A survey of the costs of corrosion protection by various coating systems

Rob White – March 2002

1. Introduction and project scope

During the carbon steel cluster analysis, one factor affecting international competitiveness of the South African steel fabrication industry was the percentage cost of corrosion protection. South Africa was shown to be uncompetitive in terms of final paint application costs. The study showed that the majority of excessive costs could be attributed to factors such as:

- the use of inappropriate specifications (over-specifying),
- communication difficulties between the parties involved (the fabricator, applicator, and paint supplier),
- the quality of labour leading to high wastage of paint and a large degree of rework.

This project was initiated to obtain a set of unbiased benchmark costs for steel specifiers, users, and fabricators. With this in mind:

- The costing model employed had to be acceptable by all participants to ensure its ongoing use.
- The model should be upgradeable & therefore some approximations will be used.
- Standard atmospheres as defined in the ISO 9223 standard were used.
- The model had to provide guidance to users, fabricators, etc.
- The expected service life should be defined together with the aesthetics required, handling and transport requirements.
- The model must allow for comparative costing of South Africa versus overseas target steel fabrication markets.
- The model should be an accepted system so that it can be enlarged to encompass other paint combinations in future, e.g. priming (to meet SAISC wish list).

The output of this project is the expected final application costs for a range of generic products to deliver a given service life with a defined appearance. No specific industrial environments were considered. The application costs were done using various paint applicators recommended by the paint suppliers. No detail of individual respondents' input is divulged publicly.

The study is not intended to replace the corrosion consultant in specifying particular paint systems. The objectives are rather to provide a baseline guide for specifiers, users and fabricators in an effort to standardize on certain forms of corrosion protection and improve efficiencies within the steel fabrication industry.

2. Methodology

Table 1 indicates typical corrosivity of the environments in terms of ISO 9223. *Corrosion of metals and alloys – Corrosivity of atmospheres – Classification* [(1)]. This standard classifies atmospheric environments in terms of time of wetness, pollution by SO_2 and airborne salinity. In addition, long-term corrosion rates are given for carbon steel, zinc, copper and aluminium. Local work has largely corroborated the classifications for the South African environment [(2)]. Indeed this work has been used to overlay the results of the CSIR 20 year exposure studies [(3)]. An atmospheric corrosion map of South Africa is therefore available. Whilst this requires the use of generalizations it is nevertheless a good starting point for any rational choice of a corrosion protection system.

Table 1. Atmospheric corrosive environments classified in terms of ISO 9223.

Class	Description	Corrosion rate (av. loss for carbon steel µm/y)	Corrosion rate (av. loss for Zn µm/y)
C1	Interior: dry	≤ 1.3	≤ 0.1
C2	Interior: occasional condensation Exterior: exposed rural inland	1.3 – 25	0.1 – 0.7
C3	Interior: high humidity, some air pollution Exterior: urban inland or mild coastal	25 - 50	0.7 – 2.1
C4	Interior: swimming pools, chemical plant, etc. Exterior: industrial inland or urban coastal	50 - 80	2.1 – 4.2
C5	Exterior: industrial with high humidity or high salinity coastal	80 - 200	4.2 – 8.4

This survey encompasses the major coatings suppliers who, in turn, recommended 3 coatings applicators. This group was used as the contact base for the study. Galvanizing costs were obtained from three batch hot dip galvanizers in Gauteng. The main coatings suppliers provided the various coating recommendations. The recommendations provided included the preparation and inspection requirements together with the costs per litre of product and the theoretical spreading rates (TSR). A typical pro-forma is attached in Appendix B.
These recommendations were for 3 predetermined environments, chosen to typify low, medium and high corrosivity areas. These were:

1. As defined in EN ISO 12944-2:1998
   C1 – very low corrosion environment
   Heated buildings with clean atmospheres, e.g. offices, shops, schools, hotels
2. As defined in EN ISO 12944-2:1998
   C3 – medium corrosion environment

Exterior: urban and industrial atmospheres, moderate sulphur dioxide pollution. Coastal areas with low salinity.
Interior: production rooms with high humidity and some air pollution, e.g. food processing plants, laundries, breweries, dairies.

3. As defined in EN ISO 12944-2:1998
C5M very high (marine) corrosion environment
Exterior: coastal and offshore areas with high salinity.
Interior: buildings or areas with almost permanent condensation and with high pollution.

The substrates chosen were carbon steel for C1 and carbon steel and hot dip galvanized steel for environments C3 and C5M. In order to define the requirements clearly, the coating systems recommended had to provide service for 10, 15 and 12 years respectively for environments C1, C3 and C5M.

The coating supplier recommendations were then passed on to recommended applicators. The following requests were included –

1. All quotes to be based upon Johannesburg location with no accommodation.
2. For the sake of this exercise, light steelwork is given as 55m^2 per tonne, medium as 30m^2 per tonne and heavy as 14m^2 per tonne. These values correspond to 4.6mm, 8.5mm and 18mm steel respectively.
3. Use the manufacturers information using their inspection requirements and theoretical spreading rates.
4. All normal costs should be included (overheads, supervision, consumables, thinners, and any other P&G costs) but excluded were:
   - Transport & dunnage,
   - Cranage, loading & offloading,
   - After erection repairs & painting of bolts,
   - Scaffolding,
   - Quantity Surveying costs, guarantees, rentals and contingencies.
5. In order to make the costs as realistic as possible, the assumption was that the job would be in excess of R500 000 in value.

The typical pro-forma supplied to each applicator is included in Appendix C.

3. Results

In essence, the recommended coatings fall into 12 types. These are shown in **Table 2**. In order to provide a basis for future comparison, **Table 2** also includes approximate equivalents in terms of SABS ISO 12944-5:1998 Paints and varnishes – Corrosion protection of steel structures by protective paint systems. Part 5: Protective paint systems [4]. Substrate preparation in all cases complied with the equivalent systems in SABS ISO 12944-5.
The applied costs for each system in shown in **Table 3**. The standard deviation provides information on the range of applied prices provided by each applicator in combination

with differences arising from the necessity to group generic coatings, even where differences in supplier DFT values occurred. In essence 3x the standard deviation would provide the full range of prices supplied around the mean value shown.

Table 2. Coating systems recommended per environment (with approximate comparison to SABS ISO 12944-5.

Substrate	System number	Recommended method of protection	Total DFT (um)	Environment C1, 10 years	Environment C3, 15 years	Environment C5M, 12 years	Equivalent system SABS ISO 12944-5
steel	1	alkyd + alkyd (alk+alk)	70 - 100	x			S1.05
steel	2	zinc phosphate + alkyd (ZnPO4+alk)	100 -125	x			
steel	3	epoxy + epoxy (ep+ep)	225 - 275	x			S1.34
steel	4	epoxy + polyurethane (ep+PU)	150 - 225		x		S1.27
steel	5	epoxy + epoxy + polyurethane (ep+ep+PU)	190 - 265		x		S1.34
steel	6	epoxy zinc + HB epoxy (ep+HB ep)	180 - 220		x	x	S3.21
steel	7	inorganic zinc silicate + epoxy MIO + polyurethane (IOZ+MIO+PU)	200 - 275			x	S7.12
steel	8	epoxy + epoxy + polyurethane (ep+ep+PU)	450 - 530			x	
steel	9	epoxy zinc + epoxy+ polyurethane (epz+ep+PU)	195 - 235			x	S7.07
galvanized steel	10	epoxy + HB epoxy (ep+HB ep)	260 - 320		x	x	S9.11
galvanized steel	11	epoxy + epoxy (ep+ep)	325 - 425		x	x	S9.12
galvanized steel	12	epoxy + polyurethane (ep+PU)	225 - 275		x	x	S9.12

Table 3. Cost comparison for the recommended coating systems

System	Light Steel ($55m^2/t$) Applied cost, R/t	std dev	Medium Steel ($30m^2/t$) Applied cost, R/t	std dev	Heavy Steel ($14m^2/t$) Applied cost, R/t	std dev
Alkyd + Alkyd	R 2,681	R 800	R 1,471	R 467	R 712	R 264
Alkyd $ZnPO_4$+ Alkyd	R 3,417	R 564	R 1,874	R 346	R 901	R 221
Epoxy + Epoxy	R 3,004	R 936	R 1,651	R 558	R 804	R 331
Epoxy + Polyurethane	R 3,418	R 555	R 1,654	R 357	R 901	R 210
Epoxy + Epoxy + Polyurethane	R 4,229	R 906	R 2,330	R 532	R 1,117	R 285
Hot Dip Galvanizing	R 2,367	R 153	R 1,933	R 58	R 1,767	R 104
Epoxy + HB epoxy	R 4,860	R 886	R 2,661	R 517	R 1,280	R 286
IOZ + MIO + Polyurethane	R 4,497	R 825	R 2,452	R 461	R 1,164	R 258
Epoxy + Epoxy + Polyurethane	R 6,171	R 944	R 3,365	R 549	R 1,590	R 299
Epz + Epoxy + Polyurethane	R 4,974	R 934	R 2,711	R 541	R 1,285	R 294
HDG* + Epoxy + HB epoxy	R 6,282	R 359	R 4,067	R 200	R 2,782	R 132
HDG* + Epoxy + Epoxy	R 5,579	R 505	R 3,683	R 277	R 2,584	R 147
HDG* + Epoxy + Polyurethane	R 4,852	R 403	R 3,250	R 173	R 2,400	R 116

* HDG approx 100um

A summery of the costing information is shown in **Figures 1 to 4** for the respective atmospheres.

Product costs have risen over the years. However, in addition, organic product types are constantly changing. It is, therefore, difficult to compare product prices over time accurately. It is hoped that continual updating of the information presented here will overcome this problem by indicating best practice at a particular time.

Figure 1. Range of coating prices suitable for C1 & C3 atmospheres

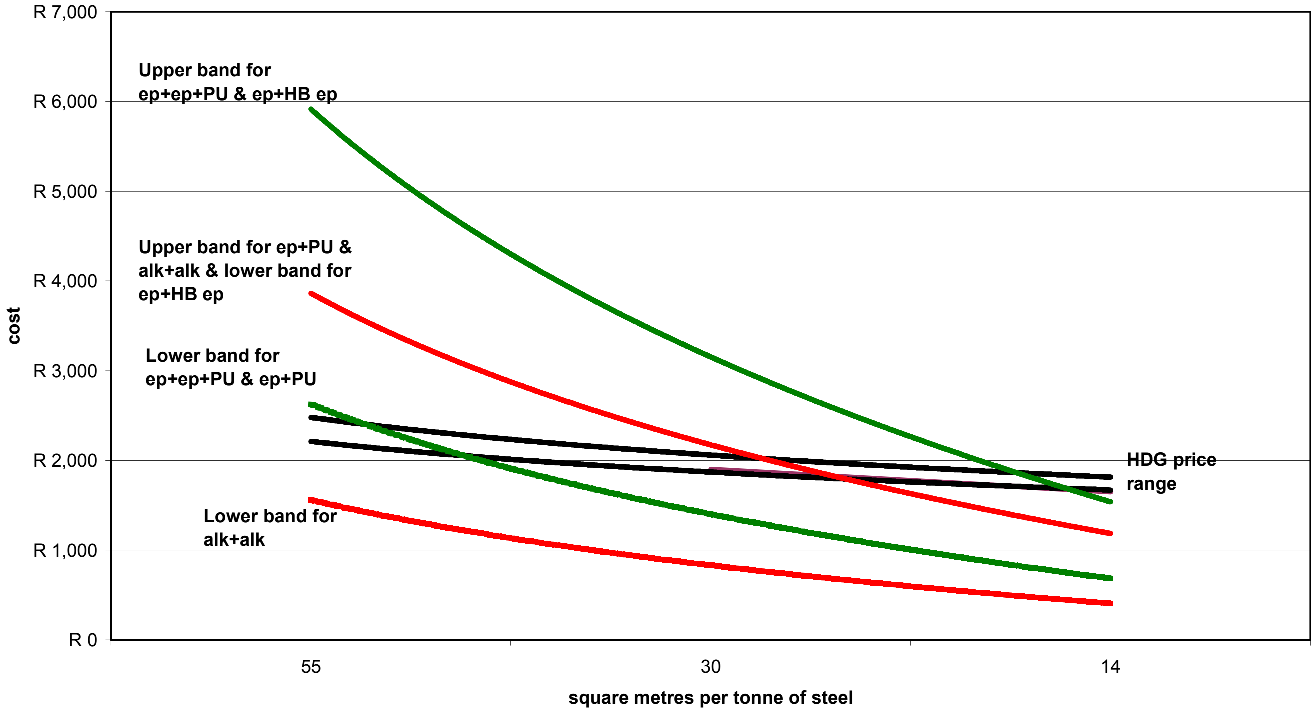


Figure 2. Range of coating prices suitable for C5M atmospheres

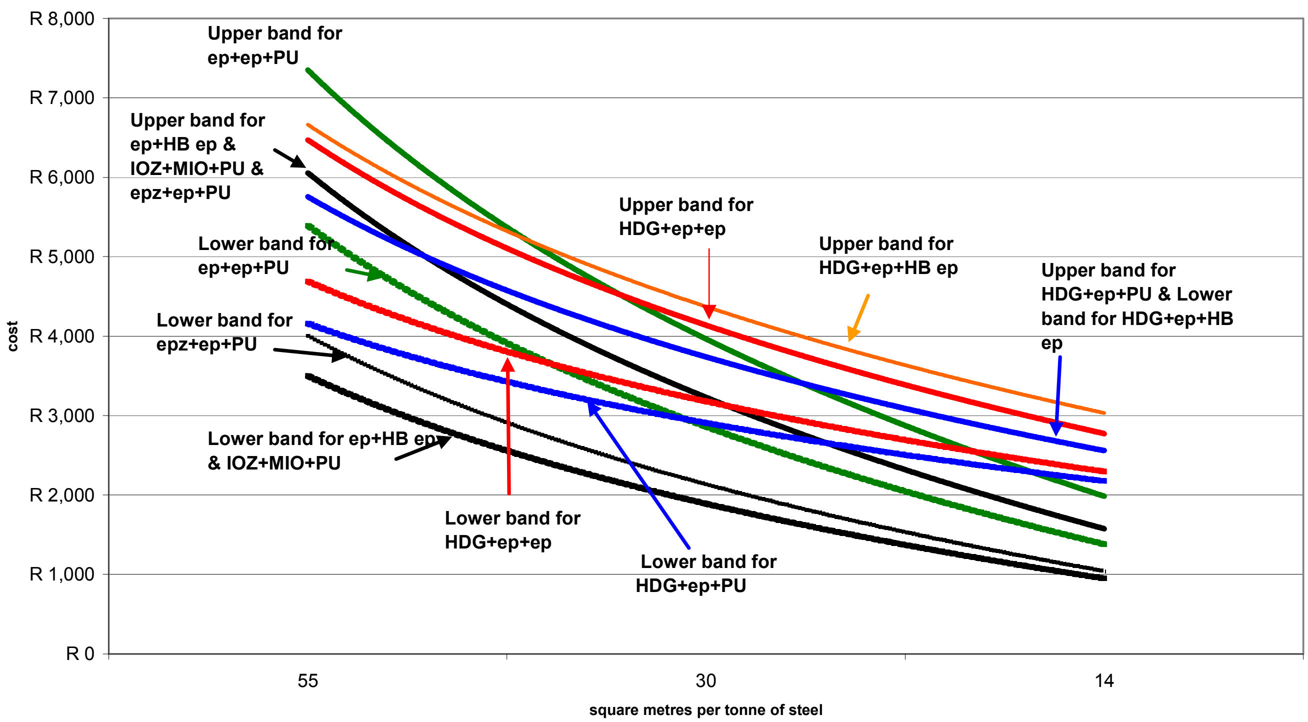


Figure 3. Average of coating prices for C1 & C3 environments

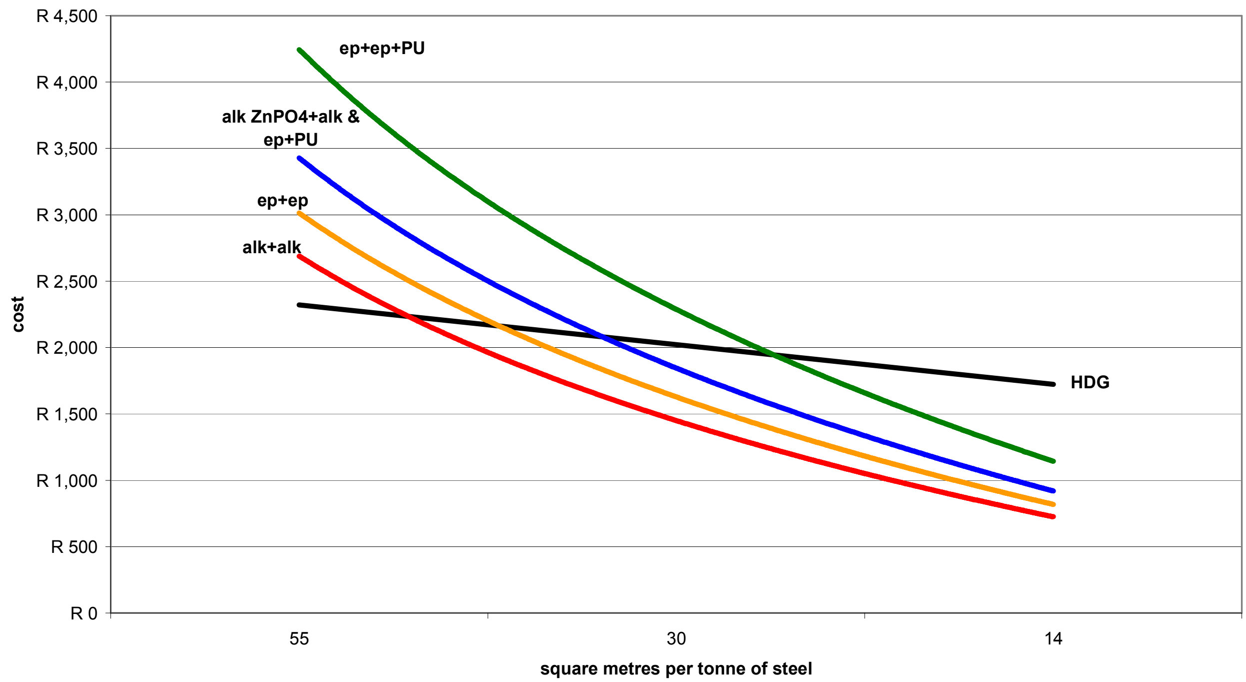
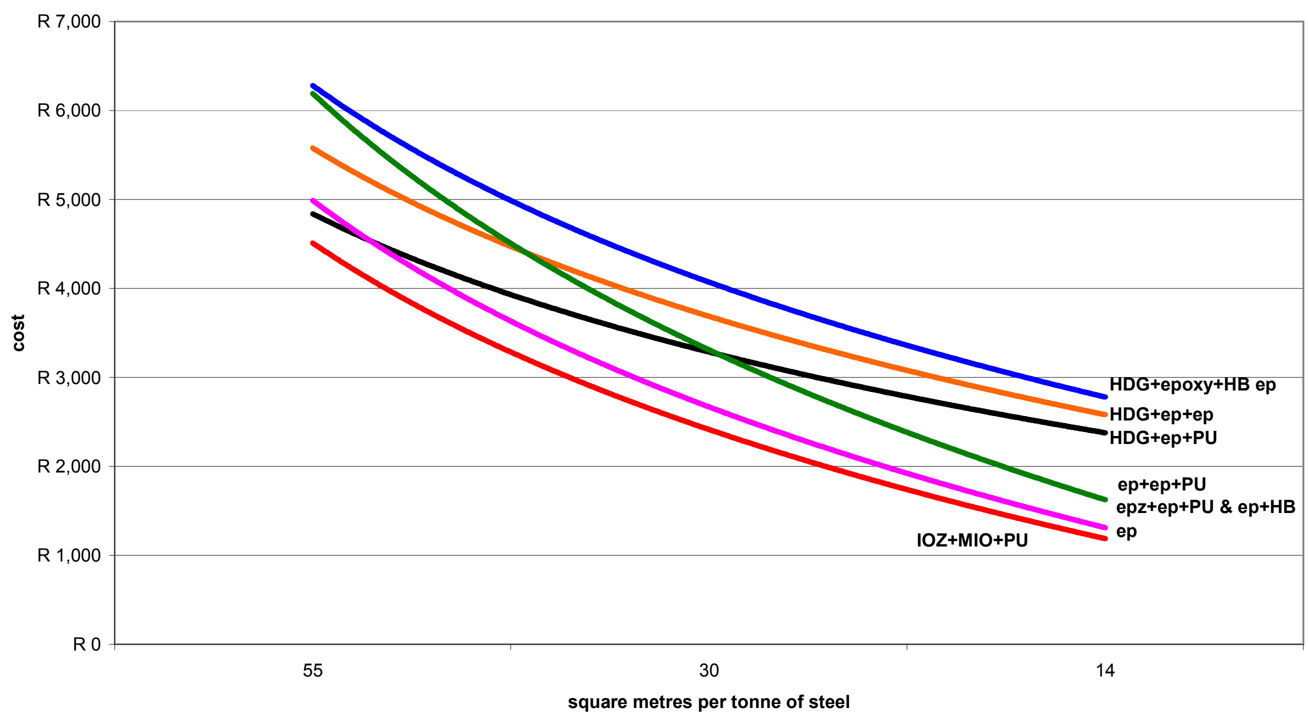


Figure 4. Average coating prices for C5M environments



4. Discussion

The wide range of prices is clearly the result of different interpretations of the original brief to the applicators. However, it is recommended that the range be used as a guideline by fabricators rather than the average values. Albeit a wide variation, this should enable sensible costings to be obtained. The steel cluster analysis indicated that the costs of corrosion protection were high in South Africa. To complete this analysis requires comparison of the figures presented here to various steel profile costs and a final analysis of typical steel costs as a percentage of the total project costs. This exercise is beyond the scope of this study.

It is clear that for indoor atmospheres (C1), a simple two-coat alkyd system could be applied for anything from R400-00 to R1600-00 depending upon steel thickness. A two-coat epoxy system despite having a total DFT of 250µm could be applied for less than a two-coat zinc phosphate plus alkyd system having a DFT of 115µm. Hot dip galvanizing applied via general jobbers is only competitive for steel lighter than 46m^2 per tonne (5.5mm material).

Epoxy polyurethane systems are the most cost-effective organic coating system for the C3 environment (**Figure 1**). Reference to SABS ISO 12944-5 indicates that these systems are suitable for C3 environments. Average applied prices were of the order of R4229-00, R2330-00 and R1117-00 for 55, 30 and 14 m^2 per tonne steel respectively. This compares to equivalent averages of R2367-00, R1933-00 and R1767-00 for hot dip galvanized steel prices. Taking average values only, hot dip galvanizing would prove cost competitive for steel protection in C3 atmospheres for steels over 26m^2 per tonne (<10mm material) when compared to a three-coat system or 32m^2 per tonne (<8mm material) when compared to a two-coat system (**Figure 3**). Epoxy plus high build epoxy, whilst assumed to be acceptable in terms of performance, was the most expensive option available.

In the C5M atmosphere experience has shown that uncoated galvanized steel will not perform adequately unless top-coated (Duplex system). The traditionally used HDG + epoxy + polyurethane topcoat compared favourably with the standard three-coat epoxy + epoxy + polyurethane beyond 28m^2 per tonne (< 9 mm material). However, for all practical purposes, the relative costs were determined to be –

Inorganic zinc + MIO epoxy + polyurethane
< Epoxy zinc + epoxy + polyurethane = Epoxy + HB epoxy
< Epoxy + epoxy + polyurethane = HDG + epoxy + polyurethane

Reference to SABS ISO 12944-5 would lead to the recommendation that all five systems could be specified for the C5M environment. The average costs are shown in **Table 3** and **Figure 4**. The range of cost values is clearly displayed in **Figure 2**.

Worldwide, increasing use is being made of guarantees. Whilst this is a contentious subject, it is worth bearing in mind that the credibility of the corrosion protection industry is often questioned. The practice of providing guarantees could well bridge this credibility gap.

5. Conclusions and Recommendations

A range of prices has been produced as guidelines for the steel fabrication industry. The results of the study clearly show that –

1. A two-coat alkyd + alkyd system is the most cost effective coating for the protection of steel in indoor applications (C1). Batch Hot Dip Galvanizing is only cost competitive in extremely light sections.
2. A two-coat epoxy + polyurethane system is the most economical coating system for the C3 atmosphere.
3. Batch hot dip galvanizing is the most competitive coating, for the C3 atmosphere, for steel parts lighter than about 32 m^2 per tonne (<8mm).
4. For C5M atmospheres, the most cost effective corrosion protection systems were determined to be:
   a) For light and medium weight steel – epoxy zinc + HB epoxy, inorganic zinc + MIO epoxy + polyurethane and HDG + epoxy + polyurethane.
   b) For heavy steel the all organic systems show the greatest cost advantages.
5. For the C5M atmosphere, HDG based systems become competitive above about 28m^2 per tonne steel (<9 mm).

Since 1979 the National Association of Corrosion Engineers (NACE) in the USA has published a biennial report entitled *The Paint and Coatings Cost and Selection Guide.* This has provided useful data for coatings engineers, specifiers and users alike. This guide has taken account of the product trends over the years and has been modified to take account of field experience from various sources. Taken in conjunction with the SABS ISO 12944 standard, the specifier and user alike should be in a position to choose a reliable coating system for any application. The study carried out here is merely a local South African costings guide. This should be updated on a regular basis to provide input into corrosion protection economics for steel fabrication work. For this reason, it is beyond the scope of the study to comment upon the correlation between the NACE studies and the recommendations made here. However, the replacement of SABS 1200 HC [(5)], by SABS ISO 12944, will enable specifiers and users to work off a common international platform. This in itself should permit greater comparison with international norms in terms of coating recommendations and the costs incurred in their application.

This study was restricted to the Gauteng area. Perhaps, in future, it should be extended to the other main regions of Kwazulu Natal and the Western Cape.

Finally, the information presented here should be used to obtain some basic data on the total costs of corrosion protection for typical projects. This would provide benchmark data on the percentage contribution of corrosion protection for the South African steel fabrication industry.

6. Acknowledgements

The author is indebted to the Hot Dip Galvanizing Association of Southern Africa for sponsoring this study, the coatings suppliers and the applicators who contributed to this survey. It is hoped that the steel fabrication industry is able to continue updating and improving upon the information provided on a regular basis.

7. References

1. ISO 9223:1992 Corrosion of metals and alloys – Corrosivity of atmospheres – Classifications.
2. Leitch, J.E. A corrosivity profile of South Africa using ISO 9223 methodology, 14th International Corrosion Congress, Cape Town, South Africa September 1999.
3. Callaghan, B.G. Results of a twenty-year national exposure programme. CSIR 1992, p43
4. SABS ISO 12944-5:1998 *Paints and varnishes – Corrosion protection of steel structures by protective paint systems. Part 5: Protective paint systems.*
5. SABS 1200:1988 – Standardised Specification for Civil Engineering Construction – HC: Corrosion Protection of Structural Steelwork

APPENDIX A – survey participants

COMPANY	**CONTACT**
Ameron	Bruce Trembling
International Protective Coatings	Meryl Nixon
Jotun	David Spencer
Sigma	Herman Putter
Stoncor	Peter Quorn
Gordon Bennett	Mike Bennett
IMPS	Chad Jadrijevich
Reef Industrial	Mike Book
Rustbusters	Michael Deib
RJ Southey	Mike Anderson
Armco Galvanizers	Dave Fensham
BarlowWorld Galvanizers	Hans Bakker
Consolidated Galvanizers	Johan Coetzee

APPENDIX B – Coatings supplier pro-forma (for C1)

SUPPLIER			
SYSTEM 1			
INSPECTION REQUIREMENT			
SUBSTRATE – steel			
ENVIRONMENT – As defined in EN ISO 12944-2:1998 C1 – very low Heated buildings with clean atmospheres, e.g. offices, shops, schools, hotels			
REQUIRED SERVICE LIFE: 10 years			
SURFACE PREPARATION: Abrasive blast clean to ISO 8501-01 1988 Grade Sa 1, profile 30 to 50µm or Hand/mechanical wirebrush to ISO 8501-01 1988 Grade St 3.			
COATING SYSTEM:			
	Primer	Intermediate (if applicable)	Finish
GENERIC TYPE			
TRADE NAME AND CODE			
VOLUME SOLIDS			
DRY FILM THICKNESS (µm)			
THEORETICAL SPREADING RATE			
APPLICATION METHOD			
OVERCOATING TIME			
COST/m^2 (based upon TSR)			

APPENDIX C – proforma sent to each applicator (for C1)

Applicator worksheet - paint costings 2002 **COMPANY** ____________________ **PERSON** ____________________

Environment	EN ISO 12944-2:1998, C1				
Description of environment	Interior - heated buildings with clean atmospheres, eg offices, shops, schools, hotels				
Required service life	10 years				
Substrate	steel				
Inspection requirements	Level 1 Inspector Hold Points: Surface preparation – grade and cleanliness; Paint coats - DFT. Check point - Overcoating times				
Supplier	**Ameron**	**Akzo Nobel**	**Jotun**	**Sigma Coatings**	**Stoncor**
Surface preparation (ISO 8501-01: 1988)					
Primer					
Generic product type					
Product trade name					
Volume solids, %					
DFT, um					
TSR - m2/l					
application method					
minimum overcoating time					
cost/m2 (based upon TSR)					
Intermediate					
Generic product type					
Product trade name					
Volume solids					
DFT, um					
TSR - m2/l					
application method					
minimum overcoating time					
cost/m2 (based upon TSR)					
Topcoat					
Generic product type					
Product trade name					
Volume solids					
DFT, um					
TSR - m2/l					
application method					
minimum overcoating time					
cost/m2 (based upon TSR)					
App cost - light ($55m^2/t$)	per tonne	per tonne	per tonne	per tonne	per tonne
App cost - medium ($30m^2/t$)	per tonne	per tonne	per tonne	per tonne	per tonne
App cost - heavy ($14m^2/t$)	per tonne	per tonne	per tonne	per tonne	per tonne