
**Dentistry — Guidance on colour
measurement**

*Médecine bucco-dentaire — Directives relatives au mesurage de la
couleur*

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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.

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The main task of technical committees is to prepare International Standards. 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.

In exceptional circumstances, when a technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example), it may decide by a simple majority vote of its participating members to publish a Technical Report. A Technical Report is entirely informative in nature and does not have to be reviewed until the data it provides are considered to be no longer valid or useful.

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ISO/TR 28642 was prepared by Technical Committee ISO/TC 106, *Dentistry*, Subcommittee SC 2, *Prosthetic materials*.

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Introduction

The colour appearance of teeth and other dentistry-related tissues needs to be matched and reproduced in order to achieve acceptable aesthetics in an efficient manner. Three major groups of issues, related to colour compatibility, colour stability and colour interactions, are identified and considered in this Technical Report. Interpretation of colour differences associated with these three groups through 50:50 % perceptibility and acceptability visual thresholds is suggested. Colour is a psychophysical phenomenon that is assessed by both visual and instrumental methods. Other elements of appearance, including gloss and translucency, affect aesthetics and may influence the characterization of colour appearance.

The International Commission on Illumination (CIE) colour difference formulae and resources, in particular CIE Pub No 15.3, were used in this Technical Report.

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Dentistry — Guidance on colour measurement

1 Scope

This Technical Report identifies three types of topics related to shade conformity and interconvertibility of monochromatic and polychromatic tissues and materials related to the discipline of dentistry; it describes visual and instrumental methods for assessment of these topics.

This Technical Report suggests interpretation of the findings through colour difference thresholds, and provides guidelines for future standardization related to dental shade conformity and interconvertibility. It also includes guidelines related to colour vision of persons undertaking visual colour assessments and instructions for reporting of colour and colour difference assessments.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 1942, *Dentistry — Vocabulary*

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3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 1942 and the following apply.

3.1

colour difference

single number or metric expressing the distance from complete match in colour or shade

NOTE 1 A colour distance metric defined by the International Commission on Illumination (CIE) is called delta E (ΔE).

NOTE 2 Two formulae for calculating ΔE are recommended in this Technical Report: CIE76 (denoted ΔE_{ab}^*) and CIEDE2000 (denoted ΔE_{00}).

3.2

50:50 % perceptibility threshold of colour difference

PT

difference in colour that can be detected by 50 % of observers, with the other 50 % of observers noticing no difference in colour between the compared objects

NOTE A nearly perfect colour match in dentistry is a colour difference at or below the 50:50 % perceptibility threshold.

3.3

50:50 % acceptability threshold of colour difference

AT

difference in colour that is considered acceptable by 50 % of observers, with the other 50 % of observers replacing or correcting the restoration

NOTE An acceptable colour match in dentistry is a colour difference at or below the 50:50 % acceptability threshold.

**3.4
colour standards in dentistry**

sets of polychromatic or monochromatic samples (tabs, chips, or patches), most frequently made of dental ceramic or resin (tooth shade guides), or silicone elastomer (skin shade guides in maxillofacial prosthodontics)

NOTE The polychromatic and monochromatic samples are fabricated for the purposes of colour matching hard and soft oral tissues, and human skin (see Reference [2]).

**3.5
coverage error**

index that describes the minimal colour differences (ΔE^*_{\min}) between the specimens of one set (e.g. a shade guide) to each specimen of another set (e.g. natural teeth)

NOTE The coverage error is calculated as the mean ΔE^*_{\min} for all best matches as follows:

$$\text{Coverage error} = \Sigma \Delta E^*_{\min} / n$$

Where n is the number of best matches.

The smaller the coverage error, the higher the chances of successful shade matching.

**3.6
tooth whitening**

change in tooth colour caused by bleaching or stain-removal agents and manifested by the increase in the value of lightness and the decrease of chroma

**3.7
colour shifting**

change in perceived colour that is a sum of a blending effect and an effect of physical translucency

**3.7.1
colour shifting due to blending**

change in perceived colour of a material due to a change in surroundings

NOTE Colour shifting due to blending is a psycho-physical phenomenon, and is not modelled by the current CIELAB mathematical model; it is an optical illusion — visually perceptible, but not currently quantifiable or measurable by any instrument.

**3.7.2
colour shifting due to physical translucency**

change in colour of translucent dental restorations caused by surroundings and background (underlying layers of hard dental tissues or other restorative materials)

**3.8
opacity**

measure of the ability of a material to block the passage of light

NOTE A material with high opacity is one with low translucency/transparency.

**3.9
transparency**

physical property of allowing the transmission of light through a material

NOTE 1 A material with high transparency is one with low opacity.

NOTE 2 Transparency is the extreme value of high translucency.

NOTE 3 A transparent material allows light to pass through undiminished, while a negligible portion of the transmitted light is scattered.

3.10

translucency

ability of a material to allow light to pass through it

NOTE 1 A material with high translucency is one with low opacity.

NOTE 2 Translucent materials allow light to pass through only diffusely (they cannot be seen through clearly).

3.11

gloss

capacity of a surface to reflect more light in some directions than in others

3.12

specular gloss

ratio of flux reflected in the specular direction to incident flux (i.e. the angle of the reflected light is equal and opposite to the angle of the incident beam) for a specified angle of incidence, source, and receptor angular aperture

NOTE These reflections normally have the highest reflectances (see References [2] and [3]).

4 Visual and instrumental colour assessment

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4.1 Devices

Frequently used devices for visual and instrumental colour assessment in dentistry are spectrophotometers, spectroradiometers, colourimeters, imaging systems for traditional digital imaging and spectral imaging, viewing booths, and different types of hand-held shade matching lights.

Spectral measurement is performed using a spectrophotometer, a device designed to measure spectral transmittance and spectral reflectance factor of objects. Compared to colorimetric measurements, spectral measurements enable more flexible measurements to calculate color differences under arbitrary illuminants and observers.

Spectrometer parameters relevant for dentistry include wavelength range, wavelength resolution, integration time and spectral sensitivity. In addition to these parameters, method of measurement, technology and geometry have to be taken in account when selecting the equipment or designing a system to measure spectra.

Spectral measurement accuracy can be measured in terms of root mean square error (rms) or degree of correlation between spectral data, and other weighted spectral measurements that emphasize the wavelength that are more relevant for human vision. Having spectral measurements of both reference and test samples it is possible to calculate how robust is the pair of samples to changes in illumination and observers by means of index of metamerism.

4.2 Setting

Colour assessment requires careful control of factors that affect colour perception and/or measurement. The following aspects of the test conditions should be specified in reporting visual assessments of colour appearance.

4.2.1 Illuminant

The characteristics of the light source or sources that illuminate the object of a colour measurement as specified preferably by the spectral power distribution (SPD) and correlated colour temperature (CCT)