Choosing the Right Prepainted Metal Product

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1. An introduction to prepainted metal

Prepainted metal is a high-quality product manufactured under strict quality control in the coil coating process. The main substrates for prepainted metal are steel and aluminium strip and these are usually coated with a liquid paint by roller-coating, although sometimes a pre-formed film is laminated to the surface and occasionally a powder-paint is applied.

A prepainted metal product is a synergistic combination of the metal substrate, a metallic coating which may be applied to the substrate, an efficient cleaning and chemical conversion process and usually two, but sometimes up to four, different paint coatings. The coil coating process allows different coatings to be used on the two sides of the metal strip, so creating unlimited combinations for the final product.

Each producer of prepainted metal offers their own, sometimes branded, selection of prepainted metal products. It is beyond the scope of ECCA to compare all of these products, but this document is a guide to the main product types, together with their advantages and disadvantages and their main end-use applications.

Prepainted Metal as a System:

The superior quality of prepainted metal compared to traditional post-coated metal is due to two key factors:

- The uniformity of cleaning, pre-treatment and coating afforded by the highly controlled coil coating process;
- The synergistic nature of the different coating layers that make up a prepainted metal product – they are designed to provide the optimum corrosion protection, surface appearance and durability.

A prepainted metal product is a combination of several layers, as shown in Figure 1.

It is the combination of these layers which provides the final properties of the prepainted metal product; these can range from high-surface quality white products for the domestic appliance market to brightly coloured, long-lasting products for construction applications. Prepainted metal products are generally referred to by their topcoat and while the focus of this document is mainly on the varieties of topcoat, it is important to remember that the other layers also contribute to the final product performance.

The choice of metal substrate and, to a lesser extent, any metallic coating, is generally one for the customer, but usually the pre-treatment and primer will be selected by the coil coater to be the most appropriate for a given combination of topcoat and substrate. Very often, the topcoat is only specified on one side, with the back-side having a simple, low-cost topcoat. However, the back-side topcoat can also be selected, depending on the end-use requirements, to give improved appearance, increased performance, additional functionality or reduced cost.

The coating thickness is usually quoted for the combination of top-coat and primer. In most products, the primer is a thin layer, typically 4 µm thick, and the majority of the coating is provided by the top-coat.

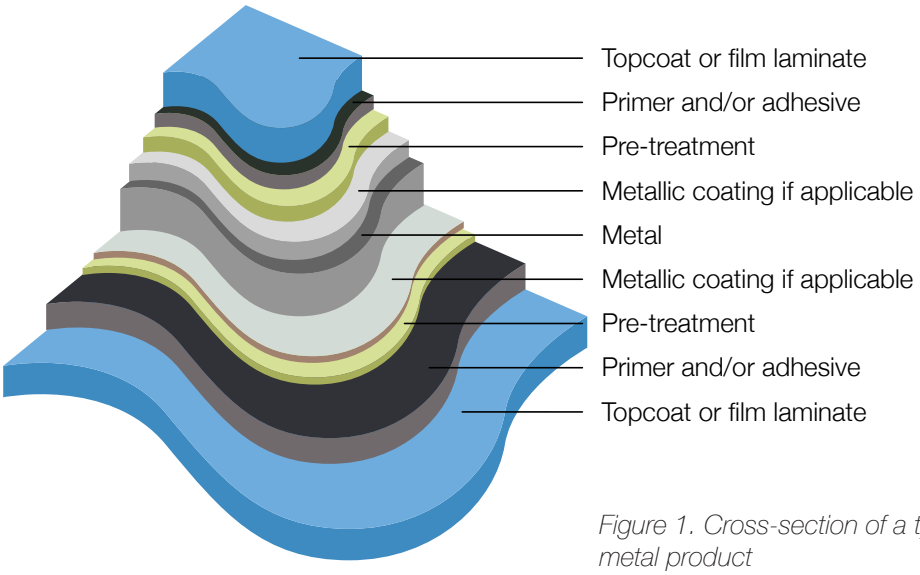


Figure 1. Cross-section of a typical prepainted metal product

However, there are products where a much thicker primer can be used, such as the high-build polyurethanes, where the primer can be up to half of the total thickness of the organic layer. For multi-coat systems, such as 3- or 4-coat PVDF, the total thickness including primer and 2 or 3 top-coats is usually quoted.

There are three main categories of top-coat:

- Liquid paint
- Film
- Powder paint

Over 90% of prepainted metal uses liquid paint, the following sections describe what makes up a liquid paint and what differentiates one paint from another. Films and powder paints are covered later in the document.

What is Paint?

Liquid paints account for more than 90% of the coatings used for prepainted metal. Liquid paints are made up of four main constituents:

- Pigments
- Binders
- Solvents
- Additives

The solvent is used as a delivery medium, allowing the paint to flow and so give a smooth wet film before drying and curing. The solvents are not incorporated into the finished product. The performance and appearance of the finished product is a combination of the binder, pigments and additives; coatings are usually categorised by the type of binder used in the coating.

The binder is a polymeric material which gives structure to the paint. The main types of polymeric binders used for coil coating paints are:

- Polyester
- Polyurethane
- Polyvinylidene fluoride (PVDF)
- PVC (plastisol)
- PTFE

Classifying coil coatings into these five main categories presents a much-simplified view, since there are many variations between coatings within each category and there are some coating types which fall outside of these categories. This document reviews these main categories in detail and discusses the different variations.

Pigments used in coil coatings are generally inorganic and they provide both colour and certain physical properties such as corrosion protection. Meanwhile, various additives are included in the paint formulation to modify aspects such as paint flow, speed of curing, UV absorption and gloss.

2. What to Expect from Prepainted Metal?

Before discussing the various coating types that are available for prepainted metal, it is important to understand the requirements which can be placed upon different prepainted metal products and how they can be best served by different products.

The requirements for a prepainted metal product are usually defined by the end use application.

Before choosing a product, it is worthwhile answering the following questions:

- How severe will the forming operation be?
- How long do I expect the product to last?
- Will the product be exposed to outdoor weathering, e.g. sun, rain and pollutants?
- Will the product be susceptible to scratching, either in manufacture or in the end use?
- Are there any special requirements for the product, e.g. temperature or chemical resistance?
- What visual appearance do I want (e.g. smooth or textured; gloss or matt)?

The answers to these questions will help in defining the performance that is required from the product; this must then to be balanced against the product cost.

The basic premise of a prepainted metal is that the finished coating is present before forming the final article. For this reason, coatings require a good degree of flexibility and scratch resistance to ensure that the coating on the finished article meets the market requirements. There has traditionally been a trade-off between the flexibility and hardness of a coating. This is still true, but in many cases, modern prepainted metal products can give a very flexible coating, capable of severe forming, while retaining a good degree of hardness and resistance to marking.

In terms of in-service performance, the demands on a prepainted metal are much the same as on any other metal coating – to look good and to continue to look good for the life of the product, while protecting the metal substrate. In some cases, this means a resistance to fading in UV light or to assist in protecting the metal substrate from corrosion, while in others, it might be about resistance to chemical attack or high temperatures.

All of these properties are available in prepainted metal products, but of course, improved performance will come at a cost, so it is important to specify a product which meets the requirements which are important in each application without over-specifying an expensive product.

3. Polyester Products

The term polyester describes a family of chemicals which can be used as the basis for paints as well as many other plastics. Polyester binders are by far the most popular for coil coating. However, different polyester binders can provide very different functionalities to the final paint coating and a polyester used for cladding products would require a different specification to one designed for consumer products.

Polyesters can be made from a wide variety of acids and alcohols to produce a large choice of resins with different properties. To produce a polyester coating, the polyester resin is cross-linked with a melamine formaldehyde resin. The ratio of solid resin to cross-linker is usually between 70:30 and 90:10 with higher melamine contents giving a harder surface, but poorer flexibility.

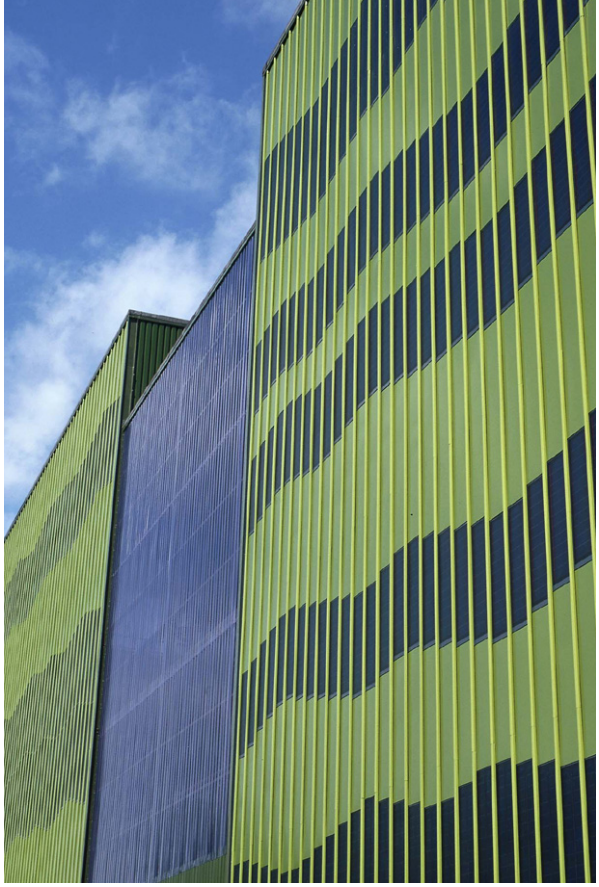


Image courtesy of ThyssenKrupp Steel

Typical properties

Polyesters coatings are used in the majority of prepainted metal products. At their most basic, polyesters can offer an economical product with reasonable corrosion and aesthetic performance. A standard polyester product would have a 20 – 25 µm coating with limited flexibility and moderate durability when exposed as the top-weathering surface. Modifications can be made which can improve the flexibility, although there is usually a penalty in hardness.

Basic polyesters have only moderate resistance to the effects of UV light and provide a basic barrier coat to help prevent corrosion of the substrate. For the basic product, resistance to chemicals, staining or dirt is moderate, but modifications are possible which improve each of these.

Modifications

As the most widely used prepainted metal product, there are many variations of the standard polyester. Thicker polyester coatings up to 60 µm are used to provide extra durability in some outdoor applications, while thinner polyester coatings are used where cost is important, or to provide a basic backing coat.

Modifications in the chemistry of the polyester binder and in the additives can provide virtually any desirable property in a polyester coating. A sub-class of products often referred to as "Highly durable polyesters" have improved formulations which have a significantly increased durability, particularly in resistance to UV degradation.

Polyesters usually present a smooth surface, but with either the addition of polyamide particles (sometimes referred to as polyamide-polyester) or with a structured base layer, textured surfaces are also available. Apart from the obvious aesthetic benefits, these textured products are often highly scratch resistant.

Uses

Polyesters are used for both internal and exterior products, but the exact specification of each is tailored to the particular application.

As an exterior product, basic polyesters are used for both wall and roof cladding on buildings, particularly in mild and dry climates. This represents the most economical choice for such building applications, although the durability can be somewhat limited. Highly durable polyesters and higher-build systems are widely used where a greater durability is required. Apart from wall and roof cladding, polyesters are used for most other external applications of prepainted metal, again subject to their limitations in durability.

Polyester coatings are the basis of most internal applications of prepainted metal. Very often the coatings can be the same as the basic exterior polyesters, but many variations are used. Many indoor applications are subject to greater scrutiny than exterior applications, so high quality aesthetics are important, often coupled with good formability for forming into specific parts and a high degree of scratch resistance. All of these properties can be available in polyester coatings which are used in highly decorative applications such as the front panels of electronic appliances and for more functional applications such as ducting.

4. Polyurethane Products

Polyurethane coatings are chemically similar to polyesters and exhibit many of the same properties as polyesters. The polyurethane cross-linking gives improved durability and colour retention.

Typical properties

Compared to polyesters, polyurethanes can produce thicker coatings and so where durability is important, high-build polyurethane coatings are finding increasing use. These thicker versions also offer improved corrosion resistance to the metal substrate.

Polyurethanes are capable of high levels of flexibility which is often desirable for prepainted metal applications and they also tend to be more scratch-resistant than polyesters. However, polyurethanes do generally cost more than basic polyesters.

Modifications

Modifying the isocyanate level in the polyurethane can provide a highly flexible product, while modifying the type of isocyanate can provide very good resistance to UV light.

Basic polyurethanes are available with a thickness of around 20 – 25 µm, but thicker products of 50 µm or even 60 µm are commonly produced, often with a high-build primer (up to 30 µm) which can help to give very good corrosion resistance for outdoor exposure.

Particularly with the thicker polyurethane coatings, polyamide beads are often incorporated which provide a textured surface and a very high level of scratch resistance. This is important in some interior products with high aesthetic demands, but also in exterior products where scratching of building panels, for example during construction, can cause long-term corrosion problems.

Uses

Polyurethane coatings generally cost slightly more than polyesters, so they are used where the benefits outweigh the cost difference. The high-build products are widely used in roof and wall cladding because of their improved corrosion and UV resistance, coupled with the scratch-resistant properties of the polyamide-modified varieties.

The other important property of polyurethanes is the improvement in the flexibility/ scratch-resistance balance, so for premium interior products such as many domestic appliance applications, they have become a much-favoured option.

5. Polyvinylidene Fluoride (PVDF) Products

PVDF is a highly stable resin which is not cured in the paint in the same way as polyesters, but it is fused in the paint layer, creating a so-called thermoplastic coating. Unlike most polymers, the PVDF resin is not affected by UV radiation, so it remains very stable for long periods in sunlight.

Typical Properties

PVDF products tend to have coatings in the thickness range of 25 µm to 28 µm, although multi-layer systems can have higher thicknesses up to 55 µm. Unlike polyurethanes, high-build PVDF is made up of up to 4 layers of paint rather than the usual two.

PVDF is not susceptible to attack by UV light, so the resin does not break down on exposure to sunlight, unlike virtually all other polymers. This gives a very high resistance to fading and chalking, and a very good long-term maintenance of gloss and colour.

There is a drawback to the UV resistance in that the UV light can then travel through the resin and attack the primer. As this breaks down, there is potential for a loss of intercoat adhesion and the PVDF layer can delaminate. For this reason, the choice of pigmentation for PVDF coatings is very important since the pigments are required to absorb UV light and protect the primer. Ceramic blue, green and black pigments should not be used on their own because they permit the passage of UV. As a result, the colour palette in PVDF can be limited. This can be overcome in high-build systems where either a pigmented base coat or a clear, UV-absorbing top-coat can be used, but the additional coating layers can add considerably to the cost.

Apart from being resistant to UV light, the PVDF resin is also highly resistant to many chemicals and it can have excellent stain resistance. PVDF coatings tend to be slightly more flexible than basic polyesters, but their resistance to damage from scratching

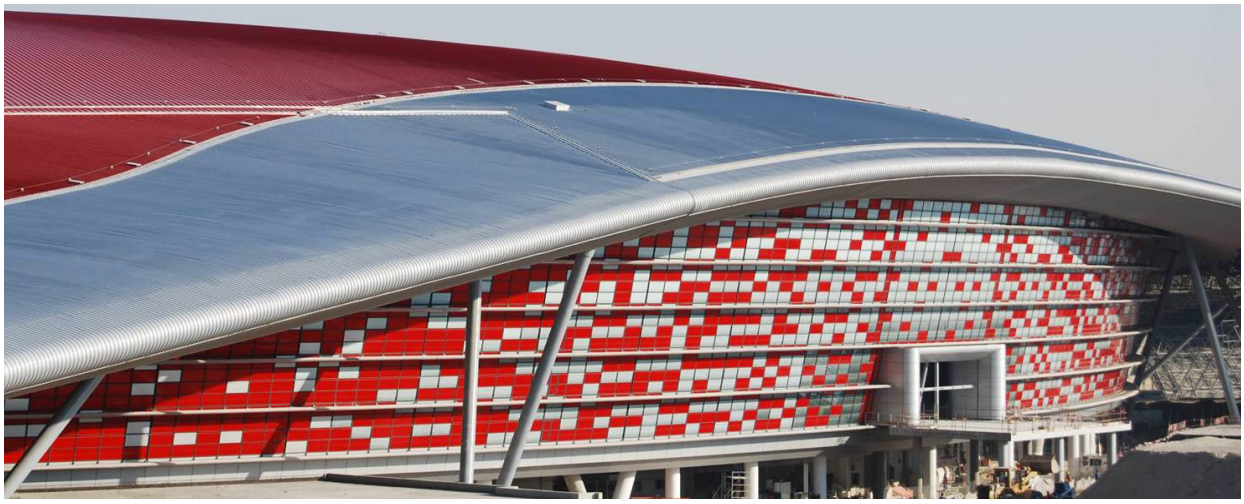


Image courtesy of Euramax Coated Products

is limited and they provide no additional corrosion protection to the metal substrate. They also tend to be more expensive than most other coating systems.

Modifications

There are different standards of PVDF resin available notably 80:20 and 70:30, the latter being the most commonly used for prepainted metal as it provides the optimum balance of performance across a range of factors and importantly for prepainted metal, the optimum flexibility.

As discussed above, multi-layer PVDF products are available. In some cases, this is used to ensure UV stability for specific colours, but it can also be used to ensure the richness of particularly bright colours or a high-gloss finish, or to provide additional robustness to the product.

As a premium building product, PVDF is often modified to provide additional functionality. An example of this is anti-dirt coatings where the exterior surface of the PVDF product will be modified to prevent the retention of dirt. In a similar way, anti-graffiti coatings can be applied to the outer surface which allow any graffiti to be easily cleaned away.

Uses

In Europe, PVDF is almost exclusively used for external wall cladding and facades. PVDF attracts a cost premium over polyester, to which the initial appearance is similar, so it is used where the long-term colour durability will be appreciated, particularly for cladding and facades on prestigious buildings.

6. Plastisols

Plastisols are high-build thermoplastic coatings based on polyvinylchloride (PVC). Plastisol coatings are dispersions of PVC resin and pigments in a plasticiser which is fused, rather than cured, in the coating process. Once cooled, the resulting film is tough and flexible. Before fully cooled, a pattern is usually embossed in the thick plastisol coating. This is very often a "leather-grain" type pattern, but other patterns are possible.

The plasticiser type and content affect the flexibility and often mixtures of plasticisers are used. Traditionally, phthalate plasticisers were used, but these have now been mostly eliminated from the coil coating industry in favour of more environmentally friendly alternatives.



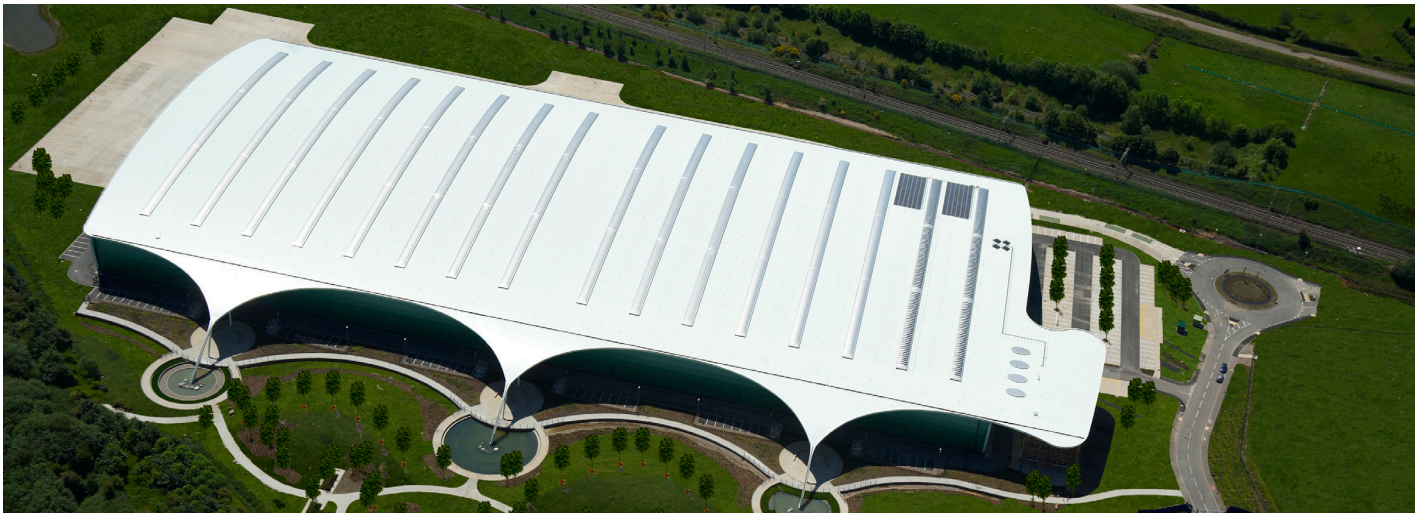
Typical Properties

Plastisols are very different to most other coil coatings in that they are thick film coatings, typically 200 µm thick, although products from 100 µm to 300 µm can be available. This thick film is very robust, giving excellent abrasion resistance. The thickness of this film also provides an element of corrosion protection to the metal substrate which is not possible with thinner coatings.

Although the coating is very thick, the thermoplastic nature means that forming stresses are very low, so plastisol products tend to be highly flexible with little thinning in formed areas.

Traditionally, plastisols have suffered from being very susceptible to colour-fade, chalking and gloss reduction. However, recent developments in plasticisers and stabilisers have mostly eliminated these problems and plastisols can now compete well on colour stability.

The thick plastisol coating gives a good barrier against weathering, but it can be susceptible to chemical attack, particularly from solvents. Being thermoplastic, the coating is also affected by high temperatures and should not be used at constant temperatures above 80 °C. Plastisols tend to also cost slightly more than basic products too.



Modifications

There are now different grades of plastisol available, the more advanced formulations are very stable in exterior applications and have very long guarantees for durability and appearance.

One of the properties of plastisol is the embossed surface and different embossing patterns are available. The typical emboss is a leather-grain, but more subtle random patterns are available, and some manufacturers are also producing plastisols with a more regular, dimpled-type emboss.

Uses

As for PVDF, plastisols tend to be a bit more costly than polyesters, so they are used where their benefits provide value to the end user. The additional corrosion protection provided by the thick coating is particularly beneficial in roofing where rain-water run-off can promote corrosion. Plastisols are also favoured for other building applications because their robustness makes damage during the construction phase less likely than for other thinner coatings.

While the main use for plastisols is in buildings, they are also sometimes used where abrasion resistance is important, for example in the casing of industrial equipment.

PTFE

For specialist, high-temperature applications, particularly bakeware, PTFE coatings can be applied by the coil coating process. As for plastisols, these coatings are fused rather than cured and very high oven temperatures are required. These coatings give excellent non-stick properties for bakeware, which can be formed from prepainted metal.

7. Powder Coatings

Powder coatings are usually applied to pre-formed parts, but in some cases, they are also applied to flat strip metal in coil coating lines. Powder coatings are made by grinding solid paint into the appropriately sized particles. The powder once applied to the substrate is heated to fuse together the individual particles and form a continuous paint film.

Powder coating is a dry process, using no solvents, so in principle it could be an environmentally friendly alternative to wet painting. However, for coil coating, powder technology suffers from limitations in speed and in producing thin paint films, both of which make this more expensive than standard coil coating. However, there are applications where powder-coated coil and sheet can be economic.

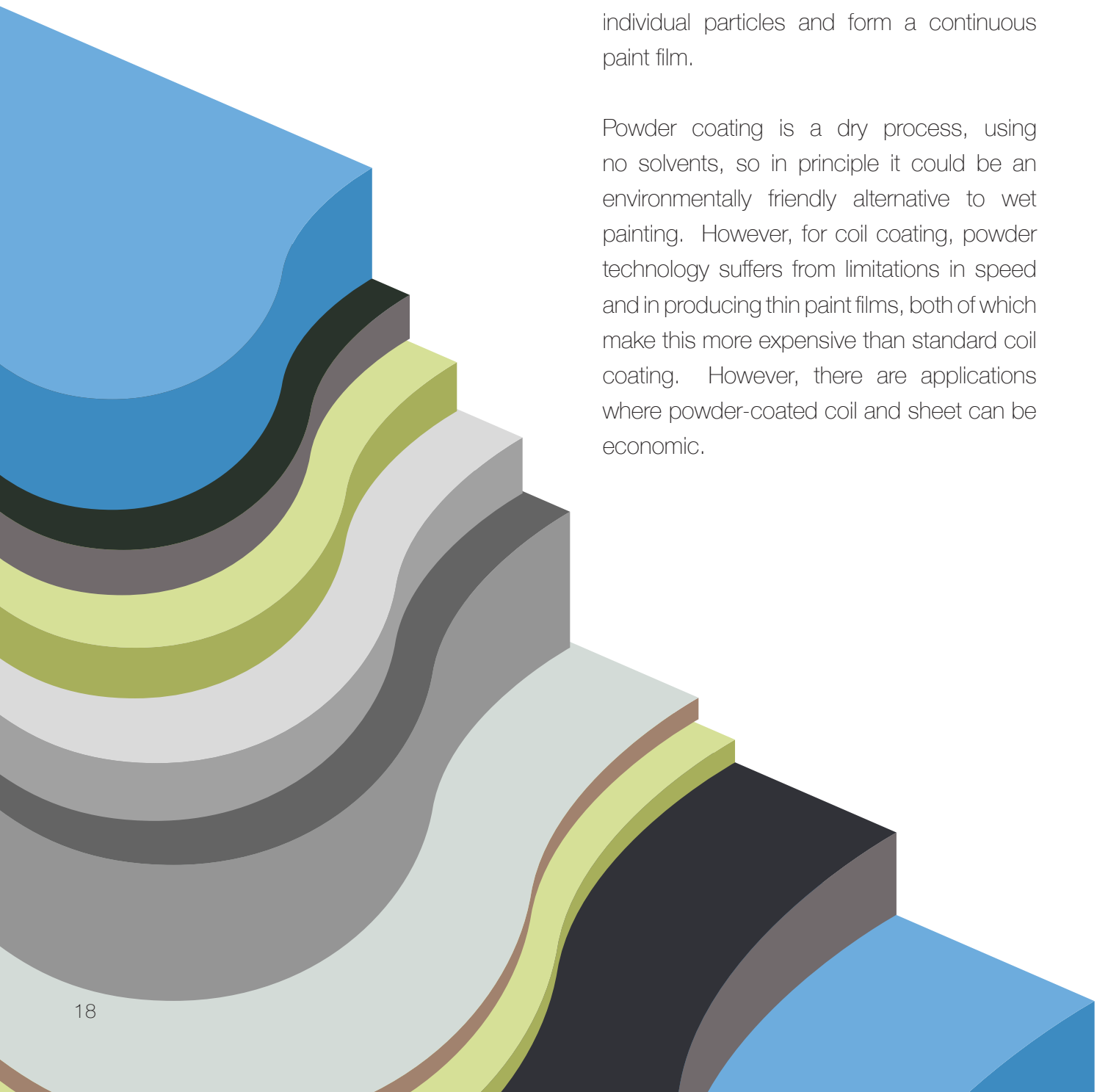




Image courtesy of Novelis

Powder coatings tend to be available in a wide range of colours and finishes in relatively small batch sizes and switching between colours is relatively easy. This is one of the main reasons why some coil coaters use powder paint. Certain surface textures, such as an “orange peel” type effect are readily achievable in powder paints, but much more difficult in coil coatings, so for specialist applications where this texture is required, powder coated coil and sheet is generally used.

In the long term, it may be that application technology will improve to the point where powder paint is cost competitive with standard coil coating, but for now, this is still a niche in the coil coating industry.

8. Laminate Films

In some cases, the surface properties required from prepainted metal are best produced off-line as a stand-alone film, which can be laminated onto the metal strip. Such products are called laminated film products. Typically, an adhesive is applied to the strip using the top-coat roller coater and the film is applied while this is still hot.

There are four main film types of laminate used: polyvinyl chloride (PVC), polyvinyl fluoride, thermoplastic acrylics and polyethylene terephthalate (PET). Their advantages include high flexibility and suitability for deep drawing, while they can also have very high gloss and good hardness.

Certain films have a primarily exterior role (resistant to rain, sun, heat, etc.) while others are resistant to fire, stains, abrasions or aggressive chemicals. These properties make laminated film products widely used in electrical appliances, furniture, clean-rooms, cold stores and ship-building.

For specific appearances, laminated films are available with printed patterns or with embossed textures.

PET films (Co-Laminates)

PET (polyethylene terephthalate) films are typically supplied clear and are hot-laminated onto the last paint layer on coil coating lines. Products obtained by this method are referred to as co-laminates, being both painted and laminated. They meet the technical requirements of domestic appliance manufacturers such as high flexibility, hardness (scratch resistance), no cracking during processing, chemical resistance (aggressive environments, detergents, solvents, etc.), anti-graffiti, foodsafe certification and fire resistance.

PET films can also be made available in colours such as those seen inside baby food cans or the bottom of aerosol cans. These are different to conventional co-laminates in that they do not use a base layer of paint to obtain colour but rather have the colour built directly into the PET layer.

Appliances like refrigerators and freezers are the most important industrial applications for co-laminates. A multitude of colours can be obtained by modifying the underlying paint colour. Both smooth or structured surface appearances, coloured or transparent films are available.

9. Substrate

Usually the main consideration in choosing a prepainted metal product is the nature of the organic coating. However, the underlying substrate is a fundamental part of the product. The first and most obvious distinction is what type of metal to use. Most prepainted metal uses either steel or aluminium, although other metals such as copper or zinc can be available with a prepainted coated surface.

In both steel and aluminium, there are various grades available which can give either greater strength or improved formability, as well as variations in resistance to corrosion.

With steel substrates, most prepainted metal products also use a metallic coating to improve corrosion resistance. This is not always the case and for some applications where corrosion resistance is not critical (e.g. dry indoor applications) the paint coatings can be applied directly to untreated, cold reduced steel.

The most common metallic coating for steel is a thin zinc layer produced by hot-dip galvanising. The zinc acts as a sacrificial corrosion protection layer, corroding slowly in preference to the steel. Some variations of the galvanising layer are also available, based on alloy combinations of zinc, aluminium, and magnesium. These different metallic coatings can further improve the corrosion resistance of the prepainted metal.

When using aluminium, the exact alloy can have a significant impact on the corrosion resistance, so it is wise to take advice on this early in the selection process. In the coil coating process, the steel or aluminium strip is efficiently cleaned and pre-treated which again helps to improve paint adhesion and corrosion resistance.

Image courtesy of Euramax Coated Products



10. Which Prepainted Metal Product to Use

To summarise, the answer to the question of which product to use depends very much on the combination of factors which are expected in the end use application. Although there are only five main coating types, there are so many variants within these that virtually any required combination of properties is available, at a price.

Some products have very specific uses, such as PVDF which is used where colour fastness is very important, for example on the facades of prestigious buildings, or plastisol which is very robust and helps prevent corrosion damage, particularly in coastal regions. However, even these products are often put to other uses and the plethora of variations of polyurethane and in particular polyester make generalisations impossible.

The descriptions given here should give a brief guide to what is available and what to expect. The exact product to use should be agreed upon between specifier and supplier and will be based on the requirements of the end product such as:

- Formability
- Durability
- Robustness
- Corrosion protection
- Visual appearance
- Cost
- And any special requirements such as chemical resistance

As discussed, it is important to match the coating to the required metal substrate, which will dictate factors such as formability and corrosion resistance. It is also important to think about the backing coat. For most applications, the reverse side is hidden and not subject to any significant wear, so a simple, thin coating (usually a polyester) can be used. However, there are cases where the backing coat can be equally as important as the top coat and here careful selection can be required.

Whatever product is chosen, prepainted metal has been developed for over 50 years by a combination of metal manufacturers and paint suppliers working together to give the best performing prepainted metal products available.



Image courtesy of Beckers

ECCA Objectives:

- Increasing the awareness of prepainted metal through promoting its environmental, cost, quality and design benefits.
- Stimulating market, application, product and process development
- Setting quality performance standards and developing test methods
- Granting of Quality and Sustainability Labels for prepainted metal on the basis of the technical and sustainability requirements defined in the ECCA Premium® Label manual and based on independent third party control
- Creating an industry network and forum for the development and exchange of ideas
- Representation of the Industry in its contacts with Public Officials, Public Authorities, other Trade Associations and Professional Bodies.

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