Reduzindo os custos da manutenção e aumentando os ganhos da produtividade no segmento de O&G pela galvanização

Reducing the costs of maintaining and increasing the productivity gains in the segment of oil and gas by galvanizing

Frank E Goodwin
IZA

The O&G Challenges

- Provide durable corrosion protection with manageable maintenance costs
- Minimize production-related costs (downtime)
- Minimize safety and environmental issues

Petrobras Paulínia (SP) Replan refinery
The largest in Brazil, 365,000 bpd

Risk of corrosion damage

- Need to predict performance of the corrosion protection system
- Need to predict performance and behavior of the structure being protected
- In theory, most corrosion protection systems can be maintained during service
- In practice, corrosion protection maintenance is often highly problematical

Petrobras XXIII
dynamic positioned deep water-drilling platform

Unpainted Galvanized Coating Service Life (5% Rust)

Layered Structure of Galvanized Coatings

Key Factors

- Metallurgical (diffusion) bond at Steel-Coating interface
- Hardness of alloy layers significantly greater than base steel
- Cathodic protection at defects in coating
- Thickness at edges greater than at surface

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Corrosion rates for Zn based upon atmospheric conditions as defined by ISO 9223

Class	Description	Corrosion rate (1st year for Zn g/m² year)	Corrosion rate (steady state for Zn µm/y)	Life of coating, thickness 55µm	Life of coating, thickness 100µm
C1	Interior: dry	**≤ 0.7**	**≤ 0.05**	**100 yrs+**	**100 yrs+**
C2	Interior: occasional condensation Exterior: exposed rural inland	**0.7 – 5**	**0.05 – 0.5**	**80 – 100 yrs**	**100+**
C3	Interior: high humidity, some air pollution Exterior: urban inland or mild coastal	**5 – 15**	**0.5 - 2**	**25 – 80 yrs**	**50 – 100 yrs**
C4	Interior: swimming pools, chemical plant, etc. Exterior: industrial inland or urban coastal	**15 – 30**	**2 - 4**	**12 – 25 yrs**	**25 – 50 yrs**
C5	Exterior: industrial with high humidity or high salinity coastal	**30 - 60**	**4 - 10**	**7 – 12 yrs**	**12 – 25 yrs**

Typical Life Cycle Costs

Probability of Steel Failure

What is a DUPLEX Coating?

- HDG as a firm base - HDG is an ideal primer for paint providing
  - Barrier Protection
  - Sacrificial Protection
- Top Paint Coating
  - Barrier Protection
  - Aesthetics & Color

"W" Tower, Vancouver Canada

How does a Duplex System Work?

- Zn products of Corrosion (WHITE) far less massive than RED Rust (Fe)
- Blistering (corrosion creep) of paint therefore far less than when it is direct onto steel
- Zinc products of corrosion tend to seal the pores in the top paint coating

Results in the "Synergistic effect", which is:

Duplex Service Life = Factor x (Zn Life + Paint Life)

e.g. Service Life = 1.5 x (9 years + 5 years)

= 21 years to 5% rust

Synergistic factors

Industrial/Marine	1.8 to 2.0
Sea water (immersion)	1.5 to 1.6
Non-aggressive climate	2.0 to 2.7

The main job of Zn in painted duplex coatings is to protect the paint after the paint has failed

Acrylic painted galvanized steel - panel scribed through to steel substrate and salt spray tested

Acrylic painted steel - panel scribed through to steel substrate and salt spray tested

Atmospheric corrosive environments classified in terms of ISO 9223

Class	Description	Corrosion rate (av. loss for Zn µm/y)	Typical life yrs to 1ST Maintenance (Z275 ±20µm)	Typical life in yrs to 1ST Maintenance (85µm Zn in HDG)	Typical life in yrs of a DUPLEX System
C1	Interior: dry	≤ 0.05	200	>200+	Not Required
C2	Interior: occasional condensation Exterior: exposed rural inland	0.05 to 0.5	40 to 200	>170	Not Required
C3	Interior: swimming pools, chemical plant, etc. Exterior: industrial inland or urban coastal	0.5 to 2	5 to 10	21 to 42	Not Required
C4	Interior: swimming pools, chemical plant, etc. Exterior: industrial inland or urban coastal	2 to 4	5 to 10	21 to 42	42 to 84
C5	Exterior: industrial with high humidity or high salinity coastal	4 to 10	3 to 5	10 to 21	18 to 37

Congresso Brasileiro de Galvanização
GALVABRASIL 2011

REALIZAÇÃO
ICZ Instituto de Metais Não Ferrosos

Design Guide

The Design of Products to be Hot-Dip Galvanized after Fabrication

AGA Zn

* Select an ISO 12944 compliant system

Table A9: Paint systems corrosivity categories C2 to C5-I and C5-M
Substrate: Hot-dip-galvanized steel[1])

The paint systems given in the following table are only examples,. Other paint systems having the same performance are possible.

If these examples are used, it shall be ensured that the paint systems chosen comply with the indicated durability when execut

Paint System No	Priming coat(s)			Top coat(s)) including intermediate coat(s))			Paint system		Expected durability 2)6) (see 5.5 and ISO 12944-1)														
	Binder 5)	Number of coats	NDFT 3) µm	Binder 5)	Number of coats	NDFT 3) µm		Total NDFT 3) µm	C2			C3			C4			C5-I			C5-M		
									L	M	H	L	M	H	L	M	H	L	M	H	H	L	H
S9.01	PVC	-	-	PVC	1	80	1	80															
S9.02		1	40		1	80	2	120															
S9.03		1	80		1	80	2	160															
S9.04		1	80		2	160	3	240															
S9.05	AY	-	-	AY	1	80	1	80															
S9.06		1	40		1	80	2	120															
S9.07		1	80		1	80	2	160															
S9.08		1	80		2	160	3	240															
S9.09	EP or PUR	-	-	EP or PUR 4)	1	80	1	80															
S9.10		1	40		1	80	2	120															
S9.11		1	80		1	80	2	160															
S9.12		1	80		2	160	3	240															
S9.13		1	80		2-3	240	3-4	320															

Binders for priming coat(s)		Paints (liquid) No of components 1-pack	2-pack	Water borne possible
PVC	= Polyvinyl chloride	x		
AY	= Acrylic	x		x
EP	= Epoxy		x	x
PUR	= Polyurethane		x	

Binders for top coat(s)		Paints (liquid) No. of components 1-pack	2-pack	Water borne possible
PVC	= Polyvinyl chloride	x		
AY	= Acrylic	x		x
EP	= Epoxy		x	x
PUR	= Polyurethane	x	x	

1) The mechanical or chemical surface preparation rerquired is described in ISO 12944-4.
2) The durability is in this case related to the paint system adhesion to the hot-dip-galvanized surface.
3) NDFT = Nominal Dry Film Thickness. See 5.4 for further details.
4) If colour and gloss retention is required, it is recommended that the last coat should be based on aliphatic PUR.
5) For explanation of abbreviations, see foot of table
6) Light grey shading indicates that the paint systems concerned would not normally be used for these corrosivity categories. They are not listed in table A.2 and/or A.3.

O&G Applications in Petrochemical Plants-1

Ambient temperature Ducts	Dutos de temperatura ambiente
Anchor Bolts	Parafusos de âncora
Beams	Vigas
Belt Guards	Cinto Guarda
Cathodic protection rectifiers	Proteção catódica retificadores
Catwalks	Desfiles
Checker Plate	Padronizada Placa
Co-generation Equipment	Equipamentos de cogeração
Columns	Colunas
Conveyor Systems	Sistemas de transporte
Cooling tower Structure	Estrutura da torre de resfriamento
Crane Supports	Suporta guindaste
Cross bracing	Cruz órtese
Decks	Plataformas
Drain Pipes	Tubos de drenagem
Drive Piling	Driven empilhando
Electrical Conduits	Condutas elétrica
Electrical Cable Ducts	Dutos cabo elétrico
Embedded Items	Itens incorporados

O&G Applications in Petrochemical Plants-2

Equipment Screens	Telas de equipamentos
Equipment Guards	Equipamentos Guarda
Fasteners	Fixadores
Fencing	Esgrima
Fire extinguishing Equipment	Equipamento de incêndio
Flare Towers	Torres incendiar
Flat Plates	Placas planas
Girts	Girts
Gratings	Grades
Handrail	Corrimão
Heat exchanger Tubing	Tubulação trocador de calor
Ladders	Escadas
Marine Terminal Structures	Estruturas Terminal Marítimo
Offshore Structures	Estruturas Offshore
Outside Switchgear	Fora Comutadores
Frames	Frames
Pipe Ways	Maneiras pipe
Pipe Supports	Suporta tubulação
Pipe Racks	Racks tubo
Pipe Bridges	Tubo de Pontes

O&G Applications in Petrochemical Plants-3

Platforms	Plataformas
Precipitator Structures	Estruturas precipitador
Prefabricated Buildings	Edifícios pré-fabricados
Process Piping	Tubulação de Processo
Process Equipment	Equipamentos de processo
Skids	Skids
Process Vessels	Vasos processo
Purlins	Terças
Railings	Trilhos
Safety Equipment	Equipamento de segurança
Sag Rods	Sag Rods
Scuppers	Embornais
Stairways	Escadas
Stringers	Longarinas
Transmission Poles	Pólos de transmissão
Walkways	Passarelas
Wastewater Treatment Equipment	Equipamento do tratamento de águas residuais

Cape Town petrochemical plant cable ladders and trays survey

Coating thickness still exceeds 55µm initial thickness requirement after 25 years!
Corrosion severity=C4

Hydrocarbon Storage Facility, Port Boynton, South Australia

- Allowed fast-tracking of construction because of damage resistance of HDG

- 800 tons of HDG used in pipe racks alone

All-HDG Compressor House

Shell Oil Corio Bay Refinery
Geelong, Vic. Australia

Built 1954: All Structural Steelwork is now HDG

HDG pipe bridge

Galvanized sheet covering insulated pipes

- Shell used 2500 tons of structural steel in this Corio Long Residue Catalytic Cracking Unit after having had experience of 15 years with NO maintenance at the No. 4 Distiller

- Measurements showed another 30 years maintenance free life is possible (70 µm Zn remaining)

Formosa Plastics Naptha Cracking Plant

Severity >>ISO C5!

This industry development zone used
300 000 tons of galvanized steel including Deep-water Port, Refinery, Co-gen plant…….

Petroleum resources Australia IsomerisationUnit, Adelaide, SA

10,000 bpd of high octane fuel
Required 130 tons of HDG

Ampol Refineries Ltd. New Reformer Unit, Brisbane

65m high structure all HDG

Galvanized steel chosen due to:

- Schedules
- Quality
- Project controls
- Contract Coordination
- Risk reduction
- Benefits during operation