Designation: E2545 – 07 (Reapproved 2012)

Standard Test Method for Objective Measurement of Gingival Color Using Digital Still Cameras[1]

This standard is issued under the fixed designation E2545; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

INTRODUCTION

The color of gingiva is an important parameter used to ascertain certain medical and esthetic information. RGB color values for gingiva are derived from the native signals generated by a digital still camera, DSC, by broadband measurement of the reflectance of gingiva. This Test Method, E2545, specifies the procedure used for the color measurement of gingival color at 45° relative to the sample plane containing the gingiva under a nearly equal energy illuminating at 45° and viewing at 0°. This method is appropriate for evaluating the color of facial gingiva.

1. Scope

1.1 This test method covers the procedure, instrumental requirements, standardization procedures, material standards, measurement procedures, and parameters necessary to make precise measurements of gingival color. In particular it is meant to measure the color of gingiva in human subjects.

1.2 Digital images are used to evaluate gingival color on the facial labial or buccal surfaces of the gingiva. The marginal gingival tissue adjacent to natural teeth may be of particular interest for analysis. All other non-relevant parts; such as teeth, tongue, spaces, dental restorations or prostheses, etc., must be separated from the measurement and the analysis. All localized discoloration; such as stains, inclusions, pigmentations, etc., may be separated from the measurement and the analysis.

1.2.1 The broadband reflectance factors of gingiva and the surrounding tissue are measured. The colorimetric measurement is performed using an illuminator(s) that provides controlled illumination on the gingiva using a digital still camera to capture the digital image.

1.3 Data acquired using this test method may be used to assess personal gingival color for the purposes of identifying overall health status, health status at specific sites in the mouth, or to track changes in personal health status for individuals over time. Pooled data may be used to assess gingival color, health and disease among populations in epidemiological surveys, evaluation of comparative product efficacy, or safety and treatment response in clinical trials involving gingival health or disease.

1.4 The apparatus, measurement procedure, and data analysis technique are generic, so that a specific apparatus, measurement procedure, or data analysis technique may not be excluded.

1.5 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E179 Guide for Selection of Geometric Conditions for Measurement of Reflection and Transmission Properties of Materials

E284 Terminology of Appearance

E308 Practice for Computing the Colors of Objects by Using the CIE System

E1345 Practice for Reducing the Effect of Variability of Color Measurement by Use of Multiple Measurements

E1767 Practice for Specifying the Geometries of Observation and Measurement to Characterize the Appearance of Materials

[1] This test method is under the jurisdiction of ASTM Committee E12 on Color and Appearance and is the direct responsibility of Subcommittee E12.06 on Image Based Color Measurement.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

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2.2 *ISO Publications:*[3]

ISO 17321–1 Colour characterization of digital still cameras (DSCs) — Part 1: Stimuli, metrology, and test procedures

ISO/IEC 1544–1:2000 – JPEG2000 Information technology – JPEG 2000 image coding system – Part 1: Core coding system, commonly known as JPEG 2000 jp2 file format

2.3 *ISCC Publications:*[4]

Technical Report 2003–1 Guide to Material Standards and Their Use in Color Measurement

2.4 *Other Publications:*[5]

TIFF Tagged Image File Format

3. Terminology

3.1 Terms and definitions in Terminology E284 are applicable to this test method.

3.2 *Definitions:* Terms included in this section are peculiar to this standard.

3.2.1 *angle of incidence, n*—θ_1 and optional θ_2, the polar angle between the central ray of the illuminator(s), I_1 and I_2, and the Z axis which is the optical axis of the camera.

3.2.1.1 *Discussion*—These are shown in Fig. A1.1.

3.2.2 *bit depth, n*—the number of digital bits used to store information contained in each color channel of each pixel.

3.2.2.1 *Discussion*—The bit depth determines the maximum number of colors that may be encoded by the system. For example, a 24 bit system comprising 8 bits per channel can encode 2^8 by 2^8 by 2^8 or about 17 million; colors far more than are distinguishable by the human observer.

3.2.3 *facial surfaces, n*—the surfaces of teeth and gingiva that are oriented outward toward the lips (labial) and cheeks (buccal), and facing away from the tongue or roof of the mouth.

3.2.4 *gingivitis, n*—inflammation of the marginal gingiva in response to dental plaque accumulation on adjacent tooth surfaces.

3.2.5 *in-vivo—adj, or adv*, within a living body.

3.2.5.1 *Discussion*—Used to describe measurements made in a living body.

3.2.6 *polarization, n*—the process by which vibrations of light are given a definite orientation; also the state produced by that process.

3.2.7 *polarizing filter, n*—a component that blocks one of the two planes of vibration of an electromagnetic wave, thus producing linearly polarized light.

4. Summary of Test Method

4.1 This test method describes the procedures for broadband reflectometry of gingival tissue. The standardization of the instrument used to measure the tissue is defined. The images of artifact standards and samples are captured with a DSC. The RGB values of these images are read and stored. The results are reported as RGB values and can be converted to other colorimetric coordinates such as CIELAB. Procedures for converting the RGB camera values to component CIELAB values are also presented.

5. Significance and Use

5.1 The color of gingiva or changes in gingival color can be observed. The light reflected from the facial surfaces of the gingiva can be used to calculate color coordinates. These data reveal information about the efficacy of a product, treatment studied, or epidemiology of anti-gingivitis treatments. For example, clinical studies of gingivitis treatment systems evaluate the efficacy of manufacturers' products.

5.2 The change in color of the facial surface gingiva can be used to determine and optimize the efficacy of anti-gingivitis treatments. For example, the data can provide the answer to the question: "What product or system is the most efficacious in the treatment of gingivitis?"

5.3 Chronic inflammatory disease of the gingiva and periodontium results in destruction of gingival connective tissue, periodontal ligament, and alveolar bone. Clinically, inflammation is seen as redness, swelling, and bleeding observed upon probing.

5.4 This procedure is suitable for use in diagnosis and monitoring, research and development, epidemiological or other surveys, marketing studies, comparative product analysis, and clinical trials.

5.5 Popular methods assess gingival inflammation via repeated clinical examination of the gingival tissues.[6,7] These methods typically quantify gingival color, which are used to assess gingival health or disease, at multiple intraoral sites on the gingiva using a simple non-linear scoring system or index. Assessment of gingival color is an important component of health status for mild-to-severe gingival disease. These techniques are time-consuming, subjective, and often invasive, and for archival purposes, separate intraoral photographs must be collected to document gingival color and appearance. Variation between and among examiners may contribute to appreciable differences in measurement.[8]

6. Interferences

6.1 The interferences identified below may be eliminated and problems avoided by controlling and regulating each factor within the constraints of the allowable experimental error. The values and limits for these factors are typically determined experimentally. If the standard laboratory conditions listed below change during the test or from test to test by an appreciable amount, these conditions may cause interferences,

[3] Available from International Imaging Industry Association (13A), 701 Westchester Avenue, Suite 317W, White Plains NY 10604, www.13a.org.

[4] Available from ISSC, Inter-Society Color Council, 11491 Sunset Hills Rd., Reston, VA 20190, www.iscc.org.

[5] TIFF, Tagged Image File Format, Adobe Systems Incorporated, San Jose, CA, http://www.adobe.com.

[6] Loe H., and Silness, J., "Prevalence and Severity," *Journal Peridontal Disease in Pregnancy*, I, *Acta Odontologica Scand*, 1963, 21:533-551.

[7] Lobene, R. R., Weatherford, T., Ross, N. M., Lamm, R. A., and Menaker, L., "A modified gingival index for use in clinical trials," *Clinical Prevention Dentistry*, 1986, 8:3–6.

[8] McClanahan, S. F., Bartizek, R. D., and Biesbrock, A. R., "Identification and consequences of distinct Loe-Silness gingival index examiner styles for the clinical assessment of gingivitis," *Journal of Periodontology*, [illegible]

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and the accuracy and precision requirements of this test method may not be achieved. In some cases these effects may only be observed during the performance of the test.

6.1.1 *Factors Affecting Test Results*—The following environmental factors are known to affect the test results.

6.1.1.1 *Extraneous Radiation*—Light including near infrared from sources other than the illuminator(s) must be shielded from the test apparatus.

6.1.1.2 *Vibrations*—Mechanical oscillations that cause components of the apparatus to move relative to one and another may cause errors in test results.

6.1.1.3 *Thermal Changes*—Temperature changes occurring during a test or differences in temperature between testing locations may affect the reflectance factor of the standardization, calibration, and verification plaques, and the apparatus spectral response function.

6.1.1.4 *Power Input Fluctuations*—Large changes in the line frequency or supply voltage may cause the apparatus to report erroneous results.

6.1.2 *Retractors*—The surface finish of the retractors affects the experimental test results. It has been determined that a glossy finish on the surface of the retractors may introduce a bias into the test results.

6.2 The system must allow for successful standardization. If the system cannot be standardized, a series of checks must be performed (lighting, camera, etc.) to identify the reason. The component of the system in error will be adjusted or replaced to bring the system back into calibration.

7. Apparatus

7.1 *General*—The components described in this section are described generically. The intention is not to exclude any component from being used, or to exclude any type of instrument that may be available commercially. Between 4 and 6 different components or component assemblies are required to accomplish the measurement.

7.2 *Geometry*—The geometry of the system is 45:0 as described in Practice E1767. The DSC System Geometry (Coordinate System) and Angular Convention are shown in Fig. A1.1 included in Annex A1.

7.3 *Components*—A block diagram of these component assemblies is shown diagrammatically in Fig. A1.2, included in Annex A1.

7.3.1 *Source Illumination Assembly*—Contains the source of illumination and associated optics to produce irradiance, E, on the sample over a specified spot area, designated A. The source is broadband and continuous in nature. A diagrammatic representation of the components of a typical source illumination assembly Unit is shown in Fig. A1.3, included in Annex A1.

7.3.2 *Spectral Power Distribution*—The light source should be spatially uniform over the area of interest, and have a spectrum that approximates CIE Illuminant D50 over the spectral range of the DSC, a choice that is customary and achieves the uniformity of practice. Commonly used light sources include incandescent lamps with filters to simulate a standard illuminant, flash xenon with filters, or white-LED lamps to realize the approximate color temperature of 5000K.

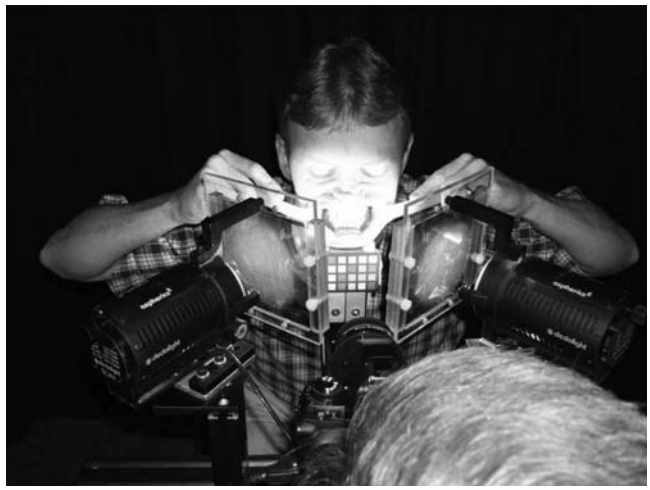

FIG. 1 Subject Positioned in Instrumentation

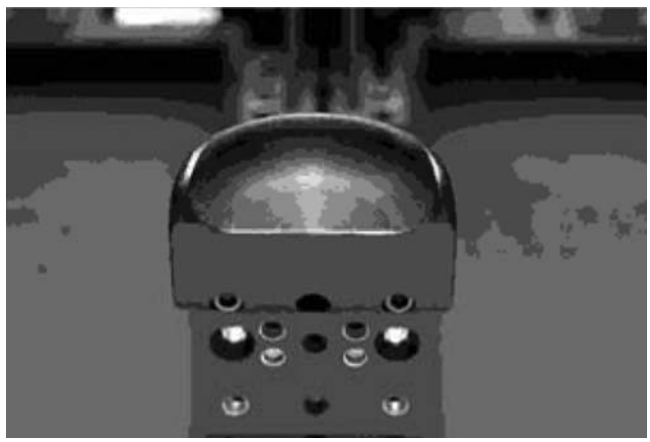

FIG. 2 Chin Rest

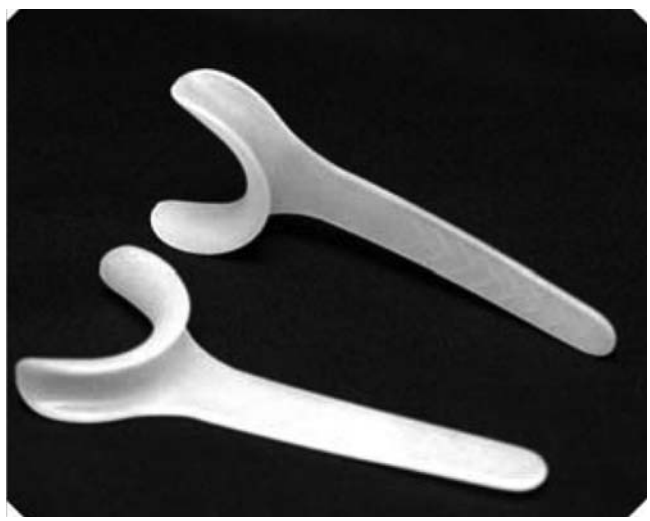

FIG. 3 Picture of Matte Lip Retractor

7.3.3 *Polarizer*—The linear polarizer provides and controls the polarization state of the incident light. This polarizer on the illuminators plus a cross polarizing filter on the lens system of the DSC eliminates glare caused by reflection of the subject's gingiva tissue during imaging. Wavelength range: reflection

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