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Paint – What Is It?

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Please note

One purpose of Canadian Building Digests is to explain the technical terms used in the many branches of building science with which architects and builders come in contact. This, the first of several Digests devoted to coatings, will describe their general composition and some of the properties of the components. It will be possible in later Digests to discuss the many types of liquid coatings commonly referred to as paints.

It should be pointed out that all the terms to be used in the Digests are not necessarily accepted internationally or even nationally. The most prominent word in this category is "paint" itself. In order to bring some measure of agreement to the industry on the meaning of specialized terms, a standard Canadian glossary of paint terms is now being compiled by the Canadian Government Specifications Board.

What then is paint if its definition causes disagreement? Part of the confusion results from the fact that paint is a word with both a general and a specific meaning. When used as a noun it applies to a whole group of materials as well as to one particular member of that group. When used as a verb it is a general term meaning "to coat or to apply", regardless of the type of coating being applied. In its general sense a paint is any liquid material which, when spread in a thin layer, solidifies into a film that obscures the surface on which it is applied. Its specific meaning will be amplified in a future Digest describing coatings.

Composition of Coatings

A knowledge of the general make-up of a paint will be helpful in understanding the differences between specific kinds of coatings. It follows from the general description that a paint is a dispersion of small, coloured, insoluble particles in a liquid medium. This composition is shown in diagrammatic form in Figure 1.

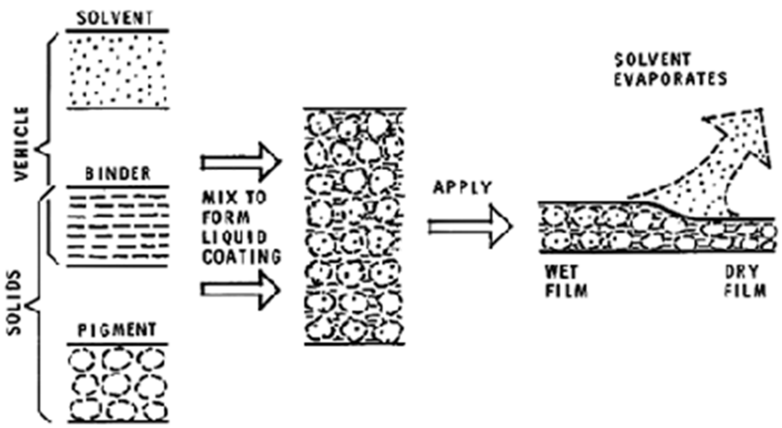

Figure 1. Generalized composition of pigmented liquid coatings and manner of film formation

Pigmented coatings, or paints, are composed of two basic materials - the pigment and the vehicle. Clear finishes contain only vehicle, except in a few unusual cases. Pigments are very fine powders that provide colour and the ability to hide the underlying surface. The vehicle, which is the liquid portion, generally consists of two parts, one nonvolatile, the other volatile. The non-volatile vehicle forms the film and is also called the binder because it binds or holds the pigment to the surface. The volatile part, called the solvent, dissolves the film-forming material and is used to adjust the viscosity of the mixture. Naturally, there are many different ingredients that can be used in each of the three main components.

Pigments

Pigments are substantially insoluble in the vehicle so that they will hide the underlying surface when present in suitable concentration. The chief difference between a dye and an organic pigment is that the dye is soluble; although a dyed film is coloured, it is also transparent and the substrate is not obscured. In spite of the fact that such a material is a coating, it is not considered to be a paint. As with most classifications there is no sharp dividing line between pigments and dyes and some organic pigments, especially reds, are relatively soluble and have poor hiding power.

Pigments must also be small to provide hiding power. The influence of particle size is illustrated by titanium dioxide, which has great hiding power at a size of 0.2 to 0.3 micron, but is a perfectly clear crystal in a large size (as in the gem, rutile). The optimum particle size for providing maximum hiding power is related to the refractive index of a pigment. A high refractive index is necessary for high hiding power when a pigment is dispersed in organic vehicles. If there is only a small difference between the indices of the pigment and the vehicle, light will be transmitted through the film regardless of the particle size. Some pigments that appear white in air are non-opaque or non-hiding in vehicles because of their low refractive index. They are used, however, because they contribute other useful properties to the coating.

It was stated that pigments are coloured. In this context black and white are considered to be colours. The method by which a pigment hides a surface depends upon its colour. Black pigments hide by absorbing at least 90 per cent of the incident light, leaving little to be reflected from the surface to the observer. White pigments of the correct refractive index and particle size, on the other hand, scatter the light within the film and reflect about 85 per cent of it. As the light does not reach the substrate it cannot reveal the characteristics of the surface. Chromatic colours such as reds and greens hide by absorbing certain wave-lengths of light and scattering the remainder.

The proportion of pigment to vehicle varies greatly with the type and use of the coating. In addition to hiding power, the amount of pigment in the non-volatile portion of the coating affects such properties of the film as gloss, flexibility, tensile strength, permeability and washability. The manner of action on gloss, one of the more evident properties, is shown in

Figure 2. When there is considerably more vehicle than pigment, the surface of the film is smooth and reflects light like a mirror. As the proportion of pigment increases, the smoothness of the film is impaired, thus interfering with surface reflection and reducing gloss. At high pigment contents the light is scattered in all directions so that there is no gloss at all.

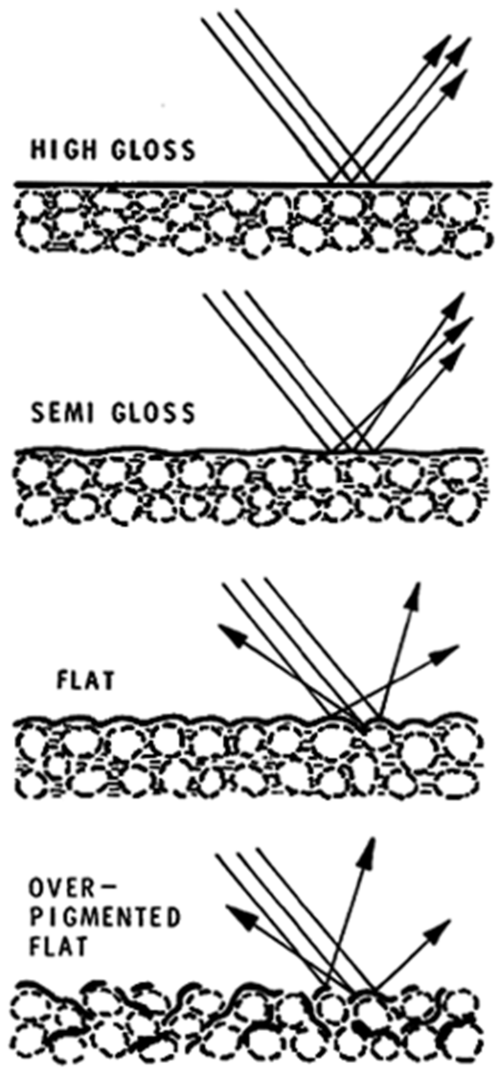

Figure 2. Effect of pigment content on gloss

Some film properties do not show this gradual change throughout the range of pigment content, but exhibit a marked change around the point at which there is just sufficient binder to coat all the pigment particles. This level is called the critical pigment volume content. If there is more pigment than can be uniformly wetted by the non-volatile vehicle, the material is said to be over-pigmented, or underbound. Under these conditions the normally non-opaque pigments contribute to hiding because some of the pigment surfaces are exposed to air. This method of formulation is used to obtain high hiding power at minimum cost, but other properties such as washability and flexibility are adversely affected.

Vehicles

The proportion of volatile to non-volatile vehicle depends upon the properties of the latter. If the binder has a low viscosity, raw linseed oil, for example, nothing additional is required and the vehicle is completely nonvolatile. If the binder is a solid or a viscous liquid, solvent is needed to liquefy the pigment-binder mixture or to reduce its viscosity so that it can be applied. Hence, other names for the solvent are reducer and thinner. The effect of the viscosity of the binder on the amount of solvent is illustrated by the following figures: vinyl lacquers where the resin is solid are 75 to 80 per cent solvent; alkyd enamels in which the alkyd resin is a very heavy syrup contain about 50 per cent solvent; oil paints may only have 10 per cent solvent.

The different properties of coatings are chiefly the result of differences in binders. To be useful in a coating the binder must remain liquid in bulk, but must solidify to a continuous film when spread over a large area. This in itself is a rather stringent requirement. For the film to solidify large molecules are required because small molecules as such either evaporate or show no change when spread in a thin layer.

Large molecules are generally polymers, i.e., large molecules with repeating units built up by the union of a large number of a few kinds of small molecules. If the small molecules are all of the same kind, the resulting large molecule is called a homopolymer. When there are two or three kinds of small molecules, or monomers, a copolymer is produced. Sometimes the term terpolymer is used to indicate that three different monomers have gone into the production of the polymer. Copolymers usually have more desirable properties than a simple mixture of homopolymers made from the same monomers.

The large molecules desirable in coatings can be obtained in three ways: 1) The binder may consist of small liquid molecules that react to form large molecules after application in a thin layer. This is how linseed oil acts and accounts for its slow-drying properties. 2) The polymer may be made before application, dissolved in solvent, and applied. As the solvent evaporates the film of binder is deposited. The larger the molecule, the tougher, stronger and more resistant will be the film. Large molecules, however, are hard to dissolve and the resulting solution is very viscous. Much more solvent is then needed to apply the material, as noted above, so that several coats may be required to provide adequate film thickness. 3) Finally, the two methods may be combined, using partly enlarged molecules in the liquid paint that react after application. Any proportion of the two basic methods is possible. The small molecules may only be doubled in size and the bulk of the reaction take place after application as with "bodied" oils. Conversely, fairly large molecules may be made and joined together after application by relatively small amounts of curing agents.

Polymer solubility is also affected by the manner in which the molecule is formed. If the polymer is a long chain then the material dries by solvent evaporation and is always resoluble in that solvent, no matter how resistant it may be to other elements. If three-dimensional networks are formed by reactions between groups of molecules, the material will become resistant to solvents as well as to other chemicals. The greater the number of reactions or cross-links, the greater will be the resistance to solvents, water, heat and mechanical action. In order to apply the material, however, too many cross-links cannot be formed before application. The cross-links in the film are caused by oxidation in air-drying materials, heat for baking materials, and chemical reaction for cold-curing materials.

Coatings are generally compromises, because it is not possible to have all the best properties in a single material. Binders of small molecules penetrate rough surfaces and adhere well, but they are slow to dry and not resistant to chemicals. Binders with large molecules that dry by evaporation alone are fast drying, but they are re-soluble in the same solvent and yield thin films. Except for some newer types of coatings the molecular groups that promote adhesion to surfaces are the ones most easily attacked chemically. Conversely, films with great chemical resistance usually have poor adhesion because there are fewer points of attraction. Hence, the latter materials are much more sensitive to surface preparation than less resistant materials. In general, the more durable the coating, the better the surface preparation has to be.

Summary

This Digest has described the main components of coatings, particularly pigmented coatings, and their functions. If the many ingredients that can be used in each part are considered, it may be seen that coatings are quite complex. Properties of the final film can vary markedly with changes in the formulation. Another complication is that although the materials are applied as liquids, they must function as solids. These requirements place additional demands on the formulator. Even with coatings intended for a specific end use, compromises are required to obtain the proper balance in the dry film.

The general properties required of nonvolatile materials, i.e., pigment and binder, have been discussed. This information will be applied in a later Digest in which the properties of specific types of coatings will be described. Subsequent Digests will then discuss the types to be used for particular purposes as related to their properties.