

# PRINCIPLES OF PROTECTION BY PAINT

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The title of this paper is of so general a nature that no apology is necessary for dealing with the subject in a rather sketchy manner. Properly to discuss the subject under review would take many hours, but in the time at our disposal I would like to consider very briefly protection of wood, of masonry and of steelwork.

In building practice there is a sharp distinction between softwood timber derived from coniferous or needle leaved trees, and hardwood timber obtained from broad leaved trees. However, some softwoods are a great deal harder than certain the hardwoods and both types vary widely in hardness. In general the greater the weight per cubic foot, the harder is the wood.

Growth in the tree takes place in the layer under the bark, generally more rapidly in the warmer part of the year so that each year a new layer of wood is added to the outside of the tree which is known as the annual growth ring. During early growth of this ring it is light in colour and in weight and may contain up to 80 per cent air spaces. Later in the growing season the wood becomes darker and denser and the air spaces may drop to as little as 40 per cent. Curiously enough paint oils as a rule penetrate this denser wood more deeply and may become separated from the surface film. Because of this it is not unusual to find more rapid deterioration of paint over such surfaces. The wood near to the centre of the tree (heartwood) is less permeable to paint oils than the sapwood and is usually more durable.

When the tree is sawn up the boards may be cut with the principal surfaces either roughly tangential to the growth rings or at right angles to them. The two types of board produced may be referred to as flat and edge grain boards, respectively. Flat grain timber has much wider bands of summerwood than edge grain, and the two surfaces differ considerably depending on whether they are bark or core side. In many species of timber the core side is inferior since applied paint tends to crack on weathering.

The first coat of paint applied to new timber is largely concerned in filling the cavities in the wood cells which were cut open during preparation of the boards and the amount of this primer required will naturally vary with the nature of the timber. It is important that this "thirst" of the wood be saturated, and in many cases the priming coat applied is inadequate. Providing an adequate primer is

applied, and the other coats are properly put on the wood itself for the first one or two years of the life of the paint exerts only a minor influence. This of course is exclusive of knots or other imperfections.

Painting of cement and asbestos cement is essentially much the same problem, i.e. adequate priming, and is associated with alkalinity of the material. Cement surfaces present the severer case because of the very great amount of water present which has to dry out. Neutralisation of the surface by treatment with acids, zinc sulphate and the like is rarely satisfactory. The best practice is to allow ample time for drying out and where oil paint is to be used, the primer at least should be alkali-resistant and at least two coats should be applied. Naturally lime-fast pigments must be used. The aim is to apply an alkali-resistant primer so that it is in the top surface and not on it so that a moisture resistant layer is produced. When the possibility exists of water reaching the back, i.e. unpainted surface, it is important that this also be sealed. Certain paints, e.g. P.V.A. emulsions have been applied with some success following the trowel. This is a dangerous expedient and although cases have occurred where the painter has "got away with it," generally there should be a drying and maturing period of at least two months.

It is astonishing how much water is present in a new building. Brickwork as laid is stated to contain 30 gallons water per cubic yard, while a  $\frac{3}{4}$  in. thick portland cement rendering contains about one gallon per square yard.

Even to-day the effect of colour on well-being is not properly recognized. Intelligent use of colour can create optical illusions which can be used to advantage in home, office or factory. Colour may minimize the effect of weight or bulk or even change the apparent dimension of the interior of buildings. Thus walls may be made to recede by being painted in white or light tints, conversely they may be made to converge by a dark paint. Colour can also be used to give an impression of warmth or coolness. There are also the practical aspects that clear colours show dirt easily and promote cleanliness. Eye strain and fatigue can also be reduced. White, for example, gives a dazzling effect and accelerates eye fatigue. Hospitals and the like can be given a clean and hygienic appearance without a preponderance of white paint, remembering however that interiors should be painted as brightly as possible without creating glare. In factories colour may be employed

to bring forward critical parts, and where for example, the main body of a machine could be painted in a cool colour causing it to recede visually, moving parts should be brought forward to the eye by being picked out in bright, easily seen colours. These so called "focal colours" include ivory, buff, light green, blue, yellow, beige, red and orange.

Most corrosion is electrochemical in origin. The hazards involved in the use of metals separated in the electrochemical series as component parts of the same piece of equipment are well known, and need no emphasis. A compilation of degree of corrosion at bimetallic contacts in a form most useful to designers of plant and equipment has recently been published by the Inter-Service Metallurgical Research Council of the Admiralty and Ministry of Supply. It is, however, well known that a sheet of metal may, according to conditions, have regions which are anodic or cathodic to the rest of the material. In air under conditions of humidity and particularly in the presence of water soluble salts, all the requisites for electrochemical attack are present. The usual picture which is presented of the corrosion of iron and steel, and one which is sufficient for our purpose, involves solution of iron at the anode with the freed electrons travelling through the metal to meet positive ions at the cathode. There are then, two distinct paths to be considered:

- (a) The electronic branch through the metal.
- (b) The ionic branch through the electrolyte.

Plainly it is not a feasible operation to interrupt the electronic current, and attention has been focussed on the ionic branch.

Most paints protect by their electrical resistivity so that the ionic corrosion current is reduced to a safe value. Local break-down of the protective insulating film, however by mechanical damage or other, may easily lead to the concentration of current over a small area, with consequent severe and localized corrosion. Apart from exceptional circumstances such as these, the protective film will ultimately fail by natural causes. The most serious type of failure is cracking as this often extends through the film and exposes the underlying metal. This, however, is readily detected and need not concern us further here. A more subtle and general type of failure is the development of water sensitive properties in the paint film. No organic film is completely impervious to water vapour, and some are relatively poor. These are sufficiently known to be avoided, but a satisfactory coating may develop a capacity for holding water with time. This arises from the nature of the material.

Organic compounds are oxidized at atmospheric exposure, at a greater or lesser rate. Whether this

oxidation is direct, photochemical, or by bacterial or fungicidal attack is not germane to the effect except insofar as it affects the time factor. However caused, the organic molecules in the paint film acquire hydroxyl, carboxyl, keto and other groups capable of fixing water, possibly by hydrogen bonding at least in the initial stages of the absorption isotherm. These groups and the associated water increase the electrical conductivity of the film and the electrochemical corrosion current rises.

No paint film protects indefinitely and the above process will occur sooner or later. The formulator of the paint has, however, a certain control of the process. Firstly and obviously, the careful testing and selection of materials is important. Secondly and less apparent, is control over the way in which a film will fail by oxidation. The two extremes may be stated to be a uniform failure throughout the film, and conversely, failure from the surface down. The second is obviously preferable as the underlying metal is largely protected until the film has eroded away. This is not to be interpreted as advocating thin coats; at least 5 mils should be applied for protection of steelwork in moderately corrosive conditions in order to obtain a reasonable life. Here it may be stressed that life of film against thickness is not a straight line function and that doubling the thickness of a paint film from, say 2 to 4 mils, more than doubles the protection period. When one considers that the cost of repainting may be up to 80 per cent labour charges, and that much of this labour is used in preparation of the surface for painting rather than the actual application of paint, it can be seen that multiple coats of protective finish are a great economy, and that it is poor practice to buy cheap paints.

In spite of the finite life of paint films, they are in most cases the only feasible means of protection. Apart from the decorative and psychological aspects, the relative ease of renewal of the protective coating is of the first importance, and properly applied a very satisfactory protection is given in all except the most unusual environments.

The South African climate is extremely hard on a paint film, and many formulations which have proved satisfactory overseas, have been found to give an indifferent performance here. Once again, it is a matter for the paint formulator, and the amount of testing and number of variants made which are tried out by a reputable firm before the release of its product would amaze the average consumer.

So much, then, for general remarks on protection of steelwork by paint, and it now appears to be a logical next step to consider the application of the paint and the materials available.

### Preparation

The importance of a proper and thorough preparation of the steel surface before painting has been stressed by every authority on the subject, and there is no doubt that cleaning to bright metal is the most desirable state. In very many cases this becomes a counsel of perfection which for practical reasons is often impossible, so that a lesser standard has to be accepted. This may involve chipping, wire brushing and the like, but the final surface cannot be compared with that obtained, for example, by sand-blasting. Mention should also be made of pickling by means of the acid jellies now on the market, which enable the process to be carried out on vertical runs. According to recent claims these acid jellies not only remove rust, but passivate the metal leaving a phosphated surface very suitable for the application of paint. It is also claimed that the cost of such treatment is 3s. 3d. per square yard.

Rust remaining on the metal after cleaning not only causes trouble with adhesion between paint and metal, but is highly hydrated and may also contain soluble salts, particularly in cases such as bridges near to the coast. The whole subject is in an unsatisfactory state; a desirable solution would be the development of a paint or paintlike material which could be applied directly to rusty steel, would penetrate to the underlying metal, and which would produce an adherent coating bonding the rust and forming a suitable surface for the application of subsequent protective layers. One commercial material claimed to be of this nature has been tested at the Paint Industries' Research Institute. Very poor results were obtained, but it is hoped to carry out research work within the Institute to improve this development.

### Primers

The anti-corrosive type of primer is the only one of interest in the present connection. A number are available and include red lead, zinc chromate, lead cyanamide, calcium plumbate and others. They depend for their action on the particular pigment present. The Institute has most types under test, but more experience is available on the red lead and zinc chromate types than on the others. Some question exists as to whether the primer should be tested alone, or as a system, and it is safest to carry out exposures on both alternatives. Exposure to salt fog gives a clear and unequivocal answer in favour of zinc chromate, but this difference disappears on outside testing, and as far as the results have gone to date, there is little to choose between the pigments. The medium has a marked influence, in general terms oils behave better with red lead, and varnish media with zinc chromate. Zinc chromate enjoys a slight advantage since it is

satisfactory on light alloys as well as steel. The primer and subsequent coats should be purchased as a system from the same manufacturer, and the practice of combining primer from one source with a second coat from another is not satisfactory as indifferent adhesion may result.

### Top Coats

The primary function of a top coat may be summarized briefly as to provide a decorative and pleasing finish, and to protect the priming coat. Anti-corrosive primers are not, in general, suitable protective coats. Their function is to produce a passive oxide layer on the metal, and to repair any breakdown of this layer. In order properly to carry out this duty, the primer itself needs protection from climatic conditions, either because it is of itself too soft for normal use, or because it contains water sensitive materials. Anyone who has been concerned with the production of enamelled wire will know the way in which the number of pinholes in a given length will fall with the number of coats applied. The same is true of other painted surfaces, and at least two top coats should be applied. The same argument applies, *mutatis mutandis*, to the primer. The application of multiple coats is rendered much easier if they differ slightly in colour, as it is often difficult to ensure complete coverage when applying a second coat of the same colour.

### Specifications for Paints

It is perhaps, not superfluous to point out that any specification lays down a minimum standard, presumably satisfactory to the user of the material. The Paint Industry is a highly competitive business, and as raw materials form a large part of the final price, differences in cost of equal materials is marginal. Generally speaking it may be said that the purchaser gets what he pays for, but in very few cases indeed has the economics of employing a material superior to that specified been worked out or even considered. In the last analysis the life of a paint must be assessed by exposure under the actual conditions of use, and any accelerated tests which can be devised must be equated to practical experience. Some exposure conditions are exceptional, and information obtained under different conditions is often very misleading. The use of composition specifications as such may keep up the quality of the constituent ingredients of a paint, but are not in themselves any guarantee of performance, and tend to emphasize the ignorance of the drafting authority of the actual performance to be expected. At the instance of the South African Bureau of Standards, the Paint Industries' Research Institute has in hand a large programme of research into practical exposure results, and their correlation with accelerated methods. It will be some time

before this work, which has been financed by the Council for Scientific and Industrial Research, can accumulate a sufficient volume of data to be of real service. Meanwhile, there is a good deal to be said for the system of laying down a standard formula in a specification, with the requirement that paint supplied should at least equal the standard in a series of specified tests. This method, while ensuring performance, leaves the manufacturer a free choice of materials, with the possibility of price reduction. At the same time, the standard required is readily adjusted up or down by alteration of the standard of comparison.

### Specialized Paints

Only a few specialized products can be mentioned here, and of these some are in the experimental or at least unproved state. As mentioned earlier, there is no real substitute for natural exposure, and complete testing lasting over many years is essential before real confidence in a product may be felt. This is one of the reasons why the accusation of excessive conservatism so often levelled at the manufacturer is less than fair.

The so-called zinc-rich paints contain over 90 per cent of metallic zinc. The volume loading is designed to ensure that adjacent particles of zinc touch, and also touch the underlying steel. Such loadings are not possible with many media, but however formulated the electrical resistivity of the dried film must be low. Under these conditions the zinc acts as a

sacrificial anode in much the same way as it does on galvanised iron, thus protecting the underlying metal. On the whole, the Institute has had favourable results with this material, but in salt laden air an unsightly white deposit of zinc oxychloride is rapidly produced. Immersion in salt water tends to blister the film, possibly due to hydrogen evolution, and the development of local highly alkaline spots has been observed. Fortunately the media usually employed are highly resistant to alkalies. It has been claimed that these paints may be applied with satisfactory results over rusty metal. In our experience this is a most undesirable practice giving very poor results.

Paints for application to wet surfaces contain surface active agents which render them capable of displacing water from metal surfaces and to obtain reasonable adherence. There is no doubt that the effect can be obtained, but the life of the film has yet to be properly evaluated.

One of the more recent developments has been improved methods of imparting thixotropy to paints by treatment of the right material in the right way with aluminium alcoholates. The basic idea is to produce a weak gel which becomes liquid under the brush and so can be spread to a satisfactory film, which after short standing, reverts to the gel state and thereafter dries normally. The advantage claimed is the ability to apply heavy coats in one application without runs or tears on the surface. Once again the material needs a complete evaluation.

(For discussion on this paper see page 96).