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CMC: Calculation of Small Color Differences for Acceptability

Developed by AATCC Committee RA36 in 1989; reaffirmed 1990; editorially revised and reaffirmed 1991, 2005, 2015; revised 1992, 1998, 2009; editorially revised 2006. Partly related to ISO 105-J03.

1. Purpose and Scope

1.1 The CMC ($\ell:c$) formula is a modification of the corresponding CIELAB color-difference formula. It has color-difference symbol ΔE_{cmc} . Even though use of the CIE 1976 $L^*a^*b^*$ (CIELAB) equation provides industry with a 'standard' means of calculating and communicating color differences of trials from their standards (see 8.1), it is recognized that CIELAB color-difference values (ΔE^*) correlate poorly with visual assessments. The lack of correlation is caused by the non-uniformity of CIELAB color space (see Fig. 1). Significantly improved correlation between visual assessments and instrumentally measured color differences is given by the CMC ($\ell:c$) color-difference formula (see 7.1 to 7.3). The improvement in correlation between visual and instrumental color-difference reports yielded by the CMC ($\ell:c$) equation will usually permit the adoption of a single-number tolerance for judging the ac-

ceptability of a color match in most situations, regardless of both the color of the standard and the direction of the color difference of any trial from it. Another equation, CIE94 has been considered, but it has not shown any significant improvement over CMC (see 8.2).

1.2 The CMC ($\ell:c$) formula retains, in modified form, the partitioning of overall color difference into differences in lightness, chroma, and hue components (see Fig. 2) which is present in the CIELAB color-difference formula. Using the ellipsoidal semi-axes (ℓS_L , cS_C , and S_H) makes the CMC ($\ell:c$) equation suitable for a wide range of uses.

2. Principle

2.1 The CMC ($\ell:c$) modification to CIELAB provides a unit of measurement for the acceptance volume about a standard color. This volume takes the shape of an ellipsoid whose semi-axes are ℓS_L , cS_C , and S_H in the directions of lightness, chroma, and hue differences, respectively, in CIELAB color space. The CMC ($\ell:c$) formula varies the ratio of the lengths of these three semi-axes systematically throughout CIELAB color space according to equality of lengths with visually equal color differences, regardless of both the color of the standard and direc-

tion of difference of any trial from it. Around any given standard color, the ratio $S_L:S_C:S_H$ is fixed regardless of the end use of the trials.

3. Terminology

3.1 **CIE 1976 $L^*a^*b^*$ equation**, n.—a commonly used equation which transforms CIE tristimulus values into a three-dimensional opposed color space. Generally abbreviated as CIELAB (see 8.1).

3.2 **CMC unit**, n.—in color difference evaluation, a measure of acceptability expressed in terms of the boundary for the CMC acceptability ellipsoid of $\Delta E_{cmc} = 1.0$.

3.2.1 CMC is an acronym for the Colour Measurement Committee of The Society of Dyers and Colourists which was largely responsible for the development of the CMC ($\ell:c$) equation.

3.3 **commercial factor (cf)**, n.—in color difference evaluation, a tolerance (specified in terms of ΔE_{cmc} units) which adjusts all axes of the unit CMC volume equally to create a volume of acceptance for commercial use.

3.4 ΔE_{cmc} , n.—in color difference evaluation, a single number defining the total color difference in CMC units of a trial from a standard.

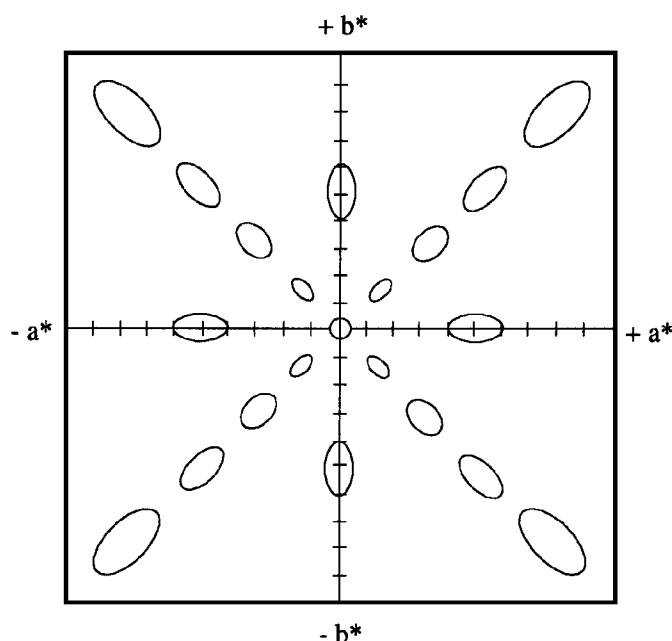


Fig. 1—CMC($\ell:1$) Unit ellipsoid cross sections in CIELAB a^*b^* diagram.

If CIELAB were uniform, these sections would be equal-sized circles.

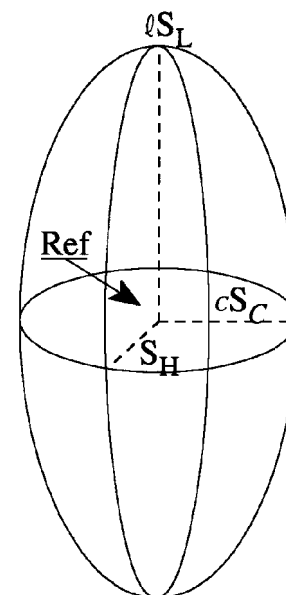


Fig. 2—Unit volume of acceptance.

Distance from standard to surface is one CMC($\ell:c$) unit.