

OPAQUE OR TRANSPARENT COLOURED PRODUCTS CALCULATIONS OF COLORIMETRIC VARIATIONS (CIE LAB 1976 SYSTEM)

Page 1/8

NO USE RESTRICTION

*This is a translation, the French original shall be used in all cases of litigation**Date of translation : 26/07/2004*

FOREWORD

*This document is in technical conformity with RENAULT test method D15 5084.**It must not be modified without prior consultation with RENAULT.**It is in conformity with the agreement reached between the Normalisation Departments of PEUGEOT S.A. and RENAULT in APRIL 1994.*

1.OBJECT AND FIELD OF APPLICATION

The object of this method is to determine by calculation from trichromatic components X, Y, Z in the CIE system (see test method D15 5083), colorimetric variations in the CIE LAB 1976 system, $L^*a^*b^*$ (see appendix 1), which exist between two opaque or transparent coloured products (excluding luminescent materials).

Surface appearance parameters interact on the colour and are included in the colour point measurements (gloss, tension, graining of plastic parts, scratching of textiles, crushed velvet, ...).

This method is drawn from the standard AFNOR NF X 08-014.

2.PRINCIPLE

The determination of colorimetric variations is carried out by calculations. Trichromatic components X, Y, Z under the illuminant and for the observer selected, are transformed into colorimetric co-ordinates $L^*a^*b^*$ (see appendix 1) which relate directly to the CIE LAB 1976 uniform space.

Note : *Trichromatic components X, Y, Z may also relate to the CIE LCH system (see appendix 2).*

In order to be representative, colorimetric variations must be related to a uniform colorimetric space, in the mathematical sense of the term, that is to say to a system of colour representation in which differences perceived by the eye between two relatively close colours, in specified conditions of observation are proportional to the distance between two corresponding colour points regardless of the determined chromatic space area.

3.CALCULATIONS OF VARIATIONS

To calculate the difference between two colours, in the following relationships, index "c" is used to identify the test specimen and index "e" to identify the standard.

3.1.CO-ORDINATES VARIATIONS

3.1.1.LUMINANCE VARIATION

The luminance variation ΔL^* , is determined by the relationship :

$$\Delta L^* = L_c^* - L_e^*$$

in which :
 L_c^* = luminance of the test specimen,
 L_e^* = luminance of the standard.

Note :

If $\Delta L^ > 0$, the test specimen is lighter.*

If $\Delta L^ < 0$, the test specimen is darker.*

3.1.2.COLOUR VARIATIONS

Colour variations Δa^* et Δb^* , are determined by the following relationships :

$$\Delta a^* = a_c^* - a_e^*$$

in which :
 a_c^* = colorimetric parameter of the test specimen, according to the green-red axis,
 a_e^* = colorimetric parameter of the standard, according to the green-red axis.

Note :

If $\Delta a^ > 0$, the test specimen is redder,*

If $\Delta a^ < 0$, the test specimen is greener.*

$$\text{and } \Delta b^* = b_c^* - b_e^*$$

in which :
 b_c^* = colorimetric parameter of the test specimen, according to the blue-yellow axis,
 b_e^* = colorimetric parameter of the standard, according to the blue-yellow axis.

Note :

If $\Delta b^ > 0$, the test specimen is yellower,*

If $\Delta b^ < 0$, the test specimen is bluer*

3.2.OVERALL COLORIMETRIC VARIATION

The overall colorimetric variation ΔE^* , is determined by the following relationship :

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

in which :
 ΔL^* = luminance variation,
 Δa^* = colour variation, according to the green-red axis,
 Δb^* = colour variation, according to the blue-yellow axis.

3.3.CHROMA VARIATION

The chroma variation ΔC^* , is determined by the following relationships :

$$\Delta C^* = C_c^* - C_e^* \\ = [(a_c^*)^2 + (b_c^*)^2]^{1/2} - [(a_e^*)^2 + (b_e^*)^2]^{1/2}$$

in which :

C_c^* = test specimen chroma,

C_e^* = standard chroma,

a_c^* = colorimetric parameter of the test specimen, according to the green-red axis,

b_c^* = colorimetric parameter of the test specimen, according to the blue-yellow axis,

a_e^* = colorimetric parameter of the test specimen, according to the green-red axis,

b_e^* = colorimetric parameter of the test specimen, according to the blue-yellow axis.

3.4.TONE VARIATION

The tone variation ΔH^* , is determined by the following relationship :

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

in which :

ΔE^* = overall colorimetric variation,

ΔL^* = luminance variation,

ΔC^* = chroma variation.

The relationship for ΔH^* gives only an absolute value.

The sign ΔH^* is positive if $(a_c^* \cdot b_e^*) - (a_e^* \cdot b_c^*) \leq 0$,

and negative if $(a_c^* \cdot b_e^*) - (a_e^* \cdot b_c^*) > 0$.

See examples of calculations in appendices 3 and 4.

4.EXPRESSION OF RESULTS

In general, the results must be expressed :

- in ΔL^* , Δa^* , Δb^* when the values of a_e^* and/or b_e^* are below 10,
- in ΔL^* , ΔC^* , ΔH^* when the values of a_e^* and/or b_e^* are above 10.

In addition, the results may be expressed in overall colorimetric variation ΔE^* .

5.TEST REPORT

As well as the results obtained, the test report must mention :

- the reference to this method,
- the reference of the method used to determine the X, Y, Z components,
- the complete references of the standard,
- the complete references of the test specimen,
- the operating details not specified in the method as well as any possible incidents likely to have affected the results.

Appendix 1

EXPRESSION OF COLOUR - CIE LAB SYSTEM 1976 OR CIE 1976 ($L^*a^*b^*$)

$$L^* = 116 Y^* - 16$$

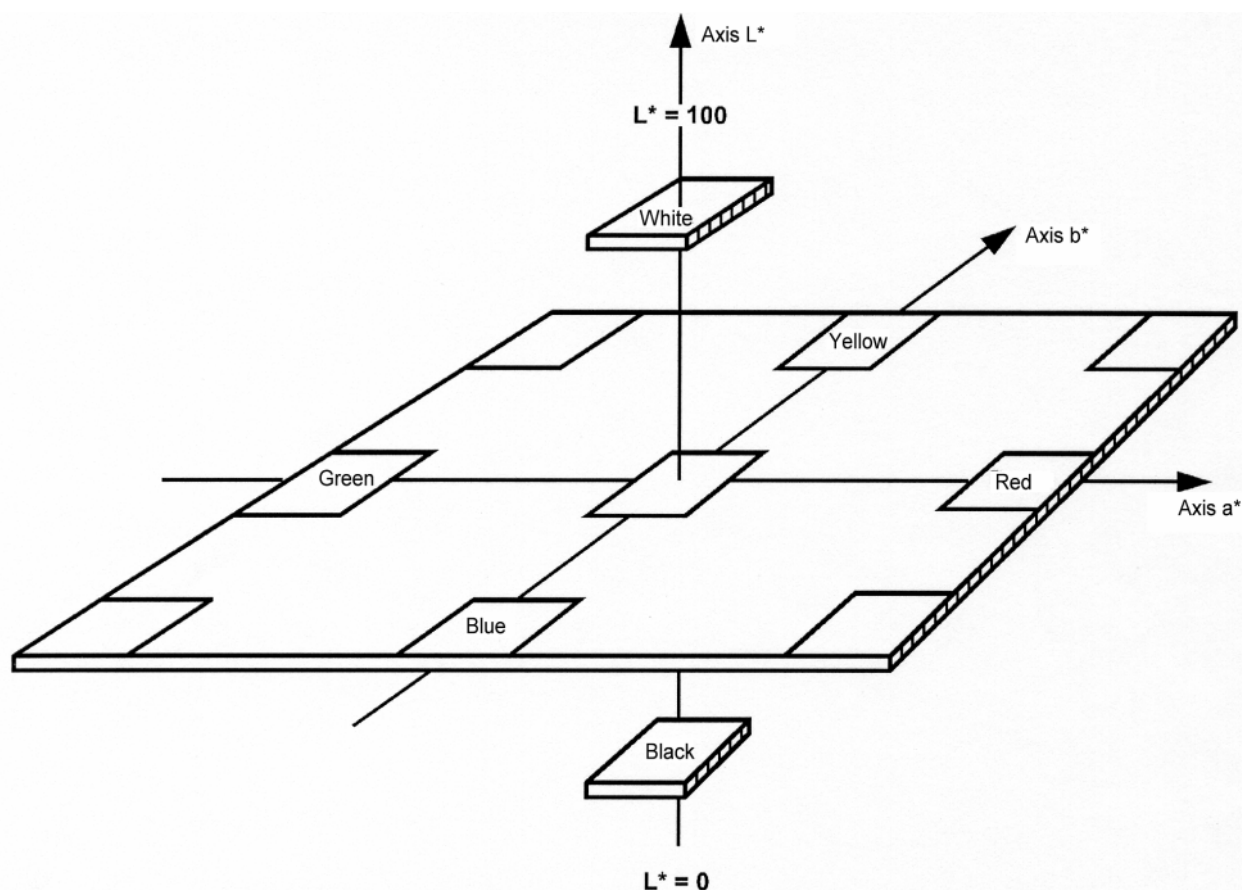
$$a^* = 500 (X^* - Y^*)$$

$$b^* = 200 (Y^* - Z^*)$$

$$\text{where } X^* = (X/X_n)^{1/3} \quad \text{for } X/X_n > 0,008856$$

$$X^* = 7,787 (X/X_n) + 0,138 \quad \text{for } X/X_n \leq 0,008856$$

Calculation of Y^* and Z^* similar to X^*



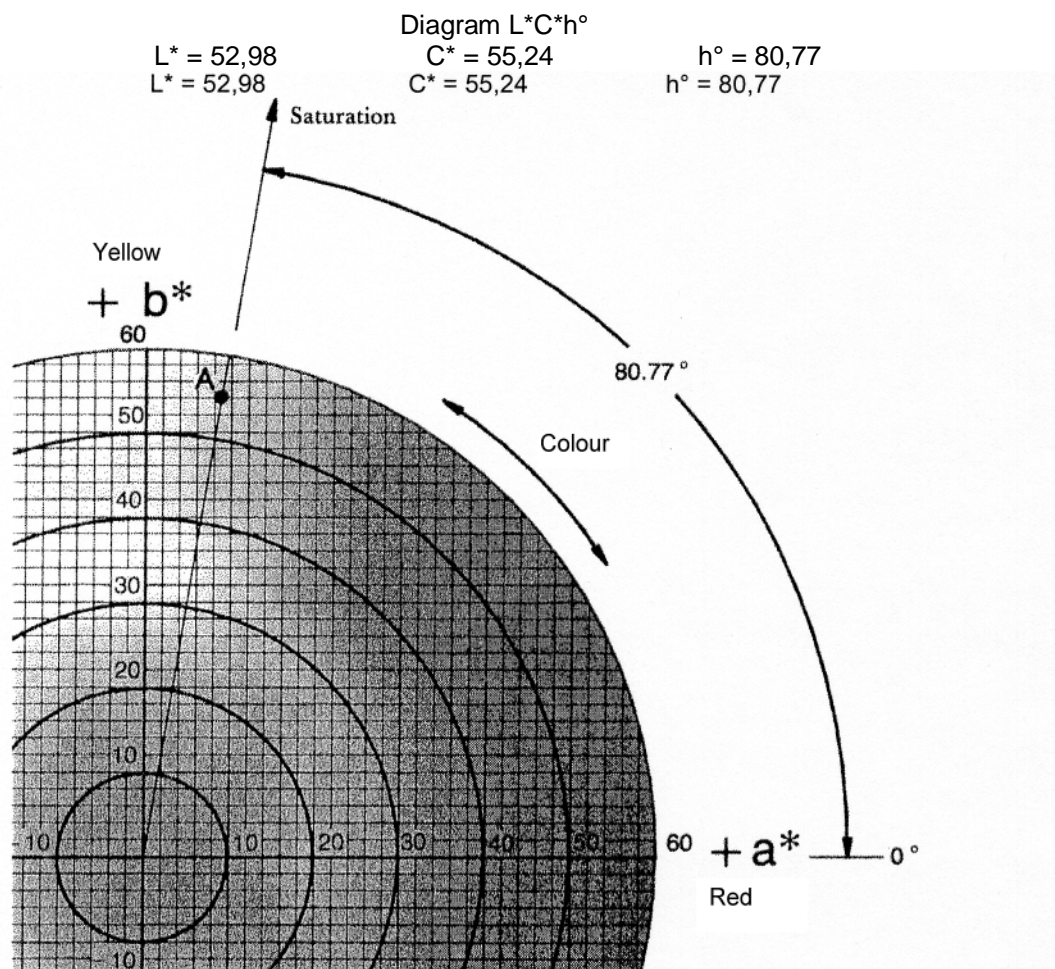
X_n , Y_n , Z_n are standard values for the colour of a perfectly white matt surface for the type of illuminant and observer to which relate the values of the trichromatic components X , Y and Z .

Appendix 2

EXPRESSION OF COLOUR - CIE LCH SYSTEM ($L^*C^*h^\circ$)

This expression of colour is derived from the CIE LAB system. L^* defines the brightness, C^* specifies chroma (saturation) and h° indicates the colour angle (between 0 and 360 degrees).

The expression $L^*C^*h^\circ$ offers the advantage over the CIE LAB system due to the fact that it is very easy to refer to systems which are still used and based on physical examples, like the Munsell colour scale.



$$L^* = 116 (Y / Y_n)^{1/3} - 16$$

$$C_{ab}^* = (a^{*2} + b^{*2})^{1/2}$$

$$h_{ab}^\circ = \arctan (b^* / a^*)$$

CALCULATIONS OF COLORIMETRIC VARIATIONS	D15 5084	6/8
--	-----------------	-----

Appendix 3

DETERMINATION OF L^* , a^* , b^*

Between trichromatic components X, Y, Z and co-ordinates L^* , a^* , b^* on which rests this determination, there are the following relationships :

- $L^* = 116 Y^* - 16$ for $Y/Y_n > 0,008856$
- $L^* = 903,3 (Y/Y_n)$ for $Y/Y_n \leq 0,008856$
- $a^* = 500 (X^* - Y^*)$
- $b^* = 200 (Y^* - Z^*)$

in which :

- $X^* = (X/X_n)^{1/3}$ for $X/X_n > 0,008856$
 $X^* = 7,787 (X/X_n) + 16/116$ for $X/X_n \leq 0,008856$
- $Y^* = (Y/Y_n)^{1/3}$ for $Y/Y_n > 0,008856$
 $Y^* = 7,787 (Y/Y_n) + 16/116$ for $Y/Y_n \leq 0,008856$
- $Z^* = (Z/Z_n)^{1/3}$ for $Z/Z_n > 0,008856$
 $Z^* = 7,787 (Z/Z_n) + 16/116$ for $Z/Z_n \leq 0,008856$

Trichromatic components X_n , Y_n , Z_n are those of the white nominal colour. The white stimulus corresponds to the spectral distribution of energy of a standard CIE illuminant.

Trichromatic components	Observer 10°	
	Illuminant	
	D₆₅	A
X_n	94,81	111,14
Y_n	100,00	100,00
Z_n	107,34	35,20

CALCULATIONS OF COLORIMETRIC VARIATIONS	D15 5084	7/8
--	-----------------	-----

Appendix 4

EXAMPLES OF CALCULATIONS

WITH THE COLOUR DIFFERENCE FORMULAS CIE LAB 1976 AND CIE LCH 1976

The colours defined below are purely theoretical

	Trichromatic components			Colorimetric co-ordinates			Colorimetric variations CIE LAB and CIE LCH formulas	
		Standard	Test specimen		Standard	Test specimen		
WHITE Observer 10° Illuminant D ₆₅	X	79,23	80,17	L*	93,48	93,85	ΔL*	0,37
	Y	84,07	84,94	a*	- 0,95	- 0,70	Δa*	0,25
	Z	90,11	92,36	b*	0,10	- 0,82	Δb*	- 0,92
							ΔE*	1,02
BLUE Observer 10° Illuminant D ₆₅	X	10,59	10,46	L*	41,96	41,32	ΔL*	- 0,64
	Y	12,48	12,07	a*	- 9,03	- 7,32	Δa*	1,71
	Z	14,40	15,43	b*	- 2,46	- 5,93	Δb*	- 3,47
							ΔE*	3,91
RED Observer 10° Illuminant A	X	62,21	62,33	L*	74,03	73,86	ΔL*	- 0,17
	Y	46,74	46,49	a*	24,00	25,00	ΔC*	- 1,50
	Z	0,06	0,09	b*	125,00	123,30	ΔH*	- 1,28
							ΔE*	1,98

6.RECORDS AND REFENCE DOCUMENTS

6.1.RECORDS

6.1.1.CREATION

- OR : 01/03/1981 – CREATION OF THE NORME

6.1.2.SUBJECT OF THE MODIFICATION

- B : 01/04/1994 – COMPLETE REWRITE OF THE NORME WITH FOREWORD ADDED.
- C : 12/06/1997 – INTRODUCED INTO IDEM (*French only*)

6.2.REFERENCE DOCUMENTS

6.2.1.PSA DOCUMENTS

6.2.1.1.Normes

D155083.

6.2.1.2.Others

6.2.2.EXTERNAL DOCUMENTS

NFX08-014(03/1983)

6.3.EQUIVALENT TO :

REND155084

6.4.CONFORMS TO :

6.5.KEY WORDS