO Item121 applied at a nominal total dry film thickness of 100 microns plus 2PK Glass Reinforced Epoxy applied at a nominal total dry film thickness of 200 microns. Where it is known that aggressive ground water reaches the internal surface of the root section consideration should be given to returning either the 2PK Epoxy MIO Item121 or 2PK Pack Glass Reinforced Epoxy internally to 250 mm above ground level to provide additional protection to the vulnerable root area.

6. Group 11 Protection Systems

(For moderate to high atmospheric corrosivity)

6.1 Hot-dip Galvanized Systems

6.1.1 System IIGP

(i) Hot-dip galvanized on the external and internal surfaces of the column in accordance with BS EN ISO 1461 and as defined in clause 5.1.1.

(ii) Prior to treatment with 'T' Wash, the external galvanized surface shall be dry and free from dirt, oil, grease, flux and corrosion products. Removing zinc salts (white rust) using water and Scotch Brite pads, rinsing clean and allowed to dry.

N.B.: *The galvanised surface should turn black when dry, indicating full conversion has taken place. Repeat the process if this does not occur, avoid over application of 'T' Wash.*

Alternatively lightly abrade the galvanized surface, removing any abrasive dust deposits prior to painting.

(iii) Application of a 2-coat paint system to the external surface consisting of a primer coat and a finishing coat. The latter may be shop or site applied. This defines a base requirement to protect the galvanized coat, but it should be noted that further coats or systems may be applied to extend the column life or the periods between maintenance.

6.1.2. System IIGM

(i) Hot-dip galvanized to BS EN ISO 1461 as specified in clause 5.1.1 (Group I System IGP).

Either:

(ii) Application of a 2-coat paint system as defined in clause 6.1.1 (iii)

(iii) Application of a root treatment providing additional protection to the vulnerable surface of the root section as defined in clause 5.1.2.

Or:

(ii) Application of a 1-coat powder or liquid thermosetting or thermoplastic polymer or polyolefin elastomeric coating

6.1.3 System IIGA

(i) As for IIGM but with an upgraded two coat paint system to provide additional protection to the external surface of the root section as defined in clause 5.1.2. Where it is known that aggressive ground water reaches the internal surface of the root section consideration should be given to returning either the 2PK Epoxy MIO Item 121 or 2PK Glass Reinforced Epoxy internally to 250mm above ground level to provide additional protection to the vulnerable root area.

Appendix 1

Classification of protections performance with respect to life expectancy and environment.

Atmospheric Environments	UK RVAD†	AACR* GAL. Zn g/m²	Group 1 (standard)	Group 11 (enhanced)	Ground Conditions
Non-polluted inland	1	13	40 + years	40 + years	Non-aggressive or passive
	2	20	↓	↓	(P)
Moderately polluted	3	26			
Non-polluted coastal			20 years	30 years	Moderately Aggressive
	4	32	//////////////		(M)
Polluted inland	5	38	//////////////	↓	
Polluted Coastal	6	45	//////////////		Aggressive (A)
Severely polluted	7	51		20 years	

† RVAD – Relative Values of Acid deposition
*AACR – Annual atmospheric Corrosivity Rates of Zinc

Appendix 2

Summary of protection systems

Group	Metallic coating	Ground condition	System definition	Reference
1 (Standard)	Zn	P	Hot-dip galvanized to BS EN ISO 1461 Internal and external	IGP
		M	As IGP plus 'light' bitumen material or equivalent on external root section	IGM
		A	As IGP plus 'light' bitumen material or equivalent on external root section	IGA
11 (enhanced)	Zn	P	Hot-dip galvanized to BS EN ISO 1461 plus external 2-coat paint system	IIGP
		M	*Either:* Hot-dip galvanized to BS EN ISO 1461 plus External 2-coat paint system with 'light' protection to external root section. *Or:* Hot-dip galvanized to BS EN ISO 1461 plus 1-coat external powder/liquid application	IIGM/1 IIGM/2
		A	IIGM/1 or IIGM/2 plus 'heavy' protection to the external root section	IIGM/1 IIGM/2

N.B.: *Improved root protection can be achieved from the use of:*
Two-Pack Epoxy MIO Item 121
Two-Pack Glass Reinforced Epoxy
Used separately or in conjunction with each other
Recommended total minimum dry film build 300 microns

It is important to apply sufficient wet paint (WFT) to meet the required dry film thickness (DFT) for the products being applied, using wet film thickness comb gauges to check this during paint application.

Also to use a dry film thickness gauge to ensure that the total dry film thickness (TDFT) of product or total coating thickness has been achieved indicated on Product Information Sheets or Specifications.

Elcometer is just one of many recognised suppliers from where to obtain these measuring devices.

Appendix 3

Galvanizing Association – Hot Dipped Galvanizing Data Sheet

Hot Dip Galvanizing Data Sheet GA

3.10 BS EN ISO 14713 – A guide to the corrosion perfomance of hot dip galvanized steel

BS EN ISO 14713 ("Protection against Corrosion of Iron & Steel in Structures – Zinc and Aluminium Coatings – Guidelines") provides information on materials that can be galvanized, design for galvanizing and coating performance that assists the specification of protective coatings for iron and steel. This Data Sheet summarises the information on corrosion performance presented in the new European standard.

General considerations

The resistance of galvanized coatings to atmospheric corrosion depends on protective surface films that form on the zinc coating surface. These usually consist of zinc oxide or zinc carbonate; where zinc interacts with oxygen and carbon dioxide present in the atmosphere.

The presence of airborne contaminants has an effect on the nature of these protective films and so influences the corrosion rate of zinc.

	Corrosivity Category	Average Annual Zinc Corrosion Rate (µm/year)
C 1	Interior: dry	<0,1
C 2	Interior: occasional condensation Exterior: rural	0,1 to 0,7
C 3	Interior: high humidity, some air pollution Exterior: urban inland or mild coastal	0,7 to 2
C 4	Interior: swimming pools, chemical plants, etc Exterior: industrial inland or urban coastal	2 to 4
C 5	Exterior: industrial with high humidity or high salinity coastal	4 to 8

Table 1. Zinc corrosion rates in different environments (Source: BS EN ISO 14713)

The most important contaminant for zinc is sulphur dioxide (SO_2) and it is the presence of SO_2 that largely controls the atmospheric corrosion of zinc. Amongst other considerations are relative humidity and, in marine environments, salt concentration. Relative humidity governs the absorption of SO_2 by the zinc surface and consequently the reaction between zinc and SO_2. Salt and nitrogen oxides have a less marked effect. Other important points to remember are that:

- Rates are generally linear for a given environment. This allows predictions of ultimate life to be made on the basis of interim assessments of coating thickness.
- Rates increase with duration and frequency of wetness.
- Rates due to contact with chemicals require special consideration. A wide range of chemicals are compatible with zinc coatings. Strong acids and strong alkalis are not compatible.
- Rates in immersed conditions require special consideration. Corrosion rates in sea water in temperate regions can be 10 µm/year to 15 µm/year. Tropical sea water, which is usually at higher temperatures, may cause higher corrosion rates.

Atmospheric corrosion - predicting coating life

Different environments are largely classified according to prevailing levels of SO_2. See Table 1 and Fig. 2.

Identifying the correct corrosivity category to allocate to a proposed structure can be difficult and often subjective. Experience with structures (case histories) can be helpful in this regard, as can the information from various test sites operated by the National Materials Exposure Programme (NMEP). The NMEP results confirm the relationship between SO_2 levels and zinc corrosion rate. The corrosion rates for zinc measured during the period 1988-90 are shown in Table 2:

For structural steelwork, where coating thickness inevitably exceeds the minimum requirements of the standard, the estimated lives will be higher than those indicated in Table 2.

NMEP Site	Average Annual SO_2 level (µg/m³)	Average Zinc Loss (µm/year)	Estimated life of 85µm coating (years)
Birmingham	37.6	2.29	37
Cardiff	21.7	2.08	41
Ashby de la Zouch	17.8	1.73	49
London	15.2	1.65	52
Caerphilly	7.3	1.43	59
Wells	6.2	1.25	68
Lough Navar	1.7	1.04	82

Table 2. SO_2 levels and zinc corrosion rates at 7 U.K. sites, 1988-90.

It is important to note that the corrosion rates for areas often described as "industrial" or "urban" are significantly lower than those quoted in other literature. In particular, BS 5493 (1977) 'Code of Practice for Protection of Iron and Steel Against Corrosion', provides corrosion data for zinc which does not reflect the recent and ongoing reductions in airborne SO_2 levels.

These reductions in SO_2 levels have been illustrated by comparing the atmospheric corrosivity maps produced by Ministry of Agriculture, Fisheries and Food (MAFF) in 1982, 1986 and 1992. The maps identify zinc corrosion rates for each 10km square of the UK. Comparison of the three maps clearly shows that the propor-

3.10 BS EN ISO 14713 – A guide to the corrosion perfomance of hot dip galvanized steel

tion of the country exhibiting historically higher zinc corrosion rates had steadily decreased between 1982 and 1992. The maps are published in Galvanizers Association's *Engineers and Architects' Guide to Hot Dip Galvanizing*. A new map is currently under preparation by the Association and will provide corrosion rates for zinc for the UK and Ireland for the period 1998 – 2000. The 2000 results can be expected to further demonstrate the increasing life of galvanized steel in many areas of the UK and Ireland.

Several studies in mainland Europe have correlated these reductions in the zinc corrosion rate with decreases in atmospheric SO_2 levels. An example from Stockholm is shown in Figure 1. Similar effects can be expected for urban areas in the UK, given that SO_2 levels have decreased in major cities.

In particular, urban locations which, in the past, may have been considered aggressive for zinc will yield significantly enhanced lives for galvanized coatings. In more remote locations these downward trends in SO_2 levels are not so pronounced and the (already low) corrosion rates for zinc would not be anticipated to be further reduced to any significant extent.

It is clear that these reductions in atmospheric corrosion rate significantly contribute to the improved life of hot dip galvanized coatings over recent years. Care must therefore be taken to utilise recent information concerning zinc corrosion rates in any estimations of coating life for exterior exposed structures. BS EN ISO 14713 gives an excellent guide to atmospheric corrosion performance and is based on more recent data.

Corrosion in soil

BS EN ISO 14713 outlines the considerations when evaluating the performance of galvanized coatings in soils. Galvanized coatings have given excellent performance in, for example, underground pipework and reinforced earth structures. Usually it is best to seek specific guidance from Galvanizers Association on performance in soils, but the standard outlines the essential factors as follows:

- Coating life is dependent on the nature of the soil mineral content, organic components, water content and oxygen content.
- Coating life will be longest in lime-containing and sandy soils (provided they are free of chlorides).
- Coating life will be a little shorter in clay soils.
- Coating life in bog or peat soils will depend on their acidity.

Corrosion cells that may be set up at the soil/air or soil/groundwater interface may reduce coating life. These factors also require specialist consideration.

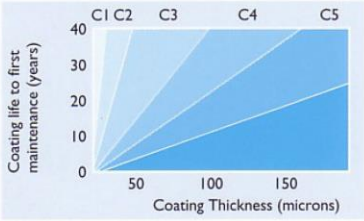

Fig. 2. Estimated lives to first maintenance of galvanized coatings in different categories of environment. (Source: BS EN ISO 14713, for description of corrosivity categories: See Table 1).

Corrosion in water

Performance of galvanized coatings in water is also outlined in BS EN ISO 14713. Again, this is a complex area of corrosion science and specialist guidance may be required in addition to that laid out in the standard. Nevertheless, the main aspects are:

- Type of water has a major influence on selection of metal coatings for protection of iron/steel in water.
- Corrosion of galvanized coatings is mainly determined by the hardness/composition of the water.
- Other factors affecting corrosion rates are temperature, flow rate, agitation and oxygen availability.

Coating lives are generally longest in cold scale-forming waters and shortest in non scale-forming waters. Galvanized coatings are not suitable for use in hot, non scale-forming waters. Contact with condensate between 55 °C and 85 °C should be avoided.

Corrosion performance in sea waters is best established by reference to experiences with similar structures (case histories). Such information is available from Galvanizers Association.

Exceptional exposures

Contamination from industrial processes and other site-specific conditions can affect coating life. A wide range of chemicals are compatible with galvanized coatings but exposure to acids should be avoided. Detailed guidance on contact with specific chemicals is not contained in BS EN ISO 14713 but is available from Galvanizers Association.

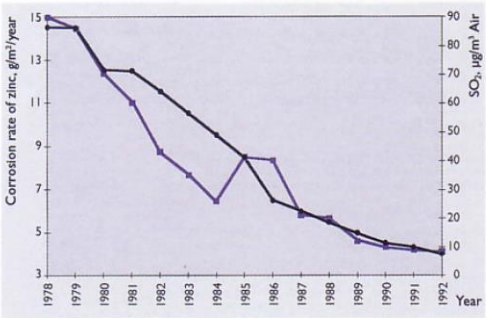

Fig. 1. Reduction in SO_2 levels in Stockholm since 1978 and accompanying decease in corrosion rate of zinc.

These Data Sheets are intended for guidance only. The standard documents themselves should be consulted when preparing specifications.

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Appendix 4 - Bibliography

- ILP Technical Report 26 – Painting of Lighting Columns.
- BS EN ISO 12944 : Paints and varnishes. Corrosion protection of steel structures by protective paint systems
- BS EN ISO 1461 : Hot dip galvanized coatings on fabricated iron and steel articles.
- Manual of Contract Documents for Highway Works Series NG 1900 Protection of Steelwork Against Corrosion (Amendment – August 2014)
  http://dft.gov.uk/ha/standards/mchw/vol1/index.htm
- Manual of Contract Documents for Highway Works Volume 2 Notes for Guidance on the Specification for Highway Works Series NG1800 Structural Steelwork
  http://dft.gov.uk/ha/standards/mchw/vol2/index.htm
- Hot Dipped Galvanised Steel Lighting Column Root Protection “Protecting the vulnerable root” document.

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