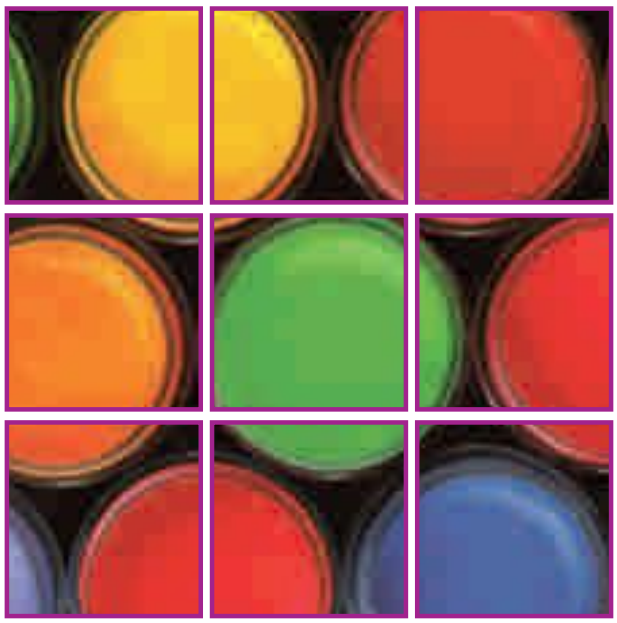
Painting

GOOD INDUSTRY PRACTICES



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ISBN: 981-05-1531-6

Foreword

The Building and Construction Authority (BCA) has been promoting the use of Construction Quality Assessment System or CONQUAS 21 as the de facto national yardstick for measuring the workmanship quality of building projects. To meet the rising expectation of the homeowners, the Quality Mark (QM) Scheme was launched in July 2002 to promote a higher consistency in workmanship standards for residential developments.

This "Good Industry Practices – Painting" is part of the CONQUAS 21 Enhancement Series on Good Industry Practices. The purpose of the guide is to share with the industry the good painting practices adopted by practitioners and to raise awareness of the different paint systems, the selection criteria and application processes. It provides simple and practical suggestions on how good quality painting can be achieved on site. Common defects associated with paints, their causes and preventive measures are also highlighted in this guide.

In this second edition, the guide has been revised to include more good practices, photographs and graphical presentations for easier reference and better illustration.

It should, however, be pointed out that this guide is not meant to dictate how painting work must be carried out. It only serves to illustrate some of the good practices that designers and applicators have adopted in selecting and applying paints. We gratefully acknowledge the contributions of these practitioners and trust that the industry will find this publication useful in its pursuit of quality excellence.

Lam Siew Wah
Deputy Chief Executive Officer
Industry Development
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Acknowledgement

"Good Industry Practices – Painting" was first published in 2001. A Technical Committee for Good Industry Practices for Painting was then formed to review and endorse on the good practices identified.

We wish to again thank the members of the Technical Committee for their valuable contributions.

Technical Committee for Good Industry Practices – Painting

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For this edition, we would like to thank the following organisations and individuals for their supports and contributions in the review of this guide.

Real Estate Developers' Association of Singapore (REDAS)
Singapore Institute of Architects (SIA)
The Singapore Contractors Association Ltd (SCAL)
Housing & Development Board (HDB)
Woh Hup (Pte) Ltd
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1. Introduction

1.1 FUNCTIONS OF PAINT

Paint is a fluid that dries to form a continuous solid film when spread over a surface or substrate. Depending on its type and properties, paint can perform one or more of the following functions:

Functions of Paint	Descriptions
a) Decorative Decorative paint for aesthetic purpose	• Paint can be used as a coating to decorate a surface or substrate. It has a wide variety of colour, texture, finishes and gross level.
b) Protective Protective paint for fuel tanks	• Paint can be designed to protect the surface or substrate against ultra-violet rays, humidity, chemicals, corrosion, algae, abrasion etc.
c) Special Purposes Luminous paint for emergency signage	• Paint can also be formulated for specific uses such as luminous paint that glow in the dark for emergency signage, anti-condensation paint to provide an insulating layer to minimise condensation, fire retardant paint to enhance the fire resistance of combustible surfaces such as softboard or hardboard. • For application of special paints, refer to manufacturer's recommendations.

Table 1.1: Functions of Paint

1.2 PAINT SYSTEMS AND COMPONENTS

A paint system is basically composed of primer/sealer, undercoat and topcoat as shown in Figure 1.1. Depending on the design requirement, texture coating may be provided. Due to volume constraint, this guidebook will focus on paints that are commonly used in the local market. The functions of each system component are illustrated in Table 1.2 below.

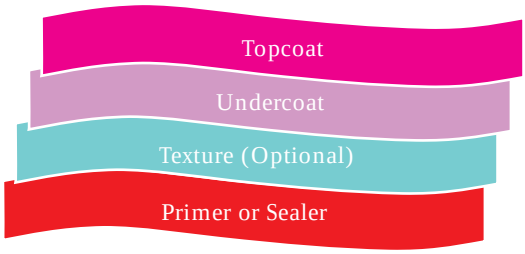


Figure 1.1: Typical paint system

System Component	Function	Remarks
Primer	– To improve adhesion – To protect metal against corrosion – To reduce porosity of receiving substrate so as to prevent undue absorption of resin from subsequent coats of paints	– Primer should be used to reduce the porosity of the surface and to provide adequate moisture resistant capability – Etching Primer should be used as pre-treatment on non-ferrous surfaces such as galvanised metals, aluminium to ensure good adhesion
Sealer	– To resist alkali attack from cement based materials – To improve adhesion – To seal problematic surfaces, e.g. resinous wood – To stabilise loose surface particles – To reduce porosity of receiving substrate so as to prevent undue absorption of resin from subsequent coats of paints	– Sealers are applied to prevent migration of substances from the substrate into later coats and should be used to reduce the porosity of the surface and to provide adequate moisture resistant capability
Texture (Optional) 	– To give a distinct 3-dimensional appearance.	– If applied, this is introduced as the second coat after application of sealer/primer. Commonly applied by spray or roller – Textures are available in multiple colours to simulate the look of granite, tiles, and wallpaper – Mock-ups are important to understand the appearance of the product
Undercoat	– To impart opacity and film build – To level out minor irregularities and provide uniform texture – To improve inter-coating adhesion	– Choice of undercoat should be compatible with the primer/sealer and the finishing coats
Topcoat	– To provide the required functions of paint as discussed in Section 1.1	– This is the finishing coat of a paint system which gives the final appearance in term of colour, gloss or sheen to the substrate.

Table 1.2: Functions of the Various Components of a Paint System

1.3 CLASSIFICATION OF PAINT

With technological advancements, the traditional classification of paints into either enamel or emulsion has become misleading. Today, the industry has enamel paints that can be diluted with water and emulsion paints that have smooth, glossy finishes. Hence, it becomes essential to identify paint by its resin components to minimise confusion.

Appendix A shows some examples of paints classified by their resin components and properties. In general, "enamel" refers to solvent-based Alkyd resin which is generally used for wood and metal surfaces.

Apart from classifying paints by their resin components, paints may also be classified in accordance with their curing mechanism, solvent used, function and market segment as shown in Table 1.3.

Classification by	Type of Paints
Curing Mechanism	Baking or Air-dry
Solvent for the Paint	Water-based or Solvent-based
Function of System Component	Primer, Sealer, Undercoat or Finishing Coat
Resin component	Epoxy, Alkyd, Acrylic, Polyurethane, etc
Market Segment	Architectural Coating, Heavy Duty Coating, Marine or Industrial Coating

Table 1.3: Classification of Paint

1.4 PROPERTIES OF PAINT

The properties of paint determine the general quality of the coating and its workability, ease of application and resistance characteristics. Table 1.4 shows some basic properties of paints.

Properties	Examples
Appearance	Gloss/ Matt/ Semi-gloss
Application Method	By Brush, Roller or Sprayer
Drying Time	Fast dry/ Slow dry
Adhesion	Adhesion to substrates/ Existing coating/ Intercoating
Mechanical Characteristics	Hardness/ Flexibility
Resistance	Ultra-violet/ Chemical/ Abrasion/ Fungus/ Algae
Outdoor Durability	Gloss retention/ Colour / Ultra-violet
Storage Stability	Settling tendency/ Viscosity stability

Table 1.4: Essential Properties of Paint

2. Material Selection

2.1 SELECTION OF PAINT SYSTEM

Different types and grades of paint systems have varying application and performance properties. Figure 2.1 summarises the key considerations in determining the existing condition of coated surface as well as in selecting the appropriate paint system.

Figure 2.1: Selection of Paint System

FOR COATED SURFACE

To ascertain the presence of defects and problems

- Presence of seepage, peeling, discoloration, algae growth, etc.
- Refer to Section 6 for the types of defects.

To determine the root cause(s) of defects

- Sources of moisture, use of incorrect paint system, presence of alkaline, too porous substrate , improper design of building and its facade etc.

To rectify the root cause(s)

- Install waterproofing, provide proper drainage of condensed water from air-conditioners, reduce the density of foliage to reduce the occurrence of algae, etc.
- Refer to Section 6 for the recommended remedy

FOR UNCOATED SURFACE

Basic Selection Criteria

Type of Substrate and its Conditions	• The common types of substrates are concrete/ cement based, timber and metal surfaces. Different substrates require different types of primer/sealer. For example, external concrete wall surface will require the use of alkali resisting sealer whilst ferrous metal surface will require corrosion inhibitive primer. • Conditions refer to the substrate's profile, porosity, and existing conditions etc. • Refer to Tables 2.1, 2.2 and 2.3 for details.
Type of Environment	• Internal or external. • Identify types of adverse elements that the paint system will be subjected to. • Refer to Appendix B for detail classification.
Expected Appearance	• Colour, texture and gloss level • Colour retention properties
Expected Performance	• Durability period, weather resistance, algal resistance, UV resistance, alkali resistance, scrub resistances, chemical resistance, waterproofing characteristic, etc.
Budget	• Balance and reconcile a realistic budget with the expectations.

In general, the various paint components used (that is the primer, sealer, intermediate coat and topcoat) should be compatible. Tables 2.1 to 2.3 provide useful information on the various common paint systems available for different surfaces and purposes. The following explanatory notes are for the use of Table 2.1 to 2.3.

Column Headings	Explanatory Notes
Surface	Receiving surfaces are categorised according to the type of base substance of the substrate, i.e. concrete/cement plaster, timber or metal. The surfaces have been further categorised into internal (sheltered) or external environmental exposures.
Finishes	Description is based on the required gloss level or texture.
Comparison of Properties	A 4-point grading scale is used to highlight strengths and weaknesses of the key properties of the system.
Paint Type	Description is based on the resin of topcoat.
Typical Paint System	Description is based on the types of sealer/primer, undercoat and topcoat to be used. Numbers of coat to be applied are also indicated.
Remarks	Brief description on the general applications.

Table 2.1: Reference Chart for Selecting Paint Systems for CONCRETE/PLASTER SURFACE

S/No	Surface	Finishes Required	Comparison of Properties					Paint Type	Typical Paint System	No. of Coats	Remarks
			Ease in Painting	Durability	Anti-Algae and Fungus	Alkaline Resistance	Chemical Resistance				
INTERNAL											
M1	Cement plastered walls and concrete related surfaces, brickwork, plaster boards, gypsum boards, ceiling panels	Matt	A	C	C	C	C	ACRYLIC COPOLYMER EMULSION	Alkali resisting sealer Acrylic emulsion SS150 (Type 2)	1 2	Quality matt emulsion. Lasting for most internal walls.
M2		Sheen	A	B	B	C	C	VEOVA (MODIFIED ACRYLIC) EMULSION	Alkali resisting sealer "Vinyl Silk" emulsion	1 2	Luxurious sheen emulsion that gives a smooth and silky appearance. Premium grade for interior decor commonly sold as Vinyl Silk emulsion.
M3		Low Sheen	A	A	B	B	B	ACRYLIC EMULSION	Alkali resisting sealer Acrylic emulsion	1 2	Premium grade with superb washable surface properties
M4	As above and all floor excluding gypsum types	Low Gloss/ Gloss	C	A	A	A	A	EPOXY	Epoxy sealer Epoxy topcoat	1 2	Excellent chemical resistance and very good hardness & abrasion resistance. Resist defect by moisture. Used in food, chemical or heavy duty environment.
EXTERNAL											
M5	Cement plastered walls and concrete related surfaces, brickwork, mineral plasters	Matt	A	C	C	B	C	ACRYLIC EMULSION	Alkali resisting sealer Acrylic emulsion SS150 (Type 1)	1 2	Good weathering and alkali resistance.

Table 2.1: Reference Chart for Selecting Paint Systems for CONCRETE/PLASTER SURFACE

S/No	Surface	Finishes Required	Comparison of Properties					Paint Type	Typical Paint System	No. of Coats	Remarks
			Ease in Painting	Durability	Anti-Algae and Fungus	Alkaline Resistance	Chemical Resistance				
EXTERNAL (cont'd)											
M6	Cement plastered walls and concrete related surfaces, brickwork, mineral plasters	Semi-Gloss	B	B	B	B	B	SOLVENT-BASED ACRYLIC	Alkali resisting solvent-based sealer Acrylic solvent-based topcoat	1 2	Excellent thermoplastic coatings for fungus/algae prone surfaces. Excellent adhesion and good durability to weather.
M7		Low Sheen	A	B	A	A	B	HIGH PERFOR-MANCE ACRYLIC EMULSION	Alkali resisting sealer High performance acrylic emulsion SS 345	1 2	High quality Acrylic emulsion with anti algae/fungi properties
M8		Gloss	C	A	A	A	A	2-PACK POLYURE-THANE	Epoxy primer Polyurethane topcoat	1 2	Excellent weather, chemical and abrasion resistance two-components paint system
M9		Sheen	A	B	B	A	B	TEXTURE COATING WATER-BASED ACRYLIC TOPCOAT	Alkali resisting sealer Texture base coat High performance acrylic emulsion SS345	1 1 2	Textured acrylic-based, decorative finish with algistatic, fungistatic & anti-carbonation properties
M10		Gloss/ Semi-Gloss	B	B	B	A	B	TEXTURE COATING SOLVENT-BASED ACRYLIC TOPCOAT	Alkali resisting solvent-based sealer Texture base coat Acrylic solvent-based finishing coat	1 1 2	Textured acrylic solvent-based coating with excellent adhesion

Table 2.1: Reference Chart for Selecting Paint Systems for CONCRETE/PLASTER SURFACE

S/No	Surface	Finishes Required	Comparison of Properties					Paint Type	Typical Paint System	No. of Coats	Remarks
			Ease in Painting	Durability	Anti-Algae and Fungus	Alkaline Resistance	Chemical Resistance				
EXTERNAL (cont'd)											
M11	Cement plastered walls and concrete related surfaces, brickwork, mineral plasters	Gloss	B	A	A	A	A	TEXTURE COATING POLYURE-THANE TOPCOAT	Epoxy primer Acrylic emulsion texture base coat Polyurethane topcoat	1 1 2	Acrylic & 2-pack polyurethane combination textured system. Excellent weather, chemical and abrasion resistance
M12		Matt	A	B	B	A	B	WATER-BASED SILICONE PAINT	Water-based silicone primer Water-based silicone paint	1 2	Excellent alkaline resistance with high water repelling properties
M13	Fair-face brick wall	Natural	A	C	C	B	C	PENETRAT-ING CLEAR WATER REPELLENT	Solvent-based penetrating clear repellent (coat to saturation)	1-2	Protection from external stains and treatment to moisture absorption problem. Water repelling, fungus and weather resistance.
M14	Roof tiles (non-glazed)	Natural	A	B	B	B	C	ACRYLIC SOLVENT BASED TILE COATING	Acrylic solvent-based	2	Acrylic solvent- based coatings for fungus/algae prone concrete and roof tiles.

Grading for Comparison of Properties

LEGEND: A Excellent B Very Good C Good D Average

Notes:

1 All external systems are suitable for internal use.
2 Resin level differs for paint types specified here. For resin and toxicity levels in paint, refer to manufacturers.
3 All systems specified are for general painting purpose. Variation is subjected to site conditions or circumstances.
4 For elastomeric coatings, please refer to SS 500:2002 - Elastomeric wall coatings for more information.
5 For surfaces not covered here, refer to manufacturers.

Table 2.2: Reference Chart for Selecting Paint Systems for TIMBER SURFACES

S/No	Surface	Finishes Required	Comparison of Properties					Paint Type	Typical Paint System	No. of Coats	Remarks
			Ease in Painting	Durability	Hardness	Yellowing Resistance	Stain Resistance				
INTERNAL											
T1	All kinds of timber products or related material	Gloss	B	D	D	D	C	ALKYD RESIN ENAMEL	Aluminium wood primer SS 38 Alkyd enamel undercoat SS 34 Alkyd enamel gloss top coat SS 7	1 1 2	High gloss enamel for painting of general doors & windows
T2		Gloss	D	A	B	A	A	2-PACK POLYURE-THANE	Epoxy primer Polyurethane topcoat	1 2	Glossy, hard and solvent resistant and non-yellowing two-components paint system.
T3		Sheen	A	D	D	C	C	VEOVA MODIFIED (MODIFIED ACRYLIC) EMULSION	Aluminium wood primer SS 38 Alkyd enamel undercoat SS 34 "Vinyl Silk" emulsion	1 1 2	Decorative emulsion for panels & ceiling trims. Commonly sold as Vinyl Silk Emulsion
T4		Gloss & Satin	D	D	B	D	A	ACRYLIC MODIFIED ALKYD NITRO-CELLULOSE (NC) LACQUER	NC acrylic lacquer	3	Aerosol spray for easy application on furniture

Table 2.2: Reference Chart for Selecting Paint Systems for TIMBER SURFACES

S/No	Surface	Finishes Required	Comparison of Properties					Paint Type	Typical Paint System	No. of Coats	Remarks
			Ease in Painting	Durability	Hardness	Yellowing Resistance	Stain Resistance				
INTERNAL (cont'd)											
T5	All kinds of timber products or related material	Natural	B	C	C	C	B	ALKYD MODIFIED POLYURE-THANE 1-PACK	1-pack polyurethane clear	3	Very durable varnish for furniture, wood panels and doors.
T6		Natural	C	B	A	B	A	2-PACK POLYURE-THANE	2-pack polyurethane clear	3	Hard coating for furniture and wood panels
T7		Natural	C	B	A	C	A	2-PACK AMINO-ALKYD RESIN ACID CURE	Amino-alkyd coating clear	3	Very tough coating for parquet floors, railing or furniture
T8		Natural	C	B	A	C	A	2-PACK EPOXY	Epoxy clear	3	Chemical-resistant coating for corrosive environment, e.g. Laboratory benches.
EXTERNAL											
T9	All kinds of timber products or related material	Gloss	B	D	D	D	C	ALKYD RESIN ENAMEL	Aluminium wood primer SS38 Alkyd enamel undercoat SS 34 Alkyd enamel gloss top coat SS 7	1 1 2	High gloss enamel for painting of general doors & windows.

Table 2.2: Reference Chart for Selecting Paint Systems for TIMBER SURFACES

S/No	Surface	Finishes Required	Comparison of Properties					Paint Type	Typical Paint System	No. of Coats	Remarks
			Ease in Painting	Durability	Hardness	Yellowing Resistance	Stain Resistance				
EXTERNAL (cont'd)											
T10	All kinds of timber products or related material	Gloss	D	A	B	A	A	2-PACK POLYURE-THANE	Epoxy primer Polyurethane finishing coat	1 2	Chemical-resistant coating for corrosive environment, e.g. Laboratory benches.
T11		Low Sheen	A	D	C	B	B	ACRYLIC EMULSION	Aluminium wood primer SS38 Alkyd enamel undercoat SS34 Acrylic emulsion	1 1 2	Exterior grade emulsions under special requirement
T12		Natural	D	A	B	A	A	2-PACK POLYURE-THANE	Polyurethane clear	3	Very durable coat for external timber structures.

Grading for Comparison of Properties

LEGEND: A Excellent B Very Good C Good D Average

Notes:

1 All external systems are suitable for internal use.
2 Resin level differs for paint types specified here. For resin and toxicity levels in paint, refer to manufacturers.
3 All systems specified are for general painting purpose. Variation is subjected to site conditions or circumstances.
4 For surfaces not covered here, refer to manufacturers.

Table 2.3: Reference Chart for Selecting Paint Systems for METAL SURFACES

S/No	Surface	Finishes Required	Comparison of Properties				Paint Type	Typical Paint System	No. of Coats	Remarks
			Ease in Painting	Durability	Hardness	Corrosion control				
INTERNAL										
F1	(Ferrous type) Iron & steel related surfaces	Gloss	A	C	D	C	ALKYD RESIN ENAMEL	Alkyd-based anti-corrosion primer* Alkyd enamel undercoat SS 34 Alkyd enamel gloss topcoat SS7	1 1 2	*Refer to SS494 for Lead and chromate-free primer Easy to use finishing coat over primed metal surfaces under non-corrosive environment.
F2		Low Gloss/ Gloss	C	A	A	A	EPOXY	Epoxy/Zinc phosphate blast primer Epoxy topcoat	1 2	Epoxy system for corrosive chemical environment on blasted metal.
F3		Low Gloss/ Gloss	C	A	A	A	EPOXY	2-pack high solid epoxy primer Epoxy topcoat	1 2	High-build epoxy system for corrosive chemical environment and NO GRIT BLAST situation.
F4		Low Gloss/ Gloss	C	A	A	A	EPOXY	Epoxy coating	3	Epoxy system. 'Non Toxic' suitable for potable tanks. Relevant certification should be obtained before use

Table 2.3: Reference Chart for Selecting Paint Systems for METAL SURFACES

S/No	Surface	Finishes Required	Comparison of Properties				Paint Type	Typical Paint System	No. of Coats	Remarks
			Ease in Painting	Durability	Hardness	Corrosion control				
INTERNAL (cont'd)										
F5	(Non ferrous type) Galvanised metal, stainless steel, copper , tin & other related surfaces	Gloss	A	C	D	C	ALKYD RESIN ENAMEL	Etching primer Alkyd-based anti-corrosion primer* Alkyd enamel undercoat SS34 Alkyd enamel gloss topcoat SS7	1 1 1 2	*Refer to SS494 for Lead and chromate-free primer Easy to use finishing system over properly primed surfaces. Under non-corrosive environment, e.g. domestic home & commercial office.
F6		Low Gloss/ Gloss	C	A	A	A	EPOXY	Epoxy primer Epoxy topcoat	1 2	Heavy-duty epoxy system for corrosive environment such as chemical industry.
EXTERNAL										
F7	(Ferrous type) Iron & steel related surfaces	Gloss	A	D	D	C	ALKYD RESIN ENAMEL	Alkyd-based anti-corrosion primer* Alkyd enamel undercoat SS34 Alkyd enamel gloss topcoat SS7	1 1 2	*Refer to SS494 for Lead and chromate-free primer Easy to use system for non-corrosive environment, e.g. residential and commercial areas.

Table 2.3: Reference Chart for Selecting Paint Systems for METAL SURFACES

S/No	Surface	Finishes Required	Comparison of Properties				Paint Type	Typical Paint System	No. of Coats	Remarks
			Ease in Painting	Durability	Hardness	Corrosion control				
EXTERNAL (cont'd)										
F8	(Ferrous type) Iron & steel related surfaces	Gloss	B	C	B	B	ALKYD-BASED MICACEOUS IRON OXIDE	Alkyd-based anti-corrosion primer* Alkyd-based micaceous iron oxide Alkyd enamel gloss topcoat SS7	1 2 2	*Refer to SS494 for Lead and chromate-free primer Modified alkyd & micaceous iron oxide offering protection in mildly corrosive & highly humid condition, e.g. towers, bridges, heavy structural steel works.
F9		Gloss	C/B	A	B/A	B/A	EPOXY/ POLYURE-THANE	Epoxy/ zinc phosphate blast primer 2-pack polyurethane finishing coat	1 2	High performance Epoxy/ Polyurethane system for highly corrosive environment on blasted metal e.g. exposed to sea salt or highly corrosive chemicals.
F10		Gloss	C/B	A	B/A	B/A	EPOXY/ POLYURE-THANE	2-pack high solid epoxy primer Epoxy built-coat 2-pack polyurethane finishing coat	1 1 2	Epoxy/ Polyurethane system for highly corrosive environment and NO GRIT BLAST situation.
F11		Sheen	C	C	C	B	EPOXY TAR HIGH BUILD	Ethyl silicate zinc rich primer Coal tar epoxy topcoat	1 3	Heavy duty Coal Tar system for long-term or periodic immersion in sea water.

Table 2.3: Reference Chart for Selecting Paint Systems for METAL SURFACES

S/No	Surface	Finishes Required	Comparison of Properties				Paint Type	Typical Paint System	No. of Coats	Remarks
			Ease in Painting	Durability	Hardness	Corrosion control				
EXTERNAL (cont'd)										
F12	(Non-ferrous type) Galvanised metal, stainless steel, copper, tin & other related alloy surfaces	Gloss	A	D	D	C	ALKYD RESIN ENAMEL	Etching primer Alkyd-based anti-corrosion primer* Alkyd enamel undercoat Alkyd enamel gloss topcoat	1 1 1 2	*Refer to SS494 for Lead and chromate-free primer Alkyd resin enamel for non-corrosive environment e.g. residential, office & light industries.
F13		Gloss	A	C	C	B	ALKYD MEDIUM-OIL TYPE	Etching primer Alkyd-based anti-corrosion primer* Medium-oil alkyd topcoat gloss	1 1 2	*Refer to SS494 for Lead and chromate-free primer Use in mild corrosive atmosphere e.g. industrial chimney, mild chemical processing plant
F14		Gloss	C	A	A	A	EPOXY/ POLYURE-THANE	Etching primer Epoxy primer 2-pack polyurethane gloss finishing coat	1 1 2	Heavy-duty Epoxy/ Polyurethane system. Excellent in corrosive chemicals conditions e.g. chemical industry, exposed to salted seawater.

Grading for Comparison of Properties

LEGEND: A Excellent B Very Good C Good D Average

Notes:

1 All external systems are suitable for internal use.
2 Resin level differs for paint types specified here. For resin and toxicity levels in paint, refer to manufacturers.
3 All systems specified are for general painting purpose. Variation is subjected to site conditions or circumstances.
4 For surfaces not covered here, refer to manufacturers.

3. Delivery And Storage

3.1 DELIVERY

The properties of paints delivered for site application should conform to the project specifications. Shelf life and colour of the paints should be verified against the documents furnished by the manufacturer. New paints should be delivered to site in sealed containers.

Random samples of the paints may be taken and sent to independent laboratories for testing. Refer to Appendix C.

3.2 STORAGE OF PAINTS

Paints have varying storage requirements and should be stored according to manufacturer's recommendations.

In general, paints should be stored in a cool, dry and well-ventilated location away from sources of heat, ignition and direct sunlight. Smoking must be inhibited and no unauthorized access to the storage place should be allowed.

Paint containers which have been opened should be properly covered and kept upright to prevent skinning and spillage. Containers should not be stored by hanging on hooks.

Paints with flash points between 21° and 32° Celsius should be stored in accordance with the Highly Flammable Liquids and Liquefied Petroleum Gas Regulation 1972.

Figure 3.1 Paint containers should be stored upright

3.3 STORAGE AND MAINTENANCE OF APPLICATION TOOLS

3.3.1 Brushes

Excess paint can be removed with a piece of thin blade before washing the brushes. Brushes should be suspended in water or thinners accordingly, up to, but not above, the stock.

Brushes used for emulsion paints should be washed immediately after use in clean running water. Varnish brushes should be suspended overnight in the appropriate thinner. Chemical-reaction-paint brushes should be cleaned immediately after use.

Brushes not required for some time should be cleaned using suitable thinners or brush cleaner, washed in hot soapy water, rinsed and laid aside to dry for future use.

New, unused brushes should preferably be stored in the original packages in which they are delivered. Loose hair should be removed from the brushes before use.

3.3.2 Rollers

Rollers and trays should be thoroughly cleaned after use. Superfluous paint may be removed by rolling the tools on newspaper and then washing them in warm soapy water or appropriate detergent. After cleaning, spin-dry the rollers to recover their original shape and hang them up for drying before storage.

3.3.3 Spray Guns

Spray guns and nozzles should be thoroughly washed and soaked in water after use.

Figure 3.2 Washing of spray gun nozzle

4. Preparatory Work

4.1 PLANNING

Quality control starts with good planning and management. An Inspection and Test Plan, ITP (refer to Appendix D) which lists down the project's inspection and testing requirements should be prepared to detail the checks required to achieve good workmanship. The plan should cover the responsibilities of each party, inspection methods, requirement references and frequency of inspections. Checklists for the in-process and final inspection on painting works should also be prepared (as in Appendix E and F).

Prior to starting any painting work, it is important for the parties involved to plan and agree on the compatible paint system as per project specification, surface preparation method, sequence of work, drying out time and method of access.

In general, the schedule of painting works should be planned in relation to the work of other trades, so as to ensure that the surfaces to be painted are prepared on time and that the subsequent construction works will not damage the paint work.

The applicator should confirm on the type and number of coats, location of application, surface preparation method and application method are in accordance with project specification. For verification of the paint colour, uniformity and compatibility of the paint system, it is a good practice to have a mock-up unit for the approval of the architect or owner before the commencement of the actual works.

4.2 SURFACE PREPARATION

Good surface preparation is critical for the paint system to function effectively. As the performance of the paint system depends largely on its adhesion with the substrate, and paint adheres best to surfaces that are clean and sound, it is essential to establish the required standard and level of surface preparation works. The receiving surfaces should be dry, and free from foreign and unstable matters such as dust, dirt, rust, spatter, salt, grease, oil, loose paint film and so forth before proceeding with the painting work.

Works by other trades that might affect the painting should be satisfactorily completed. The applicator should inform the designer of any change in the nature or condition of the receiving surfaces, which may necessitate modification of the specifications.

Refer to Table 4.1 to Table 4.4 for more details on surface preparation for various types of surfaces.

Table 4.1 Preparation of Concrete/Cement Plaster Surfaces

Condition	Tools/Methods	Remarks	
		Uncoated Surface	Coated Surface
Moisture	– Checking with moisture meter	– To ensure moisture content not exceeding 6% (or refer to manufacturer's recommendation) – Allow drying after plastering for minimum of 21 days (in compliance with CP22)	– To ensure moisture content not exceeding 6% (or refer to manufacturer's recommendation) – To check for source of dampness
Surface Contaminants such as construction soot, algae, loose paint-film (for coated surface only) etc	– High pressure water jetting	– To remove foreign and unstable matters such as construction soot, concrete/cement splashes, cement salts etc	– To remove loose particles and existing paint with flaking, dirt or chalking etc

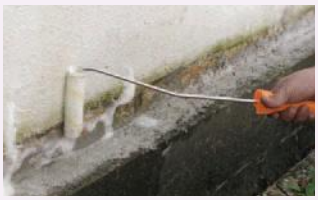
Condition	Tools/Methods	Remarks	
		Uncoated Surface	Coated Surface
Surface Contaminants such as construction soot, algae, loose paint-film (for coated surface only) etc	– Manual cleaning by chipping, scrapping or wire brushing 	– To remove foreign and unstable matters such as construction soot, algae, concrete/cement splashes, cement salts, loose paint film etc	
	– Brushing or sweeping 	– To remove foreign and unstable matters such as construction soot, algae, concrete/cement splashes, cement salts, loose paint film etc	
Surface Treatment Microbiological growth, e.g. algae or fungi growth	– Fungicidal wash  	– To kill fungal/algae spores and roots	
Surface Imperfections (i) rough, open-textured or coarse-grained surfaces	– Sanding/grinding/skim coating followed by rinsing with clean water and wiping dry 	– To reduce roughness – To improve adhesion to substrate/existing coating – To remove foreign and unstable matters such as construction soot, algae, concrete/cement splashes, cement salts etc	
(ii) hairline cracks, nail & screw holes, open joints, cracks and similar local cavities, deep and shallow depressions 	– Patching 	– Use fillers that contain a resin/binder system e.g. acrylic based putty or cement with additives – Water sensitive types e.g. gypsum-based fillers are not recommended as they may dissolve in water – Prime surface before patching if oil-based fillers are used – Patch in two stages if cavities are deep – If applied immediately beneath finishing coats, shrinkage and variations in gloss, sheen or colour may occur	

Table 4.2 Preparation of Timber Surfaces

Condition	Tools/Methods	Remarks	
		Uncoated Surface	Coated Surface
Moisture	– Checking with moisture meter	– To ensure moisture content not exceeding 15% (or refer to manufacturer's recommendation)	
Surface Contaminants such as dirt, grime, loose paint-film etc	– Sanding manually or mechanically with sandpaper followed by wiping with damp cloth	– To improve adhesion to substrate/existing coating – To remove foreign and unstable matters such as dirt, grime, loose paint-film etc – To provide a smoother and better finish	
	– Stripping by paint remover accompanied by scraping	NA	– To strip off defective paint works – Chlorinated/alkaline paint remover not recommended
Surface Imperfections (i) nail & screw holes, cracks and similar local cavities, deep and shallow depressions	– Patching with wood putty or filler	– Use wood filler for painting with transparent coatings	
(ii) rough surface	– Sanding/grinding/skim coating followed by rinsing with clean water and wiping dry	– To provide a smoother and better finish – To improve adhesion to substrate/existing coating	
Surface Treatment	– Priming	– Prime all surfaces including abutting surfaces, e.g. doorframes.	

Table 4.3 Preparation of Ferrous Metal Surfaces

Condition	Tools/Methods	Remarks	
		Uncoated Surface	Coated Surface
Surface Contaminants (i) mill scale, rust 	– On site: mechanical wire brushing 	– Wire brush till surface is free from rust (compliance with ST 3 standards or equivalent)	
	– Off site: blasting	– Compliance with SA 2.5 standards (bare metal with only traces of slight stains in spots or stripes)	– If condition allows, compliance with SA 2.5 standards (bare metal with only traces of slight stains in spots or stripes)
(ii) joints/welded areas/spot rusts, oil, grease, dirt, loose paint film, abrasive residue, debris etc	– Manual cleaning by chipping, scraping and/or wire brushing 	– To remove foreign and unstable matters such as grease, oil, loose paint film, abrasive residue etc	
	– Manual or mechanical washing down with solvent or detergent solution	– To remove foreign and unstable matters such as grease, oil, loose paint film, abrasive residue etc	
	– Blasting	– Compliance with SA 2.5 standards (bare metal with only traces of slight stains in spots or stripes)	– If condition allows, compliance with SA 2.5 standards (bare metal with only traces of slight stains in spots or stripes)
	– Stripping by paint remover	NA	– To remove loose paint film – Alkaline paint remover may be used
Surface Treatment	– Washing with clean water and allow it to dry 	– To improve adhesion/existing coating	
	– Priming exposed steel 	– To prevent corrosion	

Table 4.4 Preparation of Non-Ferrous Metal Surfaces

(include aluminium, aluminium alloys, magnesium alloys, zinc and treated steel such as galvanised surfaces, anodised aluminium etc)

Condition	Tools/Methods	Remarks	
		Uncoated Surface	Coated Surface
Surface Contaminants (i) oil, grease	– Wiping with cloth dampened with solvent	– To remove grease and oil	
	– Mechanical washing down with solvent or detergent solution	– To remove grease and oil	
	– Degreasing	– To remove grease and oil	
(ii) loose paint-film, dirt, rust etc	– High-pressure water jetting followed by sanding	– To remove foreign and unstable matters such as loose paint film, abrasive residue etc	
	– Stripping by paint removers	NA	– Rinse thoroughly with clean water after stripping to avoid chemical reaction with metal. Mild detergent should be used to remove residue
	– Sanding	– To remove foreign and unstable matters such as loose paint film, abrasive residue etc	– White rust need not be removed if found stable
Surface Treatment	– Coating the exposed surface with an etching primer.	– To ensure good adhesion	– To ensure good adhesion – Spot prime exposed surfaces immediately after cleaning

4.3 PAINT PREPARATION

Proper paint preparation is important in delivering quality work. Refer to Table 4.5 for details on preparation of paint.

In mixing of paint, the following factors should be considered:

- mix ratio;
- type of thinner used;
- induction time;
- pot life; and
- ageing time

Mixing should be carried out in compliance with the specifications and manufacturer's recommendation. No unauthorized thinning or adulteration should be carried out and no addition of driers is permitted. Where additions are authorized, the correct proportions should be strictly observed.

There should be sufficient stirring until uniformity of the paint is achieved. The pigment in paints is heavier than the vehicle and tends to settle at the bottom of the container. Failure to stir the paint properly is a common cause of unsatisfactory results. It is, hence, essential that the paint is completely uniform throughout the container.

Table 4.5 Preparation of Paint

Condition	Methods/Tools	Remarks
Confirmation of Specification	Visual checking	– Inspect name of paint, colour, location of application and numbers of coats
Settling of solid constituent in paints	Stirring: a) Manual – Long, broad-bladed stirrer – Boxing (i.e. pouring from one container to another several times) b) Mechanical – use of mechanical equipment	– Stir continuously until no solid settlement remains – Refer SS CP22 on 'Mixing & Thinning of Paints' – Used for small quantities – Used for large quantities
High viscosity paint	Thinning	– To assist workability – Use type and proportions of thinner in accordance to manufacturer's recommendations – Thinning to be carried out under supervision
Mixing different brands or types of paints	Not recommended	Not recommended
Using 2-pack materials	Mixing of two components	– Use the correct proportion in accordance to manufacturer's recommendation – Check the following: • Induction Time • Pot Life • Age-ing Time – Use paint within the pot life

4.4 PROTECTION WORKS BEFORE PAINT APPLICATION

It is a good practice to plan the sequence of works such that the final coat will be painted only after the completion of other trades such as installation of doors and carpentry works. This will ensure that the final coat of paint will not be stained during the execution of other trades.

All surfaces not intended to be painted must be protected. Doors, furniture, light fittings and similar items should be covered. Care should be taken when protecting surfaces that are sensitive to adhesive tapes.

Air Conditioner – Fan Coil Unit

Window

Building Materials

Electrical Wirings

Floor, Sliding Door Frame and Railing

Lift Button Panel and Cabinet

Figure 4.1 Examples of protection works before paint application

4.5 SAFETY

Applicator should be equipped with safety attire/ equipment, including proper working clothes, footwear and helmet. A safety belt should be used where painting is being carried out at heights. Protective accessories such as goggles or masks should be worn where necessary.

Proper access such as scaffolding and gondola should be provided to facilitate external painting works. Applicator should also make sure that there is adequate ventilation and illumination when carrying out painting works, especially for internal areas.

Figure 4.2 Proper access and safety measures for surface preparation and external painting works

5. Application

5.1 GUIDELINES TO GOOD PAINT APPLICATION

5.1.1 Differing Colours

Wherever practicable, successive coats in paint systems should differ in colour. This assists application of continuous coats of uniform thickness (especially in conditions of poor lighting) and also facilitates inspection. For application, refer to manufacturer's recommendations.

5.1.2 Intervals Between Coats

Generally, each coat in the system should be dry throughout its thickness before the next coat is applied. Rate of drying should follow the recommendations of the manufacturers. Over exposure may lead to impaired adhesion.

For 'wet-on-wet' application (that is a second coat can be applied immediately after the first coat), refer to manufacturer's recommendations.

5.1.3 Intercoat Preparation

Receiving surface should be free from contaminants before application of each coat.

Light sanding with fine-grade, preferably partly worn, sandpaper can be used to remove 'nibs' and adherent dust particles. This helps to improve adhesion and provide a smooth, leveled surface. Wet sanding is applicable if extensive sanding is necessary. However, the coating must have hardened before any sanding work can be carried out. If the coatings scratch or tear, or the abrasive paper rapidly clogs, it is an indication that the surface is not sufficiently hardened to permit abrasion.

Figure 5.1 Sanding between coats of paints

5.1.4 Environmental Conditions

Prior to painting, the following environmental conditions should be complied with:

Check	Criteria
Ambient Temperature	– Ambient temperature > 5°C or refer to manufacturers' recommendation
Substrate surface temperature	– Surface temperature of substrate < 60°C or refer to manufacturers' recommendation – Surface temperature of substrate > 3°C + ambient temperature or refer to manufacturers' recommendation
Relative humidity	– Refer to manufacturers' recommendation
Pollution level	– No airborne dust and/or pollutant in environment
Wind condition	– No strong wind

5.1.5 Unfavourable Weather or Unsuitable Conditions

Painting should not be carried out in unfavourable weather or unsuitable conditions. The application of paint to damp surfaces could result in flaking and blistering due to lack of paint penetration into the surface pores and pressure build-up of water vapour behind the coating. It should be noted that surface dampness is not always apparent, particularly if the surface is flat and porous, such as a plaster or an undercoated surface.

Painting performed on surfaces directly exposed to the sun on a hot day may be subject to patchiness or sheariness. The heat causes the thinners to evaporate too quickly, making the paint difficult to be applied and causes interference with its flow.

5.1.6 Defective Paint

Applicator should stop application if paint appears to be defective. Investigation should be conducted to ascertain the cause of defects. Remedial works should be carried out before painting work can proceed.

5.2 APPLICATION TOOLS

Applicator should ensure that operatives are skilled and experienced in the techniques of application, care and maintenance of tools and equipment and, where relevant, the setting up and adjustment of equipment to obtain optimum results.

Common Tools/Equipments	Description	Application
Brush	• Flat paint brushes ranging from 12mm - 100mm.	For general paints and coatings on small and narrow areas where paint rollers are inaccessible. Ideal for line cutting and touch-up painting jobs.
Roller	• Paint rollers are manufactured using various materials for the application of different paint types and surfaces. • The common sizes are 100mm, 150mm, 175mm and 200mm wide. • Different roller nap/ pile length are meant for different usage.	For all paints and coatings on small and large areas. Rollers can be used on all substrates with smooth to rough surfaces. Most rollers may be mounted on an extension pole to extend the operative's reach.
	Roller Nap / Pile Length	**Usage**
	Extra short pile	For smooth surface Applicable for oil-based, polyurethane, epoxy paints and varnishes
	Short pile	For smooth surface Applicable for emulsion and oil-based paints
	Long pile	For rough textured or uneven surface Applicable for emulsion and masonry paints
Sprayers ▲ Paint Pump ▲ Airless Spray Gun	(1) Airless Sprayer makes use of high pressure pump to eject paint. Paint output can be as much as 10 litres in one minute.	Mainly use for large areas where spray painting is permissible For smooth and rough surfaces Applicable for all paints and coatings

application

Common Tools/Equipments	Description	Application
Sprayers ▼ Air Compressor ▲ Spray Gun ◀ Compressed Pressure Tank	(2) Air Sprayer uses compressed air to force the paint from the container to the spray head. Paint output can be as much as 0.5 litre in one minute. It is mainly used for furniture spraying and texture coating. (3) Air-Assisted Sprayer requires air supply from a compressed pressure tank to operate. Paint output can be as much as 5 litres in one minute.	Mainly use for large areas where spray painting is permissible For smooth and rough surfaces Applicable for all paints and coatings Texture coatings can be done with Hopper/Mortar Gun

5.3 APPLICATION METHODS

Method	Basic Technique	Good Practices
Brush Application 	• Dampen the brushes prior to painting. Use water for latex or emulsion paints and paint thinner for oil or alkyd paints. Remove excess water or thinner. • Dip half the length of the bristles into the paint. Tap the brush gently against the side of the can to drain off the excess paint. • Use the bristle tips to paint a complete stroke in one direction in continual length or breadth at about one arm length.	• For new brushes, remove the loose bristles before use. • Avoid immersing the whole brush head into the paints or coatings. • Avoid exerting too much pressure in working the bristles against the surface during painting. • Do not allow too much paint on its bristles during application to minimise paint drooling on the surface. • Verify with supervisor whether survey markings should be painted over.

application

Method	Basic Technique	Good Practices
Roller Application 	• Roll from high to low using “W” format followed by “M” format to overlap. This technique is widely used to evenly disperse the paint on the surface and to minimise roller lines.	• For new roller refill, immerse it in paint and roll it over paper/ surface for about a minute to season it before use. This will prevent refill fabric from adhering to the painted surfaces during application. • Use the right roller with appropriate pile length for the painting works for better uniformity and evenness in the paint coating. • Do not roll on an ad-hoc basis, as this will tend to create roller lines or marks on the surface.
Spray Application 	• Spray painting by pressing the trigger to eject the paint onto the surface; stroke by stroke vertically or horizontally. • For airless spray, maintain a distance between the nozzle of the gun and surface of about 1 m or as specified by manufacturers.	• Use clean and appropriate spraying tip / gun nozzle for the spray-painting work. Generally, the size of the spraying tip will depend on the paint consistency. • Appropriate pump pressure level should be used for each spraying. • Masks should be used during spraying to prevent inhaling toxin and dust. • Never point the spray gun at anybody when the equipment is in operation.

5.4 PROTECTION WORKS AFTER APPLICATION

Upon completion of the painting works, the finished works should be protected from staining and damages. Protection for finished works can be achieved by placing barricades around the areas with a “Wet Paint” sign to restrict access.

5.5 INSPECTION OF COMPLETED WORKS

The completed works should be inspected for the following:

Items To Check	Description
Protection works after application	Check that all barricades and warning signs are put up.
Appearance	Check colour, hue, texture (if applicable) and evenness of paint film by visual assessment.
Thickness (optional)	Check wet film thickness using a wet film gauge. Check dry film thickness: • Metals: The thickness can be measured with magnetic or electrical gauge. The latter is more accurate and can measure film thickness on both ferrous and non-ferrous surfaces. • Masonry: The thickness can be measured by cutting a cross-section of the paint from the wall for examination by qualified technician.
Adhesion	Check adhesion of paint system after sufficient curing using adhesive tape.
Curing Condition	Allow for adequate curing period of paint film (refer to manufacturer’s specifications for curing period).

6. Common Defects

A paint defect is in many cases due to a number of causes. In some cases, several defects may occur simultaneously and hinder the determination of the causes and redemption works.

To achieve good painting work, applicators and site supervisors should understand the causes and preventive measures of common defects that occur at different stages of works. They should also be familiar with the remedial measures that can be taken to rectify any unforeseen defect.

In general, paint defects can occur during:

- Paint storage;
- Application, drying and curing; and
- Service life.

Refer to Table 6.1 to 6.3 for details on the causes, preventive measures and remedial methods for these common defects.

Table 6.1 Common Defects During Paint Storage

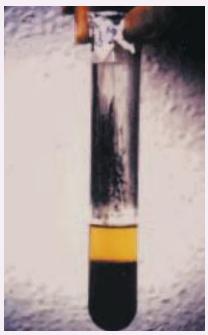
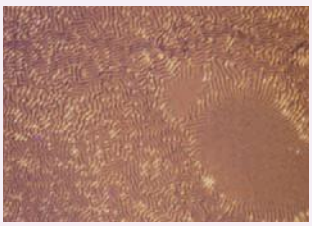
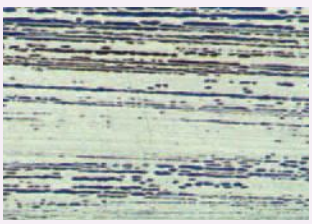
Defects	Causes	Preventive Measures	Remedial Methods
Settling Settlement of pigment to the bottom and failure to re-disperse. 	• Insufficient stirring during storage • Storage for long duration or under excessively warm condition • Excessive dilution or dilution with unsuitable materials	• Store as recommended by manufacturer • Avoid direct sunlight and long storage • Dilute with appropriate thinners as recommended by manufacturer	• Stir paint to a homogeneous consistency • Employ mechanical stirring for heavy settling • Move to appropriate storage conditions as recommended by manufacturer • Discard paint
Skinning Formation of a layer of skin on the container. 	• Use of non-airtight container • Poor formulation such as lack of anti-skinning agent • Storage under excessively warm condition	• Use airtight container • Avoid unnecessary opening of can • Store as recommended by manufacturer	• Remove the layer of skin and stir paint to homogeneous consistency • Inform manufacturer for poor formulation • Move to appropriate storage conditions as recommended by manufacturer
Gelling Decreasing viscosity caused by bacterial degradation of the protein binder or other thickening agents. This is often accompanied by an offensive odour. 	• Use of contaminated tools and water/solvents • Mixing of different brands or types of paints	• Use clean tools and water/solvents • Avoid mixing different brands or types of paints	• Discard paint

Table 6.2 Common Defects During Application, Drying and Curing

Defects	Possible Causes	Preventive Measures	Remedial Methods
Bleeding Leaching out of the existing paint film. 	• Frequent brushing on the same spot • Use of incompatible coats or thinner	• Use proper application method • Apply with appropriate coat and thinner in accordance with manufacturer's recommendation	• Allow drying before painting over with an appropriate "buffer" coat (refer to manufacturer's recommendation)
Running/ Sagging/ Curtaining Flowing or dripping of paint from upper vertical surface to the lower part forming a tear-like or wavy appearance. 	• Painting of excessively thick film layer at one time • Excessive dilution • Application of gloss paint on existing paints or surface without sanding	• Increase frequency of painting thin film • Lower dilution ratio even where operability is poor • Sand and clean receiving surface before application • Apply with appropriate coat in accordance to manufacturer's recommendation	• Remove paint film, sand, clean and re-paint as in "Preventive Measure"
Wrinkling/ Rivelling Formation of undulating wrinkling film. 	• Application of thick Oil-Alkyd, which causes shrinkage of paint film. This tends to occur when drying is expedited at high temperatures • Painting over insufficiently dried paint	• Sand and clean receiving surface before application • Apply with appropriate coat in accordance with manufacturer's recommendation • Avoid painting in thick film • Avoid accumulation of paint around bolts, angles, etc. • Observe overcoating intervals in accordance with manufacturer's recommendation	• Remove paint film, sand, clean and re-paint as in "Preventive Measure"
Crawling Slipping or inability to form a film. 	• Painting over surfaces that are not prepared, e.g. sand, dirt and dust on the surface	• Sand and clean receiving surface before application • Apply with appropriate coat in accordance with manufacturer's recommendation	• Remove paint film, sand, clean and re-paint as in "Preventive Measure"

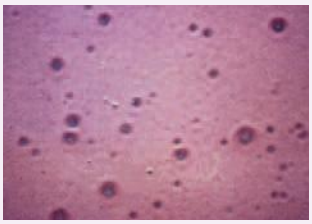
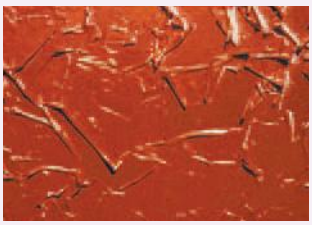
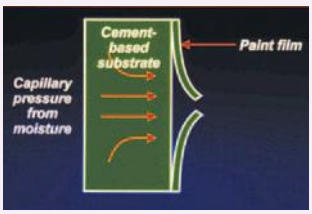
Defects	Possible Causes	Preventive Measures	Remedial Methods
Crating Formation of small bowl-shaped depressions. 	• Painting over surfaces that are not prepared, e.g. sand, dirt and dust on the surface • Use of contaminated tools and water/solvents	• Sand and clean receiving surface before application • Apply with appropriate coat as recommended by manufacturer • Use clean tools and water/solvents	• Remove paint film, sand, clean and re-paint as in "Preventive Measure"
Lifting Attacking by successive coating on existing paint. 	• Use of incompatible coats, which cause shrinkage of paint film or attacking of thinner on undercoat	• Observe overcoating intervals as recommended by manufacturer • Allow undercoating to dry before application of successive coating • Sand and clean receiving surface before application • Apply with appropriate coat as recommended by manufacturer	• Remove paint film, sand, clean and re-paint as in "Preventive Measure"
Prolonged Drying Time Inability to dry after application.	• Incorrect mixing • Use of defective paint	• Mix as recommended by manufacturer • Discard paint if it is defective	• Remove paint film, sand, clean and re-paint as in "Preventive Measure"
Loss of Gloss Reduction of lustre on drying caused by severe absorption of undercoat.	• Application on rough or unclean surfaces • Inadequate or excessive dilution • Use of unsuitable thinner • Application of excessively thin film • Result as blushing occur • Drying occurs in the presence of excessive moisture and pollutant	• Increase frequency of painting in thin film • Paint adequate thickness of film • Use appropriate thinner as recommended by manufacturer • Avoid painting at high humidity • Prepare receiving surface and apply appropriate sealer	• Remove paint film, sand, clean and re-paint as in "Preventive Measure"

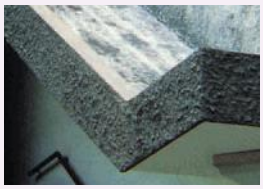
Table 6.3 Common Defects During Service Life

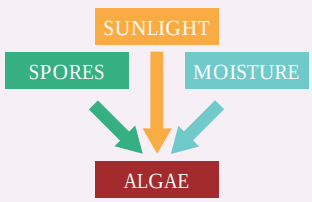
Defects	Causes	Preventive Measures	Remedial Methods
Efflorescence a) Migration of alkaline from cement based materials and crystallisation on the surface as salts. 	• Painting over insufficiently cured plaster/concrete	• Paint on receiving surface with moisture content not exceeding 6% (or refer to manufacturer's recommendation)	• Remove efflorescence, unstable matters and loose paint film • Repaint on receiving surface with moisture content not exceeding 6% (or refer to manufacturer's recommendation) • Seal off with compatible alkali resisting primer before painting • In most persistent cases, epoxy-based paint has been used with good success but at a higher cost
	• Painting over substrate's hairline cracks	• Paint on substrate with cracks not visible at 1.5m away from walls	• Patch cracks • Repaint on receiving surface with moisture content not exceeding 6% (or refer to manufacturer's recommendation)
	• Water seepage through roof, toilets etc	• Install proper waterproofing system before painting.	• Arrest moisture source • Prepare and treat the surface • Repaint on receiving surface with moisture content not exceeding 6% (or refer to manufacturer's recommendation)
	• Rise of dampness from ground	• Install proper waterproofing system before painting	• Treat dampness • Repaint on receiving surface with moisture content not exceeding 6% (or refer to manufacturer's recommendation)

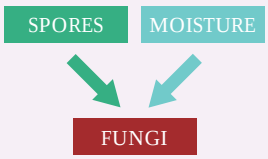
Defects	Causes	Preventive Measures	Remedial Methods
b) Migration of inherent wood gum and resins in timber.	• Painting over insufficiently dried timber • Failure to use primer	• Paint on receiving surface with moisture content not exceeding 15% (or refer to manufacturer's recommendation) • Apply appropriate primer to seal the surface before painting with the undercoat and topcoat • Observe overcoating intervals in accordance with manufacturer's recommendations	• Repaint on receiving surface with moisture content not exceeding 15% (or refer to manufacturer's recommendation) • Apply appropriate primer to seal the surface before repainting with the undercoat and topcoat
c) Discolouration of paintwork on metals. 	• Failure to remove unstable matter during surface preparation	• Employ good surface preparation before painting	• Clean surface thoroughly before repainting
Deterioration / Erosion of Pigment 	• Use of vibrant colours paint with organic particles that are easily susceptible to UV degradation • Use of paint with water sensitive pigments • Use of paint with low quality emulsions	• Select colours that are more stable • Use appropriate coating system	• Remove powder and unstable matter • Repaint with appropriate coating system • Select colours that are more stable
Yellowing	• Use of paint with certain ingredients, e.g. yellowing epoxy and alkyd resins, which are easily affected by light, heat or environmental contaminants	• Use non-yellowing paints	• Prepare surface and repaint with non-yellowing paints
Saponification 	• Use of alkyd-based paints on cement based materials. The alkalis from the cement attack the oil in the alkyd resin	• Avoid using alkyd-based paints on cement based surfaces • Use appropriate coating system	• Remove paint work and repaint with appropriate system

Defects	Causes	Preventive Measures	Remedial Methods
Chalking Natural ageing of paint. The extent of chalking will depend on paint formulation and surface exposure to weather. 	• Use of non-weathering resistant paint	• Use weather resistant paint for areas exposed to weather or UV	• Prepare surface and repaint with appropriate system
Peeling & Flaking Paint a) Moisture related 	• Water seepage through roof, toilets etc	• Install proper waterproofing system before painting	• Arrest moisture source • Prepare and treat the surface • Repaint on receiving surface with moisture content not exceeding 6% (or refer to manufacturer's recommendation)
	• Painting over insufficiently cured plaster/ concrete	• Paint on receiving surface with moisture content not exceeding 6% (or refer to manufacturer's recommendation)	• Remove efflorescence, unstable matters and loose paint film • Repaint on receiving surface with moisture content not exceeding 6% (or refer to manufacturer's recommendation)
b) Incorrect Paint System 	• Failure to use primer/sealer • Failure to use etching primer for non-ferrous metals • Use of poor alkali-resisting primer/undercoats or insufficient penetrative primer	• Prime/seal all bare surfaces with appropriate primer or sealer	• Remove all defective paint work and prepare the surface • Repaint with appropriate system
c) Poor Surface Preparation 	• Failure to remove unstable matter during surface preparation • Use of water-soluble putty/ poor adhering plaster	• Employ adequate surface preparation to remove all unstable matter • Surface must be clean, dry and stable before receiving paint	• Remove all defective and loose paint film, and unstable matter such as plaster etc • Prime/seal the surface with appropriate primer/sealer to further stabilise the surface • Re-coat with appropriate coating system

Defects	Causes	Preventive Measures	Remedial Methods
Blistering This is a moisture-related phenomenon. The amount of moisture and flexibility of the paint film determine the size of the blister. 	• Painting on a warm surface • Moisture migration through painted surface	• Paint on receiving surface with moisture content not exceeding 6% (or refer to manufacturer's recommendation)	• Remove defective paint and prepare surface accordingly to receive paint • Repaint on receiving surface with moisture content not exceeding 6% (or refer to manufacturer's recommendation)
Staining It should be noted that staining may be attributed to improper design of the building and its façade. 	• Use of details that traps and accumulates dirt. Streak marks are formed when dirt gets washed down along the sides of the painted vertical walls, especially on elastomeric coated wall.	• Avoid details and coatings that trap and attract dirt	• Remove defective paint and prepare surface accordingly to receive paint • Apply with more dirt-resistant paint system
 	• Yellowish-brown stains caused by moisture • It can be an indication of waterproofing problem in other parts of the building	• Ensure all potential water leakage and condensation are in check	• Arrest moisture source. • Prepare and treat the surface. • Repaint on receiving surface with moisture content not exceeding 6% (or refer to manufacturer's recommendation). • Repaint with appropriate system.
Rust Stains 	• Corrosion of metal elements that are attached to, adjacent to or embedded in, another substrate • Installation of metal elements that are not treated	• Protect and treat all metal parts from corrosion	• Remove metal parts and treat the metal surface • Clean the walls and prepare the surface to receive painting • Repaint with appropriate system

Defects	Causes	Preventive Measures	Remedial Methods
Algae & Fungi Growth • Temperature, humidity conditions and moisture content of the surfaces/ substrates would determine the likelihood of algae and fungi formation. • On buildings, algae are generally found outdoors such as external wall surfaces, as their chlorophyll characteristic requires sufficient sunlight for growth. Whilst fungi are commonly found on internal wall surfaces of damp areas such as bathrooms. • It should be noted that algae growth may be attributed to improper design of the building and its façade.	• Moisture source and retention • Employing of details that assist growth of algae/fungi: (i) Profile of substrates; rough-textured finishes or rough concrete surfaces 	• Avoid details with very rough textures or rough-cast plastered finishes • Use a more algae resistant paint to delay the onset of algae growth • Use capping and copings • Employ overhanging roofs to protect the walls	• Remove dirt and algae by high-pressure water jetting • Treat infected areas with fungicidal wash • Re-paint with a more algae resistant paint

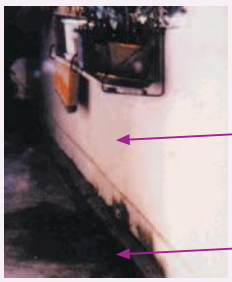


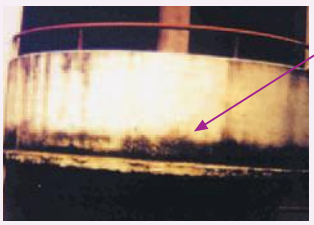
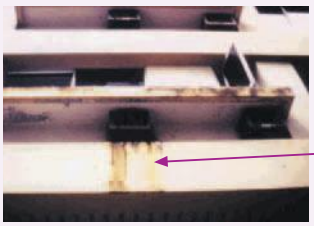
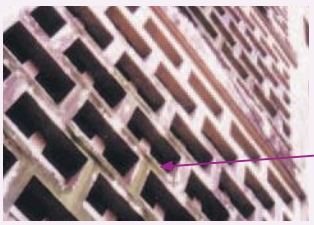


Overhanging roof details

Overhanging roof

Capping details

 	(ii) Condensation-prone walls Condensed water promoted algae growth and trapped dirt.	• Increase thickness of wall to provide more insulation so as to minimise the temperature difference • Paint on receiving surface with moisture content not exceeding 6% (or refer to manufacturer's recommendation) • Incorporate insulating material in the concrete • Apply a coating of anti-condensation paint	• Remove algae by high-pressure water jetting • Supplemented with manual scrubbing if necessary • Treat infected areas with fungicidal wash • Insulate with an anti-condensation coating • Re-paint with a more algae resistant paint • Divert condensed water from air-con outlets with trays and piping
	(iii) Concrete gutters & water-prone areas Wet area below the potted plants Scupper drains	• Ensure proper drainage • Avoid potential water retention • Use a more algae resistant paint • Ensure good workmanship	• Remove dirt and algae by high-pressure water jetting • Treat infected areas with a fungicidal wash • Re-paint with a more algae resistant paint

Defects	Causes	Preventive Measures	Remedial Methods
	(iv)Ledges Ledges can cause back splashes by rainwater. If this rainwater is slow to run down or dry, it can create a moist surface that will induce algae growth.	• Ensure proper drainage • Avoid potential water retention • Use a more algae resistant paint • Ensure good workmanship	• Remove dirt and algae by high-pressure water jetting • Treat infected areas with a fungicidal wash • Re-paint with a more algae resistant paint
	(v) Water drainage pipes and fittings Corroded down-pipes and protruding air-conditioned units with no proper drainage pipes.	• Ensure proper drainage • Avoid potential water retention • Use a more algae resistant paint • Ensure good workmanship	• Remove dirt and algae by high-pressure water jetting • Treat infected areas with a fungicidal wash • Rectify the water drainage problem • Re-paint with a more algae resistant paint
	(vi)Precast Grille Vent Such detail allows retention of water. These surfaces are likely to be more porous too.	• Avoid porous surfaces for areas exposed to weather • If necessary, seal or waterproof porous surfaces • Use a more algae resistant paint	• Remove dirt and algae by high-pressure water jetting • Treat infected areas with a fungicidal wash • Seal and waterproof the surface • Re-paint with a more algae resistant paint to delay the onset of algae growth

Appendix A

Examples of Paints classified by Resin & some of their General Properties

		WATER-BASED					SOLVENT-BASED				
Resin Classification		Acrylic	VA/Acrylic Copolymer	PVA Copolymer	Epoxy (2-pack)	Polyurethane	Alkyd	Acrylic	Epoxy (2-pack)	Polyurethane	Fluorocarbon
Principal Ingredient		Methy methacrylate modified Acrylic	Vinyl Acetate Copolymer	Polyvinyl Acetate Copolymer	Epoxy resin + amine, polyamide resin	Polyurethane resin	Oil-modified phthalic acid resin	Methyl methacrylate modified Acrylic	Epoxy resin + amine, polyamide resin	Polyurethane resin	Polyvinylidene Fluoride
Main Usage		General Cementitious-based Surface	Internal Cementitious/ Gypsum Surface	Internal Cementitious/ Gypsum Surface	Internal Chemical Environment	Chemical Environment	General steel frames, wooden surfaces	General Cementitious-based Surface	Internal Chemical Environment	Chemical Environment	Aluminium cladding and extrusions
Durability of paint	Chalk resistance	○	△	□	□	⊙	○	○	□	⊙	⊙
	Water resistance	○	△	□	⊙	○	□	○	⊙	○	⊙
	Acid proof	○	□	△	⊙	○	□	○	⊙	○	⊙
	Alkali proof	○	□	x	⊙	⊙	x	○	⊙	⊙	⊙
Classification of receiving object	Residential	○	○	○	⊙	⊙	○	○	⊙	⊙	⊙
	Industrial area	○	□	x	⊙	⊙	□	○	⊙	⊙	⊙
	Seaside	○	□	x	⊙	⊙	□	○	⊙	⊙	⊙
	Water dip	○	x	x	⊙	○	x	○	⊙	○	⊙
	Salt water dip	□	x	x	⊙	○	x	□	⊙	○	⊙
	High humidity	○	△	□	⊙	⊙	△	□	⊙	⊙	⊙
	Corrosion resistance	○	□	x	⊙	○	△	○	⊙	○	⊙
Ease in Painting		⊙	⊙	⊙	○	○	⊙	⊙	○	○	○
Suitability to receiving object	Iron	○	△	△	○	○	○	○	○	○	○
	Wood	○	△	△	○	○	○	○	○	○	○
	Concrete	○	△	△	○	○	x	○	○	○	NA

Legend ⊙ - Very Good ○ - Good △ - Fair □ - Average x - Poor NA - Not Applicable

Categories of Environment according to their Corrosive Nature

Characteristic	Description	Recommended Paint Type based on the Resin Family	
		Water-Based	Solvent-Based
INTERNAL			
Highly-Corrosive	– Chemical storage facilities. – Factory exposed to constant acidic fumes or structures immersed in water. – Chemical factory using acidic and other aggressive materials in its process.	Epoxy (2-pack) Polyurethane (2-pack)	Epoxy (2-pack) Fluorocarbon Polyurethane (2-pack) Silicone (2-pack)
Corrosive	– Factory exposed to mild acid, alkaline, heat and high humidity.	Epoxy (2-pack) Polyurethane (2-pack)	Epoxy (2-pack) Fluorocarbon Polyurethane (2-pack) Silicone (2-pack)
Mildly-Corrosive	– Light industries with mild corrosive environment.	Epoxy (2-pack) Polyurethane (2-pack) Acrylic Silicone	Epoxy (2-pack) Fluorocarbon Polyurethane (2-pack) Acrylic
Non-Corrosive	– Residential and commercial complexes with no moisture condensation and chemicals exposure.	Epoxy (2-pack) Polyurethane (2-pack) Silicone Acrylic	Epoxy (2-pack) Fluorocarbon Polyurethane (2-pack) Acrylic Alkyd

Categories of Environment according to their Corrosive Nature

Characteristic	Description	Recommended Paint Type based on the Resin Family	
		Water-Based	Solvent-Based
EXTERNAL			
Highly-Corrosive	– Structures immersed in sea. – Structures exposed to constant sunlight or industries with polluting fumes. – Structures exposed to high humidity e.g. oils refineries.	Polyurethane (2-pack)	Fluorocarbon Polyurethane (2-pack) Silicone (2-pack)
Corrosive	– Structures near to sea. – Structures exposed to Industrial pollutants with several chimneys e.g. power stations, heavy industrial complexes.	Polyurethane (2-pack) Acrylic	Fluorocarbon Polyurethane (2-pack) Silicone (2-pack) Acrylic
Mildly-Corrosive	– Commercial areas with high-traffic density or industrial estates with fumes-emitting outlets	Polyurethane (2-pack) Acrylic Silcone	Fluorocarbon Polyurethane (2-pack) Acrylic
Non-Corrosive	– Residential and Inland surroundings.	Acrylic Silicone	Fluorocarbon Polyurethane (2-pack) Acrylic

Note: Examples of main corrosive components are SO_2, CO_2, NO_x, Cl_2 and industrial dust. Moisture will aid and accelerate chemical activity.

Laboratory Tests on Paint System

Appendix C

Adulteration					Dilution	
EXTERNAL	Purpose	Emulsion-based	Enamel-based	Others	Method	Purpose
Accelerated weathering	Colour change/fastness Loss of gloss Physical change on paint film	✓	✓		In compliance with SS5	Ensure specified paint film thickness and integrity
Algae resistance	Resistance to micro-biological attack	✓				
Wet scrub abrasion	Film durability	✓				
Non- volatile matter	Compliance to specification	✓	✓	✓		
Drying time	Compliance to specification		✓	✓		
Adhesion	Compliance to specification		✓	✓		
Colour comparison	Compliance to specification	✓	✓	✓		
Impact	Compliance to specification			✓		
Hardness	Compliance to specification		✓	✓		

Sample of Inspection and Test Plan

Appendix D

Project:

Scope of Work: Painting

S/No	Activity	People-In-Charge	Inspection Method	Requirement Reference	Acceptance Criteria	Stages	Records
1	SUBMISSION						
1.1	Paint Type	AP/SE/A/O	Review	Section 4.1	Approved	Initial	Approved submissions
1.2	Technical Data	AP/SE/A	Review	–	Approved	Initial	Approved submissions
1.3	Surface Preparation Method	AP/SE/A	Review	Section 4.2	Approved	Initial	Approved submissions
1.4	Method Statement	AP/SE/A	Review	–	Approved	Initial	Approved submissions
1.5	Working Programme	AP/SE/A/O	Review	–	Approved	Initial	Approved submissions
2	INCOMING MATERIALS INSPECTION						
2.1	Check Shelf Life	AP/S/COW	Visual	Section 3.1	Conform to manufacturer's data sheet	Each delivery	Delivery document
2.2	Check Colour	AP/S/COW	Visual	Section 3.1	As per approved samples	Each delivery	Delivery document
3	IN-PROCESS INSPECTION						
3.1	Check Environmental Conditions	AP/S/COW	Visual/Measure	Section 5.1	Conform to manufacturer's data sheet	Before coating	Appendix E
3.2	Confirm Location of Application	AP/S/COW	Visual	Section 4.1	Conform to approved submission	Before coating	Appendix E
3.3	Confirm Surface Preparation Method	AP/S/COW	Visual	Section 4.2	Conform to approved submission	Before coating	Appendix E
3.4	Confirm Number of Coats	AP/S/COW	Visual	Section 2.1/4.1	Conform to approved submission	Before coating	Appendix E
3.5	Confirm Name (Type) of Coats	AP/S/COW	Visual	Section 2.1/4.1	Conform to approved submission	Before coating	Appendix E

Prepared by _____

Date _____

Verified by _____

Date _____

Approved by _____

Date _____

LEGEND AP – Applicator S – Site Supervisor SE – Site Engineer COW – Clerk of Work O – Owner A – Architect

Sample of Inspection and Test Plan (cont'd)

Project:

Scope of Work: Painting

S/No	Activity	People-In-Charge	Inspection Method	Requirement Reference	Acceptance Criteria	Stages	Records
3	IN-PROCESS INSPECTION (cont'd)						
3.6	Confirm Method of Application	AP/S/COW	Visual	Section 5.3	Conform to approved submission	Before Coating	Appendix E
3.7	Check Substrate	AP/S/COW	Visual/Measure	Section 4.2	Surface clean, stable and dry Smoothness and flatness of substrate Surface temperature	Before Coating	Appendix E
3.8	Check Protection Works	AP/S/COW	Visual	Section 4.4	Protect adjacent elements (not to be painted)	Before Coating	Appendix E
3.9	Check Safety	AP/S/COW	Visual	Section 4.5	Wear proper working attire, footwear, helmet & safety belt Use protective materials (mask, glasses) where necessary Erect proper access such as scaffold	Before Coating	Appendix E
3.10	Check Paint Mix	AP/S/COW	Visual	Section 4.3	Conform to manufacturers' data sheet	Before Coating	Appendix E
3.11	Check Application Tools	AP/S/COW	Measure	Section 5.2	Conform to approved submission	Before Coating	Appendix E
3.12	Check Painting	AP/S/COW	Visual/Measure	Section 5.5	Conform to manufacturers' data sheet	Before/ During Coating	Appendix E
3.13	Test Site Sample (Random)	AP/S/COW	Visual/Lab Test	Section 3.1/ Appendix C	Conform to specification	Before/ During Coating	Appendix E
4	FINAL INSPECTION						
4.1	Check Protection Work	AP/S/COW	Visual	Section 5.4	Protect completed work	At Completion	Appendix F
4.2	Work Acceptance	AP/S/COW	Visual/Measure	Section 5.5	Conform to specification and approved submission	At Completion	Appendix F

Prepared by _____ Date _____

Verified by _____ Date _____

Approved by _____ Date _____

LEGEND AP – Applicator S – Site Supervisor SE – Site Engineer COW – Clerk of Work O – Owner A – Architect

Sample Checklist for In-Process Inspection on Painting Work *(Concrete/Plaster Surface)*

Project: Location:

Checklist	Requirement Reference	Inspection		
		Date	Result	Sign
Surface Preparation				
1. Fresh surface cured for 21 days (applicable to new coating only)	Table 4.1			
2. Moisture level < 6% or refer to manufacturers' recommendations	Table 4.1			
3. Surface free from algae or fungus growth	Table 4.1			
4. Surface free from unstable matters	Table 4.1			
5. Surface free from grease or oil	Table 4.1			
6. Exposed surface primed	Table 4.1			
7. Substrate hairline cracks	Table 4.1			
8. Type of stopper or filler used for deep holes or shallow depressions	Table 4.1			
Paint Preparation				
9. Name, colour and type of paint	Section 4.3			
10. Thinning ratio	Section 4.3			
11. Mix ratio	Section 4.3			
12. Pot-life	Section 4.3			
Painting Environment				
13. Surrounding temperature > 5°C or refer to manufacturers' recommendations	Section 5.1			
14. No strong wind	Section 5.1			
15. Environment free from dust or pollutants	Section 5.1			
16. Relative humidity	Section 5.1			
17. Adequate ventilation	Section 4.5			
18. Adequate lighting	Section 4.5			
Paint Application				
19. No. of coats and location of application	Section 4.1			
20. Adjacent elements (not to be painted) are protected	Section 4.4			
21. Proper working attire, footwear, and helmet are worn	Section 4.5			
22. Proper gloves, protective masks or glasses are worn (where necessary)	Section 4.5			
23. Safety belts and proper accesses are provided	Section 4.5			
24. Surface clean and dry	Section 4.2			
25. Surface temperature	Section 5.1			
26. Appropriate application tools are used	Section 5.2			
27. Painting frequency	Section 5.1			
28. Painting interval	Section 5.1			
29. Drying time	Section 5.1			
30. Lab Test Submission	Section 3.1/ Appendix C			
Final				
30. Protect completed painting works	Section 5.4			

Prepared by _____ Date _____

Verified by _____ Date _____

Approved by _____ Date _____

Sample Checklist for In-Process Inspection on Painting Work *(Timber Surface)*

Project: Location:

Checklist	Requirement Reference	Inspection		
		Date	Result	Sign
Surface Preparation				
1. Moisture level < 15% or refer to manufacturers' recommendation	Table 4.2			
2. Surface free from algae or fungus growth	Table 4.2			
3. Surface free from unstable matters	Table 4.2			
4. Exposed surface primed	Table 4.2			
5. Substrate imperfections	Table 4.2			
6. Type of stopper or filler used for deep holes or shallow depressions	Table 4.2			
Paint Preparation				
7. Name, colour and type of paint	Section 4.3			
8. Thinning ratio	Section 4.3			
9. Mix ratio	Section 4.3			
10. Pot-life	Section 4.3			
Painting Environment				
11. Surrounding temperature > 5°C or refer to manufacturers' recommendations	Section 5.1			
12. No strong wind	Section 5.1			
13. Environment free from dust or pollutants	Section 5.1			
14. Relative humidity	Section 5.1			
15. Adequate ventilation	Section 4.5			
16. Adequate lighting	Section 4.5			
Paint Application				
17. No. of coats and location of application	Section 4.1			
18. Adjacent elements (not to be painted) are protected	Section 4.4			
19. Proper gloves, protective masks or glasses are worn (where necessary)	Section 4.5			
20. Proper working attire, footwear and helmet are worn	Section 4.5			
21. Safety belts and proper accesses are provided	Section 4.5			
22. Surface clean and dry	Section 4.2			
23. Surface temperature	Section 5.1			
24. Appropriate application tools are used	Section 5.2			
25. Painting frequency	Section 5.1			
26. Painting interval	Section 5.1			
27. Drying time	Section 5.1			
28. Lab Test Submission	Section 3.1/ Appendix C			
Final				
29. Protect completed painting works	Section 5.4			

Prepared by _____ Date _____

Verified by _____ Date _____

Approved by _____ Date _____

Sample Checklist for In-Process Inspection on Painting Work *(Metal Surface)*

Project: Location:

Checklist	Requirement Reference	Inspection		
		Date	Result	Sign
Surface Preparation				
1. Surface free from rust	Table 4.3 & 4.4			
2. Surface free from unstable matters	Table 4.3 & 4.4			
3. Surface free from grease or oil	Table 4.3 & 4.4			
4. Exposed surface primed	Table 4.3 & 4.4			
Paint Preparation				
5. Name, colour and type of paint	Section 4.3			
6. Thinning ratio	Section 4.3			
7. Mix ratio	Section 4.3			
8. Pot-life	Section 4.3			
Painting Environment				
9. Surrounding temperature > 5°C or refer to manufacturers' recommendations	Section 5.1			
10. No strong wind	Section 5.1			
11. Environment free from dust or pollutants	Section 5.1			
12. Relative humidity	Section 5.1			
13. Adequate ventilation	Section 4.5			
14. Adequate lighting	Section 4.5			
Paint Application				
15. No. of coats and location of application	Section 4.1			
16. Adjacent elements (not to be painted) are protected	Section 4.4			
17. Proper working attire, footwear and helmet are worn	Section 4.5			
18. Proper glove and protective masks or glasses are worn (where necessary)	Section 4.5			
19. Safety belts and proper accesses are provided	Section 4.5			
20. Surface clean and dry	Section 4.2			
21. Surface temperature	Section 5.1			
22. Appropriate application tools are used	Section 5.2			
23. Painting frequency	Section 5.1			
24. Painting interval	Section 5.1			
25. Drying time	Section 5.1			
26. Lab. Test submission	Section 3.1/ Appendix C			
Final				
30. Protect completed painting works	Section 5.4			

Prepared by _____ Date _____

Verified by _____ Date _____

Approved by _____ Date _____

Sample Checklist for Final Inspection on Painting Work

Project: Location:

Checklist	Requirement Reference	Inspection		
		Date	Result	Sign
1. Visual: • Color • Gloss • Texture (optional)	As per approved sample			
2. Adhesion	As per approved sample			

Prepared by _____ Date _____	Verified by _____ Date _____	Approved by _____ Date _____

Reference

1. SS CP 22
   The Painting of Buildings

2. SS 5
   Methods of Test for Paints, Varnishes and Related Materials.

3. SS 7
   Paint: Finishing, Gloss Enamel

4. SS 34
   Undercoat paint for Gloss Enamel

5. SS 38
   Aluminium Wood Primer

6. SS 494
   Lead and Chromate-free Primer for Iron and Steel Substrates

7. SS 150
   Emulsion Paints for Decorative Purposes

8. SS 345
   Algae Resistant Emulsion Paint For Decorative Purposes

9. SS 500
   Elastomeric Wall Coatings

10. Swedish Standard for Abrasion SA 2.5

11. Swedish Standard for Wire-brushing ST 3.0