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Coatings for Exterior Metal

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Please note

This Digest is a continuation of **CBD 90**, **CBD 91** that have described coatings for interior walls and exterior wooden parts of buildings. As the composition of underlying surfaces plays a larger part in the selection of exterior coatings than it does for interior finishes, the Digests have been segregated according to substrate.

Metals that may have to be coated for exterior service are commonly used in buildings as structural shapes such as beams and columns, as sheets for cladding, and as railings, pipes and gutters. The ferrous metals, iron and steel, are the most common, followed by galvanized steel and aluminum. Other metals such as copper and its alloys are used in relatively minor proportions.

Design Considerations

Traditionally most structural elements were enclosed within the building so that the metal only required protection while it was exposed before and during construction. More recently, beams and columns have deliberately been placed on the outside. Hence, coating systems that previously were adequate may not be satisfactory for long exposure to the elements.

Design is an important factor in preventing metallic corrosion. It should, therefore, be ensured at an early stage that the design of a building will reduce rather than increase the likelihood of corrosion. Such arrangements as dissimilar metals in contact with each other and horizontal surfaces that retain water should be avoided. In addition, metal parts must be so arranged that if failure does occur they can be repainted properly. Inverted channels are an example of surfaces that are not accessible for future maintenance.

Exposure Conditions

The type of coating system required for use on new metal depends upon two factors: the exposure conditions and the kind of metal. The metal influences the choice of primer; exposure will probably dictate the kind of topcoat needed to resist a particular environment. Naturally, primer and topcoat must be compatible.

In rural areas of Canada where there are no corrosive fumes or in the north most coatings will easily last 10 years. Low temperature is not an important element in degradation of coatings unless they must resist mechanical forces such as impact while very cold. Of all the DBR/NRC exposure sites spaced across Canada, there is the least effect on coatings and uncoated architectural metals at Norman Wells, N.W.T. Marine exposure is a severe one for organic coatings, but this zone occurs only within 500 yards of the beach at sea level, unless there are special local wind or wave conditions. Sites further from salt water or at raised elevations are usually more like rural exposures.

The most corrosive general exposure areas result from a combination of marine or near-marine atmosphere with industrial air pollution. Heavily industrialized cities frequently rank between the above areas and marine sites for rate of attack, especially on certain metals. Chemical plants have very severe localized exposures, and such locations demand coating material with the required chemical resistance, regardless of whether it retains its appearance properties upon weathering.

In recoat work the determining factor is how well the surface can be cleaned and prepared. As discussed in **CBD 76**, coatings made from the more resistant binders generally require better surface preparation because they contain fewer reactive chemical groups, which contribute most to adhesion. In this Digest the severity of exposure and the ease of preparation will be considered together in making recommendations.

Metals, as with many other materials, are most satisfactorily painted in a plant. This does not imply that cheap primers carelessly applied to unclean metal will automatically result in good durability if the application is made in a factory. It does mean that surface preparation can be more thorough and coatings applied under controlled temperatures to the correct film thickness much more readily in a plant than in the field. If all stages are properly carried out, it is possible with factory application to achieve extremely long durability, even under adverse exposure conditions, with the more resistant materials. If any of the important factors are stinted, however, there will be a disproportionate reduction in the life of the system, with the consequent necessity and expense of more frequent repainting in the field. As the cost of coatings is so small compared with the costs of the application and substrate, it is false economy to reduce what is already the smallest expense and risk a much larger increase in over-all cost.

Ferrous Metals. Because iron oxide (or rust) is chemically more stable than iron, the common structural grades of iron and steel corrode readily in most localities unless adequately protected. Steel from the rolling mill is usually covered with an oxide scale called mill scale. In the past this was left on the surface because it was thought to be an extra layer of protection and was difficult to remove by conventional means. Large areas of scale, however, accelerate corrosion of adjacent uncovered areas, and as it is impossible to ensure complete coverage by sound scale the only safe procedure is to remove it all. Another method no longer recommended for preparing steel was to expose bare steel until it was well rusted and then wire brush it to remove loosened mill scale. Numerous studies have shown that this is a very poor method of preparing iron and steel for painting.

The most effective method of preparation, and one that is absolutely essential for the more resistant coating systems, is grit or sand blasting. There are various grades of blasting ranging from light to white metal blasting. When properly carried out the process removes all contaminants and roughens the surface to improve mechanical adhesion. It is necessary, however, to control the profile or degree of roughness. If there are relatively large peaks and valleys, the peaks will only be covered by a thin coating and corrosion will commence here. Blasting must be followed by priming within a few hours or much of the advantage will be lost because the active surface produced is prone to flash rusting. Blasting is not suitable for thin sheets, which are easily warped by pressure. For recoat work blasting naturally has to be carried out in the field.

Pickling in acid and phosphating are other preparatory methods that should be restricted to in-plant use. They are not generally so effective as blasting, but are suitable for less demanding primers. Flame cleaning, i.e. passing a band of oxyacetylene flame over the surface to drive off moisture, dehydrate rust, and pop off mill scale, has been recommended, especially for field use, although it does not do as thorough a job as blasting. Power driven wire brushes, scrapers and chipping hammers should only be used on site when more effective methods cannot or, for mild exposures, need not be used. Because the work is very arduous it must be closely supervised. When steel is thoroughly cleaned in the plant, the primer to be used can be selected according to the severity of exposure or, where this is not an important factor, for quick-drying properties that ease handling problems in the plant.

Coatings. For severe exposure conditions steel can be coated, after blasting, with a vinyl system comprised of a vinyl wash or etch primer, a vinyl anti-corrosive primer, and a vinyl finish. A total dry-film thickness of 7 mils is required. Airless spray can reduce the number of coats necessary when applied by conventional spraying, thus reducing application time and costs. The vinyl system is very suitable for marine and underwater exposures. Up to 13 years durability for vinyls have been recorded on hydro-electric installations where there was no damage from ice impact.

Primers containing a high proportion of zinc dust pigment (up to 95 per cent by weight of the dry film) and referred to as "zinc rich" primers have been used increasingly under adverse conditions. In North America the inorganic type in which zinc reacts with an alkali silicate has been most popular, while in Europe organic binders are common. Primers based on binders that dry by solvent evaporation alone have performed well without topcoats in rural areas on structures such as transmission towers. In urban areas, on the other hand, they have tended to fail rapidly, and reactive organic types, such as two-component epoxy or inorganic zinc rich, are required. Because zinc is not resistant to strong acids or alkalies all zinc rich primers need to be topcoated in industrial areas. The protective power of some primers is reduced when topcoated, so that it is necessary to ensure that the type used is recoatable. For severest conditions vinyl finishes with the wash primer as a "tie" coat are usually recommended.

In some cases the longevity of the vinyl system alone is so great that the additional high cost of the zinc rich primer is not justified. Other coatings for special use in chemical plants where resistance to particular materials is required are high-build chlorinated-rubber finishes and cold-curing epoxies and urethanes. Except for the latter, application is somewhat difficult and is best carried out in a factory.

For normal architectural uses, alkyd systems offer good protection and appearance, are easy to apply, and dry fairly quickly. Where the steel has been prepared by the more thorough methods the primers can be alkyd red lead or alkyd zinc chromate. Steel thus primed can withstand considerable exposure without showing corrosion. After erection all that is required is to wash off any dirt, touch up damaged areas, and apply a full coat of the same type of primer. Steel exposed to the weather or to view will then be topcoated with alkyd enamel. If gloss retention upon weathering is particularly important, silicone modified alkyds are reported to be an improvement.

As surface preparation becomes less adequate, it is necessary to specify slower drying primers that can penetrate more readily the small particles of rust or scale left on the surface. With thorough power wire brushing it is still possible for the primer to contain chiefly zinc chromate as anti-corrosive pigment and half alkyd in the binder. These primers can be handled or topcoated with alkyd enamels after overnight drying. If the poorest preparatory methods such as hand wire brushing are used, only a red lead in oil primer will give protection. This material is very slow drying and thus unsuitable for shop application. It must be thoroughly dried - three to four days under good conditions - before alkyd enamels can be applied over it. Otherwise oil paints with their reduced durability must be used as topcoats.

Cheap, quick-drying shop coat primers pigmented with iron oxide are frequently applied to structural steel intended for interior use. Unfortunately the steel is sometimes left lying around mill yards or construction sites for a considerable time. During this period rust spreads under the primer so that after erection the surface must be prepared as for new work to prevent any subsequent coating from flaking off. If the steel is erected before rusting commences, a full coat of field primer will be required in all except the mildest climates. It is obviously less costly in the long run to use a better primer in the first place.

Over the years there have been claims that certain primers could be applied to rusty surfaces with little or no preparation and still provide good protection. In general, these claims have not been borne out in practice. More recently materials have been marketed that are said to convert hydrated ferric oxide (rust) to ferrosoferric oxide (magnetite). As most primers are a careful balance of pigment and vehicle, it is difficult to visualize how the right amount of rust could always be present on all surfaces. Unless claims for such products are well substantiated it is preferable to prepare rusty surfaces as thoroughly as possible and use the primer suitable for the cleanliness obtained.

One ferrous surface that is difficult to paint satisfactorily is stainless steel. There should be no need to protect the metal, but for aesthetic purposes some architects have specified alternate areas of uncoated and coated stainless steel. In several cases the coated areas have failed extensively after a few years' exposure. There is, as yet, no foolproof way of preparing stainless for subsequent painting, especially in the field, although light sand blasting is considered to be the process most likely to give sufficient adhesion.

Zinc. This category includes zinc used as the base metal and as the protective coat applied to steel by dipping (galvanizing) or spraying. Zinc is a durable metal except in aggressive atmospheres such as heavy industrial or marine industrial. In these locations the zinc corrosion products that protect the underlying metal in other atmospheres are dissolved, allowing corrosion to proceed. Several long-term studies have shown that a combination of zinc and an organic coating system protects steel better and is more economical than either material alone. Under mild conditions it may take fifteen years for the superiority of the combination to become evident.

The chief problem in painting zinc, especially highly spangled galvanize, is to prevent subsequent peeling of the coating. Weathering of galvanized steel for at least six months has long been recommended as one way of stopping this failure. To avoid the waiting period, numerous remedies have been proposed, but most are detrimental or, at best, ineffectual. While solutions containing copper sulphate (blue stone) have a visible effect by depositing copper, they do not improve adhesion. The most successful treatments are conversion coatings applied by dip or spray in a factory. Further complications are introduced by other treatments often employed at the mill to eliminate storage stains ("white rust"). Some of these interfere with subsequent treatments, including the conversion processes. Where long durability is of prime importance, the galvanize supplier should be consulted for the best treatment and coating procedure for his product.

Many tests have been conducted to try to determine how best to paint galvanize in the field. Those carried out at DBR/NRC indicate that the choice of primer is greatly influenced by the type of topcoat. Wash primer was satisfactory with all topcoats tested and much superior to other primers under alkyd enamels. Zinc dust-zinc oxide primer also performs well on new untreated galvanize. This material is not the same as zinc rich primer. The latter is also suitable, but because it serves the same function as the galvanize, its additional use is uneconomical. Primers pigmented with calcium plumbate are used extensively in the United Kingdom on zinc but have not been very popular in North America. Topcoats to be applied over calcium plumbate must be carefully selected for compatibility or peeling from the primer may occur.

Because sprayed zinc is slightly porous, it tends to corrode faster than other forms. Protective coatings are, therefore, mandatory. Wash primers, as on galvanize or zinc-rich, are suitable for priming sprayed zinc.

Aluminum. Aluminum is usually in the form of base metal, although occasionally it is, like zinc, applied to steel. Aluminum-coated steel is called aluminized steel. Metal alloy constituents can affect the durability of aluminum, but generally it does not need painting for corrosion prevention except in marine atmospheres. Even here, some alloys are very durable. In most cases aluminum is coated for preservation of appearance. Sprayed aluminum, however, requires a protective coating if immersed in water, and aluminum in contact with concrete should have an alkali-resistant coating system applied.

The chief problem with aluminum is in achieving good adhesion of the coating. Anodizing or chemical conversion carried out in factories are very satisfactory treatments. Anodizing does not require further protection but can serve as a good base for coatings. If the facilities are not available in the plant or field application is necessary, wash primer is preferred, although phosphoric acid treatments improve adhesion somewhat. Zinc chromate primer is applied after the acid wash or, in all except mild conditions, the wash primer. Alkyd, silicone-alkyd, or acrylic topcoats can then be applied. Clear acetate-butyrate lacquers have been widely used on aluminum window frames to maintain their initial appearance.

Red lead primers must not be used on aluminum because they accelerate corrosion of the metal. Copper-containing anti-fouling paints have the same effect. Priming coats on aluminum structures subjected to sea immersion must, therefore, be carefully applied to ensure that there are no pinholes.

Other Metals. Copper and its alloys do not need coating for protection. If they are painted to match their surroundings or to prevent development of green patina, wash primer can be used for the first coat. Clear acrylic lacquers have been shown to preserve the bright appearance of the new metal. There are no satisfactory methods of accelerating patina development so that new panels will resemble weathered ones.

Cadmium, which is similar chemically to zinc, can be treated like it. Other metals such as lead and tin are not generally used on buildings in Canada.

Summary

This Digest considers the generic types of coatings to be used on exterior metals and discussed the other elements that play an important role in the durability of coated metal. These influential factors are the design of the structure, the conditions of exposure, the degree of surface preparation and the site of painting. Film thickness is not discussed in detail. Generally, it should be recognized that thicker coating systems will have greater durability, provided the individual coats have not been applied in more than their design thickness.