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Code of practice for **Painting of buildings**

(Formerly CP 231)

Code de bonne pratique pour la peinture des bâtiments

Richtlinie für das Anstreichen von Gebäuden

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Contents

	Page		Page
Foreword	1	Section five. Application and practice	
Cooperating organizations	Back cover	42. Introduction	51
Code of practice		43. General	51
Section one. General		44. Conditions of application	52
1. Scope	2	45. Craft procedures and practices	53
2. References	2	46. Application methods	55
3. Definitions	2	47. Inspection, sampling and testing	58
4. Use of the code	2	Section six. Maintenance	
Section two. Design, specification and organization		48. Introduction	60
5. Introduction	3	49. General	60
6. Design considerations	3	50. Factors affecting decisions on maintenance	60
7. Environmental considerations	3	51. Selection of coating systems for maintenance	63
8. Documentation	3	52. Organization of maintenance work	64
9. Organization of work	4	53. Preparation of painted surfaces	64
10. Records	4	54. Application	67
11. Off-site work	4	Section seven. Health and safety	
12. Protection of components on site	5	55. Introduction	67
13. Workforce and supervision	5	56. Toxic hazards	68
14. Inspection requirements	5	57. Injury to eyes and skin	69
15. Materials sampling and testing	5	58. Fire and explosion	69
Section three. Materials		59. Noise	69
16. Introduction	5	Appendices	
17. Functions of coatings	6	A. Paint colours	70
18. Constituents of coatings	6	B. References and bibliography	70
19. General properties of coatings	8	Tables	
20. Components of coating systems	8	1. Primers for wood	10
21. Types of coatings	9	2. Primers for metal	11
22. Ancillary materials	17	3. Miscellaneous primers	12
Section four. Substrates and coating systems		4. Undercoats	12
23. Introduction	17	5. Pigmented finishes	13
24. Selection of coating systems	18	6. Natural finishes for wood	15
25. Wood	20	7. Bituminous and tar-based coatings	16
26. Plywood	24	8. Specialist coatings	16
27. Iron and steel	27	9. Environment categories and selection of coatings	20
28. Non-ferrous metals and metallic coatings	31	10. Paint systems for wood, internal and external (excluding hardwood surfaces not usually painted)	25
29. Plaster, external rendering, concrete (including precast blocks), brick and stone: general considerations	34	11. Natural finish systems for wood, external and internal	26
30. Plaster	37	12. Paint systems for iron and steel	31
31. External renderings	38	13. Site pretreatment and priming of non-ferrous metals	33
32. Concrete	39	14. Paint systems for plaster, concrete, brick, block and stone, internal	42
33. Brick and stone	39	15. Paint systems for renderings, concrete, brick, block and stone, external	43
34. Precast concrete blocks	40	16. Site priming of fibre building board, wood chipboard and plasterboard	47
35. Cement-based sheets, boards and components	44	17. Defects in paintwork and remedial treatment	61
36. Fibre building board, wood chipboard and plasterboard	44	Index	71
37. Paper and wallcoverings	47		
38. Plastics	48		
39. Glass and inorganic glazed surfaces	48		
40. Bituminous surfaces and materials	49		
41. Special conditions and requirements	49		

Foreword

This British Standard code of practice is a revision of the 1966 edition of CP 231 'Painting of buildings', which superseded the first edition published in 1952. The code has been revised to take account of the many developments in materials and processes used in the painting of buildings that have occurred since the last revision. In accordance with BSI policy of integrating British Standard codes of practice and specifications, this revision is numbered BS 6150; CP 231 is withdrawn on publication of this standard.

A principal objective during the work of revision was the presentation of essential information and guidance on good

practice in as concise a manner as possible, by the extensive use of tables and by devoting individual clauses to each substrate (or group of similar substrates) and to the treatment of each substrate or group of substrates. In consequence, the format of the revised code differs radically from that of its predecessor.

Coating materials and processes are subject to continuing development and improvement, and the recommendations in this code do not preclude the use of other materials or processes when these can be shown to have equivalent or better performance.

British Standard Code of practice for

Painting of buildings

Section one. General

1. Scope

This code provides recommendations for good practice in the initial and maintenance painting of buildings, e.g. dwellings, offices, light industrial buildings, schools, hospitals, hotels and public buildings generally, in which decoration is a significant and often the major factor. The code does, however, take into account the need to protect many building materials against the weather or other forms of attack normally encountered in the types of buildings referred to. For guidance on the protection of steel structures, reference should be made to BS 5493 and DD 24.

The recommendations made in the code are intended to facilitate achievement of standards of finish likely to be acceptable in most cases in the types of buildings referred to above, providing that the work of other trades has been completed to a satisfactory standard. Where especially high standards of finish are required, more elaborate processes and systems than those described in the code may be necessary and should be specified accordingly. The code does not cover decorative processes such as graining, marbling, glazing, scumbling, gilding and other work usually carried out by specialists.

The coatings referred to in this code are principally of conventional type, as defined in 21.2, but limited reference is made to specialist (21.3) and factory-applied coatings (21.4). In respect of materials generally, the code does not claim to cover in detail the wide and constantly increasing range available. Some materials have been excluded because of their obsolescence, limited or specialized usage or, in the case of newly-developed products, lack of experience of their performance in service.

2. References

The titles of the standards publications referred to in this code are listed on the inside back cover.

Bibliographic references are listed in B.2. Numbered references (see B.1) are indicated in the text by figures in square brackets, e.g. [1].

Product references (see 21.2) are indicated in the text by figures in parentheses, e.g. (1/2), and refer to the products listed and described in tables 1 to 8.

3. Definitions

For the purposes of this code, the definitions given in BS 2015 apply.

4. Use of the code

It should be noted that this code is not intended to be cited in its entirety as a substitute for a detailed specification.

Correct selection of coating systems and clear, precise specifying of methods and processes are essential, and it is a major function of this code to give guidance on these aspects. However, they will not alone ensure that the chosen systems perform satisfactorily, and it is equally important that consideration be given to the factors described in section two of the code. Of particular importance in relation to performances are the influence of design and detailing, proper organization and supervision and, in some circumstances, an effective inspection procedure. It is recommended that all users should refer to section two as a preliminary to the selection of coating systems.

Section three provides general information on the functions and components of coating systems and the properties of individual materials. Experienced users may not require such detailed information, but all users should familiarize themselves with tables 1 to 8 which allocate product references to the main types of coatings, these references being used for identification purposes in later sections.

Section four gives guidance on the general principles of selection and describes the characteristics, preparation and subsequent treatment of the new or untreated substrates normally encountered in buildings. The tables in this section, in conjunction with tables 1 to 8, provide basic information on systems for the various substrates and include information on life expectancy. The tables may be useful for quick reference, but study of the accompanying text, and especially of clause 24, is recommended.

Section five is concerned with the practical aspects of initial and maintenance painting, including craft practice, application methods and inspection procedures. All users, whether or not they are directly involved with application, should refer to this section since much of the information given is relevant to the preparation of specifications.

Section six describes considerations in respect of maintenance treatment not dealt with elsewhere in the code, including the economic aspects, planned maintenance and the treatment of previously painted surfaces.

Section seven describes some of the hazards that may be encountered in the painting of buildings and the precautions to be taken. It also refers to the principal legislation applicable.

Section two. Design, specification and organization

5. Introduction

This section describes aspects of initial or maintenance painting to be considered at an early stage. Where appropriate, reference is made to other sections of the code where more detailed information is given.

6. Design considerations

6.1 General. All parts of a building to which coatings are to be applied should be designed to avoid, as far as possible, the creation of features or conditions that may cause difficulties in application, impair the performance of coatings or promote decay or corrosion of structural materials. Points to which attention should be given are indicated in 6.2 to 6.6.

6.2 Accessibility. Spaces between adjacent wood or metal members, e.g. in roof trusses, should be sufficiently wide to allow access for painting. Alternatively, hidden or contact surfaces should receive protective treatment before assembly or erection. Pipes and similar components should be fixed sufficiently clear of walls to allow them to be painted completely.

Access for external repainting should be considered at the design stage. Where repainting cannot be carried out from ladders, balconies or the interior of the building, permanent cradle rails should be provided or provision made for the anchoring of cradle supports. Similar arrangements should be made for lofty internal spaces.

6.3 Exclusion of moisture. Penetration of moisture is a common cause of the premature failure of coatings; it may also lead to decay or corrosion of structural materials. Attention should be paid to the design and location of damp-proof courses and membranes, vapour barriers, flashings, weatherings, drip-mouldings and throatings. Measures should be taken to prevent the retention of water on horizontal surfaces, e.g. by bevelling or sloping them or, in the case of structural metalwork, by providing drainage holes. Rainwater run-off or dripping on to coated surfaces should be prevented by appropriate detailing. See also 25.2.1 and 27.3.

6.4 Condensation. In varying degree, condensation is likely to occur at times in some part of most buildings. Persistent heavy condensation may cause failure of coatings, and measures to prevent or minimize it should be considered at the design stage, especially where processes or activities carried on in the building create conditions of high humidity. See 41.2 and 41.3.

6.5 Profiles. Coatings have a tendency to recede from sharp edges during application and this may result in the film having inadequate thickness at these points. Arrises should be slightly rounded, a radius of 1.5 mm usually being sufficient.

6.6 Substrates and coating systems. The properties of substrates and their influence on the selection of coating systems should be considered at the design stage. These factors are discussed in section four.

Building materials to which coatings are to be applied should be chosen for their inherent properties of durability and resistance to decay or corrosion in the environments in which they are to be used. Over-reliance should not be placed on the ability of coatings to upgrade the performance of inherently unsuitable materials, especially in circum-

stances where frequent maintenance is likely to be impracticable or uneconomic.

Consideration should be given to alternative or supplementary treatments, e.g. galvanizing or sprayed metal coatings (see 28.2.2), and to ancillary treatments such as wood preservatives (see 25.3), to enhance the protection afforded by coatings. Consideration should also be given, when the facility is available, to the factory application, wholly or in part, of coating systems. This is often more satisfactory than site application and may offer a wider choice of systems.

7. Environmental considerations

The general and local environments and the conditions of service are major factors to be taken into account in the selection of coating systems. Reference should be made to clause 24 for general guidance on the principles of selection and to clause 41 for information on special conditions and requirements which may influence selection.

8. Documentation

8.1 General. Specifications and other documents that may be required in respect of initial or maintenance painting should be prepared in sufficient detail to afford proper guidance in the preparation of estimates and the execution of the work.

Where relevant, there should be an exchange of information at an early stage between the painting contractor or subcontractor and those responsible for the constructional work, including other trades whose work may affect or be affected by painting.

A painting project may involve several parties, including client, main contractor and subcontractors, suppliers and inspectors. Copies of all relevant documents should be available to all parties, including site personnel responsible for supervision.

General requirements in respect of painting specifications and associated documents are described in 8.2 to 8.5.

8.2 Specifications

8.2.1 General. The prime functions of a specification for initial or maintenance painting are as follows:

- (a) to describe the substrates to be treated and the means by which the required finish is to be achieved. 'Means' includes surface preparation, materials, systems, application methods (where relevant) and the conditions under which the work is to be done;
- (b) to provide a basis for accurate pricing and tendering;
- (c) to serve as a comprehensive reference document for all parties;
- (d) to act as a reference if disputes arise or arbitration is necessary.

Specifications should be clear, concise and unambiguous. It should not be assumed that anyone expected to comply with an instruction or requirement in a specification will correctly infer its intended meaning if an alternative interpretation is possible; nor should it be assumed that an ambiguity will be clarified by its context. Aspects to which special attention should be given in the preparation of painting specifications are described in 8.2.2 to 8.2.6.

8.2.2 Surface preparation. With the possible exception of structural steelwork, there are no standards for preparatory

work which have general application to the wide range of substrates and surface conditions likely to be encountered in the painting of buildings. Nevertheless, because of the influence of preparation on costs, appearance and subsequent performance, the nature and extent of preparatory work should be specified as clearly as possible. In particular, imprecise terms such as 'Thoroughly prepare' or 'Burn off where necessary', without further qualification, should be avoided; see also 53.2.1.

In some circumstances, it may be difficult to describe, with any degree of precision, the standard of preparation to be achieved. An example is the preparation of walls bearing thick residues of old coatings. In such cases, a sample area can be prepared as an indication for tendering purposes of the standard required. If this approach is adopted, it should be ensured that the indicated standard can be achieved on the remainder of the work.

Any particular method of preparation specified should be appropriate and relevant to the result required. For example, a requirement to 'Remove all rust and scale by chipping, scraping and wirebrushing' cannot be achieved (see 27.5.2.5); the choice lies between specifying a more effective method or accepting a lower standard of preparation.

8.2.3 Materials. All the materials in a coating system should, if possible, be obtained from the same manufacturer. Differing makes or brands specified should be compatible; see 20.5.

The specification should require materials to be applied or used strictly in accordance with the manufacturer's instructions.

8.2.4 Application methods. The specification should state if circumstances require or preclude the use of particular methods of application.

8.2.5 Application conditions. The specification should indicate any requirements or constraints in respect of the conditions under which work is to be carried out or, if necessary, suspended, e.g. of temperature, humidity, climatic conditions or other factors; see clauses 44 and 52.

8.2.6 Inspection procedure. If the work is to be subject to inspection the intended procedure should be described in the specification. See also clause 14.

8.3 Bills of quantities. These should be prepared in accordance with the relevant edition of a document such as 'The Standard Method of Measurement of Building Works', or 'The Code for the Measurement of Building Works in Small Dwellings', as appropriate.* It is essential that the relevant edition, or any other method of measurement adopted, should be stated.

8.4 Schedules. For work of modest size or where relatively few finishes or colours are to be used, information identifying different systems with particular areas can often be incorporated in the painting specification. For large or more complex projects, the preparation of a finishing schedule, detailing location, nature of substrate, coating system and (where relevant) colour, is recommended.

A schedule of finishes should not be regarded as a substitute for the painting specification; site personnel responsible for supervision should have copies of both documents.

8.5 Drawings. These may be required on large projects for tendering purposes or as an aid to the organization and control of work. Drawings are often essential in order to locate the areas referred to in schedules.

9. Organization of work

Where applicable, painting work should be planned in relation to the work of other trades, to ensure that surfaces are in a fit condition to be painted and that completed work is not damaged by subsequent building operations; in particular, ample time should be allowed for drying out of plaster and similar surfaces before they are painted.

In maintenance painting in factories and commercial buildings, it may be necessary for work to proceed without interrupting the normal functions of the building. This will require careful planning to avoid inconvenience to the occupants and minimize loss of productive time by the contractor. In such circumstances, it may be necessary to allow for the erection of temporary partitioning or other means to isolate the areas where painting is in progress.

10. Records

Much painting and decorating work is carried out at regular intervals as a maintenance operation, and a planned approach is essential. Planning, in turn, is dependent on availability of information, and it is recommended that, where expenditure on maintenance painting is significant, accurate records should be maintained. The essential information to be recorded should include dimensions, details of coating systems (including preparation) and costs. Other relevant information may include the conditions (e.g. of weather, atmosphere or environment) under which the work was done, methods of application employed, size of labour force and any special difficulties or problems encountered. When work is subject to independent inspection during application (see clause 14), inspection reports should be retained as a permanent record. Similarly, where a system of regular inspection of paintwork is in operation, as recommended in clause 49, the observations made should be recorded. Apart from its contribution to ease and economy of maintenance, a system of recording as described can assist in the investigation of failures and the settlement of disputes.

11. Off-site work

Factory application of coating systems, wholly or in part, to a variety of components is now well established. Typical examples of components partially treated by the manufacturer or supplier include primed joinery, blast-cleaned and primed steelwork, pretreated non-ferrous metal components and primed or sealed building boards. Other components may be finished completely in the factory, often with stoving or cold-curing coatings.

Where components are to be supplied partially-finished, e.g. primed, the treatment or coating should have properties appropriate to the environment or conditions of service to which it will be exposed. Also, the primer (or other treatment) and the coatings to be applied on site should be compatible. Measures to minimize damage to the treatment during transit should be taken by the supplier; recommendations for repairing any damage that may occur should be incorporated in the painting specification for the site work. Special care should be taken with components that are supplied fully finished, to prevent damage during transit and on site, as it may not be possible to effect repairs to a standard equal to that of the original finish. The manufacturer's or supplier's recommendations for repairing damage and for subsequent maintenance treatment should be obtained.

*Both of these documents are published and supplied by the Royal Institution of Chartered Surveyors.

12. Protection of components on site

Measures should be taken to prevent damage or deterioration of components and factory-applied treatments on site, i.e. during off-loading, handling, storage and erection. If mechanical lifting equipment is used in handling large or heavy components, slings should be well padded at contact points. Wrapping or other means of protection provided by manufacturers should not be removed before it is essential to do so. Factory-finished articles and components should be stored away from 'traffic' areas and be protected against damage and soiling.

Joinery, whether primed or unprimed, should not be stored out of doors, especially when it is to be installed in a centrally-heated building. If external storage cannot be avoided, the components should be protected against moisture and weather. Components, whether stored indoors or outdoors, should not be in direct contact with the ground. If stacking is necessary, spacers should be provided between the components to permit air circulation and, in the case of primed joinery, to prevent sticking at contact surfaces.

Metal components prepared and painted with part or the whole of the coating system before delivery to site should, if their size permits, be stored indoors; if stored outside they should be protected and, if necessary, stacked as described for joinery.

Primed structural steel members, if stored in the open, should be stacked in such a manner that they do not retain water even if no cover is provided. The bottom layer in the stack should be laid on timber packings to raise it above the ground and the rainwater splash zone. Spacers should be placed between subsequent layers to permit air circulation and prevent sticking.

Consideration should be given to applying additional coats, e.g. of primer, when there is a possibility of long delay between initial and final painting after erection.

13. Workforce and supervision

The number of operatives employed should be appropriate to the size of the contract, its planned duration and the nature and availability of the work involved. Preparation is generally more labour intensive than application, and the size and deployment of the workforce should allow for this. With tiring or tedious operations, such as the preparation of steelwork by manual cleaning (see 27.5.2.5), adequate manning assists in the maintenance of satisfactory standards and also facilitates priming of prepared surfaces without undue delay. On extensive ceiling and wall areas, the number of operatives deployed should be sufficient to enable working edges to be kept 'alive' (see 46.2.3) and should take into account working conditions and the characteristics of the coatings to be applied.

Operatives should be skilled and experienced in the types of work involved and with the materials, methods and equipment to be used. With novel materials, methods or equipment, special training may be required.

Adequate supervision should be provided, having regard to the nature of the work and the size and deployment of the workforce. Supervisors should be experienced in all aspects of the work for which they are responsible. They should be provided with copies of all working documents, e.g. specifications, finishing schedules and product information necessary for effective supervision and control of the work. They should also be provided with, or have ready access to, test equipment, e.g. moisture meters, film-thickness gauges and flow cups, when the nature of the work requires it.

14. Inspection requirements

For large contracts, each stage of the work may be subject to inspection and approval by a nominated person or specialist inspection organization. The essential purpose of such an arrangement is to ensure compliance with the specification; it is not of itself a guarantee of good performance if the specification is unsound or inadequate. Where a scheme of inspection is to operate, the intended procedure should be stated in the specification so that contractors are aware of the implications at the tendering stage. It should be appreciated that inspection does not remove or diminish the contractor's responsibility for proper supervision of the work.

Inspection procedures are described in clause 47.

15. Materials sampling and testing

This clause describes the general considerations in relation to sampling and testing of materials. Procedures are described in clause 47.

Routine sampling and testing is usually carried out for one or both of the following reasons:

- (a) to ensure compliance by suppliers with specifications or stated requirements for materials;
- (b) as a safeguard against overthinning, adulteration or similar undesirable practices during application.

In either case, site action is usually confined to taking or setting aside samples for examination in the specifying authority's own laboratory or with an independent testing organization.

Where sampling and testing is carried out for the reason indicated in (a) above, samples should be in the original unopened containers.

It is usually the responsibility of the specifying authority to arrange for testing, but if the specification requires the contractor to provide such samples then the frequency of sampling and the quantity of material to be provided should be clearly stated.

In respect of (b), the procedure will usually require samples to be taken during application, e.g. from painters' kettles or spray-equipment containers. Subsequent testing is generally the responsibility of the specifying authority, but the specification should define the contractor's responsibility for providing samples and describe the tests that will be carried out, e.g. by reference to BS 3900.

Sampling and testing procedures can be time-consuming and expensive and will be effective only if they are properly implemented.

Section three. Materials

16. Introduction

Materials used in the painting of buildings fall into three main categories:

- (a) pigmented coatings, i.e. paints and wood stains;
- (b) clear coatings, e.g. varnishes and lacquers;
- (c) ancillary materials, e.g. fillers, stoppers and materials similarly used in the preparation of surfaces or in coating systems.

Clauses 17 to 21 and tables 1 to 8 provide information on the types of coatings in general use in the painting of buildings as an aid to selection, specification and use. Ancillary materials are described in clause 22.

17. Functions of coatings

17.1 General. The possible functions of coatings in relation to building surfaces are many, but those described below are typical. In some situations the requirements may be so specialized as to need individual consideration by a consultant or paint manufacturer with experience in the particular field.

17.2 Protection. Essentially, this depends upon the ability of the coating to prevent moisture, atmospheric pollutants, aggressive chemicals or other destructive elements coming into direct contact with the surface. In this respect, the effectiveness of the coating will depend upon its composition and especially its thickness and also upon the severity of attack. Whenever possible and particularly in severe conditions, consideration should be given to reducing dependence on the protective properties of coatings, e.g. by using less vulnerable building materials, by modifying the design of components or by environmental changes such as improved ventilation; see clause 6.

17.3 Decoration. Even where the main emphasis is on protection or other function, coatings are usually expected to contribute to the overall appearance and decorative effect of buildings; in many instances, paint will be the main decorative medium, providing the required colours and degree of gloss or texture.

Careful choice of paint colours and their coordination with those of other elements in the decorative scheme, such as furnishing fabrics, floor coverings, laminated and ceramic goods, is important. BS 4800 provides a range of paint colours derived from the 'parent' BS 5252 and, in conjunction with other 'satellite' ranges, affords the facility for fully coordinated schemes to be designed.

The aesthetic aspects of colour are not within the scope of this code, but practical considerations relating to paint colours are described in appendix A.

17.4 Hygiene. The ability to withstand regular cleaning is often a requirement in a coating; where high standards of hygiene or sterile conditions have to be maintained, this may be the most important function. The coating should be of a type which will be resistant not only to the soiling agent but also to the cleaning agent and method used.

In situations favourable to the development of mould growths, coatings having fungicidal properties may be helpful, although too much reliance should not be placed on the ability of coatings alone to prevent mould growth and, where possible, they should be supplemented by other measures as described in 41.4.

17.5 Identification. A useful function of paint is as a means of identifying the nature of piped services and the location of safety appliances by means of colour codes. BS 1710 and BS 5378 give details of this application.

'House' colours are used by many large organizations to give corporate identity to buildings, equipment, vehicles, etc. Many standard colours of this nature used by official bodies are embodied in BS 381C.

17.6 Special functions. In some circumstances there may be specialized requirements, e.g. of resistance to high humidity or direct chemical attack, reduction of surface spread of flame and inhibition of mould growth. These and other special requirements are referred to in clause 41.

18. Constituents of coatings

18.1 General. Most coatings consist of binder, solvent or thinner and, in paints and stains, pigment. The binder is the non-volatile film-forming constituent of the coating. The solvent or thinner imparts the required degree of fluidity to the binder during application; the combination of binder and solvent forms the 'vehicle' or 'medium' of the coating.

Pigment provides colour and opacity and may have other functions in some types of coatings. Other constituents may be present to ensure the stability of the coating or to prevent deterioration in storage.

18.2 Binders.

18.2.1 General. The nature and proportion of binder present in a coating largely determine its characteristics, e.g. method of drying, compatibility with other coatings, application properties, degree of gloss, durability and resistance to attack. A characteristic of many binders is that they are dispersions or solutions of synthetic or natural resins or polymers. Individual resins and other film-forming materials differ widely in properties and provide the basis for a great variety of coatings. The types of binder in general use are described in 18.2.2 to 18.2.7.

18.2.2 Drying-oil binders. Many vegetable oils, notably linseed, soya and tung oils, dry slowly to form tough, elastic films when exposed to air; some primers employ binders of this type. More usually, drying oils are combined with resins (typically alkyds) for use as clear coatings (varnishes) or, with pigments, as paints.

Coatings based on drying-oil type binders are characterized by being relatively slow in drying and hardening compared with emulsion-based types. The actual rate depends upon their composition and the conditions of application, but typically they are dry to touch in 4 h to 8 h and recoatable overnight. Initial drying and hardening is slower or may cease altogether in cold or damp conditions or in atmospheres where the supply of oxygen is restricted. Drying and hardening may also be retarded by the presence of grease or dirt on the surface to which the coating is applied.

Drying-oil type coatings are invariably organic solvent-thinned, usually with white spirit, although manufacturer's recommendations in this respect should be observed; see 18.3.

18.2.3 Emulsion binders. These are aqueous dispersions of particles of synthetic polymers, e.g. vinyl or acrylic, alone or in combination, and contain no drying oils. Drying and hardening proceed by evaporation of the water followed by coalescence of the particles. In favourable circumstances, they are dry to touch or even recoatable in an hour or two, and full washability is attained within a day or so of application. Damp atmospheres retard evaporation and cause delay in drying whilst very low temperatures may prevent coalescence and produce an unsatisfactory film. Emulsion paints are used mainly as coatings for walls and ceilings, but many primers, undercoats and finishes, traditionally formulated with drying-oil type binders, now have emulsion-based equivalents. Bituminous emulsions are also available, see 18.2.7.

Emulsion-based coatings usually have less odour than those containing drying oils and/or organic solvents. Also, water, rather than expensive thinners, can be used for thinning and for cleaning tools and equipment after use.

18.2.4 Chemically-curing binders. Coatings employing binders of this type are supplied as two-pack materials, one container holding the 'base' and the other the appropriate quantity of 'curing agent', 'hardener' or 'activator'. The two components are combined shortly before use to induce a chemical reaction which converts the applied film from a liquid to a solid state.

Typical examples utilize epoxy or polyurethane resins and are available as clear or pigmented coatings. These have excellent resistance to chemical attack and abrasion but require high standards of surface preparation. 'Curing' of the film is temperature-dependent and is slowed or may be inhibited completely at low temperatures. These factors tend to limit the use of coatings of this type on building surfaces. Epoxy and polyurethane resins may be combined with other resins, notably alkyds, in drying-oil type binders to produce 'one-pack' materials, but these are not 'chemically-curing' and do not have the degree of chemical and abrasion resistance characteristic of the 'two-pack' types.

18.2.5 Solution binders. In these, film-forming material is in solution, and conversion to the dry film is accomplished essentially by evaporation of the solvent. Examples include solutions of shellac (knotting) treated rubber (mainly chlorinated and isomerized), vinyl-type resins, nitrocellulose and bitumen.

Although the properties of solution binders vary considerably, a general characteristic is that they tend to remain more or less soluble in the original solvent, and this may create difficulties in applying several coats of the same material, especially by brush. Another characteristic is their rapid drying which, again, may make them difficult or impossible to apply by brush to large areas. Modification with other materials can improve application properties; for example, chlorinated rubber may be combined with alkyd/drying oil although at the expense of some reduction in its chemical resistance.

18.2.6 Inorganic (cement and silicate) binders. White Portland cement forms the binding agent in cement paints for use on concrete, brickwork and similar surfaces. This type of coating is usually supplied in powder form and mixed with water immediately before use.

Some specialist coatings for the protection of iron and steel (see BS 5493) are based on silicates.

18.2.7 Bituminous binders. Bitumens and tars in solution or as emulsions are used in low-cost coatings, mainly for waterproofing.

Suitable coal tar fractions are combined with epoxy resins in some specialist coatings; see table 8.

Coatings based on bituminous materials are usually black although, with some types, a limited range of dark colours is available. They may also 'bleed' into and discolour other types of coatings applied over them; see clause 40.

18.3 Solvents. Except in the case of solution-type binders (see 18.2.5), these function mainly as 'thinners' rather than true solvents, their purpose being to impart the required degree of fluidity and facilitate application.

Coatings other than emulsion paints are generally supplied ready for use, although further additions of the recommended thinner by the user may be permissible, e.g. to assist the penetration of priming coats on absorbent surfaces or for application of coatings by spray. Emulsion paints may be formulated for use as supplied or may require thinning with water.

Over-thinning can seriously impair the opacity and other properties of coatings, but painting specifications should not preclude thinning; as indicated above, this may be necessary in some circumstances. The specifications should state, however, that thinning is to be carried out under competent supervision and strictly in accordance with manufacturers' recommendations as to type and proportion of thinner.

18.4 Pigments

18.4.1 General. The major function of the pigment is to provide colour and opacity; most pigments contribute to this to a greater or lesser degree. Additionally, and according to the nature of the pigments used, they may increase the thickness of the dry film, reinforce it physically, absorb or reflect harmful ultraviolet radiation, inhibit corrosion on metal surfaces or otherwise contribute to the durability or stability of the coating.

A wide variety of pigments, differing in origin, colour and properties, is available. The principal categories are described in 18.4.2 to 18.4.6.

18.4.2 White pigments. Because of the preponderant use of white and light-coloured finishes, white pigments are of considerable importance in the manufacture of paint. Titanium dioxide is the most widely-used white pigment; it is non-toxic, has excellent colour and opacity and is resistant to discoloration. White lead, formerly the main white pigment, is now rarely used because of its toxicity, poor colour and opacity and tendency to discolour in polluted atmospheres.

18.4.3 Tinting pigments. This category comprises pigments that are used primarily for their colour when used alone or as 'tinters' in combination with white, although some may have other properties. The main pigments in this category are natural or synthetic metal oxides, organic pigment dyestuffs and carbon black.

Coloured pigments vary considerably in properties and, in particular, in opacity. Some dyestuff pigments are relatively low in opacity and, with strongly-coloured coatings based on pigments of this type, additional coats may be required; see appendix A.

18.4.4 Extenders. These are inert materials, usually of mineral origin. Although generally classed as pigments, they may contribute little to the opacity of coatings but have other useful functions. According to the type of extender used, these functions may include reinforcing the mechanical strength of the dry film; assisting application; imparting bulk or 'structure' to the liquid paint and helping to prevent settlement of the solid ingredients during storage; improving intercoat adhesion; imparting roughness or texture to the coating when this is required.

18.4.5 Corrosion-inhibitive pigments. These have the property of inhibiting or retarding corrosion of ferrous and non-ferrous metals and are used in primers for these surfaces. They include metallic zinc and lead and derivatives of these metals, such as red lead (lead oxide), zinc chromate and

zinc phosphate. Red iron oxide, although having no inhibitive properties, is often used in conjunction with inhibitive pigments as an 'extender'.

The properties of an inhibitive pigment may be influenced by the nature of the medium in which it is used. Red lead, for example, gives best results when combined with drying-oil media. Similarly, metallic zinc is generally used in conjunction with oil-free binders of the solution or chemically-curing type, e.g. those based on chlorinated rubber or epoxy resin.

18.4.6 Laminar pigments. These pigments have a flaky structure and, within the paint film, the individual flakes lie parallel to the surface and overlap, forming a moisture barrier and improving tensile strength. Widely-used pigments of this type include micaceous iron oxide, aluminium and graphite. The two latter pigments, in addition to their general use in protective coatings, are also used in heat-resisting paints.

19. General properties of coatings

19.1 General. Properties common to several types of coatings can influence their application, appearance or performance in service. They include film thickness, viscosity, thixotropy and flow, properties that are in some degree interrelated.

19.2 Film thickness. This is determined essentially by the proportion of non-volatile solids (e.g. pigment or resin) present in the coating. The method of application may also affect film thickness; see clause 46. The protective properties of a coating are generally in direct proportion to its film thickness which may also influence the filling and levelling properties.

Film thickness may be expressed as 'wet', i.e. the thickness immediately after application, or 'dry' when the volatile constituents have evaporated. Dry film thickness is the significant factor in relation to protection and filling properties.

Given a specified solids content, most coatings have a 'natural' film thickness determined by the application and other characteristics. For most general purpose building paints, this is of the order 20 μm to 25 μm (0.0008 in to 0.001 in) per coat dry film thickness, but some special purpose coatings (e.g. 'high build' types) may yield films of 100 μm to 250 μm (0.004 in to 0.01 in).

BS 3900 : Part C5 describes methods of determining the film thickness of applied coatings.

19.3 Viscosity. In relation to most coatings, viscosity may be regarded as the resistance offered by the material to shearing forces, e.g. brushing or rolling, and, in consequence, directly affects the ease with which the material can be applied. Indirectly, it may influence film thickness because, if the viscosity is low, the coating may be spread out too far, yielding an excessively thin film. If it is too high, it may be difficult to apply the coating in a film of uniform thickness, especially by brush.

Application properties cannot always be assessed either from the apparent consistency of the material in the container or by stirring or pouring, because of the effect of thixotropy; see 19.4.

19.4 Thixotropy. Thixotropy is the property of changing reversibly from a gel or semi-liquid state when at rest to a more liquid consistency when shearing forces (e.g. brushing

or stirring) are applied. It is inherent in some types of paint (e.g. emulsion paints) and is imparted to others (e.g. alkyd gloss finishes) by the addition of gelling agents. The level of thixotropy may vary from being barely perceptible, for ease of brushing, to being very pronounced to reduce drips and/or enable thick films to be obtained without the occurrence of running or sagging.

19.5 Flow. Flow is the extent to which a coating is able to flow out to a film of uniform thickness free from brush marks and similar irregularities produced by the method of application.

Flow properties are determined by the rheology of the liquid constituents of the coating and, to some extent, by the volume and nature of the pigment used. Simple oil-based paints generally have relatively poor flow, as do most emulsion paints. Most gloss finishes, including varnishes, have good flow. Thixotropic coatings usually have poorer flow than their 'liquid' counterparts. Quick-drying coatings may exhibit apparent poor flow if the film sets before flow-out is complete.

Although good flow is a desirable attribute in a finish, excessive flow may make the material difficult to control in application and cause running and sagging. Coatings with good flow also tend to recede from external angles and sharp edges, reducing the thickness and protective value of the film at these points. For this reason, primers and undercoats are usually formulated to flow less freely than finishing coats.

20. Components of coating systems

20.1 General. Depending upon the type of surface and the nature and function of the coating, most systems will comprise at least two coats; more may be required, especially with coating systems having a protective function. Again depending upon the surface and the type of coating, systems may consist of several coats of the same material or a sequence of coats of differing type. In the latter case, a typical system may comprise a 'primer', one or more 'undercoats' and one or more coats of 'finish'; sometimes the undercoats are omitted, the finish being applied directly over the primer. The functions of the individual coats in multi-coat systems of this kind are described in 20.2 to 20.5.

20.2 Primers and sealers. An essential function of a primer is to secure good adhesion to the surface to which it is applied and, in turn, to provide a base to which the succeeding coats will adhere satisfactorily; other functions may include:

- (a) on absorbent surfaces, such as wood, lightweight blocks, plaster and many building boards, the prevention of undue absorption of 'binder' from subsequent coats, leaving them underbound or lacking in gloss;
- (b) on metal, especially iron and steel, the inhibition of corrosion;
- (c) on surfaces of an alkaline nature, such as concrete, cement rendering, asbestos-cement and some types of plaster, a reduction of the risk of attack on subsequent coats;
- (d) on new wood, metal and other materials exposed to attack by moisture or other adverse elements, the provision of protection in the interval between erection or fixing and application of the complete coating system.

'Sealer' is a term often loosely applied to coatings which may combine some of the functions of primers described above with other functions, or which may be used for purposes other than priming. Examples include:

- (e) aluminium-pigmented primers that may be used as wood primers and also as 'sealers' for bituminous surfaces other than wood; see clause 40;
- (f) primer-sealers for powdery or friable surfaces (see 53.5) or for plaster and similar surfaces of high or variable porosity (see 30.3.2);
- (g) protective coatings, usually unpigmented; e.g. clear sealers for metal-sprayed steel (see 27.4) and some multi-coloured finishes (see table 5).

Well-thinned first coats of emulsion paint may be needed on plaster of high or variable porosity; see 30.3.2. These are sometimes referred to as 'sealing' or 'mist' coats.

20.3 Undercoats. These are relatively highly pigmented matt or mid-sheen materials, applied to primed or previously painted surfaces before the application of finishing coats. Their essential function is to provide a uniformly opaque base of a colour appropriate to that of the finish, but they also contribute to the thickness, filling properties and cohesion of the paint system.

Manufacturers' recommendations regarding the use of undercoats should be observed. In some circumstances, undercoats may not be needed, or can be replaced in part by additional coats of finish. Many oil-based matt or mid-sheen finishes, for example, are applied direct without undercoats to primed or previously painted surfaces. Oil-based gloss finishes are usually applied over undercoats but, in three-coat systems on primed or previously painted surfaces and with manufacturers' approval, a system of one undercoat and two coats of gloss finish can be used in preference to two undercoats and one coat of finish, for greater durability externally or in severe internal environments.

20.4 Finishes. The final coat in the system provides the required colour, degree of gloss, texture or other attributes, including resistance to weather, chemical attack and mechanical damage. In this respect, the finish may be considered to be the most important coat in the system to the extent that its appearance and performance in service are frequently the criteria by which the system as a whole is judged. However, the finish cannot compensate for deficiencies in preceding coats in the system, whether these relate to quality, suitability or application.

20.5 Compatibility of coatings. It is essential that the individual coats in the system are mutually compatible. Compatibility is influenced mainly by the composition and physical properties of each of the coatings in the system and, to some degree, by their juxtaposition. Thus, a coating based on a 'solution' binder (see 18.2.5) may be unsuitable for use over a drying-oil type coating, because its solvents may soften or disrupt the latter, although no problem may arise if the sequence of coats is reversed. Similarly, application of a hard coating over a softer one may result in cracking of the composite film whilst application of the softer coating over the harder one may be satisfactory. Incompatibility may be a cause of poor adhesion between coats in a system.

Compatibility problems are less likely to arise with systems comprising coatings of similar composition and properties but, even with these, slight variations between different brands of the same types of coatings may adversely affect

the performance of the system. It is advisable, therefore, to ensure that all the coatings in a system are of the same brand and are used in accordance with the manufacturer's recommendations regarding the sequence and number of coats.

21. Types of coatings

21.1 General. For the purposes of this code, paints and similar coatings are grouped in three categories as follows:

- (a) conventional coatings;
- (b) specialist coatings;
- (c) factory-applied coatings.

Metallic coatings are referred to in clause 28.

21.2 Conventional coatings. These represent the greater proportion of the coatings in general use in the painting of buildings and are based mainly on drying-oil or emulsion binders. They are listed and described in tables 1 to 7, generally according to their functions within the coating system, as follows:

- Table 1 — Primers for wood
- 2 — Primers for metal
- 3 — Miscellaneous primers
- 4 — Undercoats
- 5 — Pigmented finishes
- 6 — Natural finishes for wood
- 7 — Bituminous and tar-based coatings

Included in this category are coatings based on binders of the types referred to above but modified to impart specific properties e.g. of mould-resistance or flame-retardance; see clause 41.

To facilitate use of the code, products are numbered within the relevant table, the combined table/product numbers providing a 'product reference'; e.g. the reference '2/2A' denotes the second of the products listed in table 2, a red lead metal primer to BS 2523 type A. It is emphasized that product references are intended solely as a means of identification within the code and especially in using tables 10 to 16 which describe coating systems for various substrates; they have no status in relation to specifying or ordering materials nor should they be confused with or regarded as alternatives to the product references given in BS 5493.

21.3 Specialist coatings. This category comprises coatings having properties, e.g. of chemical resistance, hardness or other characteristics, not possessed by materials of conventional type as defined in 21.2 above. They may require special techniques or conditions of application or necessitate high standards of surface preparation and may not be readily available from normal sources of supply. Often, the complete system is of specialist type and may not be suitable for use over primers or existing coatings of conventional type. For these reasons specialist coatings have limited usage in the painting of buildings.

Accordingly, the code does not refer to them in detail, but table 8 summarizes the characteristics of the principal types. Within the generic categories, there may be considerable variation in the formulation and, in consequence, the characteristics of individual materials. Reference to manufacturers is advised when there appears to be a requirement for the use of specialist coatings. BS 5493 and DD 24 give detailed recommendations regarding specialist coatings for the protection of iron and steel structures.

The comments in 21.2 relating to product references in tables 1 to 7 apply also to table 8.

21.4 Factory-applied coatings. These range from stoving or air drying paints, applied to wood and metal components by spraying or dipping, to 'coil coatings' mechanically applied to coiled flat sheet for subsequent forming and fabrication. Coatings of types unsuitable for site application may be employed; correctly chosen and applied, they can be tougher, harder and more durable than most site-applied finishes. With the possible exception of plasticized PVC coatings (see 38.4) they do not present serious difficulties in maintenance repainting.

For light gauge steel, guidance in choice of coatings is given by DD 24, although there have been improvements in and additions to the types there described. Organic finishes

for aluminium extrusions (e.g. windows) are defined in BS 4842, and the expected performance of a variety of coatings on metal and other claddings is tabulated in BS 5427. No such guidance is available for complete factory-applied systems on timber, but they can give better durability than the conventional site-applied coatings at no greater cost.

It should be noted that components for interior use are sometimes finished by processes suitable for the dry conditions of a completed building, but inadequate for exposure to weather or condensation during erection. To avoid premature failure, a higher grade coating may have to be specified. Likewise, the life indicated for various categories in DD 24 could be extended by additional coats or increased thickness.

Table 1. Primers for wood

Ref.	Description	General composition	Characteristics and usage
1/1	Low-lead, oil-based primer to BS 5358	Drying-oil/resin type binder with 'low lead' pigmentation	Primers of this type have a lead content of less than 1 % (as determined by the method described in BS 4310) but are equivalent in performance to the traditional 'pink' (white lead/red lead) wood primers. They are suitable for general use on wood not highly resinous and not treated with metallic naphthenate preservatives; also for fibre boards and wood chipboards not fire-retardant treated. Colour: Typically white or pink
1/2	Aluminium wood primer to BS 4756	Drying-oil/resin type binder with aluminium pigment	Alternative to 1/1, and more suitable for woods which are resinous or have been treated with metallic naphthenate wood preservatives or creosote. May also be used as primers for fibre boards and wood chipboards (not fire-retardant treated) and as 'sealers' for surfaces that have been coated with bituminous materials. Colour: Aluminium
1/3	Water-thinned primer to BS 5082	Emulsion-type binder (typically based on acrylic polymer) with lead-free pigmentation	These primers dry more rapidly than 1/1 and 1/2 types, usually allowing same-day recoating if required. They do not contain flammable solvents and permit tools and equipment to be cleaned with water. Their durability without top coats on exterior exposure is equivalent to that of 1/1 and 1/2 types but, as they are more permeable, they may be less effective in excluding moisture from primed joinery stacked in the open. They are more prone to raise grain than oil-based primers. They may also be used as primers for fibre building boards and woodchip boards not fire-retardant treated. Colour: Typically white, light grey or pink

Table 2. Primers for metal

Ref.	Description	General composition	Characteristics and usage
2/1A	Pretreatment, wash or etching primer, two-pack	Typically, polyvinyl butyral resin solution with phosphoric acid (as separate component) and zinc tetroxochromate pigment	The main function of these primers is to improve adhesion of paint systems to non-ferrous metals. They may also be used to provide temporary protection to blast-cleaned steel and sprayed-metal coatings. The two-pack types generally give superior performance but may be less convenient to use. Application of primers of this type does not usually obviate the need for the application of a normal type of primer subsequently. Most pretreatment primers may be used in conjunction with conventional and specialist coating systems. Colour: Typically low-opacity yellow (two-pack types) or blue (one-pack types)
2/1B	As above, one-pack	Typically, polyvinyl butyral/phenolic resin solution with tinting pigment	
2/2A	Red lead primer to BS 2523: type A	Linseed drying-oil type binder with red lead (types A and B) or red lead/white lead (type C) as the sole pigments	These are primers of traditional type for iron and steel especially in new construction when there is likely to be a lengthy delay between erection of the steel and completion of painting. More tolerant of indifferent surface preparation than most other metal primers, they are slow in hardening which is disadvantageous when early handling or recoating is necessary. Colour: Orange red
2/2B	Red lead primer to BS 2523: type B		
2/2C	Red lead primer to BS 2523: type C		
2/3	Red lead/red oxide primer	Typically, drying-oil/resin type binder with red lead/red oxide pigmentation	These primers for iron and steel are quicker in drying and hardening than 2/2 primers and are therefore more suitable for use in maintenance work or when early handling or recoating is necessary, although they are of lower durability on exposure without top coats. Colour: Red-brown
2/4	Zinc phosphate primer	Typically, drying-oil/resin type binder with zinc phosphate as the main inhibitive pigment. Other tinting pigments may be incorporated	Zinc phosphate offers advantages over other inhibitive pigments in being non-toxic and neutral in colour. Zinc phosphate primers are fairly quick-drying and can afford protection without finishing coats for reasonable periods. Established usage is for priming steelwork, but some types may be suitable for non-ferrous metals; refer to manufacturer's recommendations. Colour: Typically light grey
2/5	Chromate primer	Typically, drying-oil/resin type binder with zinc chromate as the main inhibitive pigment. Red oxide or other pigments may be incorporated	Characteristics and usage vary according to formulation, but chromate primers are usually fairly quick-drying and suitable for use on ferrous and non-ferrous metals. Colour: Typically yellow, red-brown or grey-green
2/6A	Calcium plumbate primers to BS 3698: types A and B	<i>BS 3698 types.</i> These have a linseed drying-oil binder. Type A contains 48 % calcium plumbate; type B, 33 % <i>Alternative types.</i> Typically, binder is of the drying-oil/resin type with calcium plumbate content similar to that of BS 3698 types	The main use of calcium plumbate primer is on galvanized steel; for this purpose, primers having the lower proportion of calcium plumbate are satisfactory. They may also be used on composite wood/metal components, e.g. galvanized steel window frames in wood sub-frames. BS 3698 types are fairly slow-drying, and the alternative quicker-drying types are frequently used. Not all paints adhere well to calcium plumbate primers, and compatible undercoats and/or finishes should be specified. Colour: Typically cream or light grey
2/6B	Calcium plumbate primer, alternative to above		
2/7	Metallic lead primer	Typically, drying-oil/resin type binder with at least 25 % metallic lead pigment	Metallic lead primers are relatively tolerant of indifferent surface preparation and can protect iron and steel for reasonable periods before application of finish coats. They may show advantages over red lead primers in chemically-charged atmospheres and are quicker-drying than the 2/2 types. Colour: Metallic grey
2/8A	Zinc-rich primer to BS 4652: type 1	Types 1 and 2 are based on a non-saponifiable medium, e.g. chlorinated rubber. Type 1 is supplied in two-pack form (zinc paste and thinner), type 2 in one-pack form. Type 3 is based on epoxy resin and is supplied in two-pack form (zinc paste and curing agent)	These are quick-drying primers for iron and steel with excellent rust-inhibiting properties. They should be applied only to well-prepared (e.g. blast-cleaned) steel. They may also be used for touching up damaged zinc coatings, e.g. zinc-sprayed or galvanized surfaces. Type 3 is frequently used as a prefabrication primer. Spray application is recommended, except on small areas. Colour: Metallic grey
2/8B	Zinc-rich primer to BS 4652: type 2		
2/8C	Zinc-rich primer to BS 4652: type 3		

Table 3. Miscellaneous primers

Ref.	Description	General composition	Characteristics and usage
3/1	Alkali-resisting primer	Typically, alkali-resistant drying-oil/resin type binder, lightly pigmented	Although described as 'alkali-resisting', primers of this type are intended for use on substantially dry, possibly alkali-containing, surfaces mainly beneath drying-oil type finishes; they will not necessarily prevent attack by alkalis on subsequent coats if the structure is very damp. Colour: Typically low-opacity white or off-white
3/2	Water-thinned primer or primer-undercoat	Emulsion-type binder (typically based on an acrylic polymer). May be identical in composition to 4/2	These primers are for use on dry plaster and similar surfaces. They may also be suitable for priming wood and building boards and as undercoats; see 4/2. Colour: Typically white or off-white
3/3	Primer-sealer. Other descriptions include 'Stabilizing primer or solution', 'Penetrating primer', or 'Masonry sealer'	Variable but typically drying-oil/resin type binder, lightly pigmented, or semi-transparent with a 'marker' pigment to assist even application	The essential function of a primer-sealer is to 'bind down' powdery or friable residues of previous coatings which cannot be removed completely. Too much reliance should not be placed on the ability of this type of material to penetrate unsound coatings of substantial thickness, and as much as possible of the old material should be removed. Primer-sealers may also be used to reduce absorption on surfaces of high or uneven porosity. 'Masonry sealers' are usually formulated specifically for use on exterior surfaces and may not be suitable for interior work; with other types, the reverse may apply. Reference should be made to the manufacturer's recommendations. Colour: Variable; see 'General composition'
3/4	Universal primer	Typically, drying-oil/resin type binder with white or light-coloured pigments, usually including rust-inhibitive types, e.g. zinc phosphate	Primers of this type are convenient for small-scale maintenance work involving patch-priming of a variety of substrates, e.g. wood, metal and dry plaster. For new and large-scale work, primers formulated for specific substrates are generally to be preferred. Colour: Typically white or light grey

Table 4. Undercoats

Ref.	Description	General composition	Characteristics and usage
4/1	Oil-based undercoat	Typically, drying-oil/resin type binder, pigmented with titanium dioxide and/or coloured pigments	This type of undercoat provides a matt or low-sheen surface for subsequent application of drying-oil type finishes, especially gloss finishes. In normal conditions, overnight drying is usually required before application of further coats. Most undercoats are suitable for interior and exterior use. Colour: Wide-range
4/2	Water-thinned undercoat or primer-undercoat	Emulsion-type binder (typically based on an acrylic polymer), pigmented as 4/1. May be identical in composition to 3/2 and may conform to BS 5082	These undercoats are quicker-drying than 4/1 and, in normal conditions, may permit same-day recoating. General usage as for 4/1. As primers they may be suitable for priming dry plaster and similar surfaces, building boards and wood. Only types conforming to BS 5082 should be used for priming external woodwork. Colour: May be limited to white and pale tints, especially with 'primer-undercoat' types

Table 5. Pigmented finishes

Ref.	Description	General composition	Characteristics and usage
5/1	Alkyd gloss finish	Typically, drying-oil/alkyd resin binder, pigmented with titanium dioxide and/or light-fast, coloured pigments. Some types contain small amounts of polyurethane or other resins to increase hardness or extend durability	These are high-gloss protective and decorative finishes suitable for interior and exterior use on most building surfaces. They have good durability and wearing properties in most conditions except those of direct chemical attack or very high humidity. Drying and recoating times are variable according to composition but, usually, overnight drying between coats is required. Colour: Wide range available
5/2	Alkyd 'mid-sheen' finish. Other descriptions include 'eggshell', 'satin' and 'silk'	Generally as for 5/1 but adjusted to provide a lower level of gloss	The durability and protective properties of this type of finish are of a lower order than those of 5/1, and exterior use, especially on wood and metal, is not usually recommended. Internally, this finish is suitable for use on most building surfaces. Drying and recoating characteristics are usually similar to those of 5/1. Colour: Wide range available
5/3	Alkyd matt or flat finish	Generally as for 5/1 adjusted to provide a matt finish	Essentially, this is a decorative finish for interior use only and is not generally recommended for 'hard-wear' situations or in humid conditions. Drying and recoating characteristics are usually similar to those of 5/1. Colour: Range may be limited
5/4	Emulsion paint, general purpose matt or 'mid-sheen'. Other descriptions include 'plastic emulsion', 'latex' and 'vinyl', the latter term being used increasingly as a generic description for emulsion paints rather than an indication of composition. Descriptive terms for sheen levels may be described as for 5/2 NOTE. 'Glossy' emulsion paints are available, but experience with them is limited and they are not in widespread general use at the present time. Reference should be made to the manufacturers for information regarding suitability for specific applications	Emulsion-type binder, typically based on vinyl or acrylic polymers or combinations of these, with titanium dioxide and/or coloured pigments	Emulsion paints of this type are essentially 'decorative' rather than 'protective' in function, although their wear-resistance and washability may approach those of the 5/2 finishes. They have advantages over the latter in ease of application to large areas, speed of drying (same-day recoating is usually possible), absence of solvent odour and ease of clean-up. They are widely used for ceilings and walls, mainly internally although some may be suitable for use on exterior walls. Choice of sheen level may depend largely on location and aesthetic considerations but, in general terms, washability and resistance to soiling increase proportionately to the degree of sheen. Emulsion paints are more permeable to moisture than drying-oil type finishes, and some may be unsuitable for use in situations, e.g. in some kitchens and bathrooms, where humidity is high for long periods. Colour: A wide range is available
5/5	'Contract' emulsion paint	Composition, typically, is similar to that of 5/4 but with higher pigment content	Higher pigment gives increased opacity, compared with 5/4 type, but at the expense of some reduction in washability and resistance to soiling. Finish is usually matt. Emulsion paints of this type are frequently used for new interior walls and ceilings where, apart from economy in use, their permeability allows drying-out of contained moisture. Colour: Usually limited to white and pale tints
5/6	Aluminium paint, general purpose	Typically, drying-oil/alkyd resin binder pigmented with flake aluminium	The laminar nature of the pigment (see 18.4.6) imparts excellent moisture-resistance to aluminium paints, and their reflective and heat-resistant properties are useful in many situations. They are suitable for use on most building surfaces, but their widest application is on structural steelwork, storage vessels and heated metal surfaces.
5/7	Micaceous iron oxide paint, general purpose	Typically, drying-oil or drying-oil/resin type binder pigmented with micaceous iron oxide. Small amounts of other pigments may be incorporated to modify the natural colour (dark grey) of the main pigment	Because of the laminar nature of the pigment (see 18.4.6) and the substantial thickness of the film, micaceous iron oxide paints provide good protection and are widely used extensively on structural steel, bridges, harbour installations and electricity transmission towers. On weathering, the coating develops a metallic 'sparkle'. The dark colour of the pigment restricts the range of colours available, but overcoating with alkyd gloss finish may be possible.

Table 5 (continued)

Ref.	Description	General composition	Characteristics and usage
5/8	Masonry paint, emulsion-type, smooth or fine-textured	Emulsion-type binder, typically based on acrylic, vinyl and other polymers formulated to have the degree of flexibility required for exterior use and pigmented with titanium dioxide and/or lime-resistant coloured pigments. Some types are smooth, others contain fibre, sand or other agent to give a fine texture. Most contain an additive to inhibit mould and algal growth	These are essentially 'decorative' coatings but have the weather-resistance and durability required in coatings for exterior walls. They are not generally suitable for application to wood and metal. Formulations containing fibre, sand, etc. usually provide thicker films than the smooth types. Manufacturers should be consulted regarding the use on interior surfaces of masonry paints containing additives to inhibit mould and algal growth because of the possible toxic hazard. Colour: A wide range is available
5/9	Masonry paint, emulsion-based heavy-textured. Some types may be described as 'organic renderings'	Compositions may vary considerably but consist generally of a heavy-bodied emulsion-type binder, reinforced with coarse 'extenders' and, in some cases, fibrous material and aggregates. Pigmentation is similar to that of 5/8 and mould/algal inhibitors may be incorporated	Coatings of this type have been used in Europe for external wall surfaces for many years but have become available in Britain only comparatively recently. They provide thick (1 mm to 2 mm), weather-resistant coatings, and experience in Europe indicates that they are capable of durability in excess of 10 years. Their heavy texture is derived partly from their composition and partly from the method of application, typically by means of specially-designed rollers. In addition to their use externally, coatings of this type may be suitable for internal walls where a hard-wearing textured finish is required. Colour: A wide range is available
5/10	Masonry paint, solvent-thinned, smooth or fine-textured. The latter type may be described as 'stone' paints	Composition varies considerably. Older types may be based on a drying-oil/resin type binder, others on modified or synthetic rubber film-formers. 'Stone' paints contain fine sand, stone or mica. Pigmentation is generally as for other masonry paints	The appearance of this type of coating is similar to that of the 5/8 types, and film thickness is of the same order. Permeability is usually lower, and they may therefore provide greater resistance to moisture penetration but should be applied to dry substrates. Brush application will generally be slower than with 5/8 types. Colour: May be limited
5/11	Masonry paints, solvent-thinned, thick, textured	Composition variable but typically employs a drying-oil/alkyd resin binder; may be described as 'polyester' (= alkyd). Usually contains coarse 'extender' and/or fibrous material. Pigmentation as for other masonry paints	These provide coatings of substantial thickness (0.6 mm to 1.0 mm), of relatively low permeability, and therefore have good resistance to moisture penetration. Coatings of this type are usually applied by spray or roller, often by specialist applicators. Material and application costs are likely to be high. Colour: May be limited
5/12	Cement paint to BS 4764	Based on white Portland cement with titanium dioxide or coloured pigments, and additives to assist application and increase water-repellency. Supplied in powder form and mixed with water immediately before application	Low-cost coatings giving a rough finish and used mainly for exterior wall surfaces, although they may be used inside except on gypsum plaster: not recommended for application over other types of paint. On lengthy outside exposure, pastel shades may tend to lighten and darker colours to become patchy. Colour: Range is fairly limited
5/13	Multi-colour finish	In one type, droplets of pigmented nitrocellulose or vinyl resin solution are dispersed in an aqueous medium so that the coating is water-thinnable. The pigmented droplets remain discrete in the dry film, so providing the multi-colour effect. In another type, a pigmented emulsion-type basecoat is followed, when dry, by spray-applied 'spatter' coats of similar material. Finally, an emulsion-type clear glaze-coat may be applied. In a third type, a pigmented emulsion-type basecoat is followed, when dry, by a clear emulsion glaze in which are suspended multi-coloured flakes of solid material	This is a quick-drying, hard-wearing finish for interior wall surfaces, often used in circulating areas, cloakrooms and similar 'hard-wear' locations. Application is usually by spray, but materials of the third type may be suitable for brush or roller application. Colour: A wide range of multi-colour effects is available

Table 5 (concluded)

Ref.	Description	General composition	Characteristics and usage
5/14	'Plastic' texture paint	Typically, based on gypsum and supplied as dry powder for mixing with water before use, but ready-for-use emulsion-based types are available. The term 'plastic' indicates that the material can be 'worked' after application to provide relief texture effects	This is essentially a 'decorative' coating for interior use only. It may be used as a substitute for plaster skimming on plaster board ceilings or to disguise rough or cracked walls and ceilings. Texture is achieved either directly by spraying or by brush or trowel application and subsequent combing, stippling or other treatment. Some types are self-coloured and require no further treatment; others may require over-painting, e.g. with emulsion paint

Table 6. Natural finishes for wood

Ref.	Description	General composition	Characteristics and usage
6/1	Varnish, exterior grade, full gloss	Typically, drying-oil/phenolic or alkyd resin	This provides a tough, flexible, water-resistant coating, used principally as a clear protective finish for exterior hardwood
6/2	Varnish, interior grade, full gloss	Typically, drying-oil/alkyd, urethane or urethane/alkyd resin	Harder than 6/1 type and is more suitable for use on interior hardwood joinery. Some types may be sufficiently abrasion-resistant to be suitable for use on hardwood floors, counter tops and similar 'hard wear' locations
6/3	Varnish, eggshell, satin or matt finish	Composition generally as for 6/2 but adjusted to provide a lower level of gloss	Generally as for 6/2 but is likely to be less suitable for use in 'hard wear' locations
6/4	Varnish, polyurethane, two-pack or moisture-curing one-pack	Two-pack types are supplied as separate base and 'activator' which are mixed before use to initiate chemical curing. With one-pack moisture-curing types, the reaction is initiated by absorption of moisture from the atmosphere or from the surface to which the material is applied	These coatings provide extremely hard, strong films with exceptional resistance to abrasion. The stresses set up within the film may lead to peeling and flaking especially on exterior woodwork whose surface, through long exposure without protection, has become degraded. In general, the use of this type of coating is best confined to interior woodwork where exceptional resistance to abrasion and possible chemical attack is required
6/5	Decorative wood stain	Drying-oil, spirit or water media with coloured pigments or dyes	Used essentially to modify or enhance the appearance of wood without obscuring its grain and is usually overcoated with clear finishes
6/6	Exterior wood stain, semi-transparent, Madison formula	Drying-oil binder (boiled linseed oil), paraffin wax, fungicide and pigment	Water-repellent penetrating stain that imparts an 'oiled' appearance to the wood. Suitable for brush application. Film remains soft and slightly tacky so will retain dirt and is not suitable for situations where it is likely to be abraded or come in contact with clothing. Wax component may cause difficulty if over-painting is subsequently required
6/7	Exterior wood stain, semi-transparent, low solids	Resin solution of low viscosity with fungicide and pigment	Water-repellent penetrating stain suitable for brush application. Imparts little or no sheen to surface of wood. Because of very low film thickness, offers little resistance to passage of water vapour and, in consequence, moisture content of wood may fluctuate considerably. Stains of this type can be used on interior woodwork but before doing so, it should be ascertained from the manufacturer that the fungicide contained does not constitute a health hazard
6/8	Exterior wood stain, semi-transparent, high solids	Generally as for 6/7 but higher resin content	Because of its higher resin content, this type of stain will normally impart a noticeable sheen to the surface. It is less penetrative than 6/7 and offers greater resistance to water vapour movement, so fluctuations in the moisture content of the wood are less pronounced.
6/9	Exterior wood stain, opaque	May be a solvent-thinned resin solution or an emulsion-type, with pigment and fungicide	This type may be regarded as intermediate between a stain and a paint. It has low gloss, but the texture of the wood remains evident because of the differences in penetration within the growth rings. Some opaque stains may be used over weathered but sound paintwork

Table 7. Bituminous and tar-based coatings

Ref.	Description	General composition	Characteristics and usage
7/1	Black paint (tar-based) to BS 1070: types A and B	Coal-tar or water gas-tar solutions	Moisture-resistant protective coatings for general use on metal and other surfaces where decorative appearance is unimportant. Both types are suitable for cold application, e.g. by brush. Type A is required to dry in 8 h and type B in 4 h
7/2	Black bitumen coating solutions to BS 3416: types I and II	Bitumen solutions	Generally as for 7/1. Type II is suitable for application to surfaces in contact with drinking water, i.e. will not significantly affect its taste or colour
7/3	Bituminous emulsion	Water-thinned bitumen emulsion	Black, water-thinnable moisture-resistant coating. Typical use is as a waterproof membrane on exterior walls before application of emulsion-based masonry paints

NOTE. Chemically-curing coal-tar/epoxy coatings are available; see table 8.

Table 8. Specialist coatings

Refer to 21.3 for general comments regarding specialist coatings.

Ref.	Description	General composition	Characteristics and usage
8/1	Two-pack epoxy primers, undercoats and finishes	Epoxy resin binder with amine or amide curing agent. Pigmentation according to end use; e.g. metal primers usually contain corrosion-inhibitive pigments	Resistant to acids, alkalis, oils, solvents and abrasion and used for the protection of surfaces, especially steelwork, in severe conditions where coatings of conventional type are inadequate. Should be applied only to stable, well-prepared surfaces. Blast-cleaning of steelwork is essential. May not be suitable for application to gypsum plaster; a cement plaster base is preferable. Application to substrates liable to significant dimensional change (e.g. external woodwork) may result in cracking of the film. Curing is temperature-dependent, and manufacturers' recommendations in respect of ambient and surface temperatures should be observed; see also 44.2. High humidity during application and curing may also affect the coatings. Colours: Wide range available in finishes
8/2	Two-pack coal-tar epoxy coatings	Binder as above blended with coal-tar pitch and mineral extenders	General characteristics as 8/1 but lower resistance to solvents. Main use is for protection in conditions of very high humidity or immersion in fresh or sea water. Colours: Dark colours only
8/3	Two-pack polyurethane pigmented coatings, principally finishes	Polyester resin binder with polyisocyanate curing agent and white or coloured pigments	General characteristics as 8/1, but low temperature curing is usually better and sensitivity to moisture curing greater than with epoxies. Principal usage is as non-yellowing chemical-resistant finish over epoxy primers and undercoats. Colours: Mainly white and light colours
8/4	Chlorinated rubber primers, undercoats and finishes	Solution of plasticized chlorinated rubber, pigmented according to end use, as 8/1. Some types may be modified with drying-oil/alkyd resin. Formulations yielding coatings of substantial thickness are available	Chlorinated rubber coating systems have generally good resistance to moisture (including immersion), acids, alkalis, mineral oils and some solvents, but specific properties may vary according to formulation. Suitable for use on most substrates and, as one-pack products, are more convenient to use than two-pack epoxy and polyurethane coatings, although their chemical resistance may be lower. As solution-type coatings (see 18.2.5), drying is essentially by evaporation and is less affected by low temperatures than is that of oil-based, epoxy and polyurethane coatings. Brush or roller application to large areas may be difficult, and spraying is recommended; see clause 46. Colours: Wide range available in finishes
8/5	Cellulose coatings, clear or pigmented, other than cellulose multi-colour types (ref 5/13)	Nitrocellulose/synthetic resin solutions, clear or pigmented	Quick-drying, abrasion-resistant coatings having limited application in the painting of buildings. As with other solution-type coatings (see 18.2.5) cellulose coatings are best applied by spray, although some types may be modified to allow brush application to small areas. The most frequent usage is of clear and pigmented coatings, including 'gold' and 'bronze' lacquers for shop fronts, lift doors, ornamental metalwork and similar items, work usually carried out by specialists

22. Ancillary materials

22.1 General. Materials other than coatings used in the painting of buildings include cleaning agents, sterilizing washes, knotting, stoppers and fillers, mastics, paint removers and waterproofing treatments.

22.2 Cleaning agents. Surface cleanliness is essential to the satisfactory performance of coating systems. Soap or detergent solutions or proprietary powder cleaners are usually adequate for normally soiled surfaces. For removal of oil or grease, proprietary solvent-emulsion cleaners may be required. See also 53.3.

22.3 Sterilizing washes. Surfaces contaminated with mould or algal growths should be treated before coatings are applied. Household bleach solutions are often effective in killing the growths but, in severe cases, proprietary mould-inhibitive washes will provide a measure of protection against their reappearance. See also 53.8.

22.4 Knotting (see BS 1336). A quick-drying solution (e.g. of shellac in industrial methylated spirit) should be applied to knots or resinous areas in wood before priming to prevent discoloration of light-coloured finishes. See 25.4.2.4.

22.5.1 General. The traditional distinction between 'stoppers' and 'fillers' is that the former are stiff pastes used for filling ('stopping' or 'stopping up') deep holes, wide cracks, open joints and similar imperfections, while fillers are of more fluid consistency and are used for filling and levelling shallow depressions, open grain, surface roughnesses, fine cracks and the like. However, the distinction has become less clear-cut with the widespread use of proprietary materials, many of which, although described as 'fillers', are used for both purposes. More meaningfully, the materials may be categorized as stoppers, general purpose stoppers/fillers and surface fillers, and these are described below. Methods of stopping and filling are described in 45.4.

22.5.2 Stoppers. Oil-based stoppers are preferred for woodwork, especially externally, and may be used on other substrates in oil-based paint systems. Cost considerations and the toxic hazards with lead pigments generally preclude the use of the traditional 'hard stopping' made up by the painter from paste white lead, whiting and goldsize. Proprietary oil-based lead-free stoppers are available. Linseed oil putty is widely used as a stopper but is slow hardening and tends to shrink; it is improved by the addition of goldsize or oil-based undercoat.

Limited experience with emulsion-based fillers (see 22.5.3) indicates that some may be acceptable as stoppers for exterior woodwork. For stopping deep holes in woodwork and repairing damage, e.g. to mouldings and arrises, two-pack polyester or polyurethane fillers, as used for car body repairs, can give satisfactory results.

22.5.3 General purpose stoppers/fillers. The types in general use are usually water-mixed and comprise the following.

(a) *Powder fillers.* These are supplied in powder form for mixing with water and are usually based on water-soluble cellulose and gypsum or white Portland cement.

Those containing gypsum are suitable for general use as stoppers and fillers in dry interior situations. They are not usually suitable for use for external work, especially on wood, but the manufacturer's recommendations in this respect should be observed.

Portland cement types are suitable for external use on masonry surfaces. They should not be used on woodwork.

(b) *Emulsion-based fillers.* These are usually based on vinyl or acrylic resin emulsions and are supplied in paste form, ready for use.

Materials of this type vary considerably in characteristics and usage. The manufacturer's recommendations, especially regarding suitability for exterior use, should be observed; some emulsion-based fillers may be acceptable alternatives to oil-based stoppers for external woodwork.

22.5.4 Surface fillers. These are formulated specifically for use as fillers in the traditional sense, as defined in 22.5.1, and are preferred to the 'general purpose' types when a high standard of finish is required, especially with oil-based paint systems. They are supplied ready for use as smooth, finely-ground, creamy pastes, usually applied with a wide filling knife or spatula. The types in general use are emulsion-based, but oil-based formulations are available.

22.6 Mastics and sealants. The use by painters of mastics and sealants is mainly for the repair or replacement of external pointing between window or door frames and adjacent masonry. Generally, and provided that the mastic is to be over-painted, proprietary one-pack, non-elastomeric types are suitable.

22.7 Paint removers. Information on paint removers, including the types available and the precautions to be taken in their use, is given in 53.2.3.

22.8 Water repellents. External application of water-repellent solutions may be considered when rain penetration of walls has caused internal dampness. Materials and the factors relating to their use are described in 29.4.

Section four. Substrates and coating systems

23. Introduction

In this code, 'coating system' refers to the totality of the preparatory work and the type, number and sequence of coats necessary to obtain the required finish on a specified substrate. This section describes the general principles involved in the selection of coating systems, the characteristics and treatment of the substrates encountered in buildings and the types of coatings in general use. Although it is concerned essentially with new work, surfaces which may not have been painted initially, such as external masonry or non-ferrous metal, come within the scope of the section. Maintenance treatment is described in section six, but much of the information given here is relevant.

The coatings referred to in this section are generally those of conventional type, as defined in 21.2 and described in tables 1 to 7, but clause 41 describes some functions and situations for which specialist coatings (see 21.3 and table 8) or modified conventional coatings may be required.

Information on coating systems is tabulated (tables 10 to 15) for substrates or groups of substrates having similar characteristics, and the tables may be referred to directly although preliminary reference to clause 24 is recommended.

Similarly, reference to clause 29, dealing with the problems encountered in the painting of new 'wet' materials of construction, should precede reference to the clauses relating to individual substrates such as plaster, cement rendering and brickwork.

Information is given in the relevant tables on the expected life to first maintenance, in specified environments, of the coating systems referred to. The environment categories employed are described in table 9.

24. Selection of coating systems

24.1 General. The selection of coating systems requires consideration of a number of factors and subsequent judgement, often on a qualitative basis, of their relative importance in relation to particular circumstances. Often more than one type of system will meet the requirements, and selection might be made on the basis of relative cost, availability or individual preference, but care should be taken to ensure that other factors are in fact comparable; lower initial costs may well be more than outweighed by shorter life and consequent higher maintenance expenditure. In other circumstances, a single factor may exert so strong

an influence that selection is limited to a single type of system.

The factors that have to be considered will usually include the following:

- (a) the functional requirements;
- (b) the substrates to be treated;
- (c) the nature of the environment;
- (d) constraints on selection;
- (e) the availability of suitable coatings and systems;
- (f) costs and maintenance considerations.

These considerations are listed in **24.2** in question form with an indication of reference sources within this code or elsewhere. Not every question will be relevant to all circumstances, and the importance of each may vary. There is a considerable degree of interaction between factors involved, and they should not be considered in isolation. Accordingly, answers to some questions will require reference to others, and the list should be studied as a whole before the questions are considered in detail.

24.2 Questions relating to the selection of coating systems

24.2.1 Function

(a) What are the functional requirements (e.g. of protection, decoration, hygiene or special function)?

(b) Are there any relevant statutory requirements (e.g. under the Building Regulations or Factories Act) affecting selection?

Reference sources

Refer to clauses **17** and **41**.
Design remit and experience.
Consider substrate; see **24.2.2**.
Consider environment; see **24.3**.

Relevant legislation: see also section seven.

24.2.2 Substrate

(a) What substrates are involved?

(b) Will their characteristics influence the selection of coating systems?

Design remit, specification or inspection.

Refer to clauses **25** to **40**.

24.2.3 Environment

(a) What is the general atmospheric environment, external and internal?

(b) What localized or intermittent conditions (e.g. fumes, condensation, heat) exist or are to be expected?

Consider location and functions of buildings.

Refer to **24.3**, table 9 and clause **41**.
Consider possible future developments or changes in usage which may alter the local environment.

24.2.4 Special constraints on selection

(a) Are there constraints relating to the composition of the coatings in some situations (e.g. in food factories because of the risk of toxicity or tainting)?

(b) Are any constraints imposed by the conditions under which the work has to be carried out (e.g. requiring the use of coatings which dry very quickly)?

(c) Does the condition of the substrate (e.g. its high moisture content) impose constraints on the selection?

Consult client, industry association or supplier.

Consult client, contractor or supplier.
Refer to clause **44**.

Ascertain condition, expected or actual, at time of treatment. Refer to clauses **25** to **40**.

24.2.5 Coatings

(a) Which coating systems are available?

Consider answers to preceding questions.
Refer to tables 1 to 8, clauses **25** to **41**. Consult suppliers.

(b) Are the coatings readily available from the usual sources or is special order or manufacture required?

Consult suppliers.

(c) Are the coatings suitable for site or factory application?

Consult suppliers.

(d) Are there any restrictions on methods of application on site?

Consult suppliers. Refer to section five for information on application methods.

(e) Is application by specialist contractors required?

Consult supplier. Refer to tables 1 to 8.

24.2.6 *Costs and maintenance*

(a) What is the likely first cost of the system, including preparation, materials, and application?

Cost analysis of previous work of a similar nature. Consult contractors and suppliers.

(b) What is the expected life of the system to first maintenance?

Experience of similar systems. Refer to tables 10 to 15.

(c) Will the system provide a satisfactory base for maintenance treatment perhaps with coatings of different type?

Refer to clause 51.

24.3 Environment. In relation to the selection of coating systems, 'environment' refers to the general atmosphere and conditions of use or service to which a system may be exposed. A broad distinction may be made between external and internal environments but, in either, there may be considerable variation in the severity of attack or rigours of service, even within a single building. Externally, the main variables are location, proximity to the coast and level and nature of atmospheric pollution but elevation, aspect and the direction of prevailing winds may also have a significant effect. Internally, high humidity and the presence of process chemicals and dusts may create severe conditions although, in most of the types of buildings with

which this code is concerned, the main factor will be the degree of wear or soiling likely to occur.

Table 9 indicates the broad categories of external and internal environments that may be encountered and the types of coatings likely to be suitable. It is intended to provide general guidance; it is not possible to take into account the many local variables which may influence the nature of the environment and the selection of coating systems in specific circumstances.

The ratings in respect of severity of exposure in the first column of table 9 are also used in the substrate clauses and coating systems tables in this section.

Table 9. Environment categories and selection of coatings

Severity of exposure	Typical conditions Exterior	Typical conditions Interior	Selection of coatings
Mild	Inland areas (more than 10 km from the coast), non-industrial and with average rainfall	Dry, well ventilated environments, e.g. most domestic, commercial and light industrial buildings. Possible occasional light condensation. Little soiling, abrasion or handling of surfaces	Coatings of 'conventional' type (see 21.2) will afford satisfactory service. Refer to tables 10 to 12, 14, 15 for details of substrates and systems
Moderate	Semi-coastal areas (3 km to 10 km inland), non-industrial, with average rainfall. Inland areas (more than 10 km from the coast), urban or light industrial, with mild atmospheric pollution but not in close proximity to industrial plants or similar sources of significant pollution	Generally as for 'mild' but with possibly more frequent moderate condensation, e.g. in kitchens, bathrooms, washrooms etc. Possible mild atmospheric pollution in light industrial environments. Moderate soiling, abrasion and handling of surfaces	Most coatings of conventional type are likely to afford satisfactory service. Refer to tables 10 to 12, 14, 15 for details of substrates and systems
Severe	Coastal areas subject to salt spray (e.g. up to 3 km inland), non-industrial, with average rainfall. Inland industrial areas with significant atmospheric pollution. Areas with a driving rain index of 7 or more; see BRE Digest No. 127 [1]	Environments subject to frequent high humidity or heavy condensation, especially if pollutants, e.g. sulphur dioxide or ammonia, are present. Environments in which heavy soiling or hygiene requirements necessitate frequent cleaning of surfaces. Surfaces subject to heavy abrasion or impact	In some cases, the use of specialist coatings (see 21.3, table 8 and clause 41) may be feasible and justified, e.g. on steelwork. However, especially for non-metallic substrates, there may be no alternative to the use of coatings of conventional type, accepting that service life is likely to be significantly shorter than in 'moderate' environments. In these circumstances, systems shown in tables 10 to 12, 14, 15 as having the longest 'life to first maintenance' should be used. In respect of the protection of structural steelwork in 'severe' environments, refer also to BS 5493
Very severe	Coastal/industrial areas with significant atmospheric pollution	Buildings in which processes or activities give rise to continuous high humidity or heavy condensation or are a source of aggressive fumes, dusts or waste products. Surfaces in contact with chemicals, chemical solutions, process liquors and other aggressive agents	Unless it is possible to modify the environment or avoid the use of materials requiring protective painting, specialist coatings are likely to be required, and expert advice should be obtained. In respect of the protection of structural steelwork in 'very severe' environments, refer also to BS 5493

25. Wood

25.1 Characteristics

25.1.1 Structure. Wood is a cellular material in which most of the cells are aligned vertically in the tree, giving wood its characteristic 'grain'. Other cells lie in horizontal bands (rays) running outwards in the tree.

In softwoods (coniferous trees), the vertical cells (fibres) are about 3 mm long and contain an air space, the cell cavity. Liquid movement is by way of the cavities and through openings (pits) in the walls of adjacent cells.

In hardwoods (broad-leaved trees), the cells or fibres are only about 1 mm to 2 mm long and surround much larger cells (pores or vessels). The pores are responsible for liquid movement, and their size and distribution, together with the relative thickness of the fibres, determine the texture of hardwood.

Cell walls formed later in the growing season are thicker than those formed earlier, and the alternating bands of soft and hard tissue (early and late wood) form the annual or growth rings. Quarter sawing (radial cut) produces a surface with closely alternating bands of early and late growth; with flat sawing (tangential cut) the bands are wider.

25.1.2 Moisture content. 'Green' timber contains both free water in the cell cavities and water absorbed by the cell walls. Reducing the moisture content to about 25 % to 30 % of the oven-dry mass removes free water from the cell cavities, but the fibres remain saturated and the wood is fully swollen; it shrinks progressively as more moisture is removed. Shrinkage is greatest across the grain and is reversible, so that changes in weather or humidity cause alternate swelling and shrinkage. Wood should, therefore, be painted or varnished when its moisture content is near to that at which it will stabilize in service, generally about 18 % but somewhat lower in buildings which are centrally heated continuously. Excessively dry timber will swell as it takes up moisture, imposing stresses on the coating; damp timber will shrink during drying, causing joints to open, creating further points for water to enter. Also, blistering or flaking of the surface coating is likely to occur on damp timber.

25.1.3 Permeability and penetration of liquids. The permeable nature of wood affects not only moisture movement but also the ease of impregnation by preservatives and the behaviour of paint. Penetration is deepest and most rapid through end grain, but lateral penetration is more important for preservative treatment.

Heartwood is less permeable than sapwood which, in most species, is readily penetrated but spruce, hemlock and Douglas fir are exceptions. There are also differences in permeability between early and late growth areas causing differential swelling which imposes stresses on surface coatings.

Deep penetration is not necessary for paints to adhere satisfactorily and may be both wasteful of material and detrimental to performance as binder may be absorbed, leaving the coating underbound or weak.

The large pores in hardwoods may be bridged by paint coatings, leaving an air space beneath the film and forming a weak point which may cause breakdown. To prevent this, filling (see 25.4.4) is usually required when hardwoods are painted.

25.1.4 Extractives. Many softwoods and some hardwoods (e.g. gurn, keruing and agba) contain resins which may exude and impair surface coatings. Kiln drying reduces the activity of resin in potentially troublesome timber but, when the resin content is high, exudation may continue for long periods, especially on external woodwork exposed to the sun.

Other woods, such as teak and some cedars, contain oil which may impair the drying, hardening or adhesion of coatings. These woods can usually be painted satisfactorily if an aluminium primer (1/2) is used. Water soluble tannins, present in oak and chestnut, may also interfere with the drying and hardening of oil-based priming paints and may discolour water-thinned paints.

25.2 External influences

25.2.1 Moisture. Multi-coat, oil-based paint systems are reasonably effective barriers to the movement of moisture in liquid and vapour form provided the coating is continuous and remains intact. Moisture may, however, gain entry at open joints, defective putties and sealants, inadequately protected end grain and other points. Breaks in the continuity of the film are the most frequent points of entry of moisture; the paint film may then prevent its escape.

Where joinery is to be in contact with brickwork, concrete and similar materials, vertical and horizontal damp-proof courses should be so placed that moisture penetration at contact surfaces is prevented; painting or similar treatment, although advisable, should not alone be relied upon to achieve this. Where external joints between frames and walls are pointed with mastic or sealants to prevent ingress of water, provision should be made for drainage of joints, e.g. by stopping short the sealant at a suitable point.

As a result of increased attention to heat conservation, internal condensation has assumed considerable importance as a source of moisture. The absence of flues, blocking of unused flues and airbricks, draught-proofing and similar measures have greatly reduced internal ventilation rates, especially in domestic buildings. In consequence, the water vapour produced by normal domestic activities is unable to escape readily and may migrate to colder rooms and condense on single-glazed windows, eventually penetrating open joints, defective putties and other discontinuities in the paint film. This is a frequent cause of timber decay and paint failure on wooden window frames and sills. Wet rot in timber cladding or failure of the external paint may also be caused by condensation within the wall cavity.

25.2.2 Sunlight. Exposure of unprotected timber successively to sunlight and rain causes degradation of the surface, impairing its ability to hold coating systems, and causing change or loss of colour, although very durable timbers, such as teak, are affected mainly in colour. Paint is an effective protection against the effects of sunlight; clear finishes are usually less durable because they may not filter out the damaging wavelengths in sunlight which attack the underlying wood surface. Solar heat gain causes shrinkage of wood and consequent cracking and opening of joints; it may also increase resin exudation, resulting in discoloration and disruption of coatings; see 25.4.2.4.

25.2.3 Fungal attack. Wood is susceptible to fungal attack if its moisture content exceeds about 22 % for lengthy periods. In painted woodwork, the principal agents of decay are the wet-rot fungi. Surface moulds and blue-stain fungi have little effect on the durability of timber although they are unsightly and may disfigure paintwork.

Timber species vary in their resistance to fungal attack; PRL Technical Note No. 40 [2] indicates four categories (perishable, non-durable, moderately durable and very durable) according to the resistance of the heartwood to decay. However, the sapwood of most species is susceptible and, on economic grounds, it may not be possible to exclude it completely. Nor, for the reasons indicated in 25.2.1, can it be assumed that paint or similar treatment will prevent moisture penetration in all circumstances. Consequently, most external woodwork is at risk and preservative treatment, in addition to painting or similar treatment, is advisable and may be mandatory in some cases.

25.3 Preservative treatments. Reference should be made to BS 5589 for recommendations for the preservative treatment of timber according to species, end use and desired service life, but the following notes indicate treatments likely to be suitable for components subsequently to be painted or given similar surface treatment.

(a) Treatments for external woodwork in buildings and not in ground contact

(1) *Copper/chrome/arsenic (CCA) water-borne preservatives* by vacuum pressure process according to BS 4072. Some distortion may occur during drying, hence this method is not generally employed for the treatment of completed joinery. After drying, the preservatives are insoluble and, provided that loose salts are removed, do not usually affect applied coatings.

(2) *Organic solvent preservatives* *, e.g. copper naphthenate (BS 5056), pentachlorophenol (BS 5707 : Part 1), tributyl tin oxide, zinc naphthenates. Water-repellent types, containing waxes or resins, can be used with advantage. Organic solvent preservatives may be applied by immersion, but the double vacuum process is more effective. Application by brushing or spraying is not recommended except for site treatment of cut ends etc., or in remedial work. These preservatives are generally suitable for over-painting provided a minimum of 48 h in conditions of good ventilation is allowed for evaporation of solvent, but users should satisfy themselves as to the compatibility of the particular treatment with the finish to be applied.

*This treatment is restricted to woodwork which will subsequently receive paint or similar protective treatment and be regularly maintained.

(3) *Diffusion treatment with disodium octoborate* *. This treatment has to be carried out on freshly felled timber and cannot be applied to seasoned timber. The salts remain water-soluble and may affect coatings if the timber becomes wet although, in practice, few difficulties appear to arise.

(b) *Treatments for fencing and gates in or out of ground contact*. BS 5589 lists timber species which are sufficiently durable to be used for fencing and gates without preservative treatment provided there is not an excess of sapwood present. If there is, or less durable species are used, treatment is advisable. The recommended treatment, if a paint or similar finish is required, is with CCA as in (a) (1). Alternative treatments with creosote (pressure or open tank processes) or pentachlorophenol (PCP) in heavy oil by double vacuum process are not suitable for over-painting. However, in view of the cost of painting extensive areas of fencing and the frequent maintenance treatment that may be required, consideration should be given to initial treatment with creosote or PCP by the processes referred to and subsequent maintenance by brush application of these materials.

25.4 Paint systems for wood

25.4.1 General. For the reasons given in 25.1.2, the moisture content at the time of painting should not exceed about 18 %. Moisture content may usually be measured with sufficient accuracy for painting purposes with an electrical moisture meter of the conductive type (see 29.2.1.2), preferably one having long probes so that readings can be taken at a depth not so readily affected by surface drying.

If there is a delay between delivery to site and fixing or erecting of joinery, it should be protected against ingress of moisture; see clause 12.

If timber has received preservative treatment, time should be allowed for drying out or evaporation of solvent before priming; see 25.3.

25.4.2 Surface preparation

25.4.2.1 General. Preparatory treatment of wood before priming will include cleaning, sanding and treatment of knots. Thorough preparation is especially important on wood that has been exposed to weather without protection.

25.4.2.2 Cleaning. A clean surface is essential to the satisfactory adhesion and appearance of the paint system. Dirt and surface deposits, exuded resin and soluble salts arising from preservative treatment should be removed. Solvent cleaning (see 53.3) will be necessary if the surface is contaminated with oil or grease.

25.4.2.3 Sanding. The main purpose in sanding is to smooth the surface, but it also helps to reduce paint penetration by closing the wood vessels, thus producing a thicker, more uniform film than on unsanded wood. Sanding may also be necessary to remove the degraded outer layer of wood that has been exposed to weather. Wood may be sanded mechanically or manually; the latter, using abrasive paper is more common for site work. It is essential to use a grade of abrasive paper appropriate to the surface; excessively coarse grades will damage the wood fibres, impairing the appearance and possibly the perform-

ance of the paint system. The surface should be sanded in the direction of, and not across, the grain without using excessive pressure, which may damage the wood fibres. Care should also be taken not to damage moulding andarris edges.

25.4.2.4 Knot treatment. Discoloration of paint, especially noticeable with light colours, may occur over knots and resinous areas especially if the wood has been treated with preservative containing certain organic solvents (see 25.3). It is normally prevented by the application of 'knotting' (see 22.4); two coats are more effective than one, but heavy applications and the use of knotting which has thickened through evaporation of solvent should be avoided, otherwise paint adhesion may be impaired. It may not be necessary to use knotting if woodwork is to be primed with an aluminium primer (1/2). Emulsion primers (1/3) may also have a measure of resistance to staining, but their effectiveness in this respect should be confirmed by the manufacturer before omitting treatment with knotting.

Knotting or aluminium primer is rarely effective in preventing physical disruption of paint films by heavy exudation of resin. This is more likely to occur externally over knots in surfaces exposed to strong sunlight, which liquefies the resin and makes it more active. The use of light-coloured paints reduces solar heat gain and may therefore reduce resin exudation although it is unlikely to prevent it completely; also, the resin will be more obvious on a light-coloured surface. An alternative is the use of an exterior wood stain; see 25.5.3.3.

25.4.3 Priming. Primers for wood are listed and described in table 1, and typical applications are indicated in table 10.

A good primer, applied to dry sound substrates, is the foundation of a durable paint system. Priming in the factory or works is recommended; if site priming is necessary, it should be carried out immediately after delivery of the joinery, provided that its moisture content is at a satisfactory level. Although single coats of primer retard surface degradation by sunlight (see 25.2.2), they provide only limited protection against moisture, especially if the wood has not been treated with a water-repellent preservative. The full system should therefore be applied as soon as possible. Primed joinery, if not fixed or erected immediately, should be properly stored; see clause 12.

If primed woodwork has been exposed for a lengthy period, the condition of the primer should be checked before continuing application of the paint system. It is important that areas of defective or poorly-adhering primer be removed and the exposed areas reprimed. If the primer is firmly adhering but is chalking or powdery, it should be rubbed down and a further coat applied.

25.4.4 Stopping and filling. The materials used for stopping and filling are described in 22.5 and the techniques in 45.4. Oil-based stoppers and fillers are generally preferred for wood, especially for external work, but should be used only on primed surfaces, otherwise oil will be absorbed leaving the material underbound; the same requirement applies to linseed-oil glazing putty. Water-mixed stoppers and fillers may be used on primed or unprimed wood; if used over primer, the stopped or filled areas may require repriming to prevent absorption of the binder from subsequent coats.

*This treatment is restricted to woodwork which will subsequently receive paint or similar protective treatment and be regularly maintained.

25.4.5 Finishing. Alkyd finish systems combine decorative and, in varying degree, protective functions with the elasticity necessary to accommodate movement and are used extensively for external and internal woodwork. Their durability and protective properties are broadly proportional to the level of gloss; accordingly, gloss finishes are recommended for external use and in 'severe' internal environments; these may include internal surfaces of window frames, especially on single-glazed windows where condensation is likely. Mid-sheen and matt finishes may be used in 'moderate/mild' internal environments.

A four-coat (including primer) gloss finish system should be used for exterior work and for 'severe' internal environments; it may consist of either primer, two undercoats and one coat of finish, or primer, one undercoat and two coats of finish. Not all gloss finishes are suitable for application as consecutive coats, and manufacturers' recommendations should be followed.

The use of some types of water-repellent preservatives may permit reduction of external gloss finish systems to three coats, i.e. primer, one undercoat and one coat of finish. Three-coat systems are generally acceptable for internal woodwork in 'moderate/mild' environments.

Mid-sheen and matt finish systems do not usually incorporate undercoats, successive coats of finish being applied over the primer. In the 'moderate/mild' internal environments in which these types of finish are generally used, three-coat systems, including primer, are usually satisfactory.

Gloss finishes are suitable for use on external cladding but, on large areas, textured finishes may be preferred for appearance. Oil-based, sand textured masonry paints (5/10) can have a life of 7 years to 10 years to first maintenance on timber cladding. Other types, e.g. 5/9 and 5/11, may be equally satisfactory. Usually, a primer and two coats of finish are applied, but reference should be made to manufacturers regarding systems and the suitability of the materials for use on cladding.

Table 10 shows paint systems for use on external and internal woodwork, excluding those hardwoods to which natural finishes (see 25.5) are more usually applied.

25.5 Natural finish systems for wood

25.5.1 General. Natural finishes for wood are those which, unlike paint, do not completely obscure the grain of wood although they may modify its colour in varying degree. They comprise a wide variety of finishes, many of them of a specialized nature. This subclause deals with the natural finishes, e.g. varnishes and stains used on general building surfaces and forming part of normal paintwork. It does not include french polishing and the use of cellulose or similar specialized wood finishes nor the treatment of wood floors.

On external exposure to sun and rain, unprotected wood loses its original colour and the surface degrades until it consists of a thin layer of loosely matted fibres, usually dirt-stained and darkened by fungal and iron stains. After periodic wetting and drying, the growth rings may become prominent and splitting and distortion may occur. If it is desired to preserve the natural appearance of external woodwork, protective surface treatment is, therefore, necessary.

Blue-stain fungi often contribute to the darkening of weathered wood. Once blue-stain has developed extensively under varnish, the colour of the wood cannot be restored. It is therefore recommended that exterior woodwork which

is to be varnished should first be treated with a preservative effective against blue-stain. With adequate maintenance, the fungicide in exterior wood stains will usually inhibit the development of blue-stain.

Internal exposure is unlikely to result in similar degradation of the surface, and the main functions of natural finishes on interior woodwork are to enhance its appearance, prevent soiling, staining and abrasion damage and facilitate cleaning.

Like paints, natural finishes may not prevent the entry of moisture. Accordingly, their use, even of those types described as having preservative or water-repellent properties, does not obviate the need for preservative treatment of non-durable timber as described in 25.3.

On exterior exposure, natural finishes are usually less durable than paints and therefore require more frequent maintenance to preserve appearance. This may make their use uneconomic on high-rise buildings where the cost of scaffolding is a significant proportion of the total cost of the work. On the other hand, some exterior wood stain treatments require fewer coats and less extensive preparation than paint systems so that an overall saving in maintenance costs can be made.

Standard softwood joinery often has blemishes such as knots, splits, shakes and discoloration with blue-stain fungus. Natural finishes will not obscure these blemishes, with the possible exception of blue-stain. If this is not acceptable, a higher quality of timber has to be specified. Similarly, a standard of joinery which might be appropriate for painting may be unacceptable for natural finishes because fixings, gaps and wide glue lines will not be concealed. Hardwood joinery is usually of an acceptable standard and, as the timber is relatively impermeable and dimensionally stable, natural finishes are used essentially for appearance.

With most natural finishes, putty glazing is not suitable, and new work should be designed for glazing using preformed plastics gaskets with or without glazing beads. See also CP 152.

Exposed nails, fixings, hinges and similar components should be of hot-dip galvanized, sherardized or stainless steel or non-ferrous metal to prevent rust-staining of adjacent woodwork.

25.5.2 Surface preparation. Where a high standard of finish is required, e.g. on varnished woodwork, the surface should be machined or sanded smooth, taking care to avoid tearing or scoring the grain.

Natural finish systems do not include the use of primers of conventional type but, if there is likely to be delay in completing the work, a coat of varnish or clear water-repellent finish will provide some protection against soiling and ingress of moisture. Surfaces of window and door frames in contact with wet plaster, brickwork, masonry and similar sources of moisture should be coated before fixing. An oil-based or aluminium wood primer (1/1, 1/2) may be used if care is taken to avoid its spreading on to the visible surfaces; alternatively, two coats of exterior grade oil varnish (6/1) or the natural finish primer recommended by the manufacturer may be applied.

If stopping-up of nail holes is necessary on exterior work, oil-based hard stopper or linseed oil putty should be used after application of the first coat of finish, the stopper or putty being tinted to match the colour of the treated wood. For interior work, water-soluble fillers, similarly tinted, may be used before application of the first coat of finish.