Hot Dip Galvanised (HDG) vs Thermal Diffusion Galvanising (TDG) for EN 14399-10 HRC Assemblies

Alexander Sharp *B.Eng (Mechanical) UTS*

Galvanising is the process of applying a zinc coating to a metal substrate to protect it from corrosion. HDG is the most common fastener coating in Australia and is the preferred coating for structural assemblies to be used with AS 4100 Steel Structures due to its serviceability and predictable performance. Hobson Engineering has chosen to continue to supply TCBOLTS (EN14399-10 HRC) with HDG coating due to its acceptance in the Australian market. HDG offers durability, an even coating plus resistance to wear, impact and corrosion.

Selection of the appropriate coating for an application can be complicated, this technical comment will highlight some of the key points of consideration between HDG and TDG coatings.

Hot Dip Galvanising (HDG)

Hot Dip Galvanising submerges the metal to be coated in a bath of liquid zinc. Zinc diffuses into the top layer of steel to form the ZnFe alloy whilst also retaining a layer of free zinc on the top surface. This free zinc layer will react with the atmosphere to form a zinc carbonate also know as a zinc patina. This zinc patina provides an insoluble barrier that further protects the underlying coating and will not degrade in the high UV levels of the Australian sun. This is one of the main reasons why HDG is so widely used in Australia.

Thermal Diffusion Galvanising (TDG)

Thermal diffusion techniques use zinc powder that is heated in rotating drums until it vaporizes and diffuses with the metal components. TDG techniques are an updated version of sherardizing and replace the sand that is used to mix and heat the zinc evenly with other compounds such as aluminum. Proprietary names for TDG coatings are given based on the additives present e.g. GreenKote.

	HDG	TDG
Composition	Zn + ZnFe Alloy	ZnFe Alloy + Additives (e.g. Al)
Coating Thickness	50µm	25µm
Adhesion	Metallurgic Bond	Metallurgic Bond

Table 1. HDG v TDG basic comparison

For fasteners, typical coating thickness exist for different systems, for example HDG products typically have a minimum coating thickness of 50µm and TDG/Sherardized of 25µm. When comparing coatings, coating thickness should not be used to compare corrosion resistance of two different systems. Sufficient corrosion resistance for the application should be the main consideration and is best assessed against similar real-world application.

AS 2312.2 - Guide to the protection of structural steel provides a useful table for comparing the expected life to first maintenance for different system coatings and thicknesses. This standard uses a conservative method for predicting life to first maintenance based on the corrosion rate of pure zinc in the atmospheric conditions of each corrosivity class (see table 1, 2).

TABLE 6.2

LIFE TO FIRST MAINTENANCE FOR A SELECTION OF HOT DIP GALVANIZED COATING SYSTEMS IN A RANGE OF CORROSIVITY CATEGORIES

System	Reference Standard		Minimum thickness (Note 1)		Selected corrosivity category (ISO 9223) calculated min.–max. life (years) and durability class (VS, S, M, L, VL, EL)							
			g/m^2	µm	C3		C4		C5		CX	
Hot dip galvanizing	AS/NZS 4680 (Note 2)	HDG390	390	55	26–78	EL	13–26	VL	6–13	M	2–6	S
		HDG500	500	70	33–100	EL	16–33	VL	8–16	L	2–8	M
		HDG600	600	85	40 > 100	EL	20–40	EL	10–20	VL	3–10	M
		HDG900	900	125	60 > 100	EL	30–60	EL	15–30	VL	5–15	H
Hot dip galvanized sheet	AS 1397 (Note 3,4)	Z350	140	20	10–29	VL	5–10	M	2–5	S	1–2	VS
		Z450	180	25	12–36	VL	6–12	M	3–6	S	1–3	VS
Electro galvanized tube	AS 4750	ZE100	100	14	6–20	L	3–6	S	1–3	VS	0–1	VS
		ZE300	300	42	20–60	EL	10–20	VL	5–10	M	1–5	S
Hot dip galvanized tube	AS/NZS 4792 (Note 5)	ILG100/ ZB100/100	100	14	6–20	L	3–6	S	1–3	VS	0–1	VS
		ILG140/ ZB140/140	140	20	10–29	VL	5–10	M	2–5	S	1–2	VS
		ILG300/ ZB300/300	300	42	20–60	EL	10–20	VL	5–10	M	1–5	S
Mechanical plating	AS 5056 (Note 6)		55	8	4–11	M	2–4	S	1–2	VS	0–1	VS
			175	25	12–36	VL	6–12	M	3–6	S	1–3	VS
Electroplated coatings	AS 1897	Fe/Zn 8c	55	8	4–11	M	2–4	S	1–2	VS	0–1	VS
		Fe/Zn 25c	175	25	12–36	VL	6–12	M	3–6	S	1–3	VS

Table 2. Life to first maintenance of various coating systems (AS 2312.2 Table 6.2)

Internal Hydrogen Embrittlement (IHE)

High strength fasteners with a hardness greater than 390HV that are exposed to atomic hydrogen during the manufacturing process are susceptible to internal hydrogen embrittlement (IHE). Traditionally HDG products were considered susceptible to IHE due to an acid pickling process that is used to clean the metal prior to galvanising. Recent research has shown that PC10.9 are not as susceptible as to IHE previously believed. To avoid any increased risk of IHE modern cleaning processes of high strength fasteners have removed the acid picking process and have replaced this with a mechanical cleaning process.

The other source of IHE in HDG products comes from up-quenching. When fasteners are immersed in the molten zinc during hot dip galvanising, thermal shock (up-quenching) causes trapped residual hydrogen to be released. The thick zinc coating prevents this released hydrogen from escaping where it instead accumulates at grain boundaries. Again, HDG fasteners with a hardness range of 240 to 390 HV are not susceptible to hydrogen embrittlement, this is demonstrated by the fact ISO 898-1 PC 10.9 bolts and ASTM A354BD bolts are routinely and safely hot dip galvanised. For further reading on this see the following technical report publish by the international standards organization ISO TR 20491, Fasteners — Fundamentals of hydrogen embrittlement in steel fasteners.

Coating Selection

Selecting the most appropriate coating for the application can be challenging especially when there are many proprietary coatings in the market. Hobson Engineering consider the HDG coating is the most appropriate for structural bolting which is backed by the current Australian standards. HDG is a cost effective, low risk coating that is tried and tested in all parts of Australian market.

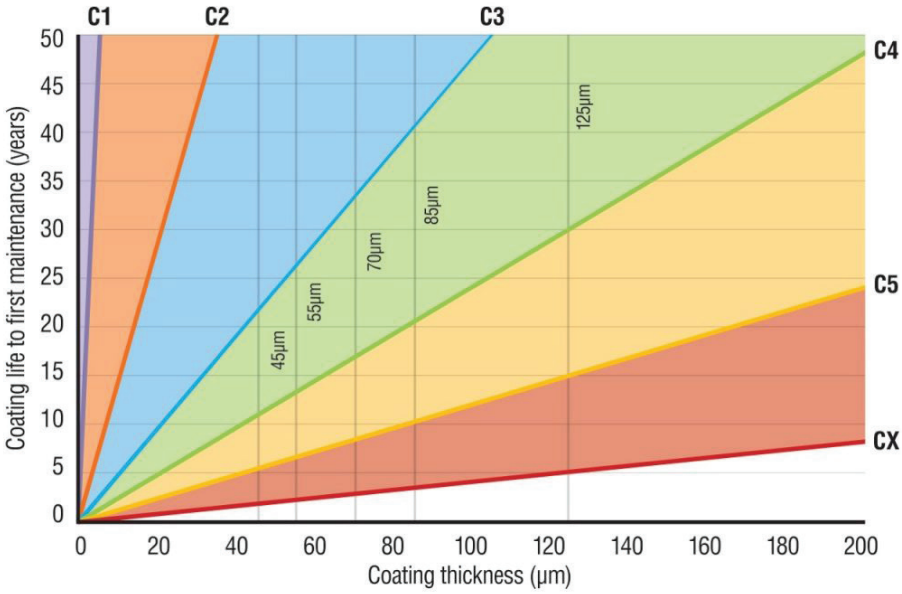

Figure 1. HDG Coating life to first maintenance in different atmospheric environments (GAA, 2021)

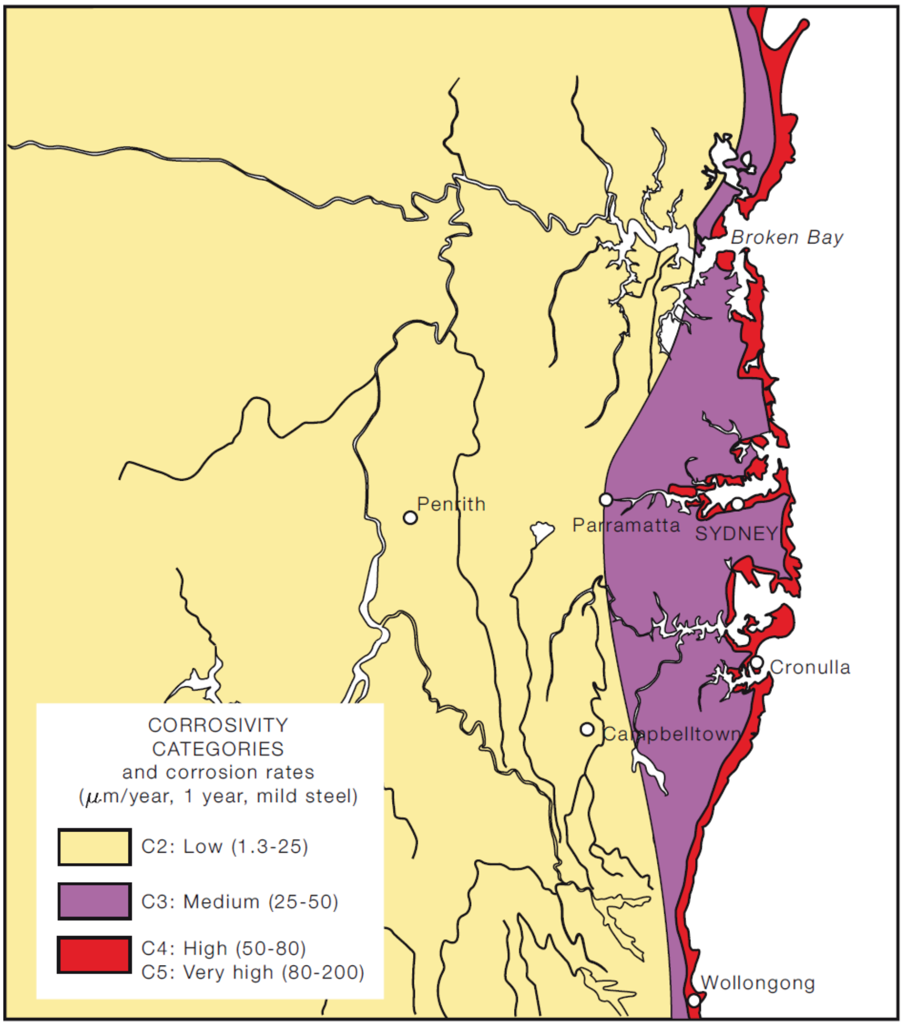

Figure 2. Corrosivity Categories for Sydney [Estimated] (AS 4312, 2018)

Description of typical atmospheric environments related to the estimation of corrosivity categories

Table C.1 — Description of typical atmospheric environments related to the estimation of corrosivity categories

Corrosivity category[a]	Corrosivity	Typical environments — Examples[b]	
		Indoor	Outdoor
C1	Very low	Heated spaces with low relative humidity and insignificant pollution, e.g. offices, schools, museums	Dry or cold zone, atmospheric environment with very low pollution and time of wetness, e.g. certain deserts, Central Arctic/Antarctica
C2	Low	Unheated spaces with varying temperature and relative humidity. Low frequency of condensation and low pollution, e.g. storage, sport halls	Temperate zone, atmospheric environment with low pollution (SO_2 < 5 µg/m^3), e.g. rural areas, small towns Dry or cold zone, atmospheric environment with short time of wetness, e.g. deserts, subarctic areas
C3	Medium	Spaces with moderate frequency of condensation and moderate pollution from production process, e.g. food-processing plants, laundries, breweries, dairies	Temperate zone, atmospheric environment with medium pollution (SO_2: 5 µg/m^3 to 30 µg/m^3) or some effect of chlorides, e.g. urban areas, coastal areas with low deposition of chlorides Subtropical and tropical zone, atmosphere with low pollution
C4	High	Spaces with high frequency of condensation and high pollution from production process, e.g. industrial processing plants, swimming pools	Temperate zone, atmospheric environment with high pollution (SO_2: 30 µg/m^3 to 90 µg/m^3) or substantial effect of chlorides, e.g. polluted urban areas, industrial areas, coastal areas without spray of salt water or, exposure to strong effect of de-icing salts Subtropical and tropical zone, atmosphere with medium pollution
C5	Very high	Spaces with very high frequency of condensation and/or with high pollution from production process, e.g. mines, caverns for industrial purposes, unventilated sheds in subtropical and tropical zones	Temperate and subtropical zone, atmospheric environment with very high pollution (SO_2: 90 µg/m^3 to 250 µg/m^3) and/or significant effect of chlorides, e.g. industrial areas, coastal areas, sheltered positions on coastline

Table 3. AS/NZS 2312.2 Corrosivity class definitions

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