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(54) Titre : INDICE DE DETERMINATION D'UNE CHROMATICITE
(54) Title: CHARACTERISTIC NUMBER FOR DETERMINING A COLOR QUALITY

10

13 15 17

Q			
1	$\langle dE \rangle_{\text{sum}(25-75)} \geq 12$	$\langle dE \rangle_{25, 45, 75} \geq 6$	$\max \langle dE \rangle_{(CIE94, 45)} \geq 6$
2	$\langle dE \rangle_{\text{sum}(25-75)} < 12$	$\langle dE \rangle_{25, 45, 75} < 6$	$\max \langle dE \rangle_{(CIE94, 45)} < 6$
3	$\langle dE \rangle_{\text{sum}(25-75)} < 10$	$\langle dE \rangle_{25, 45, 75} < 4.5$	$\max \langle dE \rangle_{(CIE94, 45)} < 4.5$
4	$\langle dE \rangle_{\text{sum}(25-75)} < 6$	$\langle dE \rangle_{25, 45, 75} < 3$	$\max \langle dE \rangle_{(CIE94, 45)} < 3$
5	$\langle dE \rangle_{\text{sum}(25-75)} < 3.9$	$\langle dE \rangle_{25, 45, 75} < 2$	$\max \langle dE \rangle_{(CIE94, 45)} < 2$
6	$\langle dE \rangle_{\text{sum}(15-110)} < 6.5$	$\langle dE \rangle_{15, 25, 45, 75, 110} < 2$	$\max \langle dE \rangle_{(CIE94, 45)} < 1.7$
7		$\langle dE \rangle_{15, 25, 45, 75, 110} < 1.73$	$\langle dS \rangle_{15, 45, 75} < 1.73$ $\langle dG \rangle < 1.73$
8		$\langle dE \rangle_{-15, 15, 25, 45, 75, 110} < 1.41$	$\langle dS \rangle_{15, 45, 75} < 1.41$ $\langle dG \rangle < 1.41$

(57) Abrégé/Abstract:

The invention relates to a method for determining an index for characterizing a quality of a matching color tone of a paint in relation to a color reference, characterized in that colorimetric coordinates of the paint and of the color reference are determined for a number of measuring geometries using a spectrophotometer, color differences are calculated from the colorimetric coordinates of the paint and of the color reference for each of the number of measuring geometries and are normalized, and a pre-established assignment rule is used for assigning a value on a scale to a group of characteristic values calculated from the normalized color differences in order to determine the index.

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(54) Title: INDEX FOR DETERMINING A QUALITY OF A COLOR

(54) Bezeichnung : KENNZAHL ZUR ERMITTLUNG EINER FARBQUALITÄT

Q		
1	$\langle dE \rangle_{\text{sum}(25-75)} > 12$	$\langle dE \rangle_{25, 45, 75} > 6$
2	$\langle dE \rangle_{\text{sum}(25-75)} < 12$	$\langle dE \rangle_{25, 45, 75} < 6$
3	$\langle dE \rangle_{\text{sum}(25-75)} < 10$	$\langle dE \rangle_{25, 45, 75} < 4,5$
4	$\langle dE \rangle_{\text{sum}(25-75)} < 8$	$\langle dE \rangle_{25, 45, 75} < 3$
5	$\langle dE \rangle_{\text{sum}(25-75)} < 3,9$	$\langle dE \rangle_{25, 45, 75} < 2$
6	$\langle dE \rangle_{\text{sum}(15-110)} < 6,5$	$\langle dE \rangle_{15, 25, 45, 75, 110} < 2$
7		$\langle dS \rangle_{15, 45, 75} < 1,73$
8		$\langle dG \rangle < 1,73$

Fig. 1

(57) **Abstract:** The invention relates to a method for determining an index for characterizing a quality of a matching color tone of a paint in relation to a color reference, characterized in that colorimetric coordinates of the paint and of the color reference are determined for a number of measuring geometries using a spectrophotometer, color differences are calculated from the colorimetric coordinates of the paint and of the color reference for each of the number of measuring geometries and are normalized, and a pre-established assignment rule is used for assigning a value on a scale to a group of characteristic values calculated from the normalized color differences in order to determine the index.

(57) **Zusammenfassung:** Die vorliegende Erfindung betrifft ein Verfahren zum Ermitteln einer Kennzahl zur Charakterisierung einer Qualität einer Farbtoneinstellung eines Lacks in Bezug zu einer Farbreferenz, dadurch gekennzeichnet, dass farbmessige Koordinaten des Lacks und der Farbreferenz mit einem Spektralphotometer für eine Anzahl Messgeometrien ermittelt

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werden und bei dem jeweilige Farbdifferenzen aus den farbmtrischen Koordinaten des Lacks und der Farbreferenz für jede Messgeometrie der Anzahl Messgeometrien berechnet und normiert werden und wobei einer Gruppe von Kennwerten, die aus den jeweiligen normierten Farbdifferenzen berechnet werden, zum Ermitteln der Kennzahl mittels einer im Voraus bereitzustellenden Zuordnungsregel ein Wert einer Skala zugeordnet wird.

Characteristic number for determining a color quality

The present invention relates to a method for determining a characteristic number for characterizing a quality of a shade setting of a paint. The present invention further relates to a computer program for implementing the method of the invention.

In the mixing of a paint, i.e., in the case of a shade setting, different shades are mixed and then compared with a color reference or a shade original. For this purpose, traditionally, the mixed paint is measured spectrophotometrically and resultant measurement values, i.e., for example, colorimetric coordinates, are compared with corresponding measurement values for the color reference. Particularly in the case of effect paints comprising a number of effect pigments, a meaningful comparison between a particular effect paint and a particular color reference is possible only using measurement values determined under different measurement geometries. This means that in order to compare a paint with a color reference, it is necessary to determine a multiplicity of measurement values for a multiplicity of measurement geometries.

25

There are methods known in the prior art which provide for limited comparison of a particular paint with a particular shade original, i.e., color reference,

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without taking account of any effect pigments present,
for only three measurement geometries.

Publication WO 2013/049796 A1 relates to a method for
5 comparing a paint with a reference, the reference used
being color characteristics of a color formula.

Publication DE 102 08 696 A1 discloses a method wherein
colors approximated to a metallic color are calculated
10 by means of color classification codes.

The US-American publication US 2011/013176 A1 discloses
a method for determining properties of a surface.

15 It is against this background that a method is
presented for determining a characteristic number for
characterizing a quality of a shade setting of a paint
in relation to a color reference, wherein colorimetric
coordinates of the paint and of the color reference are
20 determined with a spectrophotometer for a number of
measurement geometries and wherein respective color
differences are calculated and standardized from the
colorimetric coordinates of the paint and of the color
reference for each measurement geometry of the number
25 of measurement geometries, and where a group of
characteristic values calculated from the respective
standardized color differences is assigned a scale
value for determining the characteristic number by
means of an assignment rule to be provided in advance.

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A number of measurement geometries comprises at least one measurement geometry.

5 A color difference in the context of the present invention is a difference between two colors in a color space, more particularly in an $L^*a^*b^*$ color space or an $L^*C^*h^\circ$ color space.

10 A measurement geometry in the context of the method presented is a measurement setup with a measuring instrument, such as, for example, a spectrophotometer, which is arranged at a defined angle with respect to a surface treated with a particular paint.

15 Colorimetric coordinates in the context of the present invention are coordinates in a color space for describing a color or gray level, more particularly in an $L^*a^*b^*$ color space or an $L^*C^*h^\circ$ color space.

20 A group of characteristic values means a number of characteristic values which are calculated from color differences between color coordinates of a particular paint and of a particular color reference, and which
25 are used for assigning a corresponding characteristic number Q to a particular comparison of paint and reference color or color reference. Of course, the characteristic number is suitable for comparison of paint and reference color not only for solid-color

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paints but also for effect paints. This means that with the characteristic number provided in accordance with the invention, comparisons of effect paints to respective color references and/or comparisons of
5 solid-color paints to respective color references can be assessed. The group of characteristic values here may also consist of just one characteristic value, as envisaged in general when employing the method of the invention for solid-color paints.

10

The $L^*C^*h^\circ$ color space corresponds to the L^*a^*b color space with the exception that rather than Cartesian coordinates a^* and b^* , cylindrical coordinates C^* for chroma and h° for hue angle are used. Lightness (L^*)
15 remains unchanged.

In order to compare a particular paint with a color reference, such as another paint, for example, provision is made for the determination or calculation
20 of a characteristic number Q , which allows or indicates a comparison or a quality value of a match of the respective paint, i.e., for example, of an effect paint or of a solid-color paint with the respective color reference in a scale, such as a school grade scale from
25 1 to 8, for example.

For the determination of the characteristic number Q , provision is made for respective colorimetric coordinates or color coordinates to be determined,

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these coordinates being indicated, for example, in a so-called L*a*b* color space, for both the respective paint and the respective color reference under different measurement geometries, and/or using
 5 different illuminants, using a spectrophotometer, for example. On the basis of the color coordinates determined for the respective paint and the respective color reference, it is possible to calculate a corresponding color difference between the respective
 10 paint and the respective color reference for each measurement geometry, i.e., for each measurement angle and/or for each illuminant, using formula (1) for achromatic colors and using formula (2) for chromatic colors.

15

$$\langle dE_{Lab} \rangle = \sqrt{\langle dL^* \rangle^2 + \langle da^* \rangle^2 + \langle db^* \rangle^2} \quad (1)$$

$$\langle dE_{Lch} \rangle = \sqrt{\langle dL^* \rangle^2 + \langle dC^* \rangle^2 + \langle dh^* \rangle^2} \quad (2)$$

A distinction between chromatic and achromatic colors may be ascertained in accordance, for example, with DIN
 20 6175-2. Moreover, provision is made for the respective measured color coordinates in the formulae (1) and (2) to be standardized. In order to standardize the respective measured color coordinates, it is possible to make use, for example, of formula (3).

25

$$\langle dX^* \rangle = \frac{dX^*}{S_v} \quad (3)$$

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In formula (3), a standardized value $\langle dX^* \rangle$ is calculated by dividing a respective value dX^* , i.e., a value of a respective variable, of a color difference
 5 by a respective angle-specific tolerance S_x , the angle-specific tolerance or acceptance limit S_x being calculated according to equation (4).

In this case a standardization may take place, in
 10 accordance for example with equation system (4),

$$S_L = S_a = S_b = 1/3$$

$$S_C = (1 + 0.048 \cdot C_R^*)/3 \quad (4)$$

$$S_h = (1 + 0.014 \cdot C_R^*)/3$$

15

where C_R^* is the colorfulness, i.e., chroma or saturation, of a color reference R in the $L^*a^*b^*$ color space and is calculated using the
 equation $C_R^* = \sqrt{(a_R^*)^2 + (b_R^*)^2}$, the index "R" indicating the
 20 color reference R.

The color differences determined and/or the standardized color differences determined between the respective paint and the respective color reference for
 25 the different measurement geometries and/or the different illuminants together form, for example, a group of characteristic values. Additionally, a sum of the color differences or of a selection of the color differences may also represent a characteristic value

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belonging to the group of characteristic values, for the different measurement geometries and/or the different illuminants. Furthermore, as a characteristic value, it is also possible, for example, to provide a maximum value among the standardized color differences determined between a respective paint and a respective color reference for - for example - one measurement geometry and two different illuminants.

10 In order to take account of respective effect properties of an effect paint in the context of the method of the invention, provision is made for sparkle differences and graininess differences, measured with a goniospectrophotometer, to be taken into account. For
15 this purpose, respective values, measured using the goniospectrophotometer, for the sparkle differences and the graininess differences, respectively, are standardized using formula (3), for example, and are taken into account in assignment of respective
20 calculated color differences to a scale value of the characteristic number Q , i.e., in a respective assignment rule, which is to be provided in advance.

For the assignment of respective color differences
25 and/or sparkle differences and/or graininess differences, measured under different measurement geometries, to a respective scale value of the characteristic number Q , provision is made for color differences calculated and standardized for an effect

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paint for respective color geometries to be combined with one another, by summing, for example, and for the result of such a combination to be assigned to a discrete scale value of the characteristic number Q, optionally using further conditions on the basis of an assignment rule which regulates, for example, intervals between respective scale values.

In the case of a respective assignment rule, as well as respective color differences of respective measurement geometries that have been combined with one another, in an assessment of effect paints, it is possible to use further conditions, such as, for example, a minimum or maximum difference between color differences, sparkle differences and/or graininess differences of specific measurement geometries.

Provision is further made - for the case where a so-called solid-color paint is to be compared with a corresponding color reference - for color differences of only one measurement geometry, determined under at least two different illuminants, to be offset against one another by, for example, the formation of an average of the color differences determined, or determination of the maximum value among the color differences determined. A distinction between solid-color and effect paints may be determined, for example, according to DIN 6175-1. On the basis of the combined color differences, a respective solid-color paint can

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be assigned to a respective scale value of the characteristic number Q in accordance with a corresponding assignment rule, to give the characteristic number Q according to the invention.

5

The present invention further relates to a computer program with program code means to implement all steps of the method according to the invention when the computer program is executed on a computer or
10 corresponding computing unit.

The computer program according to the invention serves in particular for executing the method of the invention on a computer or computing unit.

15

One possible form of the computer program according to the invention might include, for example, the following steps:

20 1. Determination of all color coordinates for all available measurement geometries of a paint and of a color reference in a color space.

2. Calculation of respective color differences
25 between the paint and the color reference for all measurement geometries.

3. If the paint to be compared is an effect paint, calculation of respective sparkle differences and/or

- 10 -

graininess differences for each measurement geometry.

4. If the paint to be compared is a solid-color paint, calculation of respective color differences for
5 at least two illuminants.

5. Standardization of the color differences calculated in step 2 and/or 4 and also of the sparkle differences and/or graininess differences calculated
10 optionally in step 3.

6. In the case of an effect paint, summation of the respective standardized color differences.

15 7. In the case of a solid-color paint, determination of the maximum value among the determined color differences from step 4.

8. Depending on the type of paint, effect paint or
20 solid-color paint, allocation of the characteristic values determined in steps 2 and 6 or of the characteristic value determined in step 7 to a respective scale value of the characteristic number Q according to an assignment rule.

25

In accordance with the invention, therefore a specific characteristic number Q is provided for determining the color quality of a paint by means of precisely defined rules. The quality stages are defined, as set out below

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in connection with the figures, by means of unambiguous equations. This automatically produces the assignment rule with specified weighting factors according to type of shade (solid-color or effect paint). Only if all the
5 criteria are met, i.e. all the equations of a quality stage, corresponding in each case to a specific characteristic number Q , is the respective paint assigned this specific scale value for the characteristic number Q . If not all of the criteria of
10 a quality stage are met, assignment takes place to the next-lower quality stage. If not all of the quality criteria are met there either, assignment takes place to the next-lower quality stage in turn, and so on. If not all of the quality criteria are met in the second-
15 lowest quality stage, assignment takes place to the lowest quality stage. Assignment to the lowest quality stage is always made when the respective quality criteria are not met for any higher quality stage.

20 Further advantages and embodiments of the invention are evident from the description and the appended drawings.

It is understood that the features stated above and those still to be elucidated below can be used not only
25 in the particular combination specified but also in other combinations, or on their own, without departing from the scope of the present invention.

The invention is represented schematically in the

drawing, with reference to a working example, and is described comprehensively below with reference to the drawing.

5 According to an aspect, a method for determining the color adjustment quality of a vehicle paint on the basis of a color reference applied to a vehicle is provided. The method is characterized in that colorimetric coordinates of the paint and of the color
10 reference are determined with a spectrophotometer for a number of measurement geometries and using at least one illuminant and wherein respective color differences are calculated and standardized from the colorimetric coordinates of the paint and of the color reference for
15 each measurement geometry of the number of measurement geometries and each illuminant used, and where a group of characteristic values calculated from the respective standardized color differences is assigned a scale value for determining the characteristic number by
20 means of an assignment rule to be provided in advance characterized in that respective sparkle differences and/or graininess differences between the paint and the color reference, measured with a goniospectrophotometer, are standardized and used in
25 the calculation of the characteristic number, where the assignment rule is extended for corresponding sparkle differences and/or graininess differences between paint and color reference.

According to an aspect, a computer readable medium is provided. The computer readable medium stores program with program code means to implement the steps of the method described above when the computer program is
5 executed on a computer or corresponding computing unit.

Brief description of the drawings

Figure 1 shows an assignment table with assignment
10 rules for assignment of respective color differences to a respective scale value of the characteristic number Q in accordance with one possible embodiment of the method presented.

15 Figure 2 shows embodiments of the inventively envisaged characteristic number Q in relation to an average of respective color differences between five different paints and one color reference.

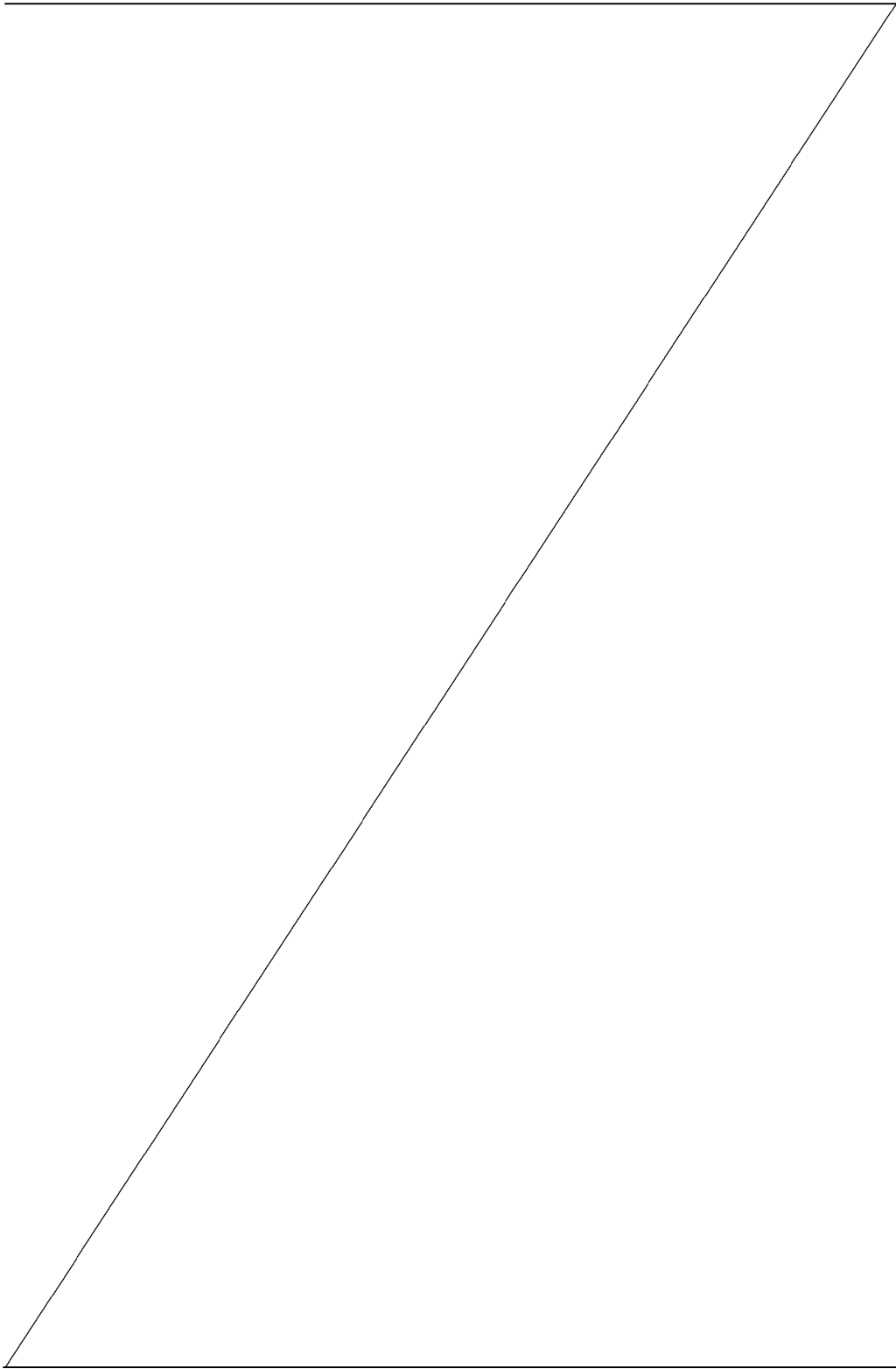
20 Figure 3 shows a graphical representation of the color differences from Figure 2.

Figure 4 shows embodiments of the inventively envisaged characteristic number Q for different solid-
25 color paints.

Figure 5 shows a graphical representation of color differences of the different solid-color paints from Figure 4.

12b

Figure 1 shows a Table 10 with three columns 13, 15,



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and 17. The first column, 13, indicates scale values of
 a characteristic number Q , which span a rating scale
 from 1 to 8, with 1 indicating the poorest quality,
 i.e., the worst possible match of a respective paint
 5 with a corresponding color reference, and 8 the best
 quality, i.e., the best possible match of a respective
 paint with a corresponding color reference.

Column 15 indicates assignment rules for calculated
 10 color differences from spectral measurements of an
 effect paint and of a corresponding color reference to
 a respective scale value of the characteristic number Q
 in the form of clear concrete equations. In order to
 assign a quality of a correspondence of an effect paint
 15 to a respective color reference of a characteristic
 number Q , there are at least four and at most ten
 conditions each defined by a specific equation, that
 must be met. The term "equation" here is to be
 interpreted broadly, namely both as "equation" in the
 20 narrower sense, as a statement concerning the identity
 of two terms, and also as "inequation" in the narrower
 sense, as a comparison of magnitude between two terms.

It is specified in line 1 of column 15, for example,
 25 that when a sum of all the calculated color differences
 for measurement geometries between 25° and 75° , i.e.,
 $\sum_{25}^{75} \langle dE \rangle$, is greater than or equal to a value of 12, and
 each of the measurement geometries 25° , 45° , and 75°
 when considered alone is greater than or equal to a

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value of 6, the respective paint is assigned to the characteristic number Q with the scale value 1. Since the characteristic number Q with the scale value 1 represents the lowest quality stage here, assignment to the characteristic number Q = 1 is also made if, for example, the sum of all the measured color differences for measurement geometries between 25° and 75°, i.e., $\sum_{25}^{75} \langle dE \rangle$, is greater than or equal to 12 but, for example, the color difference for one measurement geometry of the measurement geometries 25°, 45°, and 75° when considered alone is less than 6.

The sum $\sum_{25}^{75} \langle dE \rangle$ corresponds in general to a summation of the color differences for the individual measurement geometries 25°, 45°, and 75°. Correspondingly, $\sum_{15}^{110} \langle dE \rangle$ corresponds to a summation of the color differences for the individual measurement geometries 15°, 25°, 45°, 75°, and 110°.

At all higher quality stages, i.e. Q = 2, 3, 4, 5, 6, 7, and 8, all quality criteria and all equations assigned to the respective quality stages must be met in each case by the color differences determined, for a corresponding paint to be assigned to the respective quality stage or to the corresponding characteristic number Q = 2, 3, 4, 5, 6, 7 or 8.

Since in the case of effect paints there are also

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sparkle differences and graininess differences to be taken into account, provision is made, especially in the case of high characteristic numbers, corresponding to a high quality of a match between a respective effect paint and a corresponding color reference, for intensified conditions, i.e., additional conditions, to apply. This means that in order, for example, to satisfy respective criteria for an assignment to the characteristic number Q with a value of 7, for a respective effect paint, no color difference dE calculated in each case on the basis of measurement geometries between 15° and 110° relative to a corresponding color reference may have a value greater than or equal to 1.73. Correspondingly, each color difference dE calculated for the measurement geometries 15°, 25°, 45°, 75°, and 110° must be smaller than 1.73. In addition, a sparkle difference dS between the respective effect paint and the corresponding color reference may not be greater than or equal to a value of 1.73 for any of the measurement geometries 15°, 45°, and 75°. Moreover, a graininess difference dG between the respective effect paint and the corresponding color reference may not be greater than or equal to a value of 1.73.

25

Since solid-color paints frequently exhibit a metamerism effect, i.e., a different color or gray level on illumination with different illuminants, independent assignment rules are envisaged for solid-

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color paints, as shown in column 17.

For the assignment of a respective solid-color paint to a respective scale value with the characteristic number
5 Q, a maximum value of a color difference or of a gray level difference is calculated between a respective solid-color paint and a corresponding color reference, each measured under different illuminants, as for example under illuminant D64 and illuminant TL84, for a
10 measurement geometry of, for example, 45° in each case, on the basis of a color difference formula CIE94 based on an L*C*h° color space. This means that the solid-color paint is assigned, for example, to a characteristic number Q with a scale value of 1, when
15 the respective solid-color paint has a maximum value among the determined color differences between the respective solid-color paint and the corresponding color reference, based on spectral measurements under illuminants D64 and TL84, of greater than or equal to a
20 value of 6.

For assignment to other values of the characteristic number Q, corresponding criteria are defined in columns
15 (for effect paints) and 17 (for solid-color paints)
25 of Table 10.

Figure 2 shows a Table 20 which in a first column 21 indicates different effect paints and in column 23 indicates an average color difference calculated for a

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color reference over different measurement geometries of 15°, 25°, 45°, 75°, and 110°, and also indicates, in column 25, a corresponding scale value of the characteristic number Q. The characteristic number Q is, in particular, ordinally scaled, and so respective scale values of the characteristic number Q are always integral.

All of the paints listed in column 21 were compared with an individual color reference, in order to identify the paint having the best match to the single color reference.

Whereas for checking in accordance with the prior art it is possible only to compare the color differences determined at different measurement geometries, possibly individually for different illuminants, a qualitative match of a respective paint from column 21 to the color reference can be assessed on the basis of the characteristic number Q, as shown in column 25, while simultaneously considering a plurality of quality criteria, such as, for example, a plurality of color differences determined under different illuminants and/or different measurement geometries.

Since paint "05", i.e., the paint from the fifth line of Table 20, shows the highest scale value for Q, namely 6, the paint 5, out of all the paints shown in Table 20, is the best match with the color reference.

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Column 23 shows average color differences calculated via an arithmetic mean. It should be emphasized in this context that none of the average color differences specified in column 23 allows a conclusive assessment to be made about the quality of a match between a respective paint and the color reference. Whereas traditional measured values, such as an average color difference, for example, allow only a comparison on the basis of one condition, i.e., one position in the color space, it is possible via the characteristic number Q to jointly assess and quantify a plurality of criteria, such as, for example, color difference in the color space, sparkle difference, and behavior under different illuminants.

An increase in respective scale values of the characteristic number Q, as are shown in column 25, such increase having been determined on the basis of measurement values under different illuminants, may be accompanied by a reduction in corresponding average color differences MDE, as shown in column 23. Correspondingly, the values in columns 23 and 25 are generally inversely proportional to one another.

Figure 3 shows an experimental profile for discovering a paint with optimal correspondence to the color reference, from Figure 2, on the basis of a comparison of color differences.

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A diagram 31, comprising an abscissa 33, which indicates a respective paint 1 to 5, and an ordinate 35, which indicates color differences dE calculated for
5 respective measurement geometries of 15° , 25° , 45° , 75° , and 110° between the respective paint and the color difference, is a graphical representation of the paints described in Figure 2 and of their respective color differences with respect to a corresponding color
10 reference.

In order to compare the five different paints in Figure 2 with one another and to identify the paint which matches best with the color reference, it is necessary,
15 traditionally, to compare the color differences of the respective paints 1 to 5, plotted in the diagram 31, for each of the measurement geometries of 15° , 25° , 45° , 75° , and 110° , manually by a skilled person. In this context it is difficult to differentiate in
20 particular between paints 2 and 5, since both paints show comparable color differences and match both better and worse with the color reference, relative to the other respective paint, for different measurement geometries. It is therefore almost impossible to find
25 an objective basis for a selection between paint 2 or paint 5, whereas the characteristic number Q , as shown in Figure 2, identifies paint 5 without doubt as the paint best matching with the color reference, and evaluates paint 2 as even poorer than paint 4.

- 20 -

By means of the inventive characteristic number Q, accordingly, a respective paint best matching with a color reference can be identified quickly and without expert knowledge by a comparison of merely one
5 respective characteristic number Q per paint.

Figure 4 shows a Table 40 which, in analogy to Figure 2, describes five different paints in column 41 and
10 shows corresponding characteristic numbers Q in column 43. Since the paints described in Table 40 are solid-color paints, measured only at a measurement geometry of 45°, no averaged color difference has been calculated. This means that there is only one color
15 difference for each paint per illuminant, in this case illuminant D65, available for assessment.

Figure 5 shows a diagram 51 which corresponds to Table 40 in Figure 4 and which comprises an abscissa 53,
20 which indicates a respective paint 1 to 5, and an ordinate 55, which indicates color differences dE calculated between respective paint and a color reference. In order to compare the different solid-color paints in respect of any metamerism effect as
25 well, different measurements under different illuminants are necessary, which must be assessed in each case via an independent diagram and/or via different color differences, in order to identify a paint best matching the respective color reference.

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Since the inventive characteristic number Q unites different measurement values, determined under illuminants which are different, for example, it is possible to compare a solid-color paint, even with respect to a metamerism effect, with a respective color reference, quickly and easily, on the basis of just a single characteristic number Q per paint.

What is claimed is:

1. A method for determining the color adjustment
quality of a vehicle paint on the basis of a color
5 reference applied to a vehicle, characterized in that
colorimetric coordinates of the paint and of the color
reference are determined with a spectrophotometer for a
number of measurement geometries and using at least one
illuminant and wherein respective color differences are
10 calculated and standardized from the colorimetric
coordinates of the paint and of the color reference for
each measurement geometry of the number of measurement
geometries and each illuminant used, and where a group
of characteristic values calculated from the respective
15 standardized color differences is assigned a scale
value for determining the characteristic number by
means of an assignment rule to be provided in advance
characterized in that respective sparkle differences
and/or graininess differences between the paint and the
20 color reference, measured with a
goniospectrophotometer, are standardized and used in
the calculation of the characteristic number, where the
assignment rule is extended for corresponding sparkle
differences, graininess differences, or both sparkle
25 differences and graininess differences, between paint
and color reference.
2. The method as claimed in claim 1, characterized in
that the color differences for achromatic and chromatic
30 colorimetric coordinates are calculated with respective
color difference formulae.
3. The method as claimed in claim 1 or 2, wherein a
sum of all the standardized color differences between
35 paint and color reference is used for calculating
respective characteristic values.
4. The method as claimed in claim 1, characterized in
that particular color differences between the paint and

the color reference are calculated and standardized for every measurement geometry of the number of measurement geometries and every illuminant used, using formula

$$\langle dE_{Lch} \rangle = \sqrt{\langle dL^* \rangle^2 + \langle dC^* \rangle^2 + \langle dh^\circ \rangle^2}, \quad \text{wherein the color differences are standardized using formula } \langle dX^* \rangle = \frac{dX^*}{S_x},$$

5 differences are standardized using formula wherein X represents each of the coordinates L, C and h, respectively, and wherein for standardizing the color differences the following mathematical formula applies: $S_L = S_a = S_b = 1/3$, $S_C = (1 + 0,048 \cdot C_R^*)/3$ and
10 $S_h = (1 + 0,014 \cdot C_R^*)/3$, wherein R represents the color reference and C_R^* describes a Chroma of the color reference in the L^*a^*b color space, wherein the following mathematical formula applies:

$$C_R^* = \sqrt{(a_R^*)^2 + (b_R^*)^2}, \quad \text{and wherein the assignment rule for}$$

15 solid-color paints comprises rules which specify that a characteristic value, as maximum value of color differences, gray-stage differences, or color and gray-stage differences, between a respective solid-color paint and a corresponding color reference, each
20 measured under different illuminants, for a particular measurement geometry, is assigned to a scale value 1 when the characteristic value is greater than or equal to 6, and where the characteristic value is assigned to a scale value 2 when the characteristic value is less
25 than 6, and where the characteristic value is assigned to a scale value 3 when the characteristic value is less than 4.5, and where the characteristic value is assigned to a scale value 4 when the characteristic value is less than 3, and where the characteristic
30 value is assigned to a scale value 5 when the characteristic value is less than 2, and where the characteristic value is assigned to a scale value 6 when the characteristic value is less than 1.7, and where the characteristic value is assigned to a scale
35 value 7 when the characteristic value is less than 1.4, and wherein the characteristic value is assigned to a scale value 8 when the characteristic value is less

than 1.0, and where the assignment rule for effect paints comprises rules which specify that assignment to a scale value 1 is made when a first effect characteristic value, formed on the basis of a sum of all the color differences between an effect paint and an effect paint reference for a number of measurement geometries between 25° and 75°, is greater than or equal to 12 and respective effect color differences between the effect paint and the effect paint reference, determined for the measurement geometries of 25°, 45°, and 75°, are greater than or equal to 6 when considered each on their own, and where assignment to a scale value 2 is made when the first effect characteristic value is less than 12 and each of the effect color differences determined for the measurement geometries of 25°, 45°, and 75° is less than 6, and where assignment to a scale value 3 is made when the first effect characteristic value is less than 10 and each of the effect color differences determined for the measurement geometries of 25°, 45°, and 75° is less than 4.5, and where assignment to a scale value 4 is made when the first effect characteristic value is less than 6 and each of the effect color differences determined for the measurement geometries of 25°, 45°, 75° is less than 3, and where assignment to a scale value 5 is made when the first effect characteristic value is less than 3.9 and each of the effect color differences determined for the measurement geometries of 25°, 45°, 75° is less than 2, and where assignment to a scale value 6 is made when a second effect characteristic value, formed for a number of measurement geometries between 15° and 110°, is less than 6.5 and each of the effect color differences determined for the measurement geometries of 15°, 25°, 45°, 75°, and 110° is less than 2, and where assignment to a scale value 7 is made when the second effect characteristic value is less than 6.5, each of the effect color differences determined for the measurement geometries of 15°, 25°, 45°, 75°, and 110° is less than

1.73, and each sparkle difference between the effect paint and the effect paint reference, determined for the measurement geometries of 15°, 45°, 75°, is less than 1.73 and a graininess difference between the effect paint and the effect paint reference is less than 1.73, and where assignment to a scale value 8 takes place when the second effect characteristic value is less than 6.5 and each of the effect color differences formed for the measurement geometries of - 15°, 15°, 25°, 45°, 75°, and 110° is less than 1.41, and each sparkle difference between the effect paint and the effect paint reference, determined for the measurement geometries of 15°, 45° and 75°, is less than 1.41, and the graininess difference between the effect paint and the effect paint reference is less than 1.41, wherein the assignment rule is extended for corresponding sparkle differences and graininess differences, and wherein particular sparkle differences and graininess differences are divided and thereby standardized by the angle specific tolerance S_x , and wherein an assignment to a scale value 1 takes place every time the assignment rules for a higher scale value are not fulfilled.

5. A computer readable medium storing computer program code with program code means to implement all steps of a method as claimed in any of claims 1 to 4 when the computer program is executed on a computer or corresponding computing unit.

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Q			
1	$\langle dE \rangle_{\text{sum}(25-75)} \geq 12$	$\langle dE \rangle_{25, 45, 75} \geq 6$	$\max \langle dE \rangle_{(CIE94, 45)} \geq 6$
2	$\langle dE \rangle_{\text{sum}(25-75)} < 12$	$\langle dE \rangle_{25, 45, 75} < 6$	$\max \langle dE \rangle_{(CIE94, 45)} < 6$
3	$\langle dE \rangle_{\text{sum}(25-75)} < 10$	$\langle dE \rangle_{25, 45, 75} < 4.5$	$\max \langle dE \rangle_{(CIE94, 45)} < 4.5$
4	$\langle dE \rangle_{\text{sum}(25-75)} < 6$	$\langle dE \rangle_{25, 45, 75} < 3$	$\max \langle dE \rangle_{(CIE94, 45)} < 3$
5	$\langle dE \rangle_{\text{sum}(25-75)} < 3.9$	$\langle dE \rangle_{25, 45, 75} < 2$	$\max \langle dE \rangle_{(CIE94, 45)} < 2$
6	$\langle dE \rangle_{\text{sum}(15-110)} < 6.5$	$\langle dE \rangle_{15, 25, 45, 75, 110} < 2$	$\max \langle dE \rangle_{(CIE94, 45)} < 1.7$
7		$\langle dE \rangle_{15, 25, 45, 75, 110} < 1.73$	$\max \langle dE \rangle_{(CIE94, 45)} < 1.4$
8		$\langle dE \rangle_{-15, 15, 25, 45, 75, 110} < 1.41$	$\max \langle dE \rangle_{(CIE94, 45)} < 1.0$

Fig. 1

Fig. 2

Fig. 2

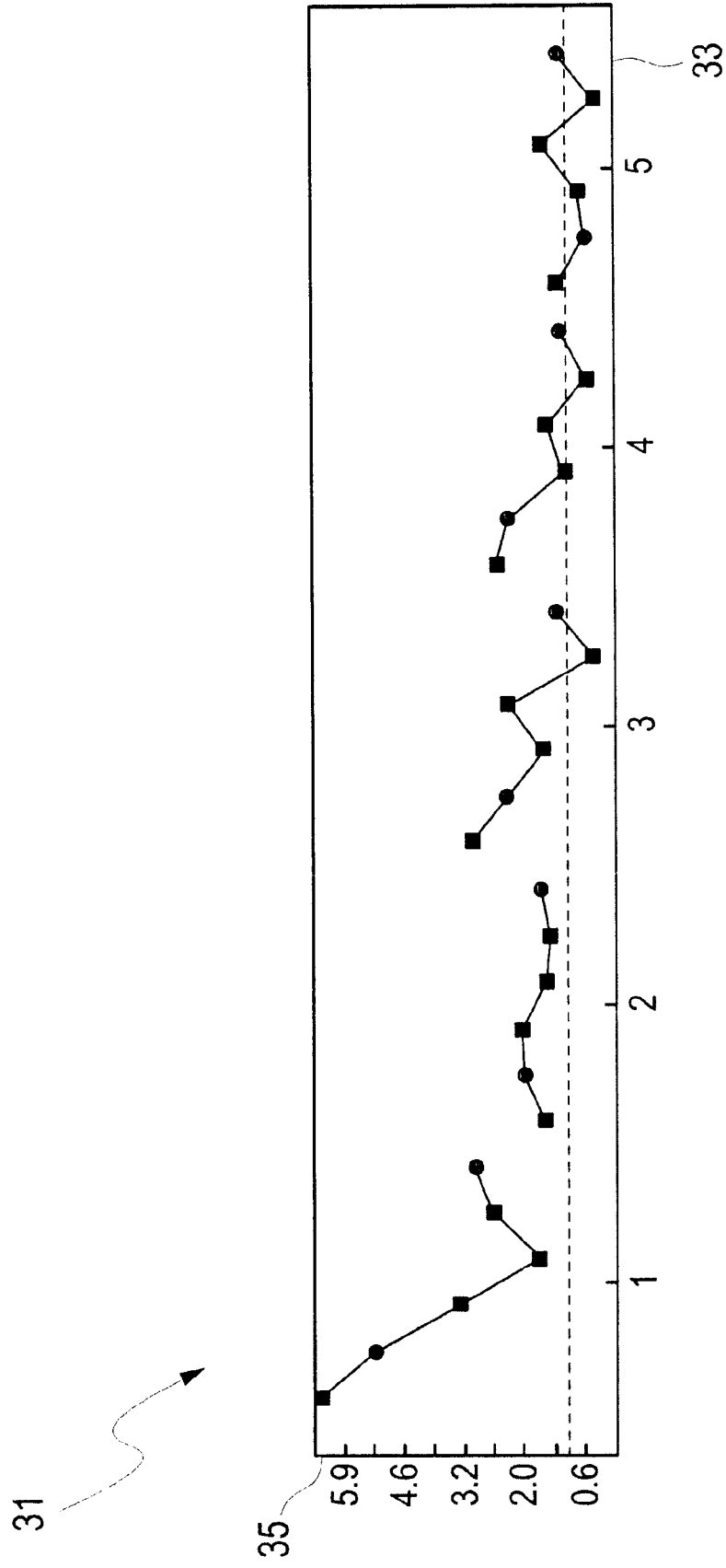


Fig. 3

40

41					43			Q
01_DE02-2014-00933_FIR GREEN SOLUTION					...	...	...	1
02_DE02-2014-00933_FIR GREEN SOLUTION					...	...	...	3
03_DE02-2014-00933_FIR GREEN SOLUTION					...	...	...	4
04_DE02-2014-00933_FIR GREEN SOLUTION					...	...	...	7
05_DE02-2014-00933_FIR GREEN SOLUTION					...	...	...	8

Fig. 4

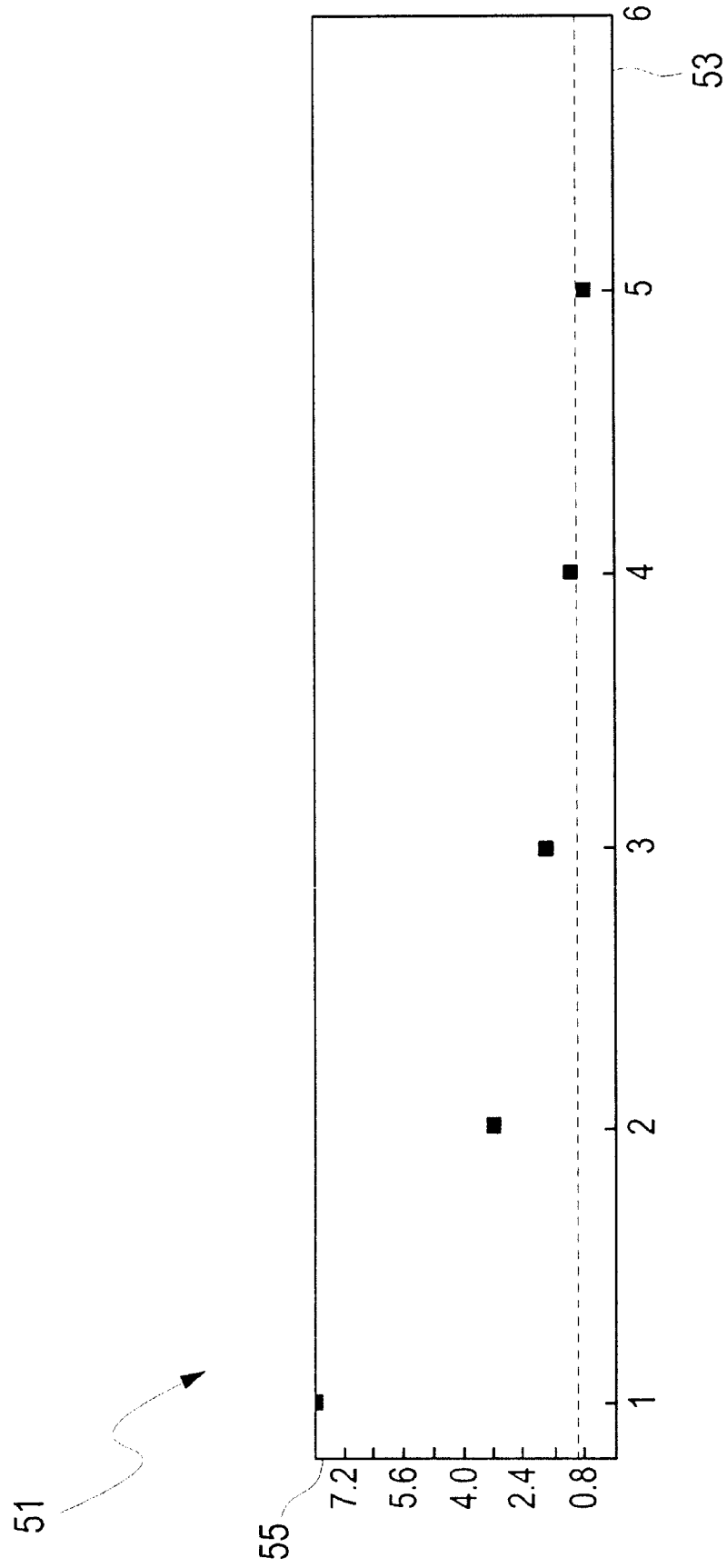


Fig. 5

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Q				
1	$\langle dE \rangle_{\text{sum}(25-75)} \geq 12$	$\langle dE \rangle_{25, 45, 75} \geq 6$		
2	$\langle dE \rangle_{\text{sum}(25-75)} < 12$	$\langle dE \rangle_{25, 45, 75} < 6$		
3	$\langle dE \rangle_{\text{sum}(25-75)} < 10$	$\langle dE \rangle_{25, 45, 75} < 4.5$		
4	$\langle dE \rangle_{\text{sum}(25-75)} < 6$	$\langle dE \rangle_{25, 45, 75} < 3$		
5	$\langle dE \rangle_{\text{sum}(25-75)} < 3.9$	$\langle dE \rangle_{25, 45, 75} < 2$		
6	$\langle dE \rangle_{\text{sum}(15-110)} < 6.5$	$\langle dE \rangle_{15, 25, 45, 75, 110} < 2$		
7		$\langle dE \rangle_{15, 25, 45, 75, 110} < 1.73$	$\langle dS \rangle_{15, 45, 75} < 1.73$	$\langle dG \rangle < 1.73$
8		$\langle dE \rangle_{-15, 15, 25, 45, 75, 110} < 1.41$	$\langle dS \rangle_{15, 45, 75} < 1.41$	$\langle dG \rangle < 1.41$

$$\max \langle dE \rangle_{\text{CIE94}, 45} \geq 6$$

$$\max \langle dE \rangle_{\text{CIE94}, 45} < 6$$

$$\max \langle dE \rangle_{\text{CIE94}, 45} < 4.5$$

$$\max \langle dE \rangle_{\text{CIE94}, 45} < 3$$

$$\max \langle dE \rangle_{\text{CIE94}, 45} < 2$$

$$\max \langle dE \rangle_{\text{CIE94}, 45} < 1.7$$

$$\max \langle dE \rangle_{\text{CIE94}, 45} < 1.4$$

$$\max \langle dE \rangle_{\text{CIE94}, 45} < 1.0$$