TECHNICAL REPORT

ISO/TR 28642

Second edition
2016-12-01

Dentistry — Guidance on colour measurement

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

Reference number
ISO/TR 28642:2016(E)

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Foreword

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The committee responsible for this document is ISO/TC 106, *Dentistry*, Subcommittee SC 2, *Prosthodontic materials*.

This second edition cancels and replaces the first edition (ISO/TR 28642:2011), which has been technically revised.

Introduction

The colour appearance of teeth and other dentistry-related tissues need 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 document. 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 document.

Dentistry — Guidance on colour measurement

1 Scope

This document 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 document 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 documents are referred to in the text in such a way that some or all of their content constitutes requirements 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*

ISO 11664-1, *Colorimetry — Part 1: CIE standard colorimetric observers*

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

3.1
colour difference
single number or metric expressing the distance from complete match in colour or shade

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

Note 2 to entry: Two formulae for calculating ΔE are recommended in this document: CIE 76 (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 under controlled conditions, with the other 50 % of observers noticing no difference in colour between the compared objects

Note 1 to entry: 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 under controlled conditions, with the other 50 % of observers replacing or correcting the restoration

Note 1 to entry: 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 1 to entry: 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 mean of minimal colour differences ($\Delta E^*_{\min}$) between the specimens of one set (e.g. a shade guide) to each specimen of another set (e.g. natural teeth)

Note 1 to entry: The coverage error is calculated as the mean $\Delta E^*_{\min}$ for all best matches as follows:

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

where n is the number of best matches.

Note 2 to entry: 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 1 to entry: 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 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 1 to entry: 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 to entry: A material with high transparency is one with low opacity.

Note 2 to entry: Transparency is the extreme value of high translucency.

Note 3 to entry: 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 to entry: A material with high translucency is one with low opacity.

Note 2 to entry: 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 1 to entry: These reflections normally have the highest reflectances (see References [2] and [3]).

4 Visual and instrumental colour assessment

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 of objects. Compared to colourimetric measurements, spectral measurements enable more flexible measurements to calculate colour 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.