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.

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

This standard is issued under the fixed designation E2970; 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.

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 reserved. Original NCS color samples are only available form 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 Coordinates[5]

[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.

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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.

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3.2.9.1 *Discussion*—In the CIE 1931 system, this quantity is tristimulus value *Y*.

4. Summary of Practice

4.1 *Visual Method*—Observers should have normal color vision. Specimens should be viewed on an essentially nonselective gray background of approximately 56 % luminance factor with natural or artificial daylight of approximately 1000 lux. The test specimen should be compared edge-to-edge to the colors in the NCS Original Collection (for example, in SS 019102 NCS Colour Atlas). The size of the specimen should be at least 40 mm by 50 mm with an immediate white surround of 85 % luminance factor. The specimen and color chip should be perpendicular to the observer with the illumination at an angle of approximately 45°.

4.2 *Instrumental Method*—CIE 1931 tristimulus values for standard illuminant D65 and the CIE 1931 standard colorimetric observer are obtained from spectrophotometric or colorimetric measurement. See Practices E308 and E1164. Computation of NCS notation values can be achieved by following the directions in Annex A1 and using the tables in the adjunct.[5]

5. Significance and Use

5.1 The Natural Colour System is a color notation system that builds on how a human being sees color. An NCS notation represents a specific color percept and describes the color as perceived; it is not dependent on limitations caused by pigments, light rays or nerve signals that have given rise to this perception. The NCS system is used internationally in such fields as architecture, corporate identity, cosmetics, education, fashion and textile forecasting and production, interior design and product design. The Natural Colour System describes colors exactly as they are seen. Any of the millions of colors that exist can be defined within the NCS system and given a precise notation. When the NCS system is known, it is possible to judge the attributes of a color by its NCS notation; for example, how much blackness, how much chromaticness, and what hue? This helps to communicate and check specifications and to identify colors. Some examples of the use of NCS are: (*1*) Architects and designers use the NCS color samples to select colors for all kind of products and materials; (*2*) They also use the NCS notation to analyze the colors in use in a particular area and to document their specifications; (*3*) Companies use the NCS color samples as the production standards for their products; (*4*) Paint manufacturers and other industries use the NCS notation and the NCS color samples to visualize the color of their products to customers, and (*5*) Companies use the NCS samples as high quality color standards in corporate identity programs and manuals.

6. Specifying Color with a NCS Notation

6.1 *NCS Notation*—An NCS notation consists of an alpha-numerical code, the letters and figures of which describe the appearance of the designated color.

6.1.1 *The Alpha-numerical Code*—The alpha-numerical basic code for an NCS notation has nine characters, which in turn indicate the blackness and NCS chromaticness, each with two figures (00–99), and thereafter the NCS hue by a hyphen followed by two capitals enclosing two figures (00–99). The capitals show the relevant chromatic elementary colors. See Fig. 1. In practice a variation of this basic code with different or fewer characters is often used.

6.1.2 A chromatic color with c < 100 and with two chromatic elementary attributes is designated by the basic code. Example: 5535-R20B designates a color with a blackness of 55, a chromaticness of 35, and a hue of (80 %) red and 20 % blue. The parentheses are added here to mark that this figure is not shown in the notation.

6.1.3 A chromatic color with c < 100 and with only one chromatic elementary attribute is designated by a code which lacks the last three figures of the basic code. Example: 5535-R.

6.1.4 An achromatic (pure gray) color, but not one of the elementary colors white and black is, however, designated by a code with a capital N instead of the last four figures of the basic code. The capital N means "neutral." Two examples: 2500-N and 7000-N.

6.1.5 A full chromatic color, but not one of the elementary colors yellow, red, blue or green is, however, designated by a code with the capital C instead of the four first characters of the basic code. Example: C-R80B.

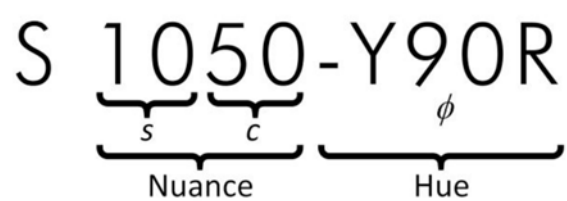
6.1.6 The six elementary colors are designated by the capitals W, S, Y, R, B and G. See Fig. 2.

6.2 *NCS Color Triangle*—An NCS color triangle is an equilateral triangle within which each point unambiguously represents a color with a certain NCS nuance, regardless of the hue of the color. See Fig. 3.

6.2.1 The three perpendicular distances from the sides of the triangle to an arbitrary point within the triangle are designated *w, s* and *c* and the height of the triangle is set equal to 100, see Fig. 3. According to the geometry of equilateral triangles, it follows that:

$$w + s + c = 100 \tag{10}$$

that is, the same as Eq 3.
This means that a given point in the color triangle unambiguously represents all colors with a certain composition of whiteness (w), blackness (s) and NCS chromaticness (c), that is, all colors with the same NCS nuance. To determine the location of the point and thereby the NCS nuance, it is sufficient to indicate the numerical values of *s* and *c*, since the sum of *w, s* and *c* is always 100.



For example in the NCS notation 1050-Y90R, 1050 describes the nuance, that is, the degree of resemblance to whiteness (40 %) and blackness which is 10 % and to the maximum chromaticness which is 50 %. The whiteness is not shown but is the remaining 40 % (100-10-50=40). The hue Y90R describes the degree of resemblance between Yellow and Red (Y and R). Y90R describes a red color with (10 %) yellowness. In the NCS notation this is written as yellow with 90 % redness. The letter S preceding the complete NCS notation (S 1050-Y90R) denotes an NCS notation that is available as standardized physical color samples in SS 19102 NCS Colour Atlas.

FIG. 1 NCS Notation

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