Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings

AS2312

Adam Hockey – NSW Branch President ACA

Who is the ACA?

Our Mission – To lead in the knowledge and management of corrosion for the benefit of society and the environment.

Pillars

In order to achieve our Mission, the Australasian Corrosion Association will work in the following areas:

- Education & Training
- Events
- Accreditation and Certification
- Policy & Advocacy
- Volunteer & Member Services
- Governance & Management

THE AUSTRALASIAN CORROSION ASSOCIATION INC.

The Cost of Corrosion

Corrosion is estimated to cost 3.5% - 5.2% of Global Gross Domestic Product.

This equates to approximately AUD$100 billion across Australia and New Zealand.

By implementing current "best practice", savings of around 15% - 35% of this cost could be achieved.

The Solution

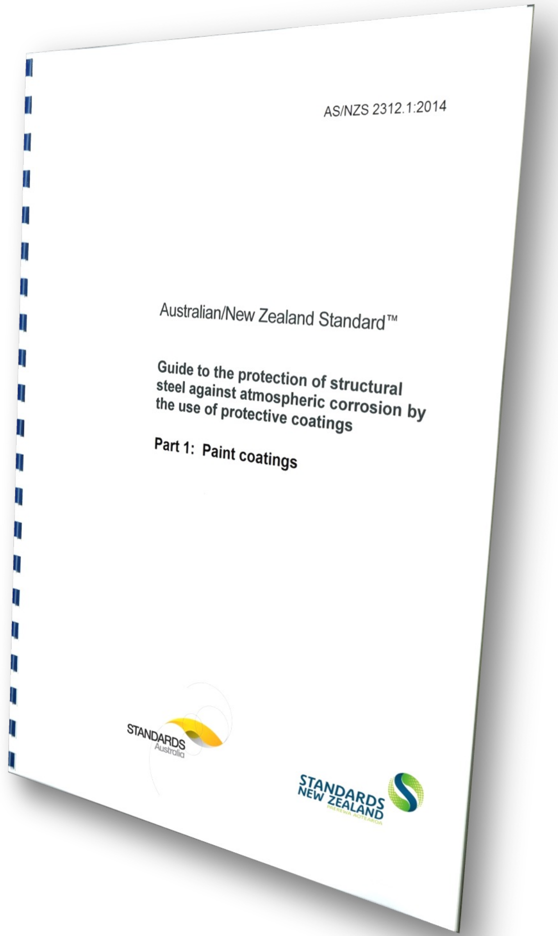
To provide protection…

That withstands and lasts **longer** to reduce environmental impact.

AS2312

AS/NZS 2312 'Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings'

- **Part 1**: Paint Coatings
- **Part 2:** Hot dip galvanising


AS/NZS 2312.1:2014

Australian/New Zealand Standard™

Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings

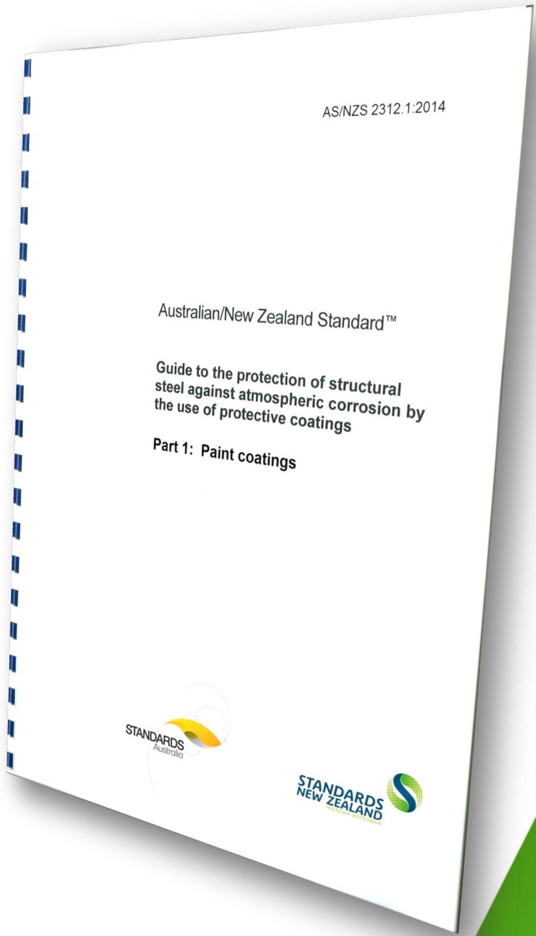
Part 1: Paint coatings

STANDARDS Australia

STANDARDS NEW ZEALAND

AS2312.1

- Australian standards set out specifications and design procedures.
- These ensure products and services perform safely, reliably, and the way they're intended to.
- National Construction Code (NCC),performance requirements reference AS2312



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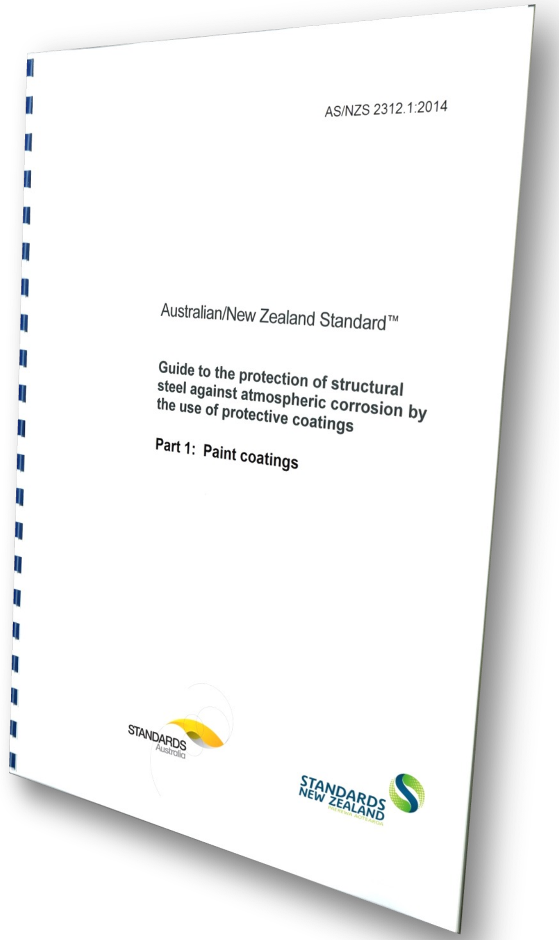
AS2312.1

1 Scope and General
2 Classification of environments
3 Planning and Design and Fabrication for Corrosion Protection
4 Surface Preparation
5 Factors Influencing Paint Coating Selection
6 Paint Coating Systems for Corrosion Protection
7 Painting and Paint Application Methods
8 Maintenance of paint coatings systems
9 Inspection and Testing
10 Preparation of Coating Specifications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Australian/New Zealand Standard™

Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings

Part 1: Paint coatings

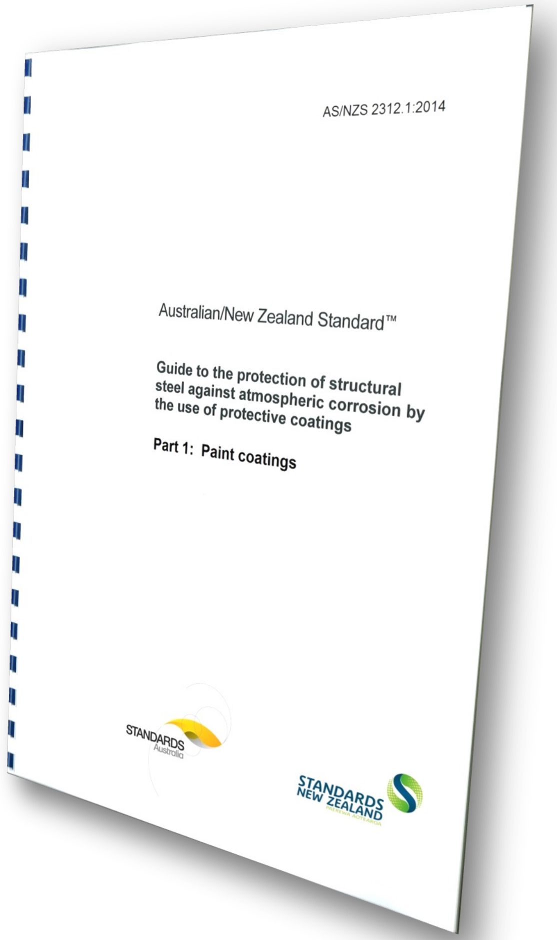
STANDARDS Australia

STANDARDS NEW ZEALAND

THE AUSTRALASIAN CORROSION ASSOCIATION INC.

Appendices AS2312.1

1. Guidance on the use of this standard
2. Factors influencing corrosivity
3. Paint coatings for non-atmospheric and hot environments
4. Description of paint types
5. Economics of corrosion protection
6. Volatile Organic Compounds (VOC's)
7. Typical criteria for selected coatings specifications
8. Powder coatings and tape wrappings



Section 1 - Scope and General

1.6 DURABILITY CONSIDERATIONS

As the protection provided by the coating systems covered by this Standard is usually shorter than the expected service life of the structure, due consideration should be given to maintenance or renewal requirements at the planning and design stage.

Any components of the structure which are not accessible after assembly should be provided with a corrosion protection system that will remain effective for the service life of the structure. If this cannot be achieved by means of a protective coating system, other measures, such as manufacturing from a corrosion-resistant material, designing for replacement or specification of a corrosion allowance, should be taken.

Section 2 - Classification of Environments

2.1 General

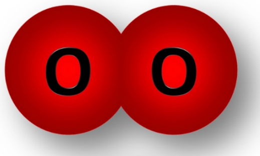
2.2 Micro-Environments

2.3 Atmospheric Corrosivity Categories

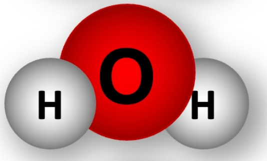
2.4 Other Environments

Section 2.1 – General

- Steel corrodes (rusts) if exposed to



Oxygen



Water

Ions e.g. Chlorides

- STOP any of these from reaching the steel, and corrosion won’t occur

Section 2 - Classification of Environments

Note : The major factors which affect atmospheric corrosion , and hence atmospheric corrosivity categories based on ISO 9223, are given in AS4312

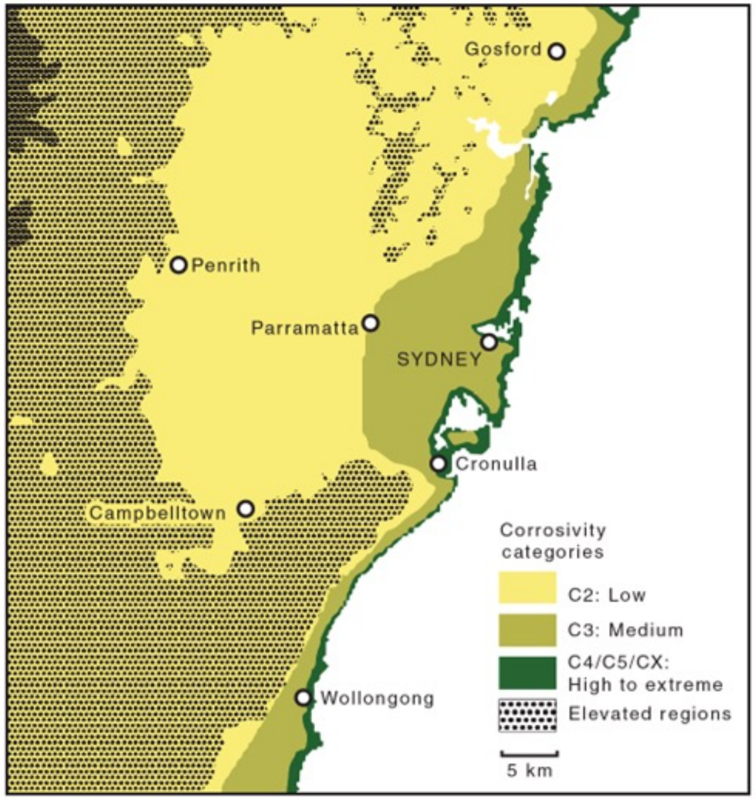


Figure A.4 — ISO corrosivity categories for Sydney (estimated)

Section 2.2 Micro-Environments

At locations where the metal surface remains damp for an extended period , such as where surfaces are not freely drained or a shaded from sunlight

On unwashed surfaces,

i.e. surfaces exposed to atmospheric contaminants, notably coastal salts,

but protected from cleansing rain

2.3 Atmospheric Corrosivity Categories

TABLE 2.1

ATMOSPHERIC CORROSIVITY CATEGORIES

Corrosivity categories	Former AS/NZS 2312 Category	Corrosion rate for steel µm/year	Corrosion rate for zinc µm/year	Typical exterior environment	Examples of interior environments
C1: Very low	A	<1.3	<0.1	Few alpine areas	Offices, shops
C2: Low	B	1.3 to 25	0.1 to 0.7	Arid/rural/urban	Warehouses, sports halls
C3: Medium	C	25 to 50	0.7 to 2.1	Coastal	Food processing plants, breweries, dairies
C4: High	D	50 to 80	2.1 to 4.2	Sea-shore (calm)	Swimming pools, livestock, buildings
C5-I: Very high (Industrial)	E-I	80 to 200	4.2 to 8.4	Within chemical plants	Plating shops, chemical sites
C5-M: very high (Marine)	E-M	80 to 200	4.2 to 8.4	Sea-shore (surf)/ offshore	—
CX	—	200 to 700	8.4 to 25	Shoreline (severe surf)	Adjacent to acidic processes
T: Inland Tropical	F	—		Non-coastal tropics	

2.3 Atmospheric Corrosivity Categories

TABLE 6.3 *(continued)*

	Coating system details													Durability—Years to first maintenance						
				1st Coat			2nd Coat			3rd Coat				Atmospheric corrosivity category						
	System designation	ISO 12944-5 designation (Note 1)	Surface preparation	Type	PRN	Nom DFT µm	Type	PRN	Nom DFT µm	Type	PRN	Nom DFT µm	Total nom DFT µm	C1 Very low	C2 Low	C3 Med	C4 High	C5-I Very high industrial	C5-M Very high marine	T Inland Tropical
	POLYURETHANE—Two pack, solvent-borne																			
	PUR1		St 3	Epoxy mastic	C32	125	Poly-urethane gloss	C26	50 (see Note 2)	—	—	—	175	*	10-15	5-10	2-5	—	—	5-15
	PUR2	A1.15	Sa 2½	Epoxy primer	C06	75	Poly-urethane gloss	C26	50 (see Note 2)	—	—	—	125	25+	10-25	5-10	2-5	—	—	5-15
A1	PUR2a	A1.17	Sa 2½	Zinc rich primer	C01a C02	75	High Build Poly-urethane	C15	75 (see Note 2)	—	—	—	150	25+	15-25	10-15	5-10	2-5	2-5	10-15
	PUR3	A4.08	Sa 2½	Epoxy primer	C06	75	High build epoxy	C13	125	Poly-urethane gloss	C26	50 (see Note 2)	250	*	25+	15-25	10-15	5-10	5-10	15-25
	PUR4	A1.20	Sa 2½	Zinc rich primer	C01a C02	75	High build epoxy	C13	125	Poly-urethane gloss	C26	50 (see Note 2)	250	*	25+	15-25	10-15	5-10	5-10	15-25
	PUR5	A1.23	Sa 2½	Zinc rich primer	C01a C02	75	High build epoxy	C13	200	Poly-urethane gloss	C26	50 (see Note 2)	325	*	25+	25+	25+	15-25	15-25	25+
A1	PUR6		St 3	Epoxy mastic	C32	75	Epoxy mastic	C32	75	High build poly-urethane	C15	75	225	*	15-25	10-15	5-10	2-5	2-5	5-15
	PUR7	A1.19 A1.20	Sa 2½	Epoxy zinc primer	C02	75	Epoxy mastic	C32	75	High build poly-urethane	C15	75	225	*	25+	15-25	10-15	5-10	5-10	10-15

* While this system would have very high durability in this atmospheric category, it is unlikely that it would be economic.

LEGEND:
PRN = Paint reference number (see Appendix D)
DFT = Dry film thickness
Sa, St — See ISO 8501-1

NOTES:

1 ISO 12944-5:2007 equivalent designation (to within ±25 µm total DFT). The durability given in ISO 12944-5 of ISO equivalent may be different.

2 Some colour finishes may require multiple coats to achieve opacity.

3 Accelerated testing of these systems suggests a much longer life expectancy than that nominated. However, because the organic polysiloxane systems are a recent development, no practical field experience greater than 20 years' service is available to confirm the accelerated testing results.

4 Some water-borne zinc silicate coating systems may give improved durability over solvent-borne zinc silicate coating systems when applied at the same film thickness.

2.4 Other Environments

Steelwork may be immersed in water or buried in soil

Other prevention methods may be required, such as cathodic prevention

The selection of such prevention methods requires specialist advice

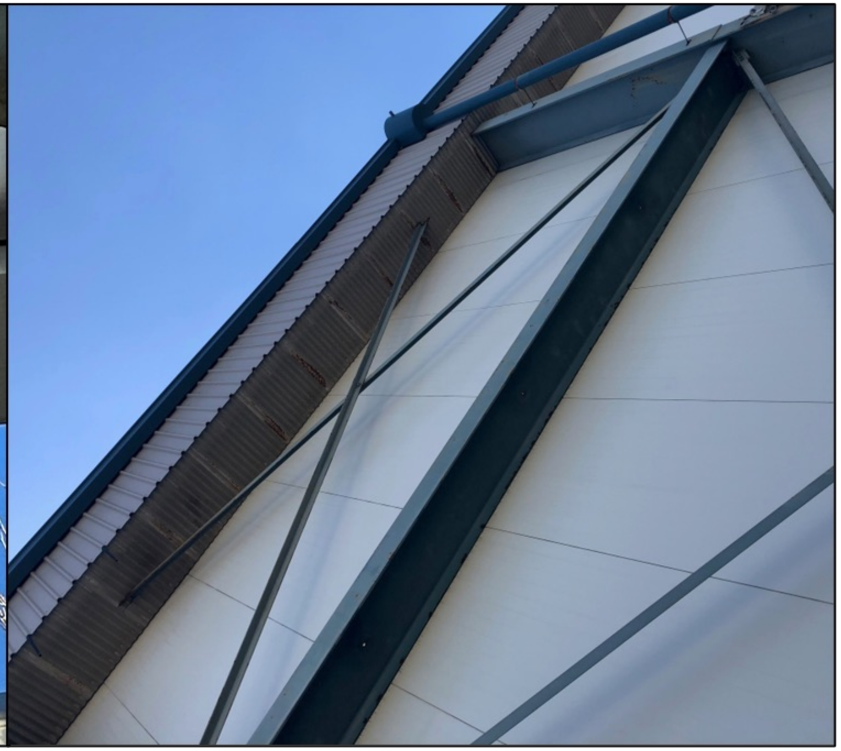
3.3 Design

- Narrow crevices
- Depressions
- Ledges
- Undrained flat surfaces
- Flat surfaces in loose contact where moisture can be drawn in between them by capillary action
- Poor air circulation
- Sharpe edges and corners
- Intermittent welding

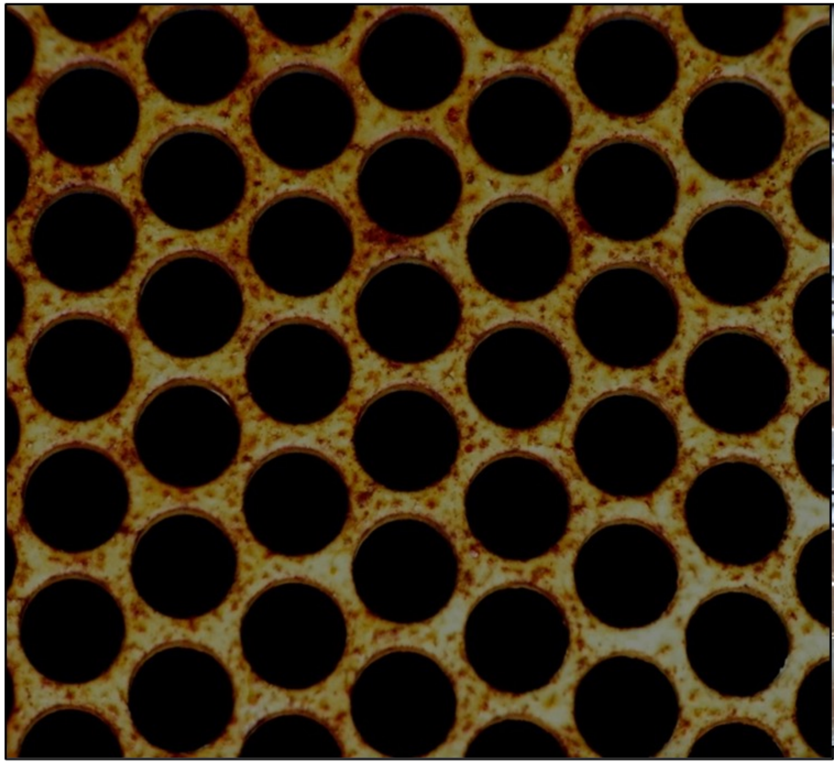
3.3 Design

3.3 Design

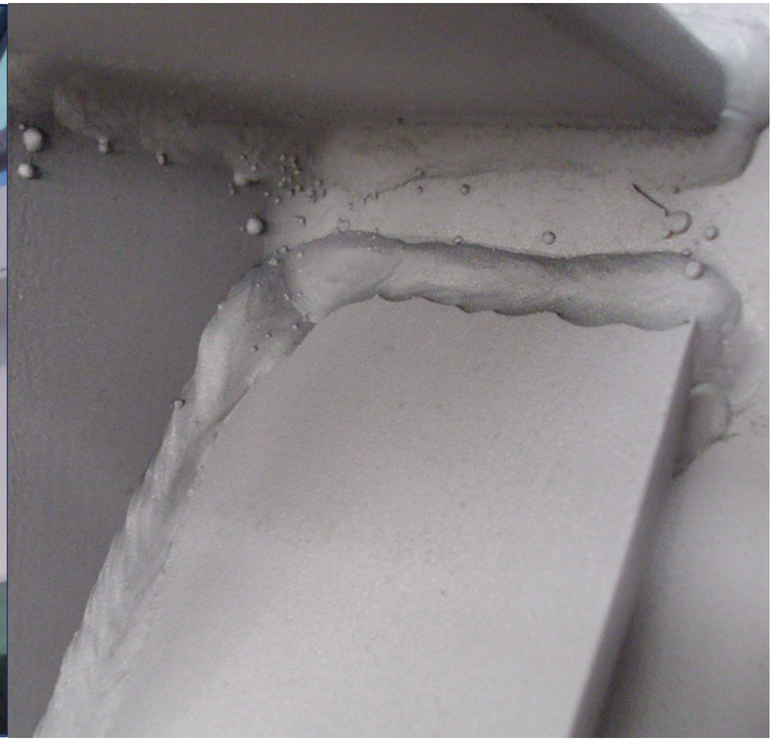
3.3 Design



3.3 Design



3.3 Design



3.3 Design

3.3 Design

3.3 Design

3.3.3.7 Concrete

- Concrete that is partially embedded in concrete may be susceptible to corrosion within the concrete near the entry point and should be partially protected
- The coating on the steel should be non-conductive and extend a minimum of 50mm into the concrete and 100mm above.
- Where reinforcement is to be used in concrete, reference in Australia should be made to AS3600

WHAT CONTRIBUTES TO CONCRETE SPALLING?
Issues that can contribute to concrete spalling are:
- Faulty concrete specification or design
- Incorrect placement of rebar and/or mesh, resulting in inadequate concrete covering
- Poor site supervision during pouring, when the rebar is pushed too close to the surface of the concrete
- Lack of a protective "anti-carbonation" surface coating to prevent ingress of acidic chemicals

Low concrete cover and no protective coatings gave the rebars no protection from atmospheric acid attack

Section 4.2 Surface Preparation Methods

4.2.1 - Cleaning with Solvents or Alkaline Solutions
To remove oil and grease

4.2.2 - Abrasive blast cleaning
Most effective process for removing mill scale and rust
and for creating an anchor pattern

4.2.3 - Power tool cleaning
Power tool cleaning is usually employed where the nature of work does not demand the removal of all mill scale and other corrosion products from the steel. Short to medium term protection can be expected

Section 4.2 Surface Preparation Methods

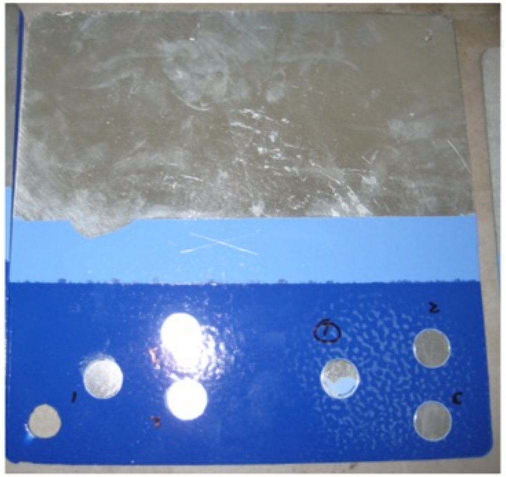
3 key ingredients for preparation

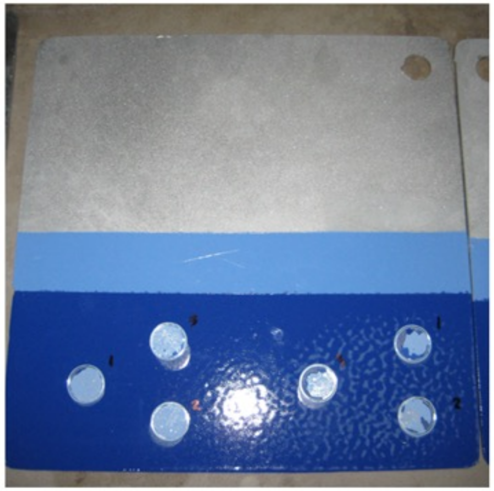
1. Remove Contaminants
2. Remove Imperfections
3. Create a Profile

Section 4.2 Surface Preparation Methods

No preparation = 2.53 MPA

Abrasive Blast Clean = 9.6 MPA





Section 4.5 Rust Conversion

- Claim to convert rust to a chemical form
- Claim to provide a sound base for painting
- Considerable amount of published literature refutes these claims
- Many contain phosphoric acid, which under ambient conditions has little or no reaction with hydrated ferric oxide(Rust)
- Unreacted acid can be trapped beneath subsequently applied coatings

Section 6 – Paint Coating Systems for Corrosion Protection

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3 Types of Protection

1. Sacrificial
2. Active
3. Passive

Section 6 – Sacrificial Protection

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Aka "Galvanic Corrosion Protection"
Zinc metal corrodes sacrificially in preference to the steel
Zinc oxidises to zinc oxide
Continues until all the zinc is depleted
Examples include:

- hot dip galvanising
- inorganic zinc silicates
- organic zinc-rich primers
- metal-sprayed zinc

Batman Bridge Tas painted in an Ethyl Zinc Silicate remained corrosion free for 20 years. Only the A frame was topcoated and remained corrosion free for 30 years

Section 6 – Passive Protection

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Locks out oxygen, water and ions from substrate.
Offshore structures generally depend on barrier coatings alone to protect against corrosion
Examples include:

- Epoxies
- Chlorinated rubbers

Most off shore structures use barrier protection only – sacrificial protection does not last long in a marine environment.

Section 6 – Active Protection

Zinc phosphate hydrolyses to produce zinc ions (Zn^{2+}) & phosphate ions (PO_4^{3-})

Phosphate ions act as inhibitors by passivating the steel to inhibit corrosion

Zinc ions act as cathodic inhibitors

Examples include:

- Zinc phosphate epoxy primers
- Zinc phosphate alkyd enamels

Section 6.3 - Coating systems for atmospheric environments

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TYPICAL CHARACTERISTICS OF TOP COATS IN PARTICULAR ENVIRONMENTAL CONDITIONS

1	2	3	4	5	6	7	8	9	10	11	12	13
Coating type (see Note 1)	**Durability when exposed to intermittent splashes of:**				**Durability on sustained exposure to:**			**Dry heat resistance, °C (see Note 2)**	**Resistance to mechanical damage**	**Initial gloss level**	**Typical colour**	**Colour and gloss retention on weathering**
	Acid	**Alkalis**	**Water, fresh or salt**	**Solvents**	**Weather**	**Water, fresh or salt**	**Soil**					
Acrylic—2-pack	G	P	G	G	VG	VP	VP	90–100	VG	Flat to full gloss	Wide range	VG
Acrylic—latex	F-G	F-G	F-G	VP	VG	VP	VP	60–70	F	Flat to gloss	Wide range	VG
Alkyd	P-F	P	P	F	G	VP	VP	90–120	G	Flat to full gloss	Wide range	G
Epoxy —2-pack —mastic	 G G	 VG VG	 E E	 VG VG	 G G	 VG VG	 VG G	 90–120 90–120	 VG VG	 Flat to full gloss Low to semi	 Wide range Wide range	 P-F P-F
Polysiloxane (organic modified)	G	G	G	VG	VG-E	G	P	120	VG	Flat to full gloss	Wide range	E
Polyurethane —2-pack —moisture cured	 VG G	 G G	 E VG	 VG VG	 VG-E G-VG	 G VG	 G G	 90–120 90–120	 VG VG	 Flat to full gloss Semi to gloss	 Wide range Limited range	 E VG
Silicones —silicone acrylic —high heat	 G G	 G E	 VG E	 P P-F	 VG E	 VP VP	 VP VP	 200–250 400	 G G	 Semi-gloss Semi-gloss	 Limited range Limited range	 G G
Zinc rich —2-pack organic —ethyl silicate —alkali silicate	 VP VP VP	 VP VP VP	 F-G G G	 G E E	 F E E	 VP P P	 VP P P	 120–250 400 400	 E E E	 Flat Flat Flat	 Mostly grey Mostly grey Mostly grey	 F F F

LEGEND:

VP = Very poor
P = Poor
F = Fair
G = Good
VG = Very good
E = Excellent

Section 6.3 - Coating systems for atmospheric environments

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TABLE 6.3 *(continued)*

System designation	ISO 12944-5 designation (Note 1)	Surface preparation	Coating system details: 1st Coat Type	1st Coat PRN	1st Coat Nom DFT µm	2nd Coat Type	2nd Coat PRN	2nd Coat Nom DFT µm	3rd Coat Type	3rd Coat PRN	3rd Coat Nom DFT µm	Total nom DFT µm	Durability—Years to first maintenance, Atmospheric corrosivity category: C1 Very low	C2 Low	C3 Med	C4 High	C5-I Very high industrial	C5-M Very high marine	T Inland Tropical
POLYURETHANE—Two pack, solvent-borne																			
PUR1		St 3	Epoxy mastic	C32	125	Poly-urethane gloss	C26	50 (see Note 2)	—	—	—	175	*	10-15	5-10	2-5	[illegible]	—	5-15
PUR2	A1.15	Sa 2½	Epoxy primer	C06	75	Poly-urethane gloss	C26	50 (see Note 2)	—	—	—	125	25+	10-25	5-10	2-5	—	—	5-15
PUR2a	A1.17	Sa 2½	Zinc rich primer	C01a C02	75	High Build Poly-urethane	C15	75 (see Note 2)	—	—	—	150	25+	15-25	10-15	5-10	2-5	2-5	10-15
PUR3	A4.08	Sa 2½	Epoxy primer	C06	75	High build epoxy	C13	125	Poly-urethane gloss	C26	50 (see Note 2)	250	*	25+	15-25	10-15	5-10	5-10	15-25
PUR4	A1.20	Sa 2½	Zinc rich primer	C01a C02	75	High build epoxy	C13	125	Poly-urethane gloss	C26	50 (see Note 2)	250	*	25+	15-25	10-15	5-10	5-10	15-25
PUR5	A1.23	Sa 2½	Zinc rich primer	C01a C02	75	High build epoxy	C13	200	Poly-urethane gloss	C26	50 (see Note 2)	325	*	25+	25+	25+	15-25	15-25	25+
PUR6		St 3	Epoxy mastic	C32	75	Epoxy mastic	C32	75	High build poly-urethane	C15	75	225	*	15-25	10-15	5-10	2-5	2-5	5-15
PUR7	A1.19 A1.20	Sa 2½	Epoxy zinc primer	C02	75	Epoxy mastic	C32	75	High build poly-urethane	C15	75	225	*	25+	15-25	10-15	5-10	5-10	10-15

Section 6.3 - Coating systems for atmospheric environments

- Abrasive blast (AS1627.9 Sa 2 ½) →
- Zinc Rich Epoxy @ 75µm →
- Epoxy @ 200µm →
- Polyurethane @ 90 µm →

This coating system conforms to AS/NZS 2312.1 PUR 5 for long term protection (15-25 years) in a Category C5-M (severe coastal) environment

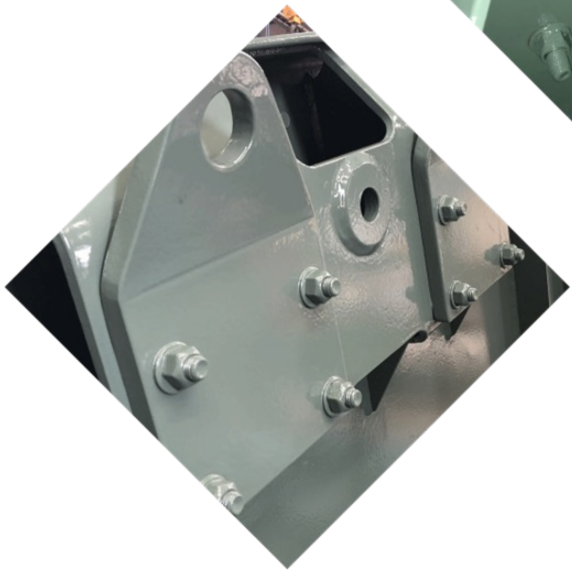
Section 6.3 - Coating systems for atmospheric environments

Environment: Soil

EUH4	Sa 2½ (profile 75–100 µm)	Ultra high build epoxy	C34	1200	Ultra high build epoxy	C34	1200	—	—	—	2400	See Notes 5 and 6
EVH2	Sa 2½ (profile 50–75 µm)	Very high build epoxy	C13a	400							400	See Note 6
EVH3	Sa 2½ (profile 50–75 µm)	Very high build epoxy	C13a	250	Very high build epoxy	C13a	250	—	—	—	500	See Notes 4, 5 and 6
PUE2	Sa 3 (profile 75–100 µm)	Elastomeric Polyurethane/ polyurea	C43	2500							2500	See Note 6

7.10.2 & 7.10.3 – Stripe coating & Painting around bolt holes

Stripe Coating is a means to ensure adequate dry film thickness is achieved on edges, corners, welds, pitted surfaces, flanges, nuts ,bolts and other irregular surfaces



8.3 - Criteria to assessing when to paint or repair

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TABLE 8.2

ASSESSMENT OF COATING CONDITION FOR FEASIBILITY OF REPAIR

Coating attribute	Test method	Repair* likely	Repair* possible	Repair* unlikely
Substrate corrosion	AS 1580.481.3	<10%	10–20%	>20%
Knife adhesion	AS 3894.9	Rating ≤3	Rating 4	Rating 5
Tensile adhesion	AS 3894.9	>2.0 MPa	1.0–2.0 MPa	<1.0 MPa
Film thickness	AS 3894.3	<500 µm	500–750 µm	>750 µm
Rust/Mill scale (Note 1)	ISO 8501-1	Not present or present and inactive	Not present or present and inactive	Loosely adhering rust/mill scale

* The repair method adopted will depend upon the economics of repairing.

9.4 Painting Project commencement meeting

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1. Review Specification
2. Standards of work (This may be comparison standards)
3. Method of Inspection (This may be QA documentation)
4. Surface Preparation
5. Application Technique
6. Drying time required
7. Method of measurement
8. Method of handling steelwork
9. Reports required

9.4 Painting Project commencement meeting

THE AUSTRALASIAN CORROSION ASSOCIATION INC.

1. Review Specification
2. Standards of work (This may be comparison standards)
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4. Surface Preparation
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9. Reports required

Design Life

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The design life of a component is the life expectancy of the item

It is the length of time between placement into service of a single item and its onset of wear out

The protective coating system offers protection to the item

To achieve the design life of an item a maintenance program is required to revive the performance of the protective coating system

Case Study: Phillip Island Bridge (Vic)

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1. The Phillip Island Bridge is in a severe marine environment
2. The coating system is subject to constant abrasion, moisture, sodium chloride and high UV radiation
3. A 3-coat system had protected the steelwork for 20 years
4. Only some of the weld joints showed corrosion

Case Study: Phillip Island Bridge (Vic)

THE AUSTRALASIAN CORROSION ASSOCIATION INC.

1. Coating DFT 338µm average
2. Inspection rating 2 - Soiled, stained, ingrained dirt, chalking or loss of gloss
3. Inspection rating 3 -Minor film damage (cracking, flaking or erosion of topcoats) in small areas

Expected Corrosion Rate as per AS2312.1 Table 2.1
C4 Atmospheric Corrosivity Environment 20 Years
Steel µm/year = 50µm - 80µm x 20 years = 1000µm / 1600µm
Zinc µm/year = 2.1µm - 4.2µm x 20 years = 42µm / 84µm
Protective Coating System – No Loss of Steel or Zinc

Duplex system AS2312.2

THE AUSTRALASIAN CORROSION ASSOCIATION INC.

1. The zinc-coated article can be further protected by the application of additional coatings

2. Hot dip galvanized coatings are sometimes required to be painted for decorative reasons

3. The Protective Coating system must take the primary role of protection when applied to avoid delamination

Duplex system AS2312.2

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TABLE 7.1

PAINTING SYSTEMS FOR HOT DIP GALVANIZED STEEL TO AS/NZS 4680

Coating system details													Durability—Years to first maintenance of paint component of duplex sytem			
System No.	Service qualities	Surface preparation	First coat			Second coat			Third coat			Total NDFT µm	Atmospheric corrosivity category			
			Type	PRN	NDFT µm	Type	PRN	NDFT µm	Type	PRN	NDFT µm		C2 Low	C3 Med	C4 High	C5 Very high
1D	Decorative	Degrease, wash and dry	Acrylic latex primer	C11	25	Acrylic latex paint	C21	50				75	5–10	5–10	NR	NR
2D	Decorative	Degrease, wash and dry, followed by sweep blast cleaning	Epoxy primer (2-pack) Inhibitive	C06	75	Polyurethane or acrylic gloss (2-pack)	C26 or C33	100				175	10–15	10–15	5–10	NR
3I	Wear and Tear Industrial	Degrease, wash and dry, followed by sweep blast cleaning	Epoxy primer (2-pack) Inhibitive	C06	75	High-build epoxy (2-pack)	C13	150				225	>15	10–15	10–15	5–10
4D	Protective Long Term Decorative	Degrease, wash and dry, followed by sweep blast cleaning	High-build epoxy (2-pack)	C13	250	Polyurethane or acrylic gloss (2-pack)	C26 or C33	100				350	>15	>15	10–15	5–10
4I	Protective Long Term Industrial	Degrease, wash and dry, followed by sweep blast cleaning	High-build MIO epoxy (2-pack)	C13	350							350	>15	>15	10–15	5–10
5D	Protective Long Term Decorative	Degrease, wash and dry followed by sweep blast cleaning	Epoxy primer (2-pack) Inhibitive	C06	75	High-build epoxy (2-pack)	C13	225	Polyurethane or acrylic gloss (2-pack)	C26 or C33	100	400	>15	>15	>15	10–15
5I	Protective Long Term Industrial	Degrease, wash and dry followed by sweep blast cleaning	Epoxy primer (2-pack) Inhibitive	C06	75	High-build MIO epoxy (2-pack)	C13	325				400	>15	>15	>15	10–15

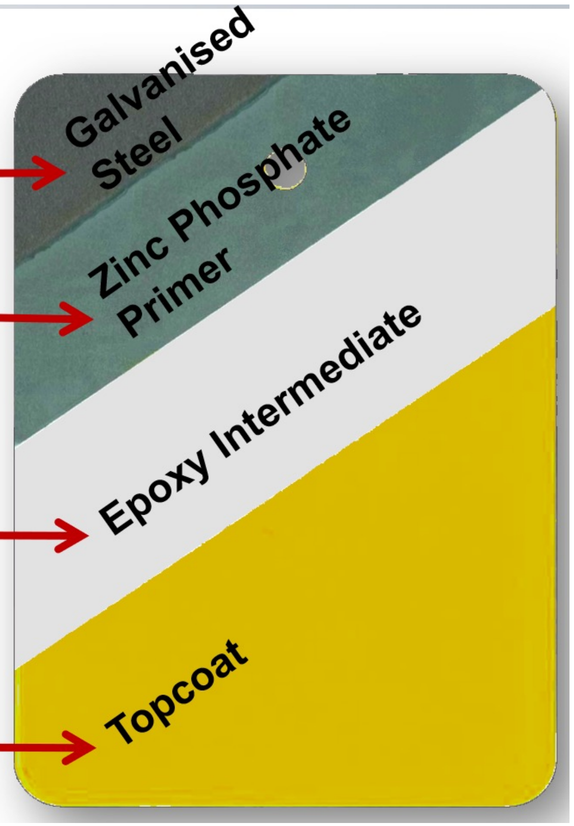
Duplex system AS2312.2

Blast cleaned **Galvanised Steel**

Inhibitive Protection

Barrier Protection

UV Protection & **Aesthetics**



THE AUSTRALASIAN CORROSION ASSOCIATION INC.

THANK YOU!

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