

The colourist and colour quality

Concerns of the textile colourist

The aesthetic appeal of the colour of a manufactured article is often the first factor to arouse the interest of the consumer. Consequently it is important that initial expectations of standards of colour performance during use are satisfied. The colourist is therefore responsible for building in the quality of the colour by ensuring appropriate selection and application of colorants that will withstand any likely aftercare treatments. Such matters are important for any manufactured coloured product such as plastics, printing inks, paints and textiles. In this book attention is devoted to the extensive topic of textile coloration, but equal weight could also be given to any other specified technology involving the use of colorants.

Thousands of new coloured compounds have appeared on the market since W H Perkin discovered the first viable synthetic route for producing a commercial dye. Of these, relatively few have become commercially significant. Even so, the dyer is confronted by a bewildering array of dyes when attempting to satisfy a customer's expectations for resistance to the destructive agencies the goods are likely to meet in use. Unless the correct choice of dyes is made, even the best-quality fabric will be perceived as substandard if the colour fades badly or washes out easily the first time the goods are cleaned.

Usually those dyes with the highest resistance to agencies such as sunlight or repeated washing are also more expensive to make, and if the use of the end product does not warrant a high price the choice of dyes is further restricted. Consequently the minimum level of fastness required is judged in accordance with the intended end use of the fabric. For some articles such as dusters or wrapping paper, or cinema curtains which will be dry-cleaned and rarely be exposed to daylight, fastness to light or wet treatments is not particularly important. At the other end of the scale goods such as furnishing materials, carpets and curtains are expected to last for many years, and resistance to light and cleaning become of paramount importance. Other articles may be required to withstand a particular treatment associated with their use; swimwear, for instance, needs to resist the effects of chlorinated water and sea-water, while children's wear must be able to stand up to repeated washing.



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Matching the fastness properties to the end use also requires a careful choice of dyeing method, because the level of wet fastness provided by a dye is inescapably linked to the ease with which a uniform dyeing can be achieved.

The general aims of the textile colourist reach well beyond the selection of appropriate colours to match the latest fashion shades. In addition to the shade strength and fastness properties of the colour, the issues of the productivity of the work force and capital costs have to be tackled on the route to the final product. These in turn are often dictated by the equipment available, the amount of material to be dyed and the energy consumption of the chosen process. Sometimes a repeat dyeing may be required years after the product was first dyed, by which time some of the original dyes may have vanished from the market; it is then necessary to reformulate the dye recipe to a price using different dyes, and possibly fabric of a different specification.

An awareness of the likely effects of processing on the fabric is also essential, since modification during processing of properties such as strength, elasticity, abrasion resistance and dimensional stability needs to be kept within prescribed limits. Clearly, the success of the dyer is dependent upon a comprehensive understanding of the user properties of fibres, yarns, fabrics and dyes as well as their expected behaviour during finishing processes.

Choosing dyes of suitable substantivity

Coloration is a stepwise process that involves attraction of the dye from the liquid or print paste to the fibre surface, from where it diffuses into the fibre. Within the fibre the dye molecules move from one point of attachment to another. Unless they become chemically bonded to the fibre or converted to an insoluble pigment, this process continues for as long as the fibres remain in the dyebath. Both the speed with which the dye molecules move into the fibre and the ease with which they can move about (*migrate*) from site to site depend upon the strength of the attraction between dye and fibre. The *substantivity* of the dye is a measure of the strength of this attraction. Within any one class of dye are dyes with a range of substantivities, and this is of significance both in practical application and in the fastness to wet treatments of the end product.

As a general rule of thumb, dyes with high substantivity have poor migration properties, since the strong interaction works against release of dye from the initial point of attachment. Such dyes are more difficult to distribute evenly – they are said to have poor *levelling* properties. But with high substantivity is associated the fastest exhaustion from the dyebath and the greatest resistance



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to washing off in clean water. Of course the converse is also true: dyes with lower substantivity exhaust more slowly, have better migration properties and are good levelling dyes. The penalty in this case is poor wet fastness properties, since the weaker dye–fibre linkages allow easier reversal of the dyeing process.

Dyers are therefore obliged to strike a balance between these properties when fitting the choice of dyes to the intended use of the product. Dyeing methods are thus governed as much by application criteria for level dyeing as they are by the chemical nature of the dye and the fibre. Consequently the logical way to aid dye selection is by sorting dyes into groups according to their best method of application. In this way dyes that are suited to protein fibres such as wool are separated from those appropriate for cellulosic fibres such as cotton, whilst those for synthetic fibres form yet another category. This aspect of fibre finishing is dealt with in Chapter 4.

Expanding activities of the colourist

Synthetic dyes for natural fibres

The first synthetic dyes were used alongside natural dyes, but gradually the latter were displaced completely by the broadening range of more easily applied colours. Dyers' understanding of the coloration process began to deepen as the quest for improved products continued, and the physical chemistry of the dyeing process came into focus in an attempt to address such questions as why dyes are attracted to fibres, how they are held, why some are less resistant to washing than others and why a distinction can be made between dyes suited to fibres of different chemical origin, as shown in Table 2.1.

Table 2.1 Main dye classes and fibre types with which they are used

Dye class	Fibre type
Acid ^a	Protein ^b , nylon
Mordant (chrome)	Protein, nylon
Reactive	Cellulosic ^c , protein
Direct	Cellulosic
Sulphur	Cellulosic
Vat	Cellulosic
Basic	Acrylic
Disperse	Polyester, nylon, acrylic cellulose acetates

a Including metal-complex acid

b Wool, silk, etc.

c Cotton and regenerated cellulose

Once ideas of the nature of the dye–fibre attachment began to develop, it became clear that the ultimate bonding between a dye and a fibre would be through a link formed by a chemical reaction, but it was not until 1956 that this goal was first realised by I D Rattee and W E Stephen. Even then, the dyes in question were under examination as potential reactive dyes for wool rather than for the cellulosic fibres for which they first became commercially available.



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In the laboratories of the time, experimental samples were numbered by attaching short loops of thin string with the relevant number of knots tied in the loose ends. Rattee noticed that at the end of the dyeing the string (made of cellulosic fibres) also became coloured, and realised that the dyes were reacting with cellulose. From then onwards intensive research led to the creation of the new class of *reactive dyes* for cellulose. Novel methods of application were devised, and since ICI's introduction of the first commercial range of reactive dyes (the Procion dyes), many other ranges have appeared, all notable for their good wet fastness and their bright shades.

Investigations like this are often regarded as esoteric in the early stages, because no one can know with certainty how the work may aid the design or application of dyes with improved performance. Very often the development work that follows leads to unexpected and difficult problems, an elegant solution of which may well appear to the outsider, with the benefit of hindsight, as an obvious answer.

Synthetic dyes for synthetic fibres

The rapid development of synthetic fibres provided further motivation for research, which was stimulated into fresh activity when cellulose acetate first appeared on the market. Until that time the only textile fibres available were *hydrophilic* (i.e. water-attracting) and could be dyed using water-soluble dyes or the soluble precursors of insoluble pigments. Acetate fibres, however, are *hydrophobic* (i.e. water-repellent) and consequently they would not accept the conventional dyes of the time. Fibres that cannot be dyed are limited in their outlets, and this defect was a serious threat to progress. But the eventual solution came with the use of insoluble or sparingly soluble pigments dispersed in water using specially formulated surface-active agents. The stability of the dispersions enabled the pigments to 'dissolve' in the fibre and give a uniform distribution of colour throughout the dyed goods.

These were the first *disperse dyes*, a class of dyes that is now always used for the coloration of certain synthetic fibres. They are very different from water-soluble dyes, particularly in their response to heat. This difference is their ability to pass into the vapour phase without melting, a process referred to as *sublimation*. It soon became apparent that some disperse dyes will sublime from the dyed synthetic fabric when stored against a current of warm air, to leave irregular pale markings on the fabric, and dyes with improved fastness to sublimation were therefore developed.



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But with the appearance of other synthetic fibres, particularly polyester, the propensity of disperse dyes to sublime became an advantage that has been exploited in two ways: firstly, in the printing of knitted goods and, secondly, in the dyeing of polyester/cellulosic fibre blends.

Knitted goods are difficult to print because the fabric is easily distorted during the application of the print paste, which is carried out under pressure. This difficulty can now be overcome using a two-stage process. The pattern is first printed on paper, using a disperse dye paste. Later the patterned paper is placed face down on the fabric and held firmly in close contact with it without distorting it, whilst the secured combination passes into a heating chamber. The dye vaporises and moves to the fabric, where it is absorbed in the well-defined localised areas of the pattern by the hot thermoplastic polyester fibres. Thus printing takes place without the printing paste touching the fabric, which is ready for use without further washing-off treatments immediately it has passed from the heaters.

Transfer of dye through the vapour phase is also useful in dyeing blends of polyester and cellulosic fibres. The requirements of polyester and cellulose for dyeing are completely different: polyester needs the disperse dyes whilst cellulose requires water-soluble dyes. One way of colouring the combination is to carry out one dyeing for the cellulose and another for the polyester, thus doubling the effort. It is possible, however, to apply to the fabric a mixture of both classes of dye. In the drying stage most of the dye is absorbed by the hydrophilic component but on subsequent heating the disperse dye transfers through the vapour phase to the polyester.

The continuing pressure to conserve water and energy is now providing a further stimulus to the development of methods and equipment. The need to eliminate toxic substances from dyehouse effluent is leading to fresh innovations, including the removal of chromium and other metals from the bath before the liquor is discharged.

Efficient colour matching

Over recent decades improvements have been concerned mainly with improving speed and economy in meeting customer requests. Progress here began with work carried out around the early 1960s. Until that time the only recognised way of matching customer shades and fastness requirements involved lengthy laboratory trials and visual assessment of the results. The process was repeated until successive corrections eventually provided the desired end result. Further adjustments were then needed to transfer the laboratory results to the equipment in use.



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The introduction at this time of a pioneering instrumental match-prediction system offered the possibility of matching a shade from suitable instrumental measurements of the customer's fabric and stored knowledge of the spectra of the available dyes. This work was the forerunner of present-day practice, but in these early stages many people perceived the work as an example of impractical theoretical concepts. The intervention of the microprocessor has left the value of the work unchallenged, however, and modern dyehouses and dye manufacturers now depend on instrumentation for the prediction of recipes. In this way the necessary quality is achieved, with dyes selected from a minimal number of stock colours. Furthermore, the required precision of dyebath and textile preparation has encouraged a marked improvement in the standards of accuracy provided by the operatives. Thus subjective judgement of colour has been superseded, along with the old routine trial-and-error methods.

Transmission of information on colour quality

Over the years each manufacturer has produced ranges of dyes suited to particular fibres under their own brand names. Consequently there are often different brand names for the same class of dye, and even chemically identical dyes may be sold under different brand names. In this situation there is a need for comparison of the qualities of the differently named products.

Provision of product information for the colourist

A dyer cannot assess from the label on the container alone whether a sample of dye from one manufacturer is equivalent to an apparently similar sample from another maker. It is impractical to carry out a full range of exploratory fastness tests on each dye of potential interest, but since the primary concern is with the quality of the end product, a comparison of fastness properties will be of more interest than a determination of the chemical structure. If the dyes have identical fastness properties then the choice can be made on the basis of cost; otherwise the merits of one chemical structure over another may become a consideration. The selection process is aided by the dye makers, who provide extensive information with regard to shade, fastness to light and washing, and recommended dyeing methods. This is usually presented in the form of pattern cards, as shown in [Plate 3](#). The dyes chosen as the example are intended for wool and the fastness ratings to standard tests are shown alongside samples of wool coloured with the appropriate dye.

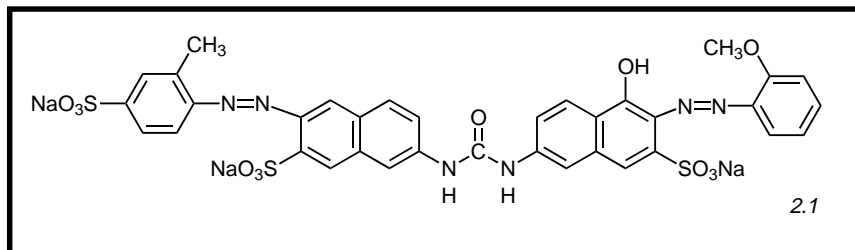


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The Colour Index

The manufacturer's brand name generally bears no obvious relationship to either the chemical or the application class of the dye. But the merit of this apparently random approach is that the colorant may be readily recognised without the need for specialised chemical knowledge. Moreover, the chemical names of dyes are often cumbersome and lengthy; for example, the full chemical name of the dye with structure 2.1 is *N*-[(2-methylbenzene-4-sulphonic acid)-2-azo-1-naphthol-3-sulphonic acid]-*N'*-[(2-methoxybenzene)-2-azo-1-naphthol-3-sulphonic acid-6-]urea sodium salt: it is sold under the name Chlorazol Fast Scarlet 4BA, however. Little imagination is needed to realise the practical difficulties that could ensue, even for a chemist, if dye containers were labelled with the correct chemical name instead of the commercial one.

Nevertheless, the need for some systematic indexing of the many synthetic dyes and pigments is clear, and this is



available in the form of a publication called the *Colour Index*, in which dyes are referred to by an unambiguous *Colour Index* number [1]. The *Colour Index* serves as a reference source for both the chemical structure and technical properties of dyes. It is divided into three parts.

Part 1 consists of three volumes that classify dyes and pigments according to their usage, as in Table 2.1 (page 17). There is a further subdivision of the dye classes into two groupings, which serves to indicate whether the absorption of dye is reversible or irreversible. Those dyes for which the absorption is easily reversed in clean water will have the lowest resistance to washing, and the loose dye will cause staining of any undyed fabric present. The dyes of the remaining classes are irreversibly absorbed by the fibre, either through the formation of a chemical bond, as with reactive dyes, or through the deposition of a water-insoluble pigment, as with sulphur and vat dyes and azoic components. Thus the general dyeing behaviour and fastness properties are reflected by the way in which the dye classes are set out in the *Colour Index*.

Dyes in each of the divisions are grouped according to their colour and each is given its own five-figure CI number, which serves as an unambiguous reference. Thus the yellow dyes of the acid type are classified as CI Acid Yellow 1, CI Acid Yellow 2 . . . through acid oranges, reds and so on,

ending with blacks. These are the CI *generic names* of dyes. For example, the generic name of Chlorazol Fast Scarlet 4BA, mentioned above, is CI Direct Red 24 and its reference number is 29185.

Part 2 is a single volume in which dyes and pigments are classified according to chemical constitution, and important intermediate products used in the manufacture of colorants are also included. Every dye in Part 1 appears also in Part 2, provided its formula is known. Formulae are grouped in order of chemical classes, such as those of monoazo, disazo, trisazo, polyazo, anthraquinone and natural dyes. The list finishes with inorganic pigments.

Part 3 includes a list of all the commercial names notified to the publishers in alphabetical order together with the appropriate CI constitution numbers and generic names. There is also a listing of these commercial products in CI generic name order.

Commercial names of dyes and pigments

The relative simplicity of commercial names has already been mentioned. Another advantage of their use is that with time a given name becomes associated with defined standards of manufacture so that the user can anticipate reliability on repeating an order. The colourist is also aided by the

broadly systematic approach to the commercial naming of dyes that is now in use. The convention used is represented in Figure 2.1.

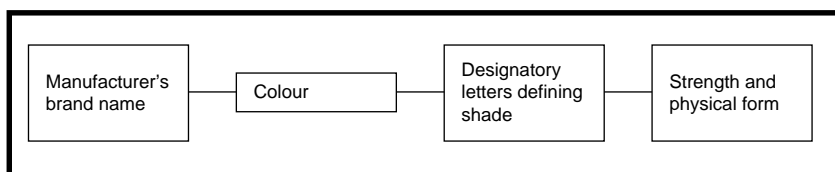


Figure 2.1 The convention for the naming of dyes

Manufacturer's brand name

The brand name of a particular class of dye distinguishes between those originating from different manufacturers. For example, Chlorazol and Durazol are the ranges of direct dyes produced by ICI, while Ciba-Geigy have chosen the names Cuprophenyl and Solophenyl for their equivalent dyes. The brand name therefore communicates to the dyer as much about the dye as names like Granada, Cavalier and Golf do to the motor car enthusiast. For example, the name Chlorazol Red makes it clear that the dye is a red direct dye manufactured by ICI.

Designatory letters

These letters are used because not all dyes of the same basic colour are exactly the same shade. Colours with a yellowish tint, such as a yellowish-red, bear the letter G (German *gelb* = yellow). Similarly those with a reddish tinge will be identified by R (*rot* = red) and those with a blue tinge by B (*blau* = blue). The designatory letters are sometimes preceded by a number which indicates the intensity of the deviation from the main colour. [Plate 3](#) shows some examples of nomenclature.

Strength and physical form

The dye powders sold by the manufacturer may contain only about 30% colouring matter. They would be prohibitively expensive if they were prepared in pure form. Consequently each new batch of dye has to be standardised to ensure a defined physical strength when used for dyeing. A proportion of a second or even a third colour component may be added to ensure the shade matches other batches of the same dye. Sometimes, for reasons of economy in transportation, dyes are required with a strength greater than standard. When a dye is prepared in different strengths this is indicated by an S at the end of the name, and strengths greater than standard are followed by numbers showing the strength relative to the standard: for example, 'Dispersol Fast Yellow A 300' means that this dye preparation is 3 times the standard strength. The standardisation is usually done by mixing dye powder with neutral electrolytes; in some cases (vat or disperse dyes) dispersing agents may be incorporated.

Dyes may be packaged in the form of fine powders, grains or pastes, and the physical form is indicated on the package labelling – for instance, 'Dispersol Fast Orange Brown RN 150 powder fine' or 'Duranol Blue G grains'. The different forms are prepared for the convenience of handling. The use of readily dispersed grains eliminates the problems arising with some dyes in powder form which 'fly' into the atmosphere and cause contamination, whilst a colorant presented in a paste form is more readily mixed evenly into a printing paste.

Informing the consumer about colour quality

Whilst the detailed information available to the colourist is helpful for choosing dyes with appropriate properties, such information is not easily available to the consumer at the point of sale. Even if it were, it is unlikely that the presentation of technical data on fastness properties would be readily understood. Nevertheless, the area of colour fastness is a dominant factor in the difficulties



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encountered with the quality of coloured textile goods. There is therefore a real need for clear, simple and informative recommendations relating to the appropriate aftercare for purchased goods.

The restoration of worn textiles to a clean and presentable state for re-use is an everyday affair, and a wide variety of possible procedures may be used. These include washing using proprietary detergents (some of which may contain bleach), drying, tumble drying, dry or steam ironing, dry cleaning and other special methods depending on the nature of the article. Generally smaller articles are more conveniently cleaned in a washing machine, whilst wool suits and more bulky items like curtains are usually dry cleaned. Apart from convenience, however, the properties inherent in both the dye and the fabric are of equal importance in relation to the cleaning conditions.

Mechanical action such as wringing, spin drying or tumble drying can have a detrimental effect on some fabrics. For example, if woollen goods are washed at too high a temperature or with severe agitation, the result will be an unacceptable shrinkage. Acrylic fabrics may stretch as a result of the degradation of their physical properties during unsatisfactory washing, whilst the use of dry cleaning solvents can have a harmful effect on some synthetic fibres. For tightly woven acetate fabrics dry cleaning is preferable to washing, because when such fabrics become wet and crumpled they may crease badly or even crack. If the melting of synthetic fibres or damage to the aftertreatments on natural fibres is to be avoided, careful attention must also be given to the temperature of ironing.

Obviously the formulation of realistic conditions for the aftercare of textile goods involves many factors. This is complicated further by the wide-ranging combinations of temperature, time, degree of agitation and spinning speeds encountered with domestic washing machines. A further complicating factor is the range of different fibres that may be used together in blends, together with their associated differences in ironing conditions. It is therefore difficult to provide simple foolproof aftercare recommendations. Until the middle 1960s some manufacturers provided aftercare recommendations as a fixed form of words. Unfortunately the confusion was exacerbated, because manufacturers tended to use different forms of words to mean the same thing. The subsequent efforts made to provide a more consistent and informative system of aftercare labelling led to the provision of sewn-in information labels.

There were two views about the form in which the information should appear on the labels. One favoured clear, compact and precise statements, whilst the other preferred the use of descriptive



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symbols. Ultimately agreement was reached to use symbols and a few informative words that encompassed the temperature of the washing water, suitable methods of water extraction and drying, and recommendations for ironing. Development of the currently used International Care Labelling Code was carried out by the Home Laundering Consultative Council (HLCC), constituent representative members of which included individuals from industries concerned with the production of textile goods.

The basic care labelling symbols in current use are presented in Figure 2.2. They convey details of washing processes (wash-tub), the ironing temperature (iron), and suitability for chlorine bleaching (triangle) and dry cleaning (circle). The HLCC in cooperation with Ginetex (the European care labelling body) have covered most eventualities by categorising the various possibilities into

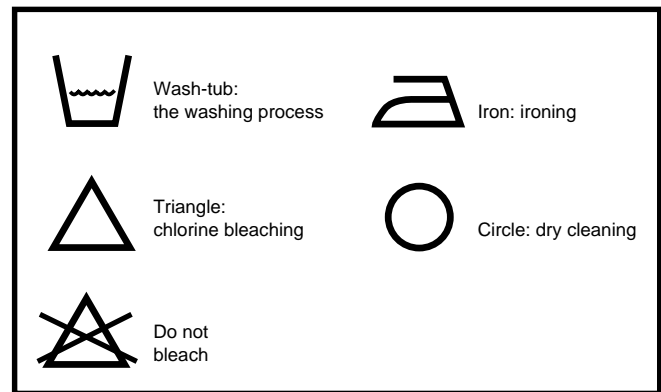


Figure 2.2 Care labelling symbols

nine groups, which are now recognised by most washing machine manufacturers. The current International Care Labelling Code together with examples of its application is shown in Figures 2.3 and 2.4.









Examples of application	Examples of application
 White cotton and linen articles without special finishes	 Acrylics, acetate and triacetate, including mixtures with wool; polyester/wool blends
 Cotton, linen or viscose articles without special finishes where colours are fast at 60 °C	 Wool, wool mixed with other fibres; silk
 Nylon; polyester/cotton mixtures; polyester, cotton and viscose articles with special finishes; cotton/acrylic mixtures	 Handwash (Do not machine wash)
 Cotton, linen or viscose articles, where colours are fast at 40 °C but not at 60 °C	 Do not wash

Figure 2.3 The International Care Labelling Code

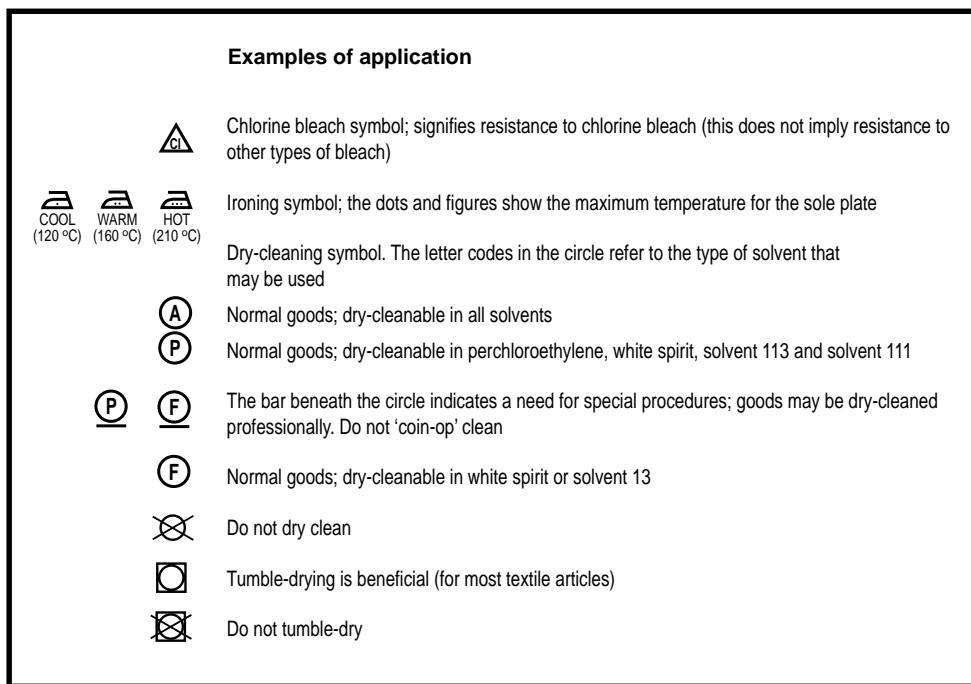


Figure 2.4 *The International Care Labelling Code*

The labels are self-explanatory and take into account localised variations in common laundry practice. A recent additional symbol has been adopted: a bar below the wash tub indicates reduced action and a short spin to reduce the danger of creasing certain fabrics. The broken bar indicates reduced action but with normal rinse and spin, whilst the absence of a bar is used for normal washing machine action together with the words 'wash as cotton'. The symbol for hand washing is reserved for those articles that are particularly delicate or for which the wet fastness properties of heavily dyed shades may result in the staining of other materials.

Reference

1. *Colour Index International*, 3rd Edn, 8 vols. (Bradford: SDC, 1971 *et seq.*).

Further reading

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- The dyeing of synthetic-polymer and acetate fibres*, Ed. D M Nunn (Bradford: Dyers' Company Publications Trust, 1979), Chapter 1.
- W R Beath, *Textiles*, **8** (1979) 42.
- J E Ford, *Textiles*, **16** (1987) 37.
- J E Ford, *Textiles*, **17** (1988) 32.