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Standard Practice for Specifying Color by the Natural Colour System (NCS)¹

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1. Scope

1.1 The Natural Colour System (NCS) (see 1.7) provides a color notation system that can be used to communicate color. This practice introduces the Natural Colour System, its terminology, and conversion to and from CIE tristimulus values.

1.2 The system described in this standard includes color percepts that appear to belong to the surface of a material, provided the surface is not perceived to be fluorescent or to exhibit directional color effects.

1.3 The system does not include colors that appear to belong to translucent or luminescent objects (so-called volume colors and luminous colors), nor does it include other visual properties of the surface layer, such as gloss and texture. An NCS notation does not describe the physical or chemical properties of an object.

1.4 This practice also specifies the conditions for visual or instrumental determination of the NCS notation of a color sample, defines the relationships between psychometrically determined NCS notations and the corresponding CIE color coordinates which are to be used in this context.

1.5 For the accuracy requirements associated with NCS standards and NCS color samples, the user is referred to Swedish Standard SS 19104. The colored illustrations in this standard shall not be used as standard color samples in any way. Color illustrations that are shown on screen or in printouts may be significantly different than the original NCS color samples with the same NCS Notation due to limited color reproduction capabilities in screens and printers.

1.6 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.7 *Acknowledgement—NCS, Natural Colour System is a trademark of the NCS Colour AB Stockholm, Sweden and is protected by copyright (www.ncscolour.com). All rights re-*

served. Original NCS color samples are only available from NCS Colour AB or any authorized NCS distributor. Commercial use of the NCS System requires a license from NCS Colour AB.

1.8 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.9 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*²

E284 Terminology of Appearance

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

E1164 Practice for Obtaining Spectrometric Data for Object-Color Evaluation

2.2 *Swedish Standards:*³

SS 19100 Colour Notation system

SS 19102 NCS Colour Atlas

SS 19104 NCS colour samples — Observation and measurement conditions and tolerances

2.3 *Other Documents:*⁴

CIE No. 15 Colorimetry

2.4 *ASTM Adjuncts:*

Spreadsheet for NCS Notations and CIE Coordinates⁵

¹ This practice is under the jurisdiction of ASTM Committee E12 on Color and Appearance and is the direct responsibility of Subcommittee E12.07 on Color Order Systems.

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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.

³ Available from Swedish Institute for Standards, Box 45443, SE-104 31 Stockholm, Sweden, www.sis.se.

⁴ Available from U.S. National Committee of the CIE (International Commission on Illumination) or CIE Webshop <http://www.techstreet.com/cie>.

⁵ Available from ASTM International Headquarters. Order Adjunct No. ADJE2970S-EA. Original adjunct produced in 2014.

3. Terminology

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

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *elementary color, n*—one of the six color percepts each of which can be described only by reference to itself.

3.2.1.1 *Discussion*—The elementary colors, which are designated with uppercase letters, are as follows: white (W), black (S), yellow (Y), red (R), blue (B), green (G). All other colors can be described in terms of their resemblance to these six. White and black are achromatic elementary colors. Yellow, red, blue and green are chromatic elementary colors.

3.2.2 *elementary attribute, n*—the degree of resemblance of a color to an elementary color.

3.2.2.1 *Discussion*—The elementary attributes, which are designated by italic lowercase letters, are: *whiteness* (*w*), *blackness* (*s*), *yellowness* (*y*), *redness* (*r*), *blueness* (*b*), and *greenness* (*g*). *Whiteness* and *blackness* are achromatic elementary attributes. *Yellowness*, *redness*, *blueness* and *greenness* are chromatic elementary attributes. All are perceptual quantities, which are expressed by a number between 0 and 100. For any arbitrary color the following apply:

(a) the color cannot simultaneously possess *yellowness* and *blueness*,

(b) the color cannot simultaneously possess *redness* and *greenness*,

(c) the sum of its elementary attributes is 100.

It follows that a color can have at most four elementary attributes in one of the following combinations:

$$w + s + c_1 + c_2 = 100 \quad (1)$$

where c_1 and c_2 are adjoining elementary chromatic colors, such as *y* and *r*, *r* and *b*, *b* and *g*, or *g* and *y*.

3.2.3 *full chromatic color, n*—a color that lacks the elementary attributes of whiteness and blackness.

3.2.3.1 *Discussion*—A full chromatic color, regardless of hue, is designated by an uppercase letter, *C*. The four chromatic elementary colors Y, R, B and G are also full chromatic colors.

3.2.4 *NCS chromaticness, n*—the degree of resemblance of a color to the full chromatic color of the same hue.

3.2.4.1 *Discussion*—NCS chromaticness is a perceptual quantity derived from the chromatic elementary attributes. The NCS chromaticness is expressed by a number between 0 and 100 for the sum of the (at most two) chromatic elementary attributes, and it is designated by an italic lowercase *c*. It follows that:

$$c = c_1 + c_2 \quad (2)$$

where c_1 and c_2 are adjoining elementary chromatic colors, such as *y* and *r*, *r* and *b*, *b* and *g*, or *g* and *y*.

Eq 1 and Eq 2 can then be written:

$$w + s + c = 100 \quad (3)$$

For achromatic (pure gray) colors including the elementary colors white and black, $c = 0$ and $w + s = 100$. For maximal colors, $w + s = 0$ and $c = 100$.

3.2.5 *NCS hue, n*—the relation between the (at most two) chromatic elementary attributes of a color, regardless of the whiteness and blackness of the color.

3.2.5.1 *Discussion*—The NCS hue is a perceptual quantity derived from the chromatic elementary attributes. The NCS hue is expressed by a number between 0 and 100 as the proportion of one chromatic elementary attribute in the sum of the (at most two) chromatic elementary attributes, that is, the NCS chromaticness. The “one” always refers to the chromatic elementary attribute which is placed last in Eq 2. In formulae (but not in NCS notations), the hue is denoted by the symbol Φ together with a suffix. The suffix consists of the italic lowercase letters for the pair of chromatic elementary attributes in question, that is, *yr*, *rb*, *bg*, or *gy*. It follows that:

$$\Phi_{yr} = 100 \ r / (y + r) = 100 \ r / c \quad (4)$$

$$\Phi_{rb} = 100 \ b / (r + b) = 100 \ b / c \quad (5)$$

$$\Phi_{bg} = 100 \ g / (b + g) = 100 \ g / c \quad (6)$$

$$\Phi_{gy} = 100 \ y / (g + y) = 100 \ y / c \quad (7)$$

Eq 4-7 can also be used in reverse to calculate the chromatic elementary properties when the NCS chromaticness and NCS hue are known.

3.2.6 *NCS nuance, n*—the composition of whiteness, blackness and chromaticness in a color, regardless of the hue.

3.2.6.1 *Discussion*—The NCS nuance is expressed by a pair of numbers which represent the blackness and chromaticness of the color. The whiteness is excluded, since it is given by Eq 3. The NCS nuance is a perceptual quantity derived from the elementary attributes. It has an unambiguous NCS notation through the first four figures in the alpha-numerical basic code.

3.2.7 *NCS saturation, n*—the relation between the chromaticness of a color and its whiteness, regardless of the hue.

3.2.7.1 *Discussion*—NCS saturation is a perceptual quantity derived from the elementary attributes. The NCS saturation is expressed by a number between 0 and 1 for the ratio of the chromaticness (*c*) of the color to the sum of its whiteness (*w*) and chromaticness (*c*). The NCS saturation is designated by an italic lowercase *m*. It follows that:

$$m = c / (w + c) \quad (8)$$

where $w + c$ is equal to 100 - *s*.

3.2.8 *NCS lightness, n*—a characteristic of a color such that it appears to have more of the elementary color black or white than another color.

3.2.8.1 *Discussion*—NCS lightness is a perceptual quantity, designated by a lowercase *v*, the value of which varies between zero (0) for the elementary color black (S) and one (1) for the elementary color white (W). For achromatic (pure gray) colors including the elementary colors white (W) and black (S), for which $c = 0$, *v* is defined as:

$$v = (100 - s) / 100 \quad (9)$$

The NCS lightness of any arbitrary color specimen is determined by comparison edge-to-edge with a reference scale of achromatic color samples ($c = 0$). The color specimen is assigned the same lightness value as that of the reference sample for which the border between specimen and reference is perceived to be least distinct.

3.2.9 *luminance factor, Y, n*—ratio of the luminance of a specimen to that of a perfect diffuser, when illuminated and viewed under specified geometric conditions.