

Evaluation Procedure for Instrumental Assessment of the Change in Color of a Test Specimen

Foreword

This Evaluation Procedure was developed in 1995 by AATCC Committee RA36. Adopted as ISO 105-A05 in 1996. The metric used in this method was developed in ISO TC38 SC1 WG-7.

1. Scope

1.1 This evaluation procedure is intended as an alternative to the visual method of AATCC EP1. It is applicable to any test method referring to gray scales except those which involve treatment with solutions containing fluorescent whitening agents (FWA).

2. Principle

2.1 The color of the specimen which has been submitted to the colorfastness test and the color of an identical untreated specimen are measured instrumentally. The CIELAB coordinates for lightness L^* , chroma C^*_{ab} , and hue h_{ab} are determined for both specimens as defined in CIE 015:2018 (see 4.4). The CIELAB differences L^* , C^*_{ab} , and H^*_{ab} are calculated and converted to a gray scale grade by means of a series of equations.

3. Referenced Documents

3.1 NOTE: Use current versions of all publications unless otherwise specified.

3.1.1 AATCC *Manual of International Test Methods and Procedures*, American Association of Textile Chemists and Colorists, AATCC EP1. Available from AATCC, P.O. Box 12215, Research Triangle Park NC 27709; tel: +1.919.549.8141; fax: +1.919.549.8933; e-mail: ordering@aatcc.org; web site: www.aatcc.org.

3.1.2 Jaeckel, S. M., The Variability of Grey-Scale Assessment and its Contribution to the Variability of a Test Method, *Journal of the Society of Dyers and Colourist*, Vol. 96, 1980, pp540-544.

3.1.3 CIE Publication 15:2018 Colorimetry, 4th Edition. Available through the US National Committee of the CIE or via the CIE web shop (www.techstreet.com/cie/).

4. Terminology

4.1 **color change**, n.—a change in color of any kind whether in lightness, hue or chroma or any combination of

these, discernible by comparing the test specimen with a corresponding untested specimen.

4.2 **gray scale grade**, n.—for color change (GSc), the numerical value that is assigned to the change in color of a test specimen as compared to an original or untreated specimen. This shall be reported as a half step number between 1 and 5 (i.e., 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5).

5. Safety Precautions

5.1 Users must consult color measuring equipment manufacturers for specific details such as equipment operating instructions and other recommendations.

6. Apparatus

6.1 Spectrophotometer or colorimeter meeting any one of the geometric definitions described in CIE publication 15-2018, subclause 6.4.

7. Test and Reference Specimens

7.1 Choose a representative sample of material, which has been subjected to a colorfastness test, of adequate size to fit the sample holder of the instrument used. Back this specimen with enough thicknesses of the original material to make the specimen opaque. (Opacity, or at least consistency, is required for accurate measurement.) Backing a single layer of the material with a white material that contains no FWAs is a permitted alternative provided both the reference specimen (original material) and test specimen are backed in an identical manner.

7.2 Form a layer of the reference specimen (original material) consisting of the same number of thicknesses as that prepared in 7.1.

8. Procedure

8.1 Measure the color of the reference specimen and calculate the CIELAB L^* , C^*_{ab} , and h_{ab} values using the data for the 10° observer and for illuminant D₆₅ (see 11.1).

8.2 Measure the color of the test specimen which has been subjected to the colorfastness test and make the same colorimetric calculations as done for the reference specimen. Then make the calculations as described below in Section 9.

9. Calculations

9.1 Symbols

9.1.1 The subscript 'ab' indicates association with the CIELAB color-difference equation.

9.1.2 The subscript 'M' is used to represent a function of the mean of the test and reference specimen.

9.1.3 The subscript 'K' is used to represent chroma corrected hue functions.

9.1.4 The subscript 'F' is used to represent the special gray scale color difference (ΔE) from others in normal use.

9.1.5 The subscript 'T' is for the test specimen.

9.1.6 The subscript 'R' is for the reference specimen.

9.1.7 The 'Round' function, Round(x,n) used below, rounds the value of x to the specified number of decimal places n, i.e., 3 in the usages below.

9.1.8 All hue angles are in degrees and not radians.

9.2 Calculate ΔE_F using the following pseudo code:

If Abs($h_{ab,T} - h_{ab,R}$) ≤ 180 then
 $h_M = (h_{ab,T} + h_{ab,R})/2$

else

If Abs($h_{ab,T} + h_{ab,R}$) < 360 then
 $h_M = (h_{ab,T} + h_{ab,R})/2 + 180$

else

$h_M = (h_{ab,T} + h_{ab,R})/2 - 180$
 endif

endif

if Abs($h_M - 280$) ≤ 180 then
 $x = [(h_M - 280)/30]^2$

else

$x = [(360 - \text{Abs}(h_M - 280))/30]^2$
 endif

$\Delta L^* = L^*_{ab,T} - L^*_{ab,R}$

$\Delta C^*_{ab} = C^*_{ab,T} - C^*_{ab,R}$

$C_M = (C^*_{ab,T} + C^*_{ab,R})/2$

$D = (\Delta C^*_{ab} \cdot C_M \cdot e^{-x})/100$

$\Delta E^*_{ab} = [(\Delta L^*)^2 + (\Delta C^*_{ab})^2 + (\Delta b^*)^2]^{1/2}$

$\Delta H^*_{ab} = [(\Delta E^*_{ab})^2 - (\Delta L^*)^2 - (\Delta C^*_{ab})^2]^{1/2}$

If ($h_{ab,T} - h_{ab,R}$) < 0 then

$\Delta H^*_{ab} = (-1) \cdot \Delta H^*_{ab}$

$\Delta C_K = \Delta C^*_{ab} - D$

$\Delta H_K = \Delta H^*_{ab} - D$

$\Delta C_F = \Delta C_K / [1 + (20 \cdot C_M/1000)^2]$

$\Delta H_F = \Delta H_K / [1 + (10 \cdot C_M/1000)^2]$

$\Delta E_F = [(\Delta L^*)^2 + (\Delta C_F)^2 + (\Delta H_F)^2]^{1/2}$

$\Delta E_F = \text{Round}(\Delta E_F, 3)$

9.3 Calculate the gray scale grade for color change (GSc) according to the following function:

```
if  $\Delta E_F \leq 3.400$  then
  GSc =  $5 - \Delta E_F / 1.7$ 
else
  if  $\Delta E_F \leq 13.600$  then
    GSc =  $5 - \text{Log}_{10} (\Delta E_F / 0.85) / \text{Log}_{10} (2)$ 
  else
    GSc = 1
  endif
endif
```

At this point, the GSc is a decimal number between 1 and 5.

10.4 To produce half-step grades (i.e., 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5), perform

the following function:

```
GSc = Round (GSc,3)
GSc = [Int (2 · GSc + 0.5)]/2
```

10. Report

Report at least the following information:

10.1 The gray scale grade(s) [GSc value(s)] for change in color of the specimen(s); follow the directions and report as directed in the appropriate test method.

10.2 The number and date of this procedure, i.e., AATCC EP7-2021.

10.3 All details necessary for the identification of the sample(s) tested.

10.4 CIE geometry type that was used.

10.5 Identification of the spectrophotometer or colorimeter used.

10.6 Whether illuminant D65 or illuminant C was used.

10.7 Whether the 1964 10° or the 1931 2° observer was used.

11. Notes

11.1 NOTE: Permitted alternative is D65/2°.

12. History

12.1 Revised in 2021 to remove table option and restructure calculations for clarity.

12.2 Revised in 2015, 1998. Editorially revised in 2019. Reaffirmed 2009, 2003, 1996.

12.3 Adopted as ISO 105-A05 in 1996.

12.4 Developed in 1995 by AATCC Committee RA36.