Technical Note No. 25

SELECTION OF APPLIED FINISHES FOR METAL

Introduction

Metal components of facades may require finishes to provide protection against corrosion or for appearance. This Technical Note describes finishes which are applied to aluminium and carbon steel. Finishes are not normally applied to other metals.

Finishes described in this Technical Note are organic coatings, which may be applied to both steel and aluminium, vitreous enamel which is generally restricted to steel and anodising which is only applicable to aluminium. These finishes are applied under factory conditions allowing organic coatings to be oven cured. Painting of structural steel is normally partly carried out before delivery to site with finishing coats applied on site after erection and is not covered by this Technical Note.

Protection

The requirements for protection depend on the type of base metal and exposure conditions as described in Technical Note 24 *Corrosion.* Protection is usually required for plain carbon steel but not normally required for other metals. The primary protection for most carbon steel is zinc coating, which may take various forms as described in Technical Note 22 *Cladding metals 1- ferrous metals.* For internal components and external elements with a design life less than 30 years this may be sufficient. However zinc coatings will corrode, albeit at a much slower rate than the underlying steel and further protection may be required.

Organic coatings provide protection by forming a barrier, which prevents access of oxygen, water and aggressive chemicals to the metal surface. Coatings are slightly permeable and hence if they are too thin they will give reduced protection. Coatings exposed to harsher environments (e.g. industrial or marine) should be increased in thickness and cleaned more frequently.

Coatings which provide protection must be maintained in good condition to prevent the onset of corrosion. Delays in carrying out maintenance can therefore lead to the need for more extensive repairs or replacement of the cladding. Where the only purpose of the coating is to provide decoration, delaying maintenance is unlikely to affect the integrity of the cladding.

Aesthetics

Colour selection

The selection of colour is primarily dependent on aesthetic considerations but the effects of colour on other aspects of performance of both the finish and the cladding need to be considered. The colour of the finish will affect surface temperatures, particularly when subject to solar radiation, which will result in thermal movement of the base metal. Temperature may also affect durability.

Paint colours are specified by the RAL, British Standard (BS 381C), NCS, Colour Dimension or Pantone reference number. Some of these colours (particularly those in the latter two ranges) are inherently difficult to formulate, and as such their availability is subject to certain technical considerations of the manufacturer; generally, purple and paler red colours are difficult. Some pigments are affected by ultra violet light hence some colours are likely to fade with exposure.

The colours of anodic films are more limited and are specified according to the reference number from the manufacturer's standard range.

Colour match/control

Ideally a project should use the same manufacturer and the same product throughout, and then the same batch and one coating applicator. Differences in stoving and ovens, and in the base material and component (i.e. wall thickness, cross sectional area and mass) can all combine to produce variations in colour, even when the coating is well specified. Material and production variations can also affect the uniformity of anodising, although modern technology available at the principal architectural anodising plants can minimise colour match problems.

In general some colour variation must be accepted and upper and lower colour/gloss limits indicating the extent of this variation need to be agreed between, and agreed samples kept by, the specifier, fabricator and applicator for comparison with the actual colour, gloss and texture of the final product. However,

unlike anodised finishes the colour variation of a metallic polyester powder cannot be reproduced very easily as samples. Colour match problems can be minimised by independent acceptance inspection (see below).

More care is required (e.g. the coating thickness may need to be increased) with certain pale, white and 'near white' colours to achieve consistency. Metallic polyester powder colours are more at risk of inconsistency than solid colours because of variations in the manufacturing process, although manufacturing techniques such as bonding metallic pigments can provide more consistent colours.

With non-standard paint colours there is more uncertainty regarding long-term fading because there is not normally time to complete testing to confirm performance - testing for colour suitability requires at least three months and possibly a further three months before the paint is available to the applicator. Non-standard colours are also more expensive than a manufacturer's standard range of colours.

Surface finish

As well as colour variations, surface finish should also be controlled for aesthetic reasons. Very thick coatings increase the degree of 'orange peel texture', a phenomenon that is more obvious with gloss finishes than with satin or matt finishes.

Organic coatings

Description

Organic coatings must be applied as part of a system, which normally includes pre-treatment of the metal surface, primer and one or more finish coats. The pre-treatment consists of cleaning to remove surface contamination and chemical treatment to reduce corrosion and aid adhesion of the coating. For aluminium a chromate treatment is normally used whereas for galvanised steel a phosphate treatment may be used.

Certain galvanising processes result in a porous zinc layer, which may cause gassing, and pin holing during subsequent coating operations. Pin holing in coated, galvanised steel is a random occurrence and the production process that overcomes the phenomenon - the substrate is degassed (by heating) prior to coating - varies according to the colour of coating.

Organic coating may be applied in liquid or powder form. In both cases the coating consists of a resin binder, which makes up the bulk of the coating and determines its properties, and a pigment, which gives colour and may affect properties of the coating by absorbing or reflecting ultra violet light. Liquid applied coatings require a carrier, which is usually a volatile solvent and the coated articles pass through an oven to cure the coating. Powder may contain additives to improve properties. Powder is sprayed on and initially adheres by electrostatic attraction. Coated articles then pass through an oven where the powder particles fuse to form a coherent coating bonded to the substrate.

The most economical method of application is coil coating prior to forming of components however this requires a coating which is sufficiently flexible to withstand the stresses of forming and is clearly not suitable for aluminium extrusions. It is also unsuitable where small quantities are required or where exposed cut ends are not acceptable aesthetically or due to the risk of corrosion.

Performance requirements

To give satisfactory performance, a coating should be resistant to mechanical damage and the environment. Mechanical damage is most likely to occur during construction but may occur in service, particularly at ground level. The main environmental factors to be considered are the effects of ultraviolet radiation and pollution.

Ultraviolet radiation may cause loss of gloss, chalking and fading of colour. Chalking results in the gradual breakdown of the coating and hence loss of thickness. Use of an ultra violet stable binder reduces the rate of deterioration. The deterioration as a result of exposure to ultraviolet will be greater in warm moist conditions.

Ultra violet can also cause breakdown of the primer if it is not adequately protected by the finish. For example PVDF which is used as a binder in some coatings is transparent to ultra violet and pigments must be chosen to inhibit transmission of ultra violet.

Pollution, particularly acids resulting from sulfur dioxide, can attack pigments causing colour changes and may cause corrosion of the underlying metal if there are breaks in the coating.

For sheet cladding the performance of the coating on the back of the sheet needs to be considered in addition to that on the exposed face. Deterioration of the reverse side may require replacement of the sheeting, as repainting is unlikely to be possible. The

selection of a durable coating for the reverse side of the cladding may limit the available coating types and colours for the exposed face.

The only totally satisfactory means of determining the performance of a coating is by examining its performance in service. However, the time involved makes this impractical and laboratory tests have been devised to assess performance in terms of film thickness, adhesion, hardness, impact resistance, permeability and resistance to alkali/acid/salt spray, artificial/natural weathering, humidity and sulphur dioxide.

Powder coatings should comply with the performance requirements of BS 6496 and 6497 for aluminium and steel components respectively. Liquid applied coatings for aluminium should comply with BS 4842 or AAMA 605.2-90. BS EN 10169 covers coil coating of steel.

A coating's properties are only as good as the quality of the pre-treatment and application processes. Most coating failures are due to poor/incorrect pre-treatment. Curing is the most important coating application process in terms of durability. Excessive thickness caused by poor production control increases the risk of the coating being under-cured and brittle, and thus prone to cracking and/or detachment on flexible backgrounds.

Coating types

The predominant organic finish for windows and curtain walling is polyester powder coating however a range of wet-applied finishes is widely used for cladding panels. The range of finishes for external use is described below.

Polyester powder

Polyester powder coatings are applied, to both galvanised steel and aluminium alloy, and are available in the widest range of colours.

This form of coating is suitable for window frames, aluminium extrusions and cladding panels. For profiled sheeting the coating is normally applied after fabrication so there are no unprotected cut edges and treatment of smaller quantities is more economical than when coil coating is used. Recent developments allow powder coating of coil.

Polyester powder coatings are tough and abrasion resistant. Different performance grades are available with some claiming lives of more than 30 years for both galvanised steel and aluminium.

PVDF

PVDF (PVF^2) may be applied by roller to galvanised steel and aluminium coil or spray applied to completed components. It is extremely durable but relatively easily scratched and abraded. The range of colours is also limited due to the need to select pigments that reduce transmission of ultra violet. PVDF coatings on galvanised steel are claimed to have a life to first maintenance of 10 years in coastal regions and 15 years inland. For aluminium substrates a decorative life of 20 years and an ultimate life of more than 30 years are claimed.

PVC

PVC plastisol is applied by roller to galvanised steel coil and usually has a 'leathergrained' finish, as it is difficult to apply with a smooth finish. It is usually applied in thicknesses of 100 to 200 μm which is much greater than other coatings.

Because of its thickness, it possesses good resistance to impact and abrasion and provides good corrosion protection to the steel substrate. It is easily damaged by temperatures greater than 70°C.

The leathergrain texture increases dirt retention and periodic washing is recommended. Life to first maintenance varies from 10 to 30 years depending on colour, environment and the orientation of the façade with respect to the sun.

Alkyd amino

Aluminium cladding panels are available with an alkyd-amino based coating. It is applied in liquid form by spray after forming the panels and therefore gives the same advantages as powder coating with regard to batch size and avoiding uncoated cut surfaces.

It is applied in thicknesses of 25 to 50μm and has an expected life of 30 years.

Polyester

Liquid applied polyester coatings are used for coil coating aluminium and galvanised steel. Polyester coatings are cheaper than those described above but are not so durable. Life to first maintenance for steel substrates is 5 years while on aluminium a decorative life of 10 years is claimed.

Addition of polyamide gives a coating with improved performance in terms of resistance to both ultra violet light and abrasion. A coating of this form known as

'abrasion resistant' is used on aluminium coil and has a claimed decorative life of 15 years.

Polyester may also be modified by the addition of silicone to give improved performance and is available as a coating for galvanised steel coil.

Vitreous enamel

Vitreous enamel finishes are available for cladding panels but are much less common than organic finishes. Vitreous enamel is a borosilicate glass, which may be used to form a decorative and protective coating to steel panels, the protection being a result of excluding air and water from the surface.

The enamel is manufactured in the form of fine particles known as 'frit'. The frit is mixed into a paste, which is applied to the panel, which is then heated in a furnace to approximately 800°C to fuse the enamel and bond it to the steel. Most processes require a ground coat 75 to 150 microns thick with a cover coat of 100 to 150 microns.

The enamel produces a hard durable and abrasion resistant surface although it is somewhat brittle. However in the event of damage, corrosion tends to remain localised. The finish will stand bending to form gently curved panels but sharp corners must be formed before coating. Vitreous enamel coatings have been used throughout the century and early examples are still to be seen on old railway and underground signs. Subject to panels not being damaged, vitreous enamel can be expected to have a life expectancy well in excess of 50 years.

Anodising

Anodising is an electrolytic process that produces a dense, hard and durable oxide layer on the surface of aluminium. The oxide layer is porous and must be sealed to prevent staining and can be coloured by introducing dyes or chemical treatment before sealing. Although the range of colours is less than for organic coatings they are more stable.

The finished appearance will be affected by the surface quality prior to treatment. For extrusions, 6063 alloy has a fine grain structure and is particularly suitable for anodising. J57S, which is a proprietary form of 5005 alloy with improved properties, is recommended where anodised sheet is required. An anodic film is integral with the metal (rather than a coating applied onto its surface) and therefore immune to loss of adhesion. Important properties of anodic films are thickness, sealing quality and surface hardness.

A film that is too thin will allow corrosion and pitting. BS 3987 requires an average film thickness of 25 microns however the AASC specification requires a minimum thickness of 25 microns and a maximum of 35microns. This is higher than standards in Continental Europe where environmental conditions are less corrosive. A film that is too thick tends to be soft and is therefore more likely to turn white when exposed to the atmosphere because of its diminished resistance to surface degradation. The seal quality is a measure of the resistance of the anodic film to staining and corrosion. A poorly sealed film enables contaminants to enter the pores and cause staining.

Anodised finishes are generally harder and more abrasion resistant than organic coatings. However, coloured anodised films, particularly those that are coloured with a tin electrolyte (due to its acidity), can be soft and more likely to degrade due to weathering; the specification should contain a clause excluding the use of tin. European anodising plants do not carry out abrasion testing on production material which is a matter of concern in the UK. Temperature increases caused by inadequate refrigeration in the plant can also cause softening of the film.

Durability of anodised finishes is superior to organic coatings with an expected life of 50 years or more. However, anodised finishes are susceptible to alkali corrosion from contact with fresh concrete or mortar and rainwater runoff from concrete surfaces. The use of copper-containing screws must be avoided, as should design details that allow contact with rainwater runoff contaminated with, copper or lead.

Anodic films should be finished in accordance to BS 3987 and *Guide to good practice for facades* (CWCT, 1996).

Design

Sheltered areas (e.g. eaves overhangs, soffits and upper areas of walls) can create surfaces that are almost always wet since the lack of rain-washing allows dirt and other contaminants to accumulate on the surface of the coating, retaining moisture and producing ideal conditions for corrosion. Coatings in areas that are more exposed to the weather (i.e. regularly washed by rainwater) usually perform better in terms of durability, but may be more vulnerable to fading, erosion etc. Good design

allows for inspection, cleaning, repair and replacement of the finished metal.

Guarantees

A paint manufacturer's guarantee only covers performance of the paint, for example its weathering characteristics in terms of film integrity, colour retention, chalking resistance, gloss retention and erosion resistance. However, since paint mainly fails by separating from the base metal - often because of defective pre-treatment - it should be protected against such an occurrence by an applicator's guarantee. Guarantees on application and paint performance are given by UK and continental European applicators.

Quality assurance

Use of applicators who are covered by quality assurance schemes is desirable. Quality assurance schemes include BS EN ISO 9000, which is a general scheme applicable to all products, Qualicoat and GSB, which are schemes for coatings, and Qualanod, which covers anodising. Both Qualicoat and Qualanod are widely adopted in Europe and GSB operates in Germany. UK practice has tended to rely on the use of Approved Applicators controlled by material suppliers.

Independent testing

The metal finish specification can require an independent acceptance inspection laboratory to check the finish based on the sampling procedures of BS 6001. Inspections should be carried out at the finishing company because if the finish is rejected, the problem is more easily rectified than when the fabricator has formed the end product. This procedure also avoids fabricators paying for defective finishes.

Installation

The finishes described in this Technical Note are factory applied before delivery to site and are therefore susceptible to damage during delivery and installation. Protective tapes and films may be used to reduce the risk of damage and should be removed carefully to avoid stripping the finish.

While coated surfaces are more resistant to alkalis than are anodised surfaces, they are less hard, and can therefore be damaged by the mechanical removal of dried mortar splashes, plaster etc. Light scratches where the metal has not been exposed may be removed by polishing. Small areas of minor damage/scratches that penetrate to the substrate can be remedied with air-drying touch-up paint (e.g. two-part polyurethane or alkyd), although it will weather differently to the stoved coating. Major coating damage requires re-application away from site or replacement of the complete component.

Unprotected cut edges and drill holes will lead to corrosion. This is a significant cause of deterioration for galvanised steel cladding but unlikely to be a problem for aluminium, except in extreme conditions. It is recommended that cut edges on galvanised sheets are protected but this is not always carried out.

With application defects, the programme of remedial work will depend on the extent of the problem: is the entire facade affected or just one or two components? This can only be assessed by a properly equipped independent laboratory.

Maintenance

To preserve the decorative and protective properties of any metal finishing, it is essential that atmospheric deposits are removed at frequent intervals. The frequency of cleaning depends on:

- Geographical location;
- Local environment;
- Level of atmospheric pollution;
- Prevailing wind;
- Degree of protection from nearby buildings;
- Air-borne debris.

It is particularly important to remove deposits regularly from surfaces that are not exposed to the washing effects of the rain. The manufacturer should be consulted for the correct maintenance procedures; guidance on the care and maintenance of finishes is also given in Appendices A and B of BS 6496/7 for polyester powder coatings and Appendix E of BS 3987 for anodising.

Paints are available for repainting surfaces with organic finishes. These paints will have a shorter life than the original factory applied coatings (typically about 10 years) and in some cases it may be more cost effective to replace the cladding.

Summary

The architect/specifier should consider the metal finishing options available and seek advice on applicators and materials early in the design process. Five steps should be followed:

- Choose the metal finish most appropriate to the particular application. The performance of alternative systems should be understood and compared, taking account of cost implications and the required design life.
- Use a fully detailed, complete specification in the tender document (for example those published by the Architectural Advisory Service Centre (AASC)).
- Choose a reputable applicator, preferably covered by a quality assurance scheme.
- Ensure what is provided complies exactly with what was paid for - by independent acceptance inspection for example - before practical completion certificates or final accounts are signed.
- Provide the building owner with details of maintenance requirements.

Glossary

RAL - Reichs-Ausschuβ für Lieferbedingungen (in 1980 changed to Deutshes Institut für Gütesicherung und Kennzeichung e.V.) - German Institute for Quality Assurance and Labelling.

PVDF - Polyvinylidene Fluoride

PVC - Poly-Vinyl-Chloride

AAMA - Architectural Aluminium Manufacturers Association

NCS - Natural Colour System

References and bibliography

AAMA 605 *Voluntary Specification for high performance organic coating on architectural aluminium extrusions and panels,* American Architectural Manufacturers Association.

AASC *Metal Finishing Specifications,* Architectural Advisory Service Centre.

BS 3987, 1991, *Specification for Anodic oxidation on wrought aluminium for external architectural applications,* British Standards Institution.

BS 4842, 1994, *Specification for liquid organic coatings for application to aluminium alloy extrusions, sheet and preformed sections for external architectural purposes, and for the finish on aluminium alloy extrusions, sheet and preformed sections coated with liquid organic coatings,* British Standards Institution.

BS 6496, 1984, *Specification for powder organic coatings for application and stoving to aluminium alloy extrusions, sheet and preformed sections for external architectural purposes, and for the finish on aluminium alloy extrusions, sheet and preformed sections coated with powder organic coating,* British Standards Institution.

BS 6497, 1984, *Specification for powder organic coatings for application and stoving to hot-dip galvanised hot-rolled steel sections and preformed steel sheet for windows and associated external architectural purposes, and for the finish on galvanized steel sections and preformed sheet coated with powder organic coatings*, British Standards Institution.

BS EN 10169, *Continuously organic coated (coil coated) steel flat products,* Part 1, 1997*, General information (definitions, materials, tolerances, test methods)* British Standards Institution.

CWCT, 1996, *Guide to good practice for facades,* Centre for Window and Cladding Technology, University of Bath.

AFA, 1999, *Finishing aluminium. A guide for architects,* Aluminium Finishing Association.

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