Outlines of Paint Technology

Third Edition

W M MORGANS

Consultant Paint Technologist

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Preface to the second edition

VOLUME 1

The object of this work remains essentially as in the first edition, namely, to provide an 'Outline' of the subject and so provide the reader with a general framework which can be filled in, if desired, by a study of more specialized works and original papers. The book makes no claim to be a comprehensive treatise, and the number of examples quoted as illustrations in each class is, in general, but a fraction of the total.

When considering this revision, it became apparent that several advantages would accrue from a division of the work into two volumes, Volume One to cover Materials and Volume Two, Finished Products. Volume One is likely to be of interest to technologists in other industries such as printing inks and artists' colours to whom Volume Two is unlikely to make a great appeal. Other factors in favour of two volumes are ease of handling and division of expenditure.

Advances made in paint technology since the date of publication of the first edition have necessitated a number of changes to the text. In addition, the increased awareness of the health hazards associated with the use of certain paint ingredients has resulted in several Acts and Regulations to which reference is made in the text.

The manufacture of pigments is now a highly specialized industry and so the description of manufacturing operations and plant has been reduced, more attention being paid to properties and performance. Colour science has become more important and this is reflected in the text. Some pigments (and resins) which are no longer used but have some historic interest are listed in Appendix E.

Oleoresinous varnishes based on phenolic or modified phenolic resins continue to be used on a limited scale, but those based on fossil resins are virtually obsolete in this country. The treatment of these, therefore, has been curtailed and more attention paid to the wide range of alkyds and polymeric binders generally. Increased space has also been given to water-based media which are growing in importance for reasons of low toxicity, non-pollution of

the atmosphere, and absence of fire risk. Oil-bound distempers, which have been replaced by latex emulsions, have been deleted. The section on water-soluble media has been extended to include media for both anodic and cathodic methods of electrodeposition.

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A special tribute is due to my wife for her patience and understanding and to Mrs Audrey Walford who so efficiently deciphered my notes and typed the manuscript.

Finally, the author's thanks are accorded to the publishers for their patience and help at all times.

W. M. MORGANS

Walberswick, May 1981

VOLUME 2

Since publication of the first edition considerable changes have taken place in the technology of surface coatings. A great number of new materials have been introduced (many of which are discussed in Volume 1), resulting in the availability of coatings suited to practically every type of surface and exposure condition. To discuss every type in a work of moderate size is clearly impossible, and it is hoped that the examples chosen and the depth of treatment will provide at least a suitable foundation for further study.

A deeper understanding of the basic principles of pigment dispersion, coupled with the use of new types of polymer and dispersion aids, has brought about a radical change in the methods of paint production. Roll mills are used only for certain types of printing ink and other high consistency materials. Emphasis is now on high-speed dispersion, and the ball mill, which for many years formed the backbone of paint production units, is being displaced by high-speed open dispersers and bead mills.

Among the requirements of modern building construction is one for 'long-life' or 'high-durability' paint which will provide satisfactory protection, especially in areas difficult of access, for periods of 15 to 20 years or longer. In order to achieve their potential, such paints must be applied to a clean, properly prepared surface. The methods of surface preparation of most common surfaces are discussed, together with the present-day methods of application and cure.

Discussion of the composition of many paints is illustrated by type formulations. These are presented as typical examples only and may not necessarily be the best for a particular application; paint formulation allows considerable

latitude in the choice and manipulation of raw materials. They are put forward in good faith but without liability, since conditions of manufacture and use are not within the author's control.

The production of this volume would not have been possible without the invaluable help and suggestions from a number of friends to whom the author extends his sincere thanks. He offers his thanks also to the following companies who provided literature, discussion and illustrations; the latter are acknowledged also in the text.

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W. M. MORGANS

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April 1983

Preface to the third edition

At the time of publication of the Second Edition there were valid reasons for presenting the work in two volumes but in preparing this Third Edition serious consideration has, of necessity, been given to changes in the structure of the industry as well as to escalating costs of book production. The outcome was a decision of revert to a single volume which, it is hoped, readers will find more convenient.

The object of the work remains essentially the same as that of earlier editions, namely, to present a general framework which can be filled in, if desired, by a study of more specialised works or original papers. The text is illustrated, wherever possible, with typical examples of coatings for various end uses but the book is not claimed to be a comprehensive treatise nor are the examples quoted necessarily the best for any particular application. Paint formulation allows considerable latitude in the selection and proportioning of ingredients and the formulations are put forward in good faith but without liability since conditions of manufacture and use are not within the author's control.

The general structure of the work follows that of earlier editions. Chapters 1–13 discuss materials and 14–27 are concerned with finished products, application, substrates and uses. The following comments are of general interest.

In the field of pigments, particle size distribution and surface characteristics are more closely controlled resulting in easier dispersion and improved dispersion stability. Refinements in the measurement of colour, particularly parameters associated with colour space, are reflected in a selection of instruments capable not only of measuring very small colour differences but also of providing correction figures.

The decline in use and therefore of interest in lead and chromate pigments on toxicity grounds together with the increased use of organics has reduced the space devoted to coloured inorganic pigments. These are discussed in Chapter 5.

Among the organic pigments there are many improved versions of pigments based on established chromophores and new developments in polycyclic and heterocyclic types have extended the range of pigments possessing outstanding lightfastness and durability.

Changes in the pattern of use of certain types of solvents have resulted from studies of health hazards. Threshold Limit Values (TLV) have been replaced by the similarly time-weighted Occupational Exposure Limits (OEL). New and very low OEL values have been assigned to certain solvents including ethers and ether-esters of ethylene glycol. These have been replaced in paint formulations by the relatively less toxic propylene glycol derivatives. OEL values are published annually by the Health and Safety Executive in Guidance Note No. 40 so that users can be kept informed annually of all alterations and additions to the list. For this reason OEL values are not quoted in the text.

The reduction of atmospheric pollution caused by organic solvents, mainly in the paint-using industries, has stimulated interest in water-borne and other types of coating. Water-borne coatings are now of sufficient importance to justify a separate chapter (19). Other types are the high-solids and solvent-free coatings. Powder coatings are, of course, solvent free and have made serious inroads in the field of industrial finishes.

Although natural vegetable oils are the main source of fatty acids for resin manufacture, very little oil is used in paint manufacture. Both linseed and tung oils continue to be used with hard resins in varnish manufacture and so are treated in this context.

In paint media, alkyd resins continue to hold pride of place in terms of quantity used. Improvements in drying characteristics have resulted from the introduction of 'chain stopped' alkyds whilst new long-oil types compete with the widely-used silicone/alkyd co-polymers for use in 'long life' coatings. A wide variety of stoving finishes is available by cross linking reactions involving modifications of basic types such as epoxies, hydroxylated acrylics and polyesters with amino resins and isocyanate derivatives.

A notable change in the industrial application field has been the replacement of anodic electrodeposition by the cathodic system. The latter offers many advantages in terms of film integrity and protection against corrosion.

Many other interesting developments, not the least being the use of 'anti-carbonation' coatings for the protection of reinforced concrete, are described in the text and it is hoped that the work will present a realistic outline of present day paint technology.

The author is very greateful to many friends and colleagues for helpful discussions and suggestions. He also extends his thanks to the following companies for their ready and willing co-operation.

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Walberswick 1988 W. M. Morgans

Contents

1

Introduction

The nature of paint

Paint can be defined as a fluid material which, when spread over a surface in a thin layer, will form a solid, cohesive and adherent film.

Paints have been used for decorative purposes for many centuries. The paintings produced in ancient Egypt have been shown to incorporate gum arabic, gelatin, eggwhite and beeswax. Gum arabic was used also by the Persians. In classical Greece extensive use was made of paint in sculpture (for the hair, lips and eyes of statues), architecture and in painting ships. It was used also in interior decoration and, of course, by artists.

The evolution and use of paints in Europe, prior to the Industrial Revolution, was mainly in the hands of artists although some was used in ship painting. The Industrial Revolution created a demand for paint for a number of purposes and this can be regarded as the beginning of the modern paint industry.

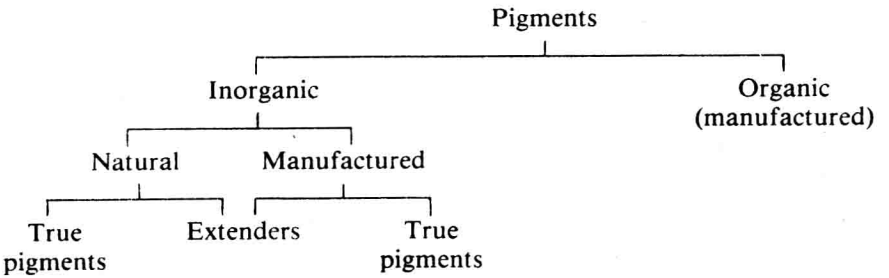
Ingredients of paint

A liquid paint contains three major ingredients together with smaller quantities of 'additives' which play an essential rôle. The major ingredients are pigments (including extenders), binder (or film former) and solvent or thinner. A dispersion of the pigment in the binder constitutes the paint film the properties of which depend, to a large degree, on the nature of the binder, but the nature and quantity of pigment are also important. The solvent or thinner is used to render the pigment/binder mixture sufficiently fluid for application as a thin film after which it is lost by evaporation and plays no part in the performance of the dry paint film. The additives employed comprise materials such as driers, anti-skinning and anti-settling agents, fungicides or bactericides and surface active agents used to assist pigment dispersion.

The following is a brief summary of the general nature and functions of the major paint ingredients, all of which are discussed in some detail later in the book.

Pigments

These are finely divided solids, the average particle size of which can vary from 0.2 to 10 μm (micrometres). They may be inorganic or organic in constitution. The general classification of pigments can be illustrated by the following scheme



Extenders have been included with the inorganic pigments since they are all inorganic solids. They differ from 'true' pigments in their behaviour when dispersed in organic media. True pigments exhibit opacity or hiding power in varying degree, whereas extenders are practically transparent. Extenders are used in certain types of paints (notably undercoats, primers and some low-gloss finishes) to modify or control physical properties. They make no contribution to colour (unless they are very impure) or to opacity.

True pigments are used to provide colour and opacity or hiding power. In finishes they contribute to durability. A pigmented film is more weather-resistant than an unpigmented film of the same binder. In primers for metals, specific pigments are used to check or inhibit corrosion of the metal.

The majority of natural pigments are oxides or hydroxides of iron but may contain appreciable quantities of clay or siliceous matter. The colours are less bright than the corresponding manufactured oxides and hydroxides.

The manufactured inorganic pigments contain the whites and a wide range of colours, including yellows, reds, oranges, greens and blues. Carbon black, consisting essentially of elementary carbon, is usually included in the inorganic pigments.

The organic pigments cover the entire spectrum range, but the brilliance and opacity vary considerably. There are no white organic pigments and organic blacks find only limited use; carbon black satisfies most paint requirements.

In general, organic pigments are brighter than the inorganic counterparts but show much greater variation in opacity and in lightfastness, the latter particularly when mixed with white. Organic pigments derived from plant and animal sources are no longer employed in paint manufacture. Although some possess bright self-colours, they lack permanence. A number which are of historic interest are listed in Appendix C.

The chemical constitution of pigments (and dyes) is set out in the Colour Index [1] and in the following pages the Colour Index description (CI –) follows the pigment name.

The testing of pigments is usually carried out by the generally accepted