Guidance document: permitted color tolerances of unicolor powder coatings for architectural applications

Issued by the German Paint Industry Association (Verband der deutschen Lackindustrie VdL)

Preface

This guidance document was prepared by the technical committee of the powder group of the German paint federation (VdL) in the years 2002 and 2003 to inform applicators of powder coatings for architectural use on suitable methods and on acceptable limits regarding the assessment of color tolerances.

1. Introduction

Powder coatings are widely used for the decoration of architectural sections made from various materials, mostly however of aluminium. The occurrence of color differences is often unavoidable for technical reasons.. A color tolerance nominally acceptable on paper can give rise to a distinctly appreciable color deviation, where human visual perception of color differs. By color deviation we understand the magnitude of a perceptible difference between two color tones.

Since powder coatings are industrial products, which are subject to inherent deviations owing to their industrially-manufactured raw materials and their preparation processes, it is the powder coating manufacturer's wish to have color tolerances sufficiently large to achieve acceptance of their products. In contrast it is the wish of the powder coating applicator and end customer to define these tolerances as narrowly as possible.

The color tolerances for powder-coated parts arise from a combination of tolerances for the powder coatings themselves and those of the application process. In chapter 7 are given the most important parameters during the application process

In this guidance document the test conditions and color tolerances are defined, from the viewpoint of the powder coating supplier, for powder coatings at point of supply in uni-color shades for use in the architectural sector.

Color tolerances resulting from application parameters in processing, as well as shade variations caused by changing light sources (metamerism, see DIN 6172), are not covered by this guidance document. Metallic and effect shades are also not included in this guidance document because of their differing means of assessment.

2. Scope

Within this guidance document are described the comparison samples, test methods and permitted color tolerances for differences both between an original standard and a new batch and between two batches. This guidance document is not valid for finished coated objects and building components, but deal exclusively with the assessment of the color of powder coatings which have been applied on test panels under standardized laboratory conditions.

3. Submissions for color matching

Submissions for the matching and production of colors in powder coatings must comply with the following requirements:

- The finish must be opaque and as close as possible to the desired paint surface (in cases of larger differences in surface and gloss, greater visual and measured variations are to be expected)
- The assessment area must be flat and uninterrupted. The size must be sufficient for a reliable assessment of the color. Ideal size for standards is between DIN A6 (minimum) and DIN A5.

It should be noted that commercially-available color cards (e.g. RAL and NCS) are as a rule, pigmented differently from powder coatings and can show marked color deviation at any given time from the manufacturer's original standards. Some series of color cards, such as RAL 841-GL and in part NCS Edition 2, are measured against the standards by the manufacturers. Furthermore it should be noted that cards of the matt RAL register 840-HR appear both perceptibly and to instrumental measurement as lighter and less saturated than the same shades of the gloss RAL register 841-GL.
A visible and measurable color difference can therefore occur between two sample cards, even of the same designation. Because of this, where necessary a special card is to be agreed upon between the interested parties as a standard; this is to be rotated between the parties as required. Calculation of reference values based on details on standards (as for instance with RAL 841-GL) has not proved successful in practice and we strictly advise against this. In case of doubt, for a coating manufacturer's stock products the color card of the incumbent supplier will count as the relevant standard.

Since commercial color cards have only a finite lifespan as defined by the manufacturer, these cards must be replaced regularly. In order, however, to avoid a change in the color of the powder coating, the measurement data in the color analyzer system is not altered, but the deviation of the new color card is recorded.

For products with gloss below 65 units (at 60° measuring angle), the register RAL 840-HR is mostly used for RAL shades, and at higher glosses the register RAL 841-GL. Since, however, other arrangements can be agreed, in specification of an exact shade the RAL register must also be stated.

In the case of special colors, large variation in gloss level and structured surfaces it is the practice to define powder coating matches as standards. This applies also when adequate matching of a special original is not possible for technical reasons related to the pigments.

Standards must be stored protected, in the dark at room temperature. Since the color of standards can change with time, these should be checked regularly and replaced as necessary. The influence of normal use (scratches, fingerprints, etc.) should also be noted.

4. Requirements for comparison panels (batch panels)

Coated panels for the documentation and evaluation of the color of powder coating batches must meet the following requirements:

- The surface must be opaquely coated. As a rule the film thickness for color assessment as per EN ISO 2808 should lie between 80 and 100 µm , although for reasons of hiding power, surface or by special agreement it may be necessary to use a different film thickness. In particular with saturated red, orange and yellow shades where the manufacturer does not use toxic pigments, e.g. lead or chrome-based, a higher film thickness can be necessary to achieve sufficient opacity.
- The substrate for the assessment is a degreased aluminium panel meeting the requirements of GSB or Qualicoat guidelines unless special agreement is made for a product.
- Application is with standard commercial coating guns, and curing is achieved using laboratory electric ovens under the powder supplier's specified parameters. In particular, curing conditions according to DIN 55990-4 are to be observed. If curing windows are given in the datasheet, the exact cure conditions to be used must be agreed upon between the interested parties in order to avoid color tolerances from differences in cure.

5. Color testing

Two principal options are available for the monitoring of color differences between a standard and a comparison panel (batch panel) or between two batches:

- visual assessment under defined conditions (EN ISO 3668)
- analysis using a color measuring system (ISO 7724 or. DIN 5033 and DIN 6174)

For the pass/fail decision on a batch the result of the visual assessment is the deciding factor, instrumental color analysis represents an aid which can be used in cases of dispute to reach a decision. In visual assessment only small differences should be allowed, which do not essentially affect the overall impression. The permitted tolerances for instrumental evaluation are detailed in point 6.

The assessment of color differences according to this guidance document must take place exclusively under standardized conditions, using a standard light source corresponding to mid-day natural light.

5.1 Visual assessment under defined conditions (EN ISO 3668)

The samples to be checked (as point 3 or 4) are placed in a color assessment cabinet and inspected under standard illuminant D65. The samples must lie at the same level, and have as similar as possible a surface structure and gloss level, to eliminate errors in judgment caused by these influences. The assessment must be carried out by persons with normal color vision, and is subjective with respect to acceptable tolerances and therefore operator-dependent. In persons with defective color vision, false assessments can arise, in which the color vision defect is however not uniformly distributed across the whole color space but can lead to incorrect judgments only in certain color regions.

Assessment in an inspection cabinet is essential to ensure that the samples are illuminated exclusively with the desired light of the required intensity and without dazzling. To exclude the influence of atmospherics and temperature on the apparent color of the samples, the assessment must take place in unpressurized conditions and at room temperature.
Details of these assessment conditions can be found in the standard EN ISO 3668.

5.2 Analysis using a color measuring system (ISO 7724, DIN 5033 and DIN 6074)

Analysis of the samples (as point 3 or 4) must take place using appropriately calibrated and suitable measuring devices. For the assessment of powder coated surfaces the measurement geometries d/8 or 8/d (Ulbricht sphere) are to be used exclusively. Measurement is carried out with specular gloss included (i.e. without gloss trap). Evaluation of the measurement results is carried out according to the CIELab formula under a 10° normal observer with standard illuminant D65. Details of the measurement and evaluation conditions can be found in the named standards.

Measurement of samples with specular gloss excluded is not recommended, since significant deviations from the visual impression can arise through influence of the surface structure and gloss.

Furthermore attention must be brought to unavoidable measurement tolerances and differences between results from different instruments (even of the same manufacturer). In cases of doubt it is essential to agree upon a specified measuring instrument for an arbitrating analysis.

Color tolerances generally permissible for supplied powder coatings, from the viewpoint of the powder supplier, are detailed in chapter 6.

6. Definition of permitted color tolerances for uni-colored powder coatings

For a given color shade, the generally permissible color deviation of a powder coating under the stated laboratory conditions can be defined in relation to the standard from the following "color footprint" on basis of x and y values (see ISO 7724-1). The x and y values describe the

current color and its saturation. The “footprint” is defined in DIN 6175-1 in detail. In these guidance document the individual ranges are newly named, and a special definition of the permitted tolerances has been made for powder coatings. For region A a differentiation in tolerance values has been made, based on practical experience, according to the lightness value L (after CIELab) of the standard.

For some critical saturated shades in the red, orange and yellow region, it is appropriate to refer to a standard prepared in powder coating.

It is expressly pointed out that the colour tolerance values detailed in DIN 6175-1 relate exclusively to automobile refinish paints, and for a variety of reasons (inability to tone down, deviations in gloss and appearance, justifiable expense etc.) are not applicable to powder coatings.

Graph will be replaced by a coloured one without subtitle being not copied out of a standard

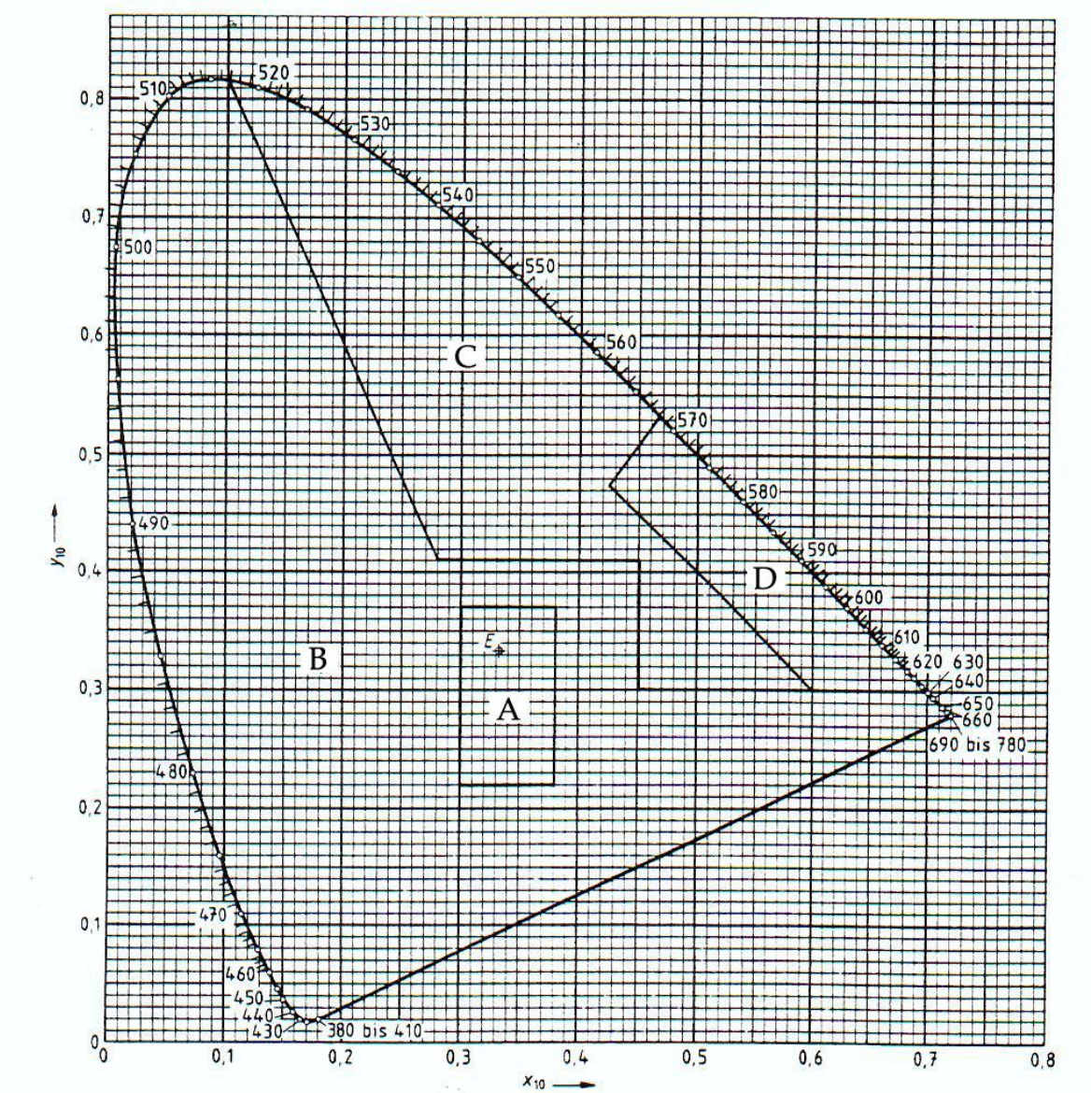

Bild 1. Normfarbtafel (für den 10°-Normalbeobachter) nach DIN 5033 Teil 3 mit Farbbereichen für unterschiedliche Farbtoleranzen ΔE^*_{ab} für Unilacke in der Automobillackierung

Region	Maximum difference from standard ΔE* after CIELab	Batch consistency[1)] ΔE* after CIELab
A L – value > 85	≤ 0,8	≤ 0,5
A L – value 60-85	≤ 1,0	≤ 0,7
A L – value < 60	≤ 1,4	≤ 1,0
B	≤ 2,0	≤ 1,5
C	≤ 2,8	≤ 2,0
D	≤ 3,6	≤ 2,5

These figures are valid for samples with a gloss level (60° measuring angle) ≥ 65 units. Please find for information as a result of this scheme the values of acceptable color differences of colors of the color register RAL 841-GL.

For gloss levels < 65 units these values are to be multiplied by a factor of 1,3 and rounded to one decimal place.
If there is an additional difference in surface structure between the samples, the tolerance values derived through these rules should again be multiplied by a factor of 1,3 and rounded to one decimal place. In this case measurement is however recommended against a standard prepared in powder coating.

[1)] Batch consistency : maximum permissible color difference between two supplied batches of one supplier.

7. Advice to applicators

This guidance document refers exclusively to the control of powder coatings at point of supply, on test panels applied under standardized laboratory conditions.
The applicator is advised to carry out a powder coating entry test under the same criteria.

Since color differences can arise as a result of the coating and curing process, the coated parts must be subjected to a quality control by the coating company, independent of the normal controls within the professional duty of care, to reduce rejects.

In particular the following parameters, which lie outside the control of the powder coating supplier, can have a large influence on the color of the coated parts, e.g.:

- differences in film thickness (because of irregular coating)
- cure temperature of the parts and duration in the oven (e.g. in plant stoppages, breaks, plant start-up, alteration of plant parameters such as line speeds etc.)
- marked differences in the coated parts especially in terms of substrate material, wall thickness, geometry etc.
- type of pre-treatment
- type of curing oven, e.g. direct heated gas ovens, because of chemical reactions with the powder, infra-red zones, cavity ovens with longer loading intervals, etc.
- influence of the reclaim system
- discontinuous throughput
- emission of production media

To avoid unacceptable color differences and metamerism, it is recommended to avoid the combination of like colors which have been coated under different application conditions, or come from different suppliers or powder product ranges. In subsequent supplies for existing

objects the applicator must warn the powder supplier of special requirements for color consistency.

7) Standards and literature

EN ISO 2808: .Coating materials – determination of film thickness
EN ISO 2813: Coating materials – determination of the reflectometer value of coatings
EN ISO 3668: Coating materials – visual comparison of the color of coatings
ISO 7724-1 to -3: Paints and coating materials; color measurement
DIN Report 49: Process for agreement of color tolerances
DIN 5033 -1 to -7: Color measurement
DIN 6172: Metamerism Index of sample pairs on change of light source
DIN 6173-1 and -2: Color assessment
DIN 6174: Colorimetric evaluation of color differences in surface colors according to the CIELab formula
DIN 6175-1: Color tolerances for automobile finishing; uni-color finishing
DIN 55990-4: Powder coatings – determination of cure conditions.

Color register RAL 840-HR and RAL 841-GL
Color register NCS Natural Color System Edition 2
Quality and test regulations of piecework coating of aluminium building components, GSB International, Schwäbisch Gmünd
Specifications for a quality label for paint, lacquer and powder coatings on aluminium for architectural applications, Qualicoat, Zürich

Anex (informative)

Color tolerances regarding the color register RAL 841-GL

RAL – color card	Maximum difference from standard	Batch consistency	RAL color card –	Maximum difference from standard	Batch consistency	RAL color card –	Maximum difference from standard	Batch consistency
1000	2,0	1,5	4007	1,4	1,0	7004	1,0	0,7
1001	2,0	1,5	4008	1,4	1,0	7005	1,4	1,0
1002	2,0	1,5	4009	1,0	0,7	7006	1,4	1,0
1003*	3,6	2,5	4010*	2,0	1,5	7008	2,0	1,5
1004*	3,6	2,5	**5000**	2,0	1,5	7009	1,4	1,0
1005	3,6	2,5	5001	2,0	1,5	7010	1,4	1,0
1006	3,6	2,5	5002*	2,0	1,5	7011	1,4	1,0
1007	3,6	2,5	5003	2,0	1,5	7012	1,4	1,0
1011	2,0	1,5	5004	2,0	1,5	7013	1,4	1,0
1012	2,8	2,0	5005	2,0	1,5	7015	1,4	1,0
1013	0,8	0,5	5007	2,0	1,5	7016	2,0	1,5
1014	2,0	1,5	5008	2,0	1,5	7021	1,4	1,0
1015	0,8	0,5	5009	2,0	1,5	7022	1,4	1,0
1016*	2,8	2,0	5010	2,0	1,5	7023	1,4	1,0
1017	2,8	2,0	5011	2,0	1,5	7024	1,4	1,0
1018*	2,8	2,0	5012	2,0	1,5	7026	2,0	1,5
1019	1,0	0,7	5013	2,0	1,5	7030	1,0	0,7
1020	2,0	1,5	5014	2,0	1,5	7031	2,0	1,5
1021*	3,6	2,5	5015	2,0	1,5	7032	1,0	0,7
1023*	3,6	2,5	5017	2,0	1,5	7033	1,4	1,0
1024	2,0	1,5	5018	2,0	1,5	7034	1,4	1,0
1027	2,8	2,0	5019	2,0	1,5	7035	1,0	0,7
1028*	3,6	2,5	5020	2,0	1,5	7036	1,0	0,7
1032	3,6	2,5	5021	2,0	1,5	7037	1,4	1,0
1033	3,6	2,5	5022	2,0	1,5	7038	1,0	0,7
1034	2,8	2,0	5023	2,0	1,5	7039	1,4	1,0
1037	3,6	2,5	5024	2,0	1,5	7040	1,0	0,7
2000	3,6	2,5	**6000**	2,0	1,5	7042	1,0	0,7
2001	2,8	2,0	6001	2,8	2,0	7043	1,4	1,0
2002*	2,8	2,0	6002	2,8	2,0	7044	1,0	0,7
2003	2,8	2,0	6003	2,0	1,5	7045	1,0	0,7
2004*	3,6	2,5	6004	2,0	1,5	7046	1,4	1,0
2008	3,6	2,5	6005	2,0	1,5	7047	1,0	0,7
2009*	3,6	2,5	6006	1,4	1,0	**8000**	2,0	1,5
2010	2,8	2,0	6007	1,4	1,0	8001	2,0	1,5
2011	3,6	2,5	6008	1,4	1,0	8002	2,0	1,5
2012	2,8	2,0	6009	1,4	1,0	8003	2,0	1,5
3000	2,8	2,0	6010	2,8	2,0	8004	2,0	1,5
3001	2,8	2,0	6011	2,0	1,5	8007	2,0	1,5
3002	2,8	2,0	6012	1,4	1,0	8008	2,0	1,5
3003*	2,8	2,0	6013	2,0	1,5	8011	2,0	1,5
3004	2,0	1,5	6014	1,4	1,0	8012	2,0	1,5
3005	2,0	1,5	6015	1,4	1,0	8014	1,4	1,0
3007	1,4	1,0	6016	2,0	1,5	8015	2,0	1,5
3009	2,0	1,5	6017	2,8	2,0	8016	1,4	1,0
3011	2,8	2,0	6018*	2,8	2,0	8017	1,4	1,0
3012	2,0	1,5	6019	1,0	0,7	8019	1,4	1,0
3013	2,8	2,0	6020	1,4	1,0	8022	1,4	1,0
3014	2,0	1,5	6021	2,0	1,5	8023	2,8	2,0
3015	1,0	0,7	6022	1,4	1,0	8024	2,8	2,0
3016	2,8	2,0	6024	2,8	2,0	8025	1,4	1,0
3017	2,8	2,0	6025	2,8	2,0	8028	1,4	1,0
3018	2,8	2,0	6026	2,0	1,5	**9001**	0,8	0,5
3020*	2,8	2,0	6027	2,0	1,5	9002	0,8	0,5
3022	2,8	2,0	6028	2,0	1,5	9003	0,8	0,5
3027	2,8	2,0	6029	2,0	1,5	9004	1,4	1,0
3031	2,8	2,0	6032	2,8	2,0	9005	1,4	1,0
4001	1,4	1,0	6033	2,0	1,5	9010	0,8	0,5
4002	2,0	1,5	6034	2,0	1,5	9011	1,4	1,0
4003*	1,4	1,0	**7000**	2,0	1,5	9016	0,8	0,5
4004*	2,0	1,5	7001	2,0	1,5	9017	1,4	1,0
4005	2,0	1,5	7002	1,4	1,0	9018	1,0	0,7
4006	1,4	1,0	7003	1,4	1,0			

* Examples of critical colors as mentioned in chapter 3. It is recommended to refer to powder coating matches as standards