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**Paints and varnishes — Visual comparison  
of the colour of paints**

*Peintures et vernis — Comparaison visuelle de la couleur des peintures*



Reference number  
ISO 3668:1998(E)

## Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 3668 was prepared by Technical Committee ISO/TC 35, *Paints and varnishes*, Subcommittee SC 9, *General test methods for paints and varnishes*.

This second edition cancels and replaces the first edition (ISO 3668:1976), which has been technically revised.

Annexes A and B form an integral part of this International Standard. Annex C is for information only.

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# Paints and varnishes — Visual comparison of the colour of paints

## 1 Scope

This International Standard is one of a series of standards dealing with the sampling and testing of paints, varnishes and related products.

It specifies a method for the visual comparison of the colour of films of paints or related products against a standard (either a reference standard or a freshly prepared standard) using either natural daylight or artificial light sources in a standard booth.

It is not applicable to coatings containing special-effect pigments, e.g. metallics, without previous agreement on all details of illuminating and viewing conditions.

## 2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 1512:1991, *Paints and varnishes — Sampling of products in liquid or paste form.*

ISO 1513:1992, *Paints and varnishes — Examination and preparation of samples for testing.*

ISO 1514:1993, *Paints and varnishes — Standard panels for testing.*

ISO 2808:1997, *Paints and varnishes — Determination of film thickness.*

ISO 3270:1984, *Paints and varnishes and their raw materials — Temperatures and humidities for conditioning and testing.*

ISO 7724-1:—<sup>1)</sup>, *Paints and varnishes — Colorimetry — Part 1: Principles.*

ISO 7724-2:—<sup>2)</sup>, *Paints and varnishes — Colorimetry — Part 2: Colour measurement.*

ISO 7724-3:—<sup>3)</sup>, *Paints and varnishes — Colorimetry — Part 3: Calculation of colour differences by CIELAB.*

CIE Publication No. 51:1981, *A method for assessing the quality of daylight simulators for colorimetry.*

CIE Publication No. 15.2:1986, *Colorimetry.*

1) To be published. (Revision of ISO 7724-1:1984)

2) To be published. (Revision of ISO 7724-2:1984)

3) To be published. (Revision of ISO 7724-3:1984)

### 3 Principle

The colours of the paint films to be compared are observed under specified illumination and viewing conditions, either in natural daylight or in artificial light, using a colour-matching booth in the latter case. For the expression of colour difference components (hue, chroma and lightness), a procedure is described, i.e. description using a particular rating scheme. Assessment of metamerism is also taken into account.

### 4 Required supplementary information

For any particular application, the test method specified in this International Standard needs to be completed by supplementary information. The items of supplementary information are given in annex A.

### 5 Illumination for colour matching

#### 5.1 General

For routine colour matching, either natural or artificial daylight may be used. The quality of natural daylight is variable, and observers' judgements are likely to be affected by nearby coloured objects. For reference purposes therefore, closely controlled artificial illumination in a colour-matching booth shall be used. The observer shall wear clothing of a neutral colour, and no strongly coloured surfaces, other than the panels under test, shall be permitted in the field of view.

#### 5.2 Natural daylight illumination

Diffuse daylight, preferably from a partially cloudy north sky in the northern hemisphere and a partially cloudy south sky in the southern hemisphere, and not reflected from any strongly coloured object such as a red brick wall or green tree, shall be used. Illumination shall be uniform over the area in which test panels are displayed and at a level of at least 2 000 lx. Direct sunlight shall be avoided.

#### 5.3 Artificial illumination by means of a colour-matching booth

The colour-matching booth shall be an enclosure from which external light is excluded and which is illuminated by a light source giving a spectral power distribution falling on the test panel, approximating to that of CIE standard illuminant D65 or CIE standard illuminant A.

Where a light source having a different spectral distribution is used, it shall be agreed by the interested parties.

The quality of simulation of daylight shall be assessed by the method described in CIE Publication No. 51. The spectral distribution of the illuminant shall be in category BC (CIELAB) or better.

The level of illumination at the colour-matching position shall be between 1 000 lx and 4 000 lx, a figure towards the upper end of the range being desirable for dark colours.

The interior of the colour-matching booth for general use shall be painted a matt neutral grey (the amount of  $a^*$  and  $b^*$  shall be less than 1,0) with a lightness  $L^*$  of about 45 to 55. However, when mainly light colours and near-white colours are to be compared, the interior of the booth may be painted so as to have a lightness  $L^*$  of about 65 or higher in order to give a lower brightness contrast with the colour to be examined; when mainly dark colours are to be compared, the interior of the booth may be painted matt black with a lightness  $L^*$  of about 25.

NOTE —  $L^*$ ,  $a^*$  and  $b^*$  refer to the CIELAB system (see ISO 7724-1).

To ensure an appropriate surrounding field for colour comparison, the table surface in the booth shall be covered by a neutral grey panel, its luminance factor being chosen to be similar to that of the samples to be compared.

A diffusing screen shall normally be used to avoid the reflection of an image of the lamp from the test panel. The spectral distribution properties of the light source shall include the spectral transmission of the screen.

The manufacturer of the light source shall disclose the number of running hours during which the product can be expected to conform to this International Standard.

## 6 Observer

Observers shall have normal colour vision and shall be selected carefully because a significant proportion of people have defective colour vision. An Ishihara test will reveal severe defects but, to confirm an observer's suitability, more sensitive tests, for example the Farnsworth 100 hue test or stricter anomaloscope measurements, are desirable. If an observer wears glasses to correct his or her vision, these shall have uniform spectral transmission throughout the visible spectrum. As colour vision changes significantly with age, it is desirable that observers over 40 years of age are tested using a proper method whereby the observer is requested to choose the best match from a metameric series of colours. For colour comparison work, not only normal colour vision but also colour discrimination ability or experience is important.

To avoid eye fatigue effects, pastel or complementary colours shall not be viewed immediately after strong colours. When comparing bright, saturated colours, if a decision cannot be made rapidly, the observer shall look away for some seconds at the neutral grey of the surrounding field before attempting a further comparison.

The quality of visual judgements falls off severely if the observer works continuously. Rest periods of several minutes during which no colour matching is attempted shall, therefore, be taken frequently.

## 7 Test panels and reference standards

### 7.1 General

Both test panels and reference colour standards shall be flat and preferably about 150 mm × 100 mm in size. Suitable materials for test panels are tinfoil, hard aluminium, glazed cardboard, steel or glass, complying with ISO 1514.

Panel size and viewing distance shall be chosen so that the panel subtends an angle at the eye of about 10°. If larger panels are used, a viewing field corresponding to the 10° observer shall be formed using a grey mask.

Typical viewing distances and sizes for the square openings in the mask are given in table 1.

**Table 1 — Viewing distances and opening sizes of masks**

Viewing distance cm	Opening size cm × cm
30	5,4 × 5,4
50	8,7 × 8,7
70	12,3 × 12,3
90	15,8 × 15,8

### 7.2 Reference standards

Only colour standards of satisfactory colour permanence shall be used as reference standards. Wherever possible, the reference standards shall be of the same size as the test panels and shall have closely similar gloss and surface texture.

### 7.3 Preparation and coating

Prepare test panels as specified and, where appropriate, in accordance with ISO 1514. The panels shall be coated by a closely specified or agreed method, because the method of application and film thickness may affect the colour considerably.

If the test panel is to be compared against a standard paint, it shall be coated with the paint or system under test and a similar panel coated with the standard paint or system. The method of application and the applied film thickness shall be as closely as possible identical.

NOTE — The film thickness applied should preferably be such as to ensure complete hiding of the substrate, in order to eliminate the influence of the substrate. To check that this is the case, black and white charts may be used.

### 7.4 Drying

Dry (or stove) each coated test panel for the specified time and under the specified conditions and, unless otherwise specified, condition in the standard atmosphere as specified in ISO 3270 for a minimum of 16 h with free circulation of air and not exposed to direct sunlight.

### 7.5 Thickness of coating

Determine the thickness, in micrometres, of the dried coating by one of the procedures specified in ISO 2808.

## 8 Procedure for colour comparison

### 8.1 General

**8.1.1** For standardized colour comparison, it is necessary to have an observer with normal colour vision, and reproducible illumination and viewing conditions. Most paints are required to match a standard in daylight, but the spectral composition of daylight varies considerably. Hence it is preferred to use artificial daylight for colour evaluation, as individual sources are more stable over a limited period than daylight and therefore enable more reproducible colour comparisons to be made.

**8.1.2** Unless otherwise agreed, this method of test makes use of natural daylight or of two artificial light sources. Average daylight — natural or artificial — is used for routine comparisons. Artificial average daylight illumination is represented by CIE standard illuminant D65. Incandescent illumination is additionally used to check for metamerism. Incandescent illumination is represented by CIE standard illuminant A.

In cases of dispute, the referee comparison shall always be made under artificial light.

**8.1.3** The visual assessment of colour differences using the components hue, chroma and lightness should preferably be performed in accordance with the rating scheme given in annex B. By agreement between the interested parties, a simplified rating scheme comprising less than six steps can be used. However, in order to avoid confusion the meaning of the individual ratings given in annex B shall not be changed.

### 8.2 Routine method

View the two panels, or the panel and the reference colour standard, either under natural daylight (as specified in 5.2) or in artificial daylight in a colour-matching booth (5.3).

Place the panels side by side, touching and in the same plane, at a distance of about 500 mm from the eyes. Compare the colour of the paint film prepared from the material under test with that of the reference colour standard or of the film prepared from the standard paint. To improve accuracy of comparison, compare the colours with the positions of the panels reversed from time to time.

When, exceptionally, films of widely different levels of gloss are to be compared, the method of viewing shall be agreed between the interested parties. The panels may be viewed either in natural daylight or in a colour-matching booth.

#### a) Viewing in natural daylight

View the panels at an angle which minimizes gloss differences, for example from a nearly normal direction, so that the specular reflection does not reach the eye.

Observe colour difference components of hue, chroma and lightness with an indication of the order of prominence of these components. For example, note that a specimen is moderately yellower, slightly darker and very slightly less in chroma than the standard panel, or DH: 3ye, DL: -2 and DC: -1 using the component difference rating scheme given in annex B.

NOTE — DH, DL and DC are not colorimetric values, but just values used for difference classification.

#### b) Viewing in a colour-matching booth

View the panels at an angle of 45° with illumination at an angle of 0° or *vice versa*. Observe total colour difference, or colour difference components as described in 8.2 a).

### 8.3 Referee method

In cases of dispute, comparisons shall be made in artificial daylight conforming to CIE standard illuminant D65, unless an alternative light source has been agreed between the interested parties.

## 9 Assessment of metamerism

If the standard and test panels contain dissimilar pigment mixtures, they may match under the standard source but not under another light. This phenomenon is known as metamerism (see annex C).

A small degree of metamerism, whether arising with the same or with different pigments, may be acceptable, depending on the particular circumstances, as the importance of metamerism depends very much on the use for which the paint is intended. Where close colour matching in different lighting conditions is important, the acceptable degree of metamerism, if any, shall be agreed between the interested parties.

In addition to assessing the rating of the match under artificial average daylight illumination (D65), make the comparison under incandescent illumination (A), and assess whether the match is maintained or not.

If a numerical description of the metamerism is required, spectral measurements shall be made in accordance with ISO 7724-1 and ISO 7724-2, using CIE standard illuminants D65 and A, and the colour differences shall be calculated as described in ISO 7724-3.

## 10 Test report

The test report shall contain at least the following information:

- a) all details necessary to identify the product tested;
- b) a reference to this International Standard (ISO 3668);
- c) the items of supplementary information referred to in annex A;
- d) a reference to the international or national standard, product specification or other document supplying the information referred to in c);

- e) whether the comparison of colour was carried out using natural daylight or artificial daylight and the type of artificial light if used;
- f) details of the colour-matching booth, if used, e.g. manufacturer and lightness of the interior;
- g) a description of the rating scheme, in accordance with annex B (see 8.1.3);
- h) the result of the test, including any metamerism noted, and whether the comparison was carried out against a freshly prepared standard or against a reference colour standard;
- i) any deviation from the test method specified;
- j) the date of the test, and the person/persons who carried out the test.



## **Annex A**

### **(normative)**

### **Required supplementary information**

The items of supplementary information listed in this annex shall be supplied as appropriate to enable the method to be carried out.

The information required should preferably be agreed between the interested parties and may be derived, in part or totally, from an international or national standard or other document related to the product under test.

- a) The material, thickness and surface preparation of the substrate.
- b) The method of application of the test coating to the substrate.
- c) The duration and conditions of drying (or stoving) and ageing (if applicable) of the coating before testing.
- d) The thickness, in micrometres, of the dry coating and the method of measurement in accordance with ISO 2808, whether it is a single coating or a multicoat system, and whether the coating ensures complete hiding of the substrate.
- e) Any gloss differences between the samples, if relevant for the visual assessment.

## Annex B (normative)

### Colour difference rating scheme

**Table B.1 — Rating scheme for components of colour difference by visual assessment<sup>\*)</sup>**

Rating	Degree of difference
0	No perceptible difference
1	Very slight, i.e. just perceptible, difference
2	Slight, but clearly perceptible, difference
3	Moderate difference
4	Considerable difference
5	Very major difference

<sup>\*)</sup> Derived from ISO 4628-1:1982, *Paints and varnishes — Evaluation of degradation of paint coatings — Designation of intensity, quantity and size of common types of defect — Part 1: General principles and rating schemes.*

Components of colour difference are:

#### **Hue difference**

Designation: DH (difference in hue)

Assessment: 0 to 5; more yellow (ye, y), more green (gr, g), more red (re, r), more blue (bl, b)

EXAMPLE: DH: 5ye (test specimen is 5 and more yellow)

#### **Chroma difference**

Designation: DC (difference in chroma)

Assessment: 0 to 5; more (+) or less (–)

EXAMPLE: DC: –2 (test specimen is 2 less in chroma)

#### **Lightness difference**

Designation: DL (difference in lightness)

Assessment: 0 to 5; lighter (+) or darker (–)

EXAMPLE: DL: –2 (test specimen is 2 and darker)

## Annex C (informative)

### Metameric matches

When two paints have identical spectral reflection curves, they will match visually under any illuminant irrespective of its spectral characteristics. This is termed a "spectral match".

It is also possible for two paints having different spectral reflection curves to match visually under a given light source, but not to match under another light source with different spectral characteristics. Such matches are termed "metameric".

Where the pigments in two matching paints are different, some metamerism inevitably occurs; in certain cases, there may even be a small degree of metamerism when the same pigments are used.

The simplest method of determining whether a match made under an artificial light source conforming to this International Standard is metameric or not is to inspect it in addition under the light from a tungsten filament lamp, and it is recommended that this be done unless it is known that identical pigments have been used. If the match is maintained under the tungsten lamp, it is unlikely to be metameric; if the paints no longer match, but the degree of mismatch is not obvious, then it is unlikely that any greater degree of mismatch will occur under most generally occurring natural and generally used artificial illuminants with continuous spectra. However, this may not be the case for illuminants with a line emission spectrum, such as fluorescent, TL84 and sodium and mercury vapour lamps.

A metameric match made under an artificial light source conforming to this International Standard may not continue to be a match under certain daylight conditions (for example north light from a blue sky or sunlight from a low sun), but it will continue to be a match under the most frequently occurring phases of daylight. It must be noted, however, that, in any case of metamerism, differences in the colour vision of normal observers may influence their assessment as to whether the colours of two paints match or not.

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**ICS 87.040**

**Descriptors:** paints, varnishes, tests, daylight tests, artificial light tests, determination, colour, visual inspection (testing), comparison analysis, standard colour.

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