NAMING THE COLORS

Color names designation from the colorimetric values
The French GPEM/PV work revisited

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ABSTRACT

This publication describes a method for assigning a color name to an object whose colorimetric characteristics have been measured. This method concerns the French language and was the subject of a recently published book.
The method is the result of an old work published by Afnor, the French standardization organization, work unfortunately obsolete by its colorimetric part. The publication describes the work that has been done for its modernization and to lead to an easy implementation.
The text, by presenting some excerpts from the tables and graphs published in the French book, shows the interest of a simple and rigorous method of naming colors. This is a very important subject for which there are very few publications. This is indeed a subject that should interest a large number of users for whom only numerical information on color cannot be sufficient.

INTRODUCTION

A book describing the designation of color names related to the French language, deduced from their colorimetric values, was recently published [22] : *"Donner leur nom aux couleurs - Dénomination des couleurs évaluées par colorimétrie"* (*LEXITIS éditions, 19 rue Larrey, 75005 Paris*) This publication is related to the work done 40 years ago by a French study group of paint products, named "*Groupement permanent d'étude des marchés de Peintures, Vernis et Produits connexes*" (quoted in the following by its abbreviation GPEM/PV). This group made the decision to study a color-order system with the designation of color names. This work was concluded in 1977 by the informative publication [2] AFNOR X 08-010. Part of this document explains how to get the name of a surface color using the colorimetric practice. Unfortunately this work is partly obsolete and not easy to use. In the year 2015, this Afnor publication X 08-010 was cancelled.

The correspondence between color names and colorimetric values is a difficult problem for which there are only few publications. A few years ago, it seemed to the author that it would be of very great interest to study this matter again. For a wide range of users in the industrial, technical and marketing areas, the names associated to the colors are often confusing and contentious. It therefore seems very important to be able to unambiguously associate a color name with an object whose colorimetric values are known, whereas these colorimetric values alone are not enough to provide significant information about the appearance of this object. This is the goal of this new French publication that has saved the GPEM/PV's work from oblivion, gives it renewed value, and makes it easy to use. It also provides the essential basis for any critical review of the choices made in 1977 to allow for possible changes or improvements, and perhaps adaptations to the vocabulary of current practice, such as project adaptations by various users and associations.

This present publication describes the new book published in French [22,23] following a major updating work carried out from 2013 to 2016, although some of the work was started in 1995 [20] and continued in 2008 [21]. It clearly explains how to get the name of a surface color with the current colorimetric practice. Examples of published tables and graphical charts are also presented.

1 - DATA TRANSFORMATION FOR CIELUV

Basis of the GPEM/PV work

In the Afnor document, surface colors are evaluated by the chromaticity coordinates x and y associated with the tristimulus value Y, computed for the CIE XYZ 1931 system, with reference illuminant C, today obsolete as a reference illuminant.

Thanks to these values, the document introduces quantities in a significant relation with the visual perception characterizing the colors : a tone index T evaluating the hue, a saturation index S evaluating the saturation and Y evaluating the lightness. This method was related to the work of Professor Manfred Richter (Germany), the work behind the German standard [6] DIN 6164 published in 1955, related to the well-known DIN color system [18].

These three indices T, S, Y are defining, by their numerical values, a general method for dividing the color space into blocks that can be designated by a specific color denomination. These color blocks that have been defined by the GPEM/PV are described by a set of 30 diagrams included into the Afnor document. However, these diagrams do not make it possible to clearly or easily identify the boundaries of each block.

The tone index is a number T ranging from 0 to 24 which separates the various hues of the surface colors. This is the basis of an angular division of the chromaticity diagram that uses half-lines radiating from the reference illuminant (Figure 1). The values of this T index have been determined experimentally by M. Richter, so that the perceptive variations of the hue, for colors having the same saturation and the same lightness, are well represented by the variations of this index.

The saturation index S is a positive number which creates an annular division of the chromaticity diagram, to evaluate the saturation [6] of the surface colors, starting from the reference illuminant (index $S = 0$) up to an upper limit, which depends strongly from the hue, of value $S = 7$ approximately for the yellows and approximately reaching the value $S = 16$ for the green monochromatic colors. According to the work of M. Richter, the same index represents for the various shades a perceptive impression of equal saturation and the intervals between two different indices represent an identical perception of saturation variation, whatever the hue or the saturation index.

The x y chromaticity coordinates for various tone index T and for saturation index $S = 5$ are given in an appropriate numerical table of the Afnor document [2].

Comments about the GPEM/PV document

From a certain point of view the colors require to be seen, named and identified by numerical quantities. The work of the GPEM/PV addresses the last two aspects [1, 2]. It lacks the material reality of colors surfaces that have certainly been realized, which are sorely lacking and of which there is no longer any trace. Unfortunately, it has not been possible to know if documents related to the work about document X08-010 of 1977 have been kept by Afnor organization.

Besides, the author is not known to what specific conditions were observed surface colors : light source used, visual illumination, size of samples, observing conditions, number of samples, observation background, age, number, and field of activity of observers, number of observations, nature of judgments, and so on.

The actual observation of the materialized colors has certainly not been made according to the conditions of the 1931 standard colorimetric observer, called 2° observer used for the numerical computations. It can be assumed that the colored objects had an area such that they were observed at an angle greater than 4°. Afnor standard X 08-002 [1] mentions specimens measuring 2 cm x 3 cm and others are measuring 5 cm x 5 cm. It is well known that the use of the 10° colorimetric system, introduced in 1964, called at that time supplementary system, was not frequently considered in industry in 1977.

Transformation of the GPEM/PV system

The task of updating the 1977 document was mainly to transform the numerical data of the 1977 document for the D65 reference illuminant and to develop a simple and well-documented method for finding the name of a given surface color.

The transformation to be performed corresponds to a change by chromatic adaptation. It also appears that the corresponding data of the DIN standard have also been transformed to switch to the D65 illuminant according to a chromatic adaptation method. A 1979 publication [24] mentions a typical von Kries transformation. This method of chromatic adaptation is that described under the name of method Helson, Judd, Warren. It was used in 1963 by the CIE for the determination of the CIE color rendering index [3, 7, 8]. This well-known method, which has the advantage of preserving the lines of constant tone index *T*, has been used for this work.

The evaluation of the saturation index *S* is a second problem. However, in the CIELUV system, the *S* values, for a given set of hue angle and lightness, are proportional [9] to the CIELUV saturation s_{uv}. It is therefore necessary to go from the CIE system *x y* to the CIELUV system whose chromaticity diagrams are projections of each other and keep the straight lines of the dividing lines of the hues. The CIELUV system is therefore the essential system for updating the work of the GPEM/PV.

The results of these transformations are given in table 1 and served as a basis for the new distribution of hues. Then the tone index is no longer useful, it can be replaced by the CIELUV hue angle h_{uv}. The lightness index *Y* can also be replaced by the CIE lightness L^* which depends only on it. The dominant wavelength, a very useful value, ignored in the 1977 work, was determined for each value of hue angle.

The transition to the CIELUV system deduced from the CIE 1964 $X_{10} Y_{10} Z_{10}$ system, related to a wide field of vision, would have been a better choice. But there is no established data transformation method for a reference observer with a 2° field of view, for values relative to a reference observer with 10°,field of view, and attempts made in this sense by the German standardization [6] showed substantial disagreements between the results of the transformation and the visual observations. This transformation is therefore not conceivable.

Description of the transformed GPEM/PV system

As previously said, the correspondence between the color name and the colorimetric measurement of a color is obtained by a division of the three-dimensional color space in contiguous parts such that any part can be characterized by only one color name. These parts of the color space are called in French "domaines chromatiques" (color blocks) and can be compared to the color-name blocks defined by ISCC [15].

In this document we have made the choice, for many reasons, not to translate the names of colors. Firstly the work done by the GPEM/PV is specific to the French language, and a translation might not make sense. It is also difficult to translate some French color name without misunderstanding, for example "violet" and "pourpre".

The color blocks defined by the GPEM/PV and studied in this publication are parts of the color space defined by the CIELUV color system with trirectangular coordinates L^* u^* v^*, or with cylindrical coordinates L^* C^*_{uv} h_{uv}. The color space is divided entirely into contiguous parts :

1 - By radial planes passing through the black-white axis, defined by the hue angles that separate the various hues.

2 - By horizontal planes perpendicular to the black-white axis, defined by the values of CIE lightness L^*, which separate the various lightness.

3 - By conical surfaces with an apex at the origin of the coordinates, defined by the saturation indices *S*, which separate the various saturations.

Each block thus defined is identified by a specific color name, chosen by the GPEM/PV according to a logical method of designation. The division and the designation are in fact two dissociable aspects, the choice of the names can be modified while preserving the limits of the color blocks and vice versa.

The set of color blocks is bounded by the optimal colors limit [21], non-fluorescent colors having the maximum achievable saturation for colors of a given lightness and hue. However, the division of the GPEM/PV does not extend to the part of color space having a saturation index *S* greater than 7 which relates to relatively infrequent surface colors.

The hue angles division of the GPEM/PV creates 7 main color families identified by the color names : violet, bleu, vert, jaune, orangé, rouge, pourpre (fig. 1). The families are themselves divided into a variable number of parts forming a set of 30 color families to which illustrative diagrams correspond. This angular division into 30 families is shown in table 1, conversion of original data with rounded hue angle values. The dominant wavelengths, computed for the D65 reference illuminant, have been determined and are also shown in the same table.

The additional division by the lightness values and saturation index *S* led the GPEM/PV to divide the color space into 536 color blocks, of which 11 for the achromatic colors and 169 for the nearly achromatic colors. The 1977 document contains no indication other than diagrams, fixing the boundaries of color blocks. We innovated by introducing tables, which accurately define the boundaries of all color blocks, but without fixing a central point. It was arbitrarily decided that the colors exactly at the lower limits of each color block (for hue, lightness and saturation) would be included in this color block.

A general index of all the color names used, placed at the end of the book, allows each case to find the diagrams where it is located.

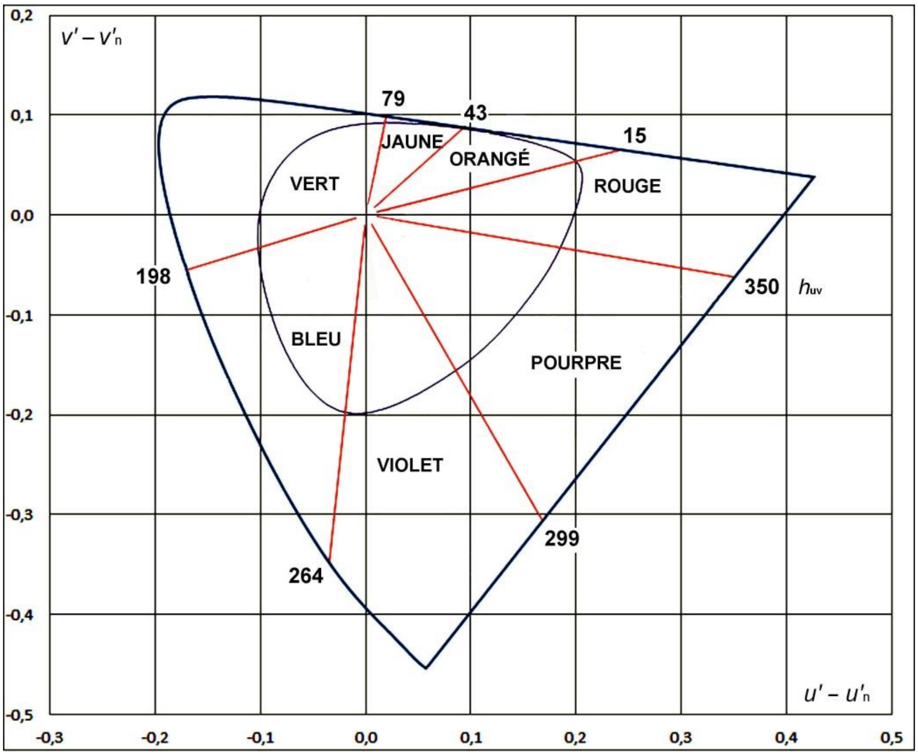

Figure 1 - *CIELUV chromaticity diagram for D65 Illuminant, giving the 7 basic hue families. The hue angle limits by radial lines are given in degrees.*
The saturation division is represented only by the line of saturation index S = 7 which limits the set of color-name blocks, included in the GPEM/PV work.

Determination of color blocks

Conventional colorimetric measurements of a surface color most often provide the three L^* a^* b^* values of the CIELAB system and sometimes the three L^* u^* v^* values of the CIELUV system, systems which have been standardized for years. Here we use the CIELUV system [4] noting that if we have only the CIELAB values [5] we can easily deduce the three tristimulus values X Y Z of the CIE 1931 system which will then allow us to compute the CIELUV values.

Starting from the L^* u^* v^* values of the CIELUV system evaluated with D65 as reference illuminant, the CIELUV hue angle h_{uv} is computed. The saturation index S must also be known to give access to the color block of the surface color concerned. It is important to note that the proportionality factor that links the index S to the CIELUV saturation s_{uv} varies with the hue angle h_{uv}. Consequently, it is not possible to replace the index S by the saturation CIELUV $s_{uv} = C^*_{uv}/L^*$. The proportionality factor between, these quantities has been empirically evaluated by M. Richter and can be computed from the colors of saturation index $S = 5$ published in the Afnor tables. By setting $\sigma = s_{uv} / S$ one obtains $S = (1/\sigma)\, C^*_{uv} / L^*$. This quantity σ, a function of h_{uv}, is the unit of the saturation index.

The computation of the saturation index S should require, for each hue angle, a table of values σ. It is better to use an empirical formula to compute σ knowing the hue angle. An equation is published in the French publication [22] to compute σ when necessary. Some values of σ are given in table 1 for a set of hue angles. When the saturation index S is known, it is easy with the hue angle and the CIE lightness and using tables, or the appropriate diagram, to find the color block of the color studied and to obtain the name of the color. For this purpose, table 1 gives for the hue angles, the reference number of the representative lightness-saturation diagram to be used. Referring to it, we identify by its coordinates S and L^* the color block of the studied color and we read the name of the color. Figure 5 is an example of these lightness-saturation diagrams.

An EXCEL computer program written for a PC computer (Windows 7 – Excel 2010) was designed to automatically determine color names from the colorimetric data. The program is open access. The colorimetric data to be introduced are of course three in numbers, but the colorimetric system used is entirely left to the choice of the user.

We can use :

The CIE 1931 system with the tristimulus values X, Y, Z
or the Y tristimulus value, with the two chromaticity coordinates x and y
the CIELAB system with the quantities L^* a^* b^*
or with the quantities L^* C^*_{ab} h_{ab}
the CIELUV system with the quantities L^* u^* v^*
or with the quantities L^* C^*_{uv} h_{uv}
or with the quantities L^* S (saturation index) h_{uv}.

The colorimetric system used is identified by the introduction of a code specifying the chosen system which allows the program to use the appropriate relationships. The program performs some checks to eliminate major errors, such as negative values for the tristimulus values, or too high values for chromaticity coordinates x and y, and so on. Then, from the selected system, the program computes colorimetric values of all the colorimetric systems. The program displays at the same time the name of the color resulting from the method described in this publication, the reference number of the lightness-saturation diagram where the chosen color is located, and the name of the hue family.

It also gives the color saturation index S if it has not been used, the CIELUV saturation, the dominant wavelength or the complementary wavelength. Additional guidance is also provided when the color is close to the optimum color limit.

2 - COLOR–NAME BLOCKS

At all times, colors have been named and the variety of areas of interest has nourished the variety of designations. A large number of publications [10, 17, 19, 26] can therefore be given in the field of the designation of colors.

As far as our narrow area of interest is concerned, a set of important publications [12, 13, 14, 15, 16] has been published, since 1933 at least, by the ISCC in close collaboration with the NBS. One of them, published in 1939, aims at a "Method of designating colors" [12]. The three dimensional color space is divided into contiguous blocks, each block being identified by a name taken from a small and simple list of customary color designations [15, 16]. It is interesting to read on this issue a comment from Dr E. N. Gathercoal, first President of the ISCC, quoted by Judd & Kelly in the 1939 paper : “ *…. such designation to be sufficiently standardized as to be acceptable and usable by science, sufficiently broad to be appreciated and used by science, art, and industry, and sufficiently commonplace to be understood at least in a general way by the whole public*”. The same goal was set by the GPEM/PV.

Most often the color designations are different according to the area of interest and the activity. The work of the ISCC starts from the request of the Pharmaceutical organizations [15]. But later on, the color designation has been extended to many other areas. These publications are therefore of great interest and cannot be ignored. These ISCC publications are therefore obvious prior to the 1977 Afnor publication. Specifically, however, it can be seen that all these ISCC–NBS publications link color names to the Munsell color system and color samples of this atlas (Fig 2). As Kelly explains, the work enters the field of developing an universal means of color communication, and creates a general way of color identification, for which the Munsell system is an important element. This work is part of a six-level System [16] of identification.

Despite the analogies, the purpose of our work is notoriously different. It is a correspondence between a simple and precise denomination of surface colors and a colorimetric identification by three numerical values resulting from physical measurements and thus linking the color designations to the CIE colorimetric systems. In addition, this work is completed by a set of diagrams giving the color-name blocks with CIE colorimetric coordinates and by a set of tables giving the CIE colorimetric values of the boundaries of these color-name blocks.

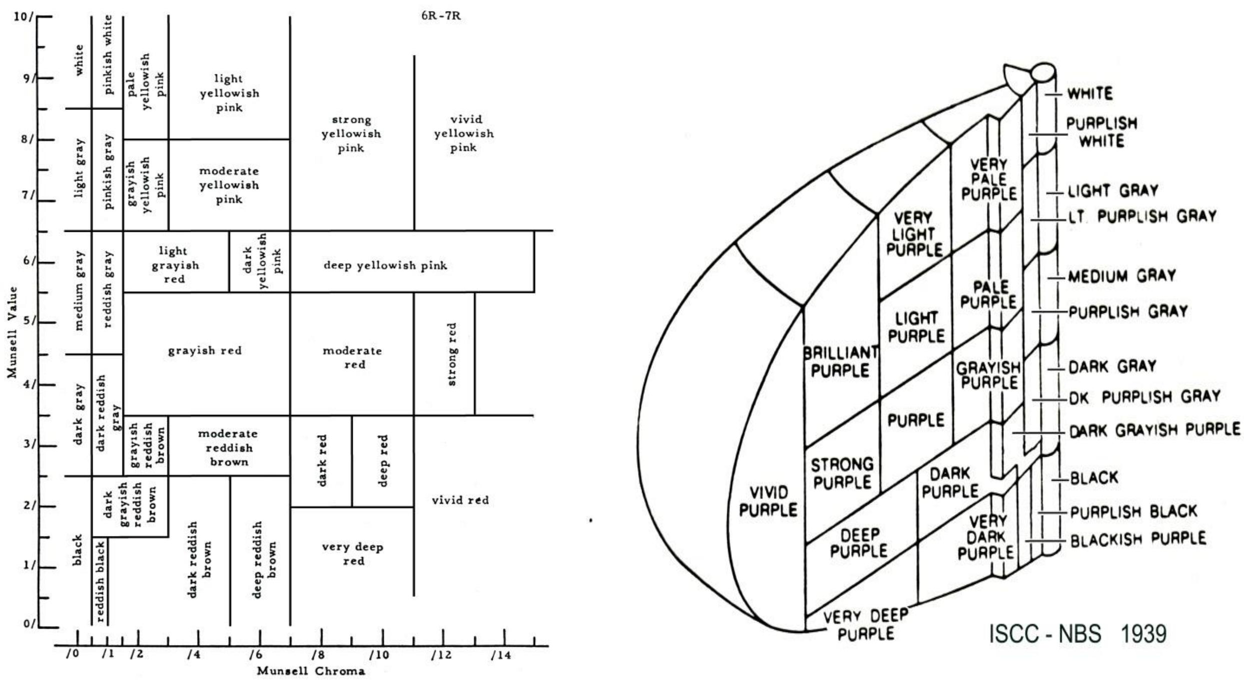

Figure 2 – *Division of the color space into color-name blocks published by Kelly and Judd* [11,12, 15, 16, 25].
On the left, a section plane by the black-white axis for 6R-7R Munsell hues with color names.
On the right, a 3D view showing the color-name blocks in a part of the color space.

Names of colors

All the color designations used by the GPEMP/V are oriented towards paints and related materials. No doubt this choice is better suited to technical uses. GPEM/PV used 3 dozens of words, much in the same way as the ISCC [15, 16] choice in 1939. Nevertheless, many differences can be observed between the two works. Among them, we can highlight the use of the French words "pourpre" which is not equivalent to the English word "purple" and the fact that the word "olive" is not used in French by the GPEM/PV.

GPEM/PV uses 18 nouns for the main colors and 8 for the complementary colors, instead of 7 and 3 used by ISCC.
Main names are : ***blanc, gris, noir*** and ***violet, bleu, vert, jaune, orangé, rouge, pourpre*** which are used to create 7 sets of 3 hue sequences :

violet-pourpre,	***violet,***	***violet-bleu,***
bleu-violet,	***bleu,***	***bleu-vert,***
vert-bleu,	***vert,***	***vert-jaune,***
jaune-vert,	***jaune,***	***jaune-orangé,***
orangé-jaune,	***orangé,***	***orangé-rouge,***
rouge-orangé,	***rouge,***	***rouge-pourpre,***
pourpre-rouge,	***pourpre,***	***pourpre-violet.***

In these sequences the first color name is dominant, so, "***bleu-vert***" is bluer than "***vert-bleu***", and "***vert-jaune***" is greener than "***jaune-vert***".

Complementary names are : ***ivoire, crème, beige, rose, kaki, brun, marron, bordeaux.***

GPEM/PV uses 9 lightness and saturation modifiers, 8 hue modifiers, and for gray colors 7 lightness modifiers, instead of 15, 6 and 3 for the ISCC.
Modifiers : ***pâle, clair, vif, grisé, moyen, intense, sombre, foncé, profond***
violacé, bleuté, verdâtre, ivoire, crème, rosé, brun, pourpre
très clair, clair, moyen clair, moyen, moyen foncé, foncé, très foncé

Another difference between the two methods is related to the division of the color space into 536 blocks by GPEM/PV much more than the 267 blocks described by Kelly in 1955 for the ISCC [15]. This could be mainly related to the close relationship made by the ISCC with the Munsell system. Another reason is related to the use by GPEM/PV of color names such as "ivoire, crème, beige, rose, kaki, marron, brun, bordeaux" to create a large number of blocks in the families of yellow hues and orange. These differences are also related to differences in linguistic usage with regard to color.

The result of these divisions in color blocks clearly shows an important fact, and perhaps not sufficiently recognized. The spacing of the hue angles in the CIELUV color system reflects the uniformity of the perceived color differences, while the spacing in the color names deviates significantly ; concentrated in yellows and oranges it is much distended in greens and blues. Half of the color-name blocks (in French) occupy only a quarter of the color space. Conversely, blues and greens are extending over a little more than 180° of hue angles, with only 63 on 536 color-name blocks. **The perception of a color difference does not coincide with the change of the color name at least for the French language**. We know indeed, to take only one example in French, that in the field of the hue "bleu", all the shades are called "bleu" that they are clear or dark, saturated or not. For the "orangé" and the "jaune", on the contrary, the less saturated colors are called "crème" or "beige" depending on their lightness, the dark ones are called "brun", the saturated shades are "orangé-jaune". The variety of the names reflects differences in perception that are different in nature from the color differences evaluated by the colorimetric formulas (CIELAB, CMC, CIEDE2000, etc.).

TABLE 1 – Hue family for CIELUV and D65 illuminant transformed from GPEM/PV

By multiplying the CIELUV saturation C^*_{uv} / L^* by $1/\sigma$ we obtain the saturation index S

By multiplying the saturation index S by σ we obtain C^*_{uv} / L^*

HUE family French color name	Lightness – saturation diagrams				Wavelength dominant or complementary	Hue angle boundaries (h_{uv} degrees)
	Reference number	h_{uv} (degrees)	$1 / \sigma$	σ		
VIOLET-POURPRE	1	290°	2,96	0,338	*– 561,2*	286° ≤ h_{uv} < 299°
VIOLET	2	280°	2,81	0,355	*– 565,6*	273° ≤ h_{uv} < 286°
VIOLET-BLEU	3	270°	2,71	0,369	456,8	264° ≤ h_{uv} < 273°
BLEU-VIOLET	4	250°	3,09	0,324	476,2	246° ≤ h_{uv} < 264°
BLEU	5	236°	3,70	0,270	481,1	231° ≤ h_{uv} < 246°
BLEU-VERT	6	210°	4,67	0,214	487,4	198° ≤ h_{uv} < 231°
VERT-BLEU	7	170°	5,43	0,184	498,6	154° ≤ h_{uv} < 198°
VERT	8	140°	5,74	0,174	532,4	135° ≤ h_{uv} < 154°
VERT-JAUNE	9	100°	5,92	0,169	565,6	79° ≤ h_{uv} < 135°
JAUNE-VERT	10	76°	5,62	0,178	573,5	75° ≤ h_{uv} < 79°
	11	74°	5,58	0,179	574,1	72° ≤ h_{uv} < 75°
JAUNE	12	68°	5,40	0,185	575,9	63° ≤ h_{uv} < 72°
	13	62°	5,18	0,193	577,7	60° ≤ h_{uv} < 63°
	14	58°	5,01	0,200	579,0	57° ≤ h_{uv} < 60°
JAUNE-ORANGÉ	15	52°	4,72	0,212	581,0	48° ≤ h_{uv} < 57°
	16	46°	4,40	0,227	583,2	43° ≤ h_{uv} < 48°
ORANGÉ-JAUNE	17	40°	4,05	0,247	585,7	38° ≤ h_{uv} < 43°
	18	36°	3,81	0,262	587,6	35° ≤ h_{uv} < 38°
ORANGÉ	19	30°	3,43	0,292	590,9	28° ≤ h_{uv} < 35°
	20	27°	3,24	0,309	592,8	26° ≤ h_{uv} < 28°
ORANGÉ-ROUGE	21	24°	3,05	0,328	595,1	22° ≤ h_{uv} < 26°
	22	20°	2,81	0,356	598,9	15° ≤ h_{uv} < 22°
ROUGE-ORANGÉ	23	12°	2,57	0,390	611,7	9° ≤ h_{uv} < 15°
ROUGE	24	6°	2,62	0,382	647,9	4° ≤ h_{uv} < 9°
ROUGE-POURPRE	25	0°	2,73	0,366	*– 494,9*	0° ≤ h_{uv} < 4° or 350° ≤ h_{uv} ≤ 360°
POURPRE-ROUGE	26	348°	2,90	0,345	*– 499,5*	346° ≤ h_{uv} < 350°
	27	340°	2,99	0,335	*– 504,4*	335° ≤ h_{uv} < 346°
POURPRE	28	332°	3,05	0,328	*– 511,9*	329° ≤ h_{uv} < 335°
	29	320°	3,09	0,324	*– 532,4*	313° ≤ h_{uv} < 329°
POURPRE-VIOLET	30	306°	3,08	0,324	*– 550,7*	299° ≤ h_{uv} < 313°

The complementary wavelengths are in italics and with the sign –

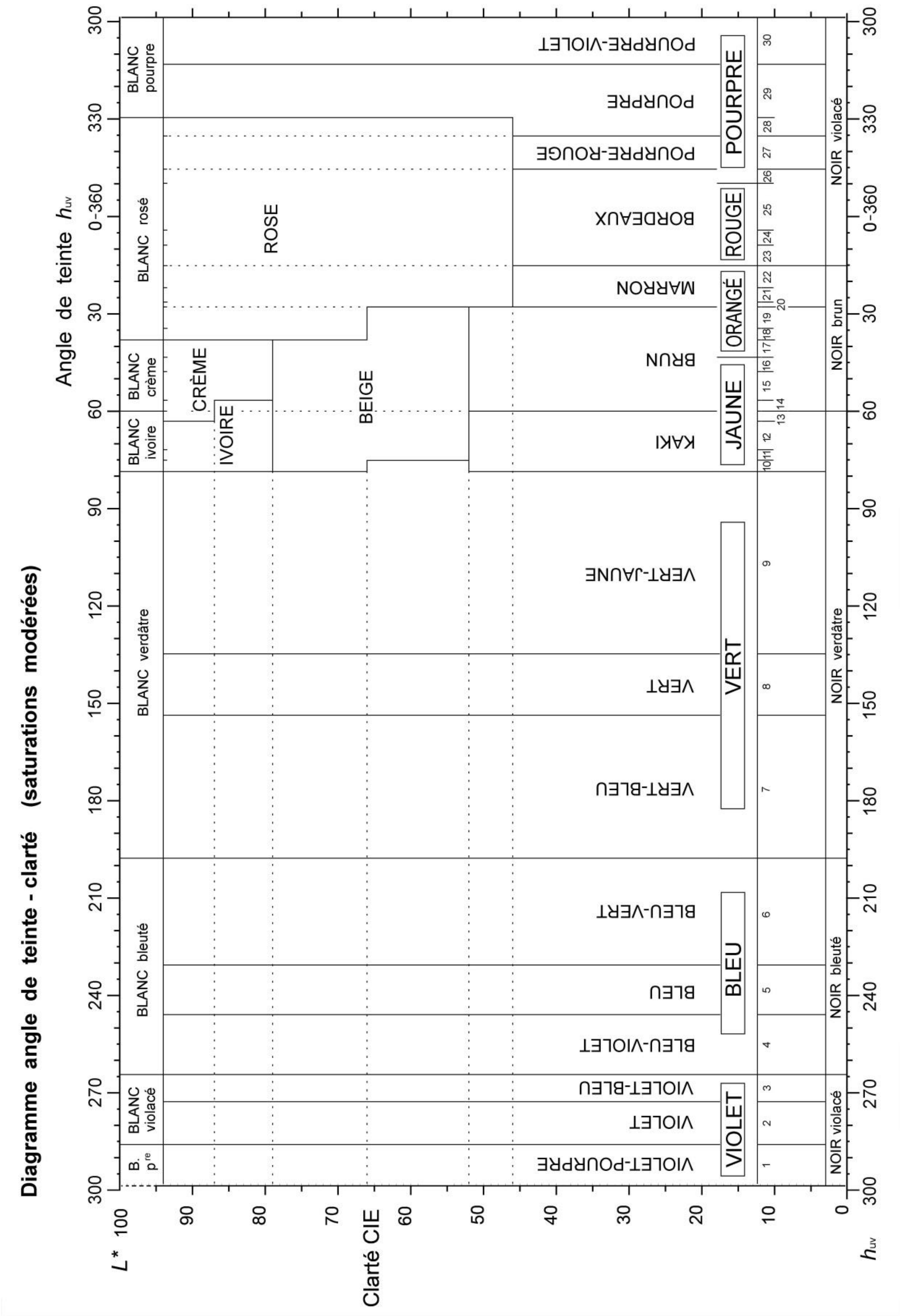

Figure 3 - *This diagram displays the hue and color families with French color names as a function of the CIE lightness L* and of the hue angle h_{uv}.*
Saturation being not used in this diagram, grays are not displayed ; however, non-achromatic whites and blacks are shown.
In order for the hues to be arranged in the usual order from left to right, it should be noted that the hue angle scale proceeds in the opposite direction to the usual direction. Moreover, the zero hue angle is not at one of the ends of the coordinates.
The small numbers from 1 to 30 at the bottom of the diagram are the reference numbers of the hue families used for the lightness-saturation diagrams.

Color–name blocks boundaries

The lightness-saturation diagrams are the only information related to color blocks boundaries available in the Afnor document, except the one concerning achromatic colors. These limits can only be deduced by a careful examination of the graphical representations called "*coupes axiales CCR*[1] ". An essential preliminary task was therefore to draw up tables defining these limits.
It is however necessary to replace the values of the Y component, read on the Afnor diagrams, by the values of the lightness L^*. This replacement is is in principle easy. But while the integer values of the Y component limit the color blocks of the GPEM/PV, they are corresponding values that require decimals for CIE lightness L^*. To avoid this complication, integer values of CIE lightness were chosen for the boundaries of the color blocks, which seem acceptable given the experimental uncertainties.

From these determinations, the boundaries of the 536 color blocks were established. They are published in a set of 15 tables. These tables are an accurate and reliable means of identifying color blocks, not subject to inaccuracies in the making or reading of illustrative diagrams. Here, we give as an example only one table of these limits.

Table 2 : BEIGE *h_{uv}: 28° to 79°* *λ_d : 572,5 to 592 nm*

Color names (in French)		Diagrams	h_{uv} limits in degrees	L^* limits	S limits
BEIGE	clair	13 – 14	$57^\circ \le h_{uv} < 63^\circ$	$73 \le L^* < 79$	$\mathrm{N} \le S < 3$
		15	$48^\circ \le h_{uv} < 57^\circ$	$73 \le L^* < 79$	$1{,}5 \le S < 3$
	grisé	13 to 15	$48^\circ \le h_{uv} < 63^\circ$	$62 \le L^* < 73$	$\mathrm{N} \le S < 1{,}5$
	moyen	13 to 15		$62 \le L^* < 73$	$1{,}5 \le S < 3$
	intense	13 to 15		$62 \le L^* < 73$	$3 \le S < 4$
	sombre	13 to 15		$52 \le L^* < 62$	$\mathrm{N} \le S < 1{,}5$
	foncé	13 to 15		$52 \le L^* < 62$	$1{,}5 \le S < 3$
BEIGE – BRUN		14 to 19	$28^\circ \le h_{uv} < 60^\circ$	$43 \le L^* < 52$	$\mathrm{N} \le S < 1{,}5$
BEIGE – JAUNE	clair	11 to 15	$48^\circ \le h_{uv} < 75^\circ$	$73 \le L^* < 79$	$3 \le S < 4$
	foncé	11 to 15		$52 \le L^* < 62$	$3 \le S < 4$
BEIGE – KAKI		11 to 13	$60^\circ \le h_{uv} < 75^\circ$	$43 \le L^* < 52$	$\mathrm{N} \le S < 1{,}5$
BEIGE – ORANGÉ	clair	16 – 17	$38^\circ \le h_{uv} < 48^\circ$	$73 \le L^* < 79$	$3 \le S < 4$
	intense	16 – 17	$38^\circ \le h_{uv} < 48^\circ$	$62 \le L^* < 73$	$3 \le S < 4$
		18 – 19	$28^\circ \le h_{uv} < 38^\circ$	$62 \le L^* < 66$	$3 \le S < 4$
	foncé	16 to 19	$28^\circ \le h_{uv} < 48^\circ$	$52 \le L^* < 62$	$3 \le S < 4$
BEIGE – ROSE	clair	16 – 17	$38^\circ \le h_{uv} < 48^\circ$	$73 \le L^* < 79$	$1{,}5 \le S < 3$
	grisé	16 – 17	$38^\circ \le h_{uv} < 48^\circ$	$62 \le L^* < 73$	$\mathrm{N} \le S < 1{,}5$
		18 – 19	$28^\circ \le h_{uv} < 38^\circ$	$62 \le L^* < 66$	$\mathrm{N} \le S < 1{,}5$
	moyen	16 – 17	$38^\circ \le h_{uv} < 48^\circ$	$62 \le L^* < 73$	$1{,}5 \le S < 3$
		18 – 19	$28^\circ \le h_{uv} < 38^\circ$	$62 \le L^* < 66$	$1{,}5 \le S < 3$
	sombre	16 to 19	$28^\circ \le h_{uv} < 48^\circ$	$52 \le L^* < 62$	$\mathrm{N} \le S < 1{,}5$
	foncé	16 to 19	$28^\circ \le h_{uv} < 48^\circ$	$52 \le L^* < 62$	$1{,}5 \le S < 3$
BEIGE verdâtre	clair	10 to 12	$63^\circ \le h_{uv} < 79^\circ$	$73 \le L^* < 79$	$\mathrm{N} \le S < 3$
	grisé	10 to 12		$62 \le L^* < 73$	$\mathrm{N} \le S < 1{,}5$
	moyen	10 to 12		$62 \le L^* < 73$	$1{,}5 \le S < 3$
	intense	11 to 12	$63^\circ \le h_{uv} < 75^\circ$	$62 \le L^* < 73$	$3 \le S < 4$
	sombre	11 to 12		$52 \le L^* < 62$	$\mathrm{N} \le S < 1{,}5$
	foncé	11 to 12		$52 \le L^* < 62$	$1{,}5 \le S < 3$
BEIGE – VERT	clair	10	$75^\circ \le h_{uv} < 79^\circ$	$73 \le L^* < 79$	$3 \le S < 4$
	intense	10		$62 \le L^* < 73$	$3 \le S < 4$

N : *means that the lowest saturation is the saturation of the nearly achromatic color having the same lightness.*

Diagrams of color-name blocks

The diagrams representing the blocks of color-name make it both easier to find the name of a color and to illustrate the arrangement and juxtaposition of these blocks. Three-dimensional representations do not allow easy use. Plane representations are necessary but can be chosen in different ways. For example, plane sections of the three-dimensional space can be made, for a set of lightness appropriately selected. These sections are perpendicular to the black-white axis and are illustrated in figure 4 for à CIE lightness $L^* = 75$.

It is also possible to select planes passing containing the black-white axis for a suitably chosen set of hue angles. The lightness L^* is plotted on the ordinate, but for abscissas there is a choice between the chroma C^*_{uv} and the saturation index S. This second alternative was made by GPEM/PV and is illustrated by figure 5. Lightness-saturation diagrams are not sections of the color space, but have the advantage of giving parallel color blocks boundaries to the sides of the diagram. By this choice, when the lightness decreases, the representative scale increases, giving to the darks colors an important area which is not conform to the chromatic perception.

Two kinds of illustrative diagrams have been published :

5 sections of color space for the lightness values $L^* = 90$ $L^* = 75$ $L^* = 60$ $L^* = 45$ $L^* = 30$.

30 lightness-saturation diagrams for the 30 hue angles given in Table 1.

One example of each set has been reproduced in this publication. Figure 4 for the section of the color space for $L^* = 75$, and the figure 5 for a lightness-saturation diagram for $h_{uv} = 12°$.

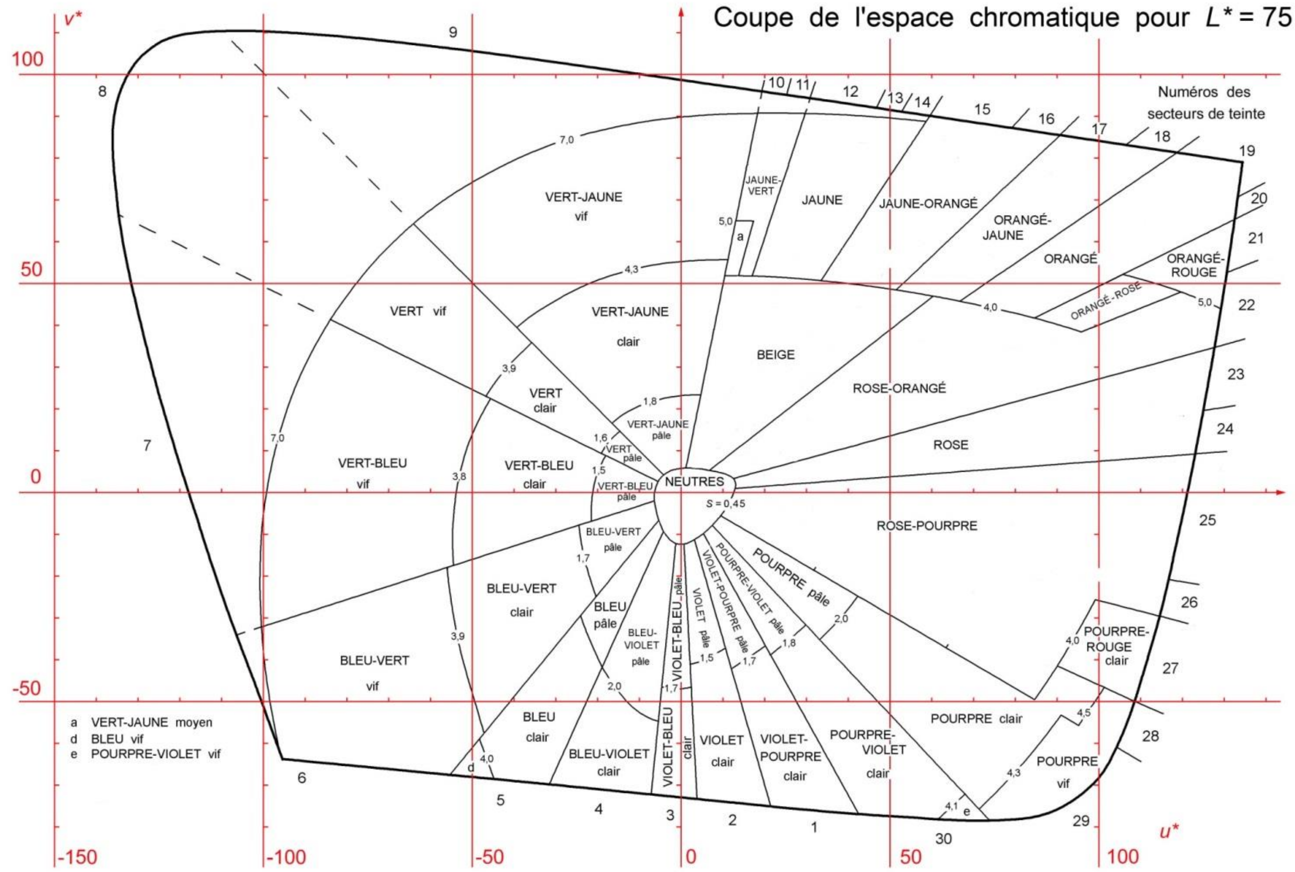

Figure 4 – *Example of a cross section of the color space at a constant CIE lightness with French color names. Coordinates are u* and v* with red scales. The thick line is the limit of non-fluorescent colors and the numbers placed at its vicinity are giving the reference numbers of the hue families. The saturation index S is given by numbers placed on the curved lines. Not all color-name blocks have been shown, in the yellow and red part of the diagram to avoid visual confusion.*

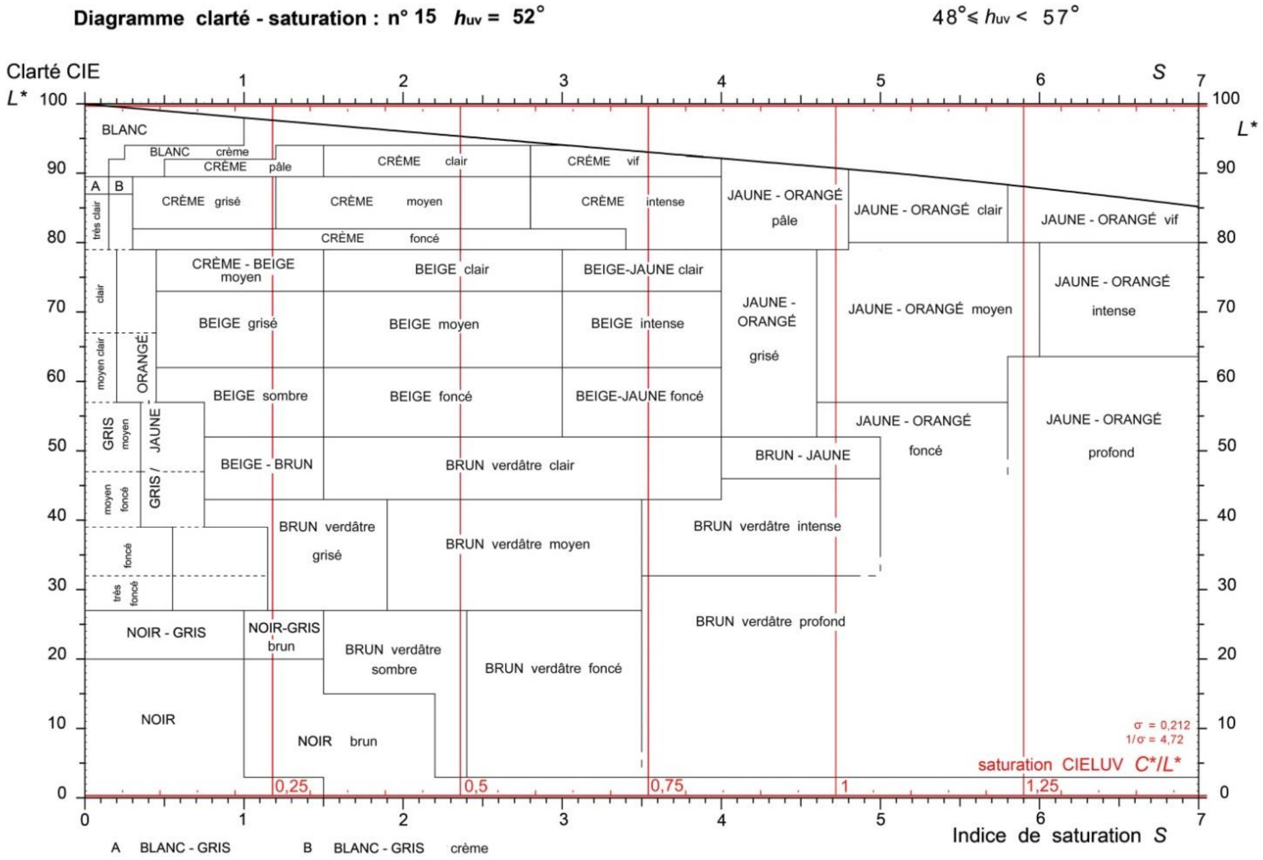

Figure 5 - *Example of a lightness-saturation diagram with French color names. The scale for the CIELUV saturation in red is only valuable for the hue angle $h_{uv} = 52°$. For values between 48° and 57° saturation index S must be used because the proportionality between both scales is slightly changed, according to the change of the value σ.*

For any lightness-saturation diagram, the saturation index S in abscissas, and the CIE lightness L^* in ordinates, are the coordinates of the diagram. These diagrams are drawn for a given value of the hue angle mentioned on each diagram, and give the name of the color- blocks. The diagrams also show the relationship between the different color- blocks.

For a given diagram, the value of σ is well defined and mentioned on the diagram with the value of $1/\sigma$. Due to the specified value of the hue angle, the CIELUV saturation and the saturation index are in a fixed relation. Thus the CIELUV saturation C^*/L^* scale printed in red in abscissas can be used. This makes it possible to dispense with the calculation of the index S, when the hue angle has the exact value mentioned at the top of the diagram.

But for any lightness-diagram, in the range of hue angles that are mentioned at the top right of each diagram, the boundaries of the color- blocks remain unchanged, with regard to the lightness L^* and to the saturation index S. In this range of hue angles, which appreciably changes, is the proportionality factor between the CIELUV saturation C_{uv}^*/L^* and the S index. As a result the value of the CIELUV saturation $s_{uv} = C_{uv}^*/L^*$ also changes and in this case the abscissas scale printed in red must no longer be used.

CONCLUSION

This new updated publication retains the options chosen by the GPEM/PV thanks to the chromatic adaptation method used and the use of the CIELUV system. By developing a quick and easy to use procedure this update corrects the defects of the original work in the practical determination of a color designation.

Nevertheless, the work presented here goes far beyond a simple update of the 1977 document. The tables giving the precise definitions of the color blocks are entirely new. They give the values that define the color blocks in a different way than by the imprecise reference to a set of diagrams. The plane sections with constant lightness are also completely new and illustrate very well the structure of the color- blocks in the CIELUV color space.

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