Introduction
Painting is the application of a liquid coating to a material to protect it. It is an old technology used for corrosion control and certainly the most recognized method. Without this method the corrosion protection field would not exist. Paint drying is a complex process that is often taken for granted. It involves the application of different mechanisms by which they protect steel. Through reducing the amount of oxygen that can reach the substrate by preventing the conditions that efficiently lead to the breakdown of a metal, metal protective coatings and these also have a positive influence on the environment – belies the reality of the sophisticated technology that is required to do it effectively.

Although protective coatings have been in existence for many years, it was only in the mid 1900’s that the true protection mechanisms of paint coatings were understood. Prior to then, it was thought that paint coatings worked by providing a complete insulator between the protected metal and the environment. In fact, the reality was much more complex and led to improvements in the way paint was used to protect metal, most commonly steel.

It is now known that most paints to a certain extent allow moisture and atmospheric components to travel through them in varying quantities. Rather than being a problem, this property can actually assist in the paint’s corrosion protection of the base metal. Modern protective coatings are highly specialized and have unique characteristics depending on the type of protection required. These modern coatings protect in different ways, are made of different materials and require varied surface preparation and application. Specifiers need to be aware of the different properties available in the large range of protective coatings. Although many different types of metals are protected by painting, this discussion will focus primarily on structural steel.

How Coatings Work
To Protect Metal
There are many different types of protective coatings and these also have different mechanisms by which they protect steel.

Barrier coatings protect the metal substrate by preventing the conditions and factors that cause corrosion from reaching its surface. They can be thought of as insulating the metal from the surrounding environment. For example, in coastal environments, without a protective barrier coating, salt may settle on the surface of the steel and this salt will increase the conductivity of any moisture present. This will facilitate electrochemical transfer between anodic and cathodic sites, thus setting up a corrosion cycle. A correctly specified barrier coating will prevent salt reaching the surface of the steel and therefore inhibit corrosion. Barrier coatings can also work by preventing oxygen from reaching the metal surface. A barrier coating can be thought of as an impermeable filter that excludes the corrosive aspects of the environment from reaching the surface of the metal.

Note that it is practically impossible to produce a paint coating that is impermeable to water vapour and oxygen. However, by limiting or totally excluding the conductive ions and oxygen, key ingredients in the corrosion recipe, the coating can be considered to have performed its function.

Coatings can also work via cathodic protection. This involves the paint coating being loaded with the dust of a more anodic metal than the substrate it’s protecting. So, in the case of steel, this usually involves zinc dust. These zinc dusts are what are commonly termed “zinc rich paints.” There has to be sufficient metallic zinc in the paint to make sure that there is high enough conductivity to enable effective cathodic protection.

Another method by which coatings can protect is to promote passivation of the surface of the substrate metal. These are primers that contain inhibitive pigments. They encourage the formation of a passive film at the interface of the metal and the primer. As the name suggests, they are usually applied directly to the surface of the metal and then provide a stable base for further paint layers.

What are paints made of?
There are many different types of protective coatings, but most are made up of the following:

1. Pigments
2. Binders
3. Solvents
4. Additives

Pigments are particles added to the paint to give it different properties. Despite their name, pigments are not only used for colouring purposes. The main types of pigments are colour pigments, extending or filler pigments and anti-corrosive pigments.

Colour pigments contribute a number of different properties beyond the cosmetic, they also provide opacity. This is known as the “hiding power” of the protective coating. It describes how well the colour of the substrate below the paint is hidden. The higher the opacity, the less the lower colour gets through visually, and it means that less paint can be used if this is an important consideration.

The selection of certain colour pigments will also improve the UV absorption and protective qualities of the final paint coating.

Extending or filler pigments are also added for a variety of reasons. They add viscosity, contribute to the structure of the paint and can also help to reduce the cost.

Anti-corrosive pigments, as their name implies, improve the corrosion protection properties of the paint. They can perform one of two roles: to prevent or retard the progression of corrosion in components through the paint or they can be active pigments, such as zinc, which provide the sacrificial or cathodic protection described above or inhibitive pigments such as zinc phosphate.

The binder is the “body” of the paint. In paints, they are normally loaded with metal pigment, as used in coatings with cathodic protection properties, it is usually the largest solid component and is generally used as the reference name for the medium. Bag acrylic, epoxy, etc. There are many other terms used for the binder and some common ones include plasticizer, vehicle and matrix. The binder is what holds the components of the protective coating together.

Many protective coatings in their liquid state also contain a solvent. The solvent helps to impart flow and enhances the application properties of the paint. It also dissolves the base resin and allows solid components, i.e. the binder, pigments and fillers to be applied as a wet film. The solvent is volatile and does not remain a part of the protective coating after it has dried. Once the paint has been applied, the solvent evaporates or breaks down, leaving behind the dry film of the protective coating. An important property of protective coatings manufacturers is reducing the amount of volatile organic compounds (VOCs) in their products to improve their environmental performance. Some protective coatings have low VOCs at all.

Finally, there are also other additives that are added to protective coatings to impart different qualities to them. These additives can control or improve factors such as viscosity, shelf life, UV resistance, abrasion resistance, drying times and many others.

It is important for designers to realise that protective coatings are sophisticated and that there are many different types used in different systems so various conditions. The general overview above will be expanded upon in further discussions on the specific qualities of different protective coatings under various conditions.

Protective Coatings as a Component of Corrosion Protection Systems
Protective coatings require significant development and are manufactured in many different variations, but ultimately, the only way to be assured of the surface of the metal effectively so that it can protect it. Preparation of the surface is one of the key steps, if not the key step, in the successful adhesion of a protective coating and its subsequent satisfactory performance. Effective surface preparation is so important that there are standards devoted to it, both in Australia and New Zealand, and internationally. In Australia and New Zealand, both the AS1627 series and AS/NZS 2312 provide guidance on surface preparation.

Surface preparation is such an important process that it will be dealt with separately in more detail later, but it is important that designers and specifiers understand that there are many different types of preparation processes and levels depending on the type of paint being used, the substrate to be protected and the conditions under which it has to perform. As with the development of protective coatings, surface preparation has also been researched in recent years, both in terms of ensuring the adhesion of the paint system to the metal and also in its efficacy in corrosion protection. It is no coincidence that protective coatings are described as coating systems since all of the components of surface preparation, paint selection and the system selection combine to make up the overall system.

The Dry Protective Coating
There are two main ways in which a protective coating forms its protective film. There is the non-convertible type of formation, which most closely follows the term “drying” commonly by most paint users, and there is the convertible or “curing” type where the protective coating undergoes a chemical change during its formation into a protective film.

In the non-convertible formation, the paint dries from a liquid to a solid as the solvent evaporates. This is shown in the diagram below.

Examples of non-convertible coatings include chlorinated rubber, vinyl and bituminous paints.

Conversible coatings, as their name implies, go through a number of methods: exposure to air (oxygen), by chemical curing agents, exposure to moisture and by the application of heat to the “wet” coating. Convertible coatings may still contain solvents, but the chemical reaction is the key process. The convertible based coating cure process is shown below.

Common examples of protective coatings that are curred via a conversion process are epoxies, polyurethanes and polyureas.

It will be noted that there are references to WFT and DFT in the figures below. These denote “wet film thickness” and “dry film thickness” respectively.
Durability of Protective Coatings

The durability of protective coatings, like all corrosion protection systems, relies heavily on a number of different factors apart from the coating itself. Design of the steelwork, suitability for the substrate, preparation, application technique and environment are all significant factors in the performance of a protective coating.

The standard that provides a guide to many of these issues is AS/NZS 2312:2002. The standard is titled “Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings.” The standard is indeed a guide: it is by no means definitive. However, it does provide a significant amount of information that is useful to designers and specifiers.

Protective coatings have qualities that mean their life in certain environments varies between different coating types and systems. A more expensive coating may not be required if a maintenance schedule is set up that allows a cheaper coating to be effective. Ultimately, it becomes a consideration of life cycle costs for the assets being protected and what type of maintenance schedule is put in place. A more expensive coating may have a higher initial cost, but this could be offset by the significantly decreased maintenance intervals that are required. Also, the importance of the asset should be considered. If the asset is required to have almost one hundred percent availability and failure or removal from service is not desirable or even not an option, then the extra expense of a more sophisticated protective coating system may be vindicated. There are no hard and fast rules as to the selection of coating systems, but AS/NZS 2312 does provide a guide to coating selection in certain atmospheric corrosivity classifications.

Conclusion

Protective coatings are the oldest and most widespread method of protecting steel structures. They are constantly under development and their sophistication and performance belies their simple appearance to the casual observer. Protective coatings are an ideal method of both protecting steelwork and providing an aesthetic finish.

Further discussion will focus on the different options available to the specifier in selecting protective coatings and also in the preparation and design of steelwork to maximise the performance of their selected coating or coating system.

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