

Verband der deutschen Lack- und Druckfarbenindustrie e.V.
(German Paint and Printing Ink Association)



VdL Guidance Document VdL-RL 10

Guidance Document Permitted colour tolerances of solid-colour powder coatings in architectural applications

‘VdL Guidance Document: Colour Tolerances’

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Foreword

This guidance document was drawn up by the 'Powder coatings' Technical Committee of the 'Powder coatings' Sector Group of VdL (German Paint and Printing Ink Association) in 2002 and 2003, and updated in 2013, to inform architectural applicators of powder coatings on suitable methods for assessing colour tolerances, and on the limits permitted when making such assessments.

1. Introduction

Powder coatings are widely used for decorating architectural components made of various materials (in most cases, aluminium). For technical reasons, the occurrence of colour differences is often unavoidable. Bearing in mind that the colour perception of the human eye varies from one individual to the next, a colour tolerance that is still acceptable on paper may still give rise to a distinctly perceptible colour distance. By 'colour distance', we mean the magnitude of the perceptual difference between two colours as defined in DIN 5033-1.

Since powder coatings are industrial products whose raw materials (also industrially produced) and manufacturing processes make them subject to certain fluctuations, it is in powder-coating suppliers' interest to ensure that sufficiently wide colour tolerances are accepted for their products. Conversely, powder-coating applicators and end-customers wish these tolerances to be defined as narrowly as possible.

Colour tolerances for powder-coated parts are made up of the tolerances for the powder coatings themselves, and of those from the application process. The main factors affecting the application process are outlined in Point 7 hereof.

This guidance document defines the test conditions and tolerances which powder-coating suppliers deem necessary for powder coatings – in the as-delivered condition – that are intended for architectural use as solid-colour shades. If the requirements specified here are to be applicable to other powder-coating systems and applications as well, this must be agreed separately and explicitly between the supplier and the user.

Colour tolerances caused by application parameters at the applicator's, and colour changes brought about by varying light sources (metamerism, see DIN 6172), are not covered by this guidance document. Because of their different modes of assessment, metallic and effect colours are also not covered by this guidance document.

2. Scope

This guidance document describes the comparison samples, testing methods and permissible colour tolerances for differences between the template and the delivered product, and between two different batch deliveries. This guidance document does not apply to the assessment of finished coated objects and building components, but is relevant only to samples produced in standardised laboratory conditions.

3. Templates for colour matching

Templates for matching and producing colours in powder coatings must meet the following requirements:

- The surface finish must be opaque, and as similar as possible to the desired paintwork finish. (The greater the differences between the surfaces, in terms of e.g. texture and gloss, the greater the visual and measured deviations that may be expected.)
- The assessment area must be flat and uninterrupted, and sufficiently large to permit reliable assessment of the colour. The ideal format for templates lies between DIN A6 (minimum) and DIN A5.

When referring to commercially available colour charts (e.g. RAL and NCS), it should be remembered that these charts are generally pigmented in a different manner from that which is possible with powder coatings. Examples of such charts are given in the Annex. They may deviate in colour – at times substantially – from the manufacturers' applicable reference colour specimens.

Several series of colour charts, such as RAL 840-HR and RAL 841-GL, and to some extent NCS Edition 2, are calibrated against the reference colour specimens by the manufacturers. Note that charts of the matt RAL 840-HR collection appear lighter and less saturated – both to the human eye and to instrumental measurement – than do the same colours in the glossy RAL 841-GL collection. A visible and measurable colour difference may therefore occur even between sample charts of the same designation.

If necessary, then, the parties involved should agree a special chart as a template, and rotate this between them as needed. Calculating reference values based on data on templates (as for instance with RAL 841-GL) has not proved successful in practice and we thus strongly advise against it.

For powder-coating suppliers' standard products, the only relevant template for performing an assessment in case of doubt is the colour chart of the powder-coating supplier concerned.

As the commercially available colour charts have only a finite lifespan, as defined by the manufacturer, they must be replaced regularly. However, in order to prevent any change in the colour of the powder coating, the measured data in the manufacturers' colour analyser systems are not changed, but only the deviation of the new colour charts is recorded.

For RAL-colour products having a gloss of < 65 units (at a 60° measuring angle), the RAL 840 HR collection is mostly used, with the RAL 841 GL collection being used for products with a higher gloss rating. As other agreements may also be made, however, when the exact colour is specified the RAL collection must always be stated as well.

In the case of custom colours, wide deviations in gloss levels and with textured surfaces, it is advisable to define powder-coat colour matches as templates. This still applies even when adequate colour matching of a special template is not possible for pigment-related technical reasons.

All templates must be stored in a suitably protected manner, in the dark and at room temperature. As the colour templates may change over time, they must be checked regularly and replaced as necessary. Wear-and-tear from normal use (scratches, fingerprints etc.) must also be taken into account in this regard.

4. Requirements for comparison panels (batch panels)

Coated panels for documenting and assessing the colours of powder-coating batches must meet the following requirements:

- The surface should be opaquely coated. A coating thickness (measurement method as per EN ISO 2808) of between 80 µm and 100 µm has been found expedient for the purposes of colour assessment, unless other coating thicknesses are necessitated by the hiding power, the nature of the surface, or other agreements. Especially in the case of saturated colours in the red, orange and yellow region where powder-coating suppliers no longer use toxic pigments such as lead chromate, greater coating thicknesses may be needed in order to obtain sufficient hiding power.
- The substrate for assessing the colour distance is a degreased aluminium panel meeting the requirements of the GSB / Qualicoat guidelines, unless separate agreements have been made for a particular product.
- The coating is applied using standard commercial coating guns, and curing is performed in laboratory electric ovens, in accordance with the application parameters laid down by the powder-coating supplier. In particular, the curing conditions specified in the manufacturers' technical datasheets must be complied with. If curing windows are given in the datasheet, the curing conditions to be used must be agreed upon between the parties involved, in order to prevent colour tolerances arising from different curing procedures.

5. Production testing of colours

There are basically two possible ways of assessing the colour differences between a template and a comparison panel (batch panel), or between two separate batch deliveries:

- visual colour comparison under defined conditions (DIN EN ISO 3668)
- instrumental comparison with a colour analyser system (ISO 7724 / DIN 5033 and DIN EN ISO 11664 Part 4)

The critical factor determining whether a batch is passed or failed is the result of visual colour comparison. Colorimetry represents an additional tool with which a decision can be taken in the event of dispute. In visual colour comparison, only minor differences in colour tone should be accepted that do not significantly impair the overall visual impression. The tolerances permitted in instrumental comparison are set out in Point 6 hereof.

The assessment of differences in colour tone, as defined in this guidance document, is to be performed solely in standardised conditions and under a standard illuminant corresponding to average daylight.

5.1 Visual colour comparison under defined conditions (DIN EN ISO 3668)

The specimens for checking (as per Points 3 and 4 hereof) are placed in a colour-matching booth and inspected under lighting from a standard D65 illuminant. The specimens to be assessed must all be lying in the same plane, and exhibit a similar gloss level and as identical a surface texture as possible, so as to preclude any misjudgements that might result from these influences. The assessment must be carried out by persons with normal colour vision, although assessing acceptable tolerances is perceptually subjective and will thus vary from one person to another. Persons with faulty colour vision risk making misjudgements; in most such cases, however, these persons' vision defect does not apply evenly across the entire colour space, but only causes certain colour types to be misinterpreted.

It is necessary to perform colour comparison in a colour-matching booth so as to ensure that the specimens are illuminated solely with the desired type of light, at the necessary illumination level, and without dazzling. In order to rule out any risk of temperature and reactive atmospheric gases influencing the colour impression given by the specimens, the assessment must be carried out at room temperature, unaffected by such gases.

Details of these colour-comparison conditions may be found in the DIN EN ISO 3668 Standard.

5.2 Instrumental comparison with a colour analyser system (ISO 7724, DIN 5033 and DIN EN ISO 11664 Part 4)

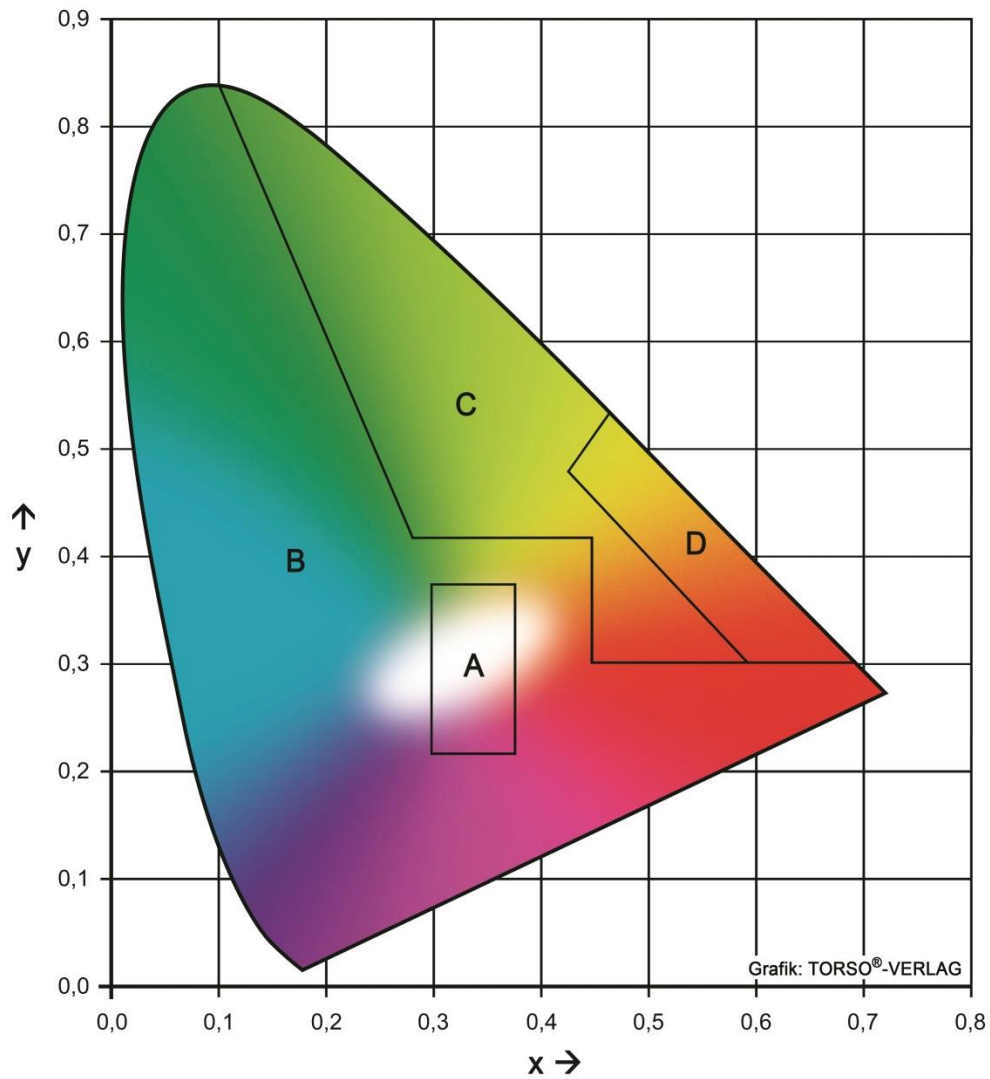
The measurements on the specimens (as per Points 3 and 4 hereof) must be carried out using appropriately calibrated and suitable measuring instruments. Only reflectometer geometries d/8 or 8/d (Ulbricht-type integrating sphere) should be used in the assessment of powder-coated surfaces. Measurement is carried out in 'specular-included' mode (i.e. without the use of a gloss trap). The measurement results are evaluated using the CIELab formula for a 10° Standard Observer and a standard D65 illuminant. Details of the measuring and evaluation conditions may be found in the above-mentioned Standards. Measuring the specimens in 'specular-excluded' mode is not advisable, as the influences of surface texture and gloss may lead here to significant deviations from the visual impression.

Attention must also be drawn here to unavoidable measurement tolerances and to differences in the results as between different measuring instruments (even ones from the same manufacturer). In case of doubt, the parties will have to agree upon one particular measuring instrument to be used for the arbitration analysis. Colour tolerances that are generally permissible (from the suppliers' point of view) in the powder coatings supplied are outlined in Point 6 hereof.

6. Schedule of permissible colour tolerances

The colour deviation from the template, and/or between two batch deliveries, that is permissible for a given colour can be read off from the horseshoe-shaped chromaticity diagram shown below, with reference to the x- and y-values (see ISO 7724-1) of the template. In this case, the x- and y-values describe the respective colour and its saturation. The chromaticity diagram is defined in detail in the DIN 6175-1 Standard. In this VdL Guidance Document, the individual regions have been renamed, and the permissible tolerances for powder coatings have been specially defined. In the light of empirical experience, the tolerances for Region A have been differentiated with reference to the lightness value L (as per CIELab formula) of the template. For certain critical saturated colours in e.g. the red, orange and yellow regions, it is advisable to refer to a matched powder-coated standard panel.

It is expressly pointed out that the colour tolerance values set out in the DIN 6175-1 Standard only apply to automotive refinishing paints and that for various technical reasons (no scope for tinting, deviations in gloss and appearance, justifiable extra work and expense etc.) they are not applicable to powder coatings.



Region	Maximum deviation from template ΔE^* as per CIELab	Batch consistency ¹ ΔE^* as per 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

¹ Batch consistency: maximum permissible colour distance between batch deliveries of one material from one supplier

These data are valid for specimens with a gloss level (60° measuring angle) ≥ 65 units. For readers' information, the permissible colour tolerances resulting from the above table are stated for the colours of the RAL 841 GL collection, in an annex to this guidance document.

For gloss levels of < 65 units, these values must be multiplied by a factor of 1.3 and rounded to one decimal place.

If there is also a difference between the specimens in terms of their surface texture, then the tolerances obtained from this rule must be multiplied once again by a factor of 1.3 and rounded to one decimal place. However, it is recommended to perform a measurement against a matched powder-coated standard panel.

7. Guidelines to applicators

This guidance document only refers to inspection & control of the powder coatings supplied, on test panels prepared under standardised laboratory conditions. Applicators are advised to perform inbound quality testing on powder coatings in accordance with the same criteria.

As changes in colour tone may occur in the course of the coating and curing process, the coated items must always be given goods-outward inspection by the coating firm – quite apart from the usual checks which it would in any case perform as part of its duty of care – in order to prevent defective deliveries.

In particular, the following parameters, which are outside powder-coating suppliers' control, may greatly influence the colour impression given by the coated parts:

- differences in coating thickness (caused by uneven coating)
- curing temperature of the parts and dwell time in the oven (e.g. plant stoppages, workbreaks, plant start-up, changes in plant parameters such as conveyor speeds etc.)
- considerable differences among the parts to be coated, especially in terms of substrate, wall thickness, geometry etc.
- type of pre-treatment
- type of curing oven, e.g. direct gas fired ovens (chemical reactions with the powder), infra-red zones or chamber ovens with longer loading intervals, etc.
- effects from the reclaim system
- discontinuous batch coating
- emissions of operating substances

To prevent unacceptable colour differences and metamerism, it is advisable to avoid combining the same colours if these have been applied under differing conditions and/or if they are from different suppliers or from different series of powder-coating products. When ordering follow-up supplies for existing projects, the applicator must draw the powder-coating supplier's attention to any special requirements for colour consistency.

8. Standards and literature

DIN EN ISO 2808: Paints and varnishes – Determination of film thickness
DIN EN ISO 2813: Paints and varnishes – Determination of specular gloss of non-metallic paint films
DIN EN ISO 3668: Paints and varnishes – Visual comparison of the colour of paints
ISO 7724-1 to -3: Paints and varnishes – Colorimetry
DIN Technical Report 49, 1995 issue: Procedures for agreeing colour tolerances
DIN 5033-1 to -4 and -6 to -7: Colorimetry
DIN 6172: Special metamerism-index for pairs of samples at change in illuminant
DIN 6173-1 and -2: Colour matching
DIN 6175-1: Tolerances for automotive paints; uni paints
DIN EN ISO 11664 Part 4: Colorimetry - Part 4: CIE 1976 L*a*b* Colour space

RAL 840-HR and RAL 841-GL colour collections
NCS Natural Colour System Edition 2
AL 631 quality regulations issued by GSB International e.V., Düsseldorf
VOA Qualicoat, Nuremberg, Germany – Rules for obtaining the quality mark for wet and powder coatings on aluminium for architectural applications

9. User information

Non-members of VdL (German Paint and Printing Ink Association) are also recommended to use this VdL Guidance Document. They must first submit a written statement to VdL committing themselves to abide by the Guidance Document. VdL reserves the right to verify both the information given it, and users' compliance with the Guidance Document. VdL shall be entitled to prohibit non-compliant users from making reference to the VdL Guidance Document, and to take legal action against any misleading statements.

Annex: Colour tolerances (ΔE^* as per CIELab) for the RAL 841-GL collection.

RAL chart	Tolerance versus template	Batch consistency	RAL chart	Tolerance versus template	Batch consistency	RAL chart	Tolerance versus template	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
3028	2.8	2.0	6032	2.8	2.0	9005	1.4	1.0
3031	2.8	2.0	6033	2.0	1.5	9010	0.8	0.5
4001	1.4	1.0	6034	2.0	1.5	9011	1.4	1.0
4002	2.0	1.5	6037	2.8	2.0	9016	0.8	0.5
4003*	1.4	1.0	7000	2.0	1.5	9017	1.4	1.0
4004*	2.0	1.5	7001	2.0	1.5	9018	1.0	0.7
4005	2.0	1.5	7002	1.4	1.0			
4006	1.4	1.0	7003	1.4	1.0			

* Examples of critical colours as stated in Point 3. It is advisable to refer to a colour-matched powder-coated standard panel