

VERBAND DER BAHNINDUSTRIE IN DEUTSCHLAND (VDB)
GERMAN RAILWAY INDUSTRY ASSOCIATION

VDB GUIDELINES

CRITERIA FOR EVALUATING THE COATED SURFACES OF RAIL VEHICLES

INTRODUCTION

High quality products are the hallmark of member companies of the German Railway Industry Association (VDB, Verband der Bahnindustrie in Deutschland).

The coated surfaces of rail vehicles are a key quality feature. They influence to a large degree how passengers perceive the quality of the rail vehicles and hence have direct influence on the reputation of the railway companies and transport associations that use these rail vehicles for their services. High quality coatings also prolong the service lives of rail vehicles.

The quality of coated surfaces is therefore very important for the customers of the rail vehicle manufacturers. Member companies of the VDB and rail operators consequently pay great attention to coating processes and the inspection of coated rail vehicles.

Up until now, differing criteria and procedures have been adopted for evaluating coated surfaces during customer inspections. This is far from ideal because objective evaluation and inspection are not possible without standardized descriptions and procedures. Indeed, such a situation opens the door for different interpretation, leading to unclarity for all involved and in some cases to conflict and delays in product approval.

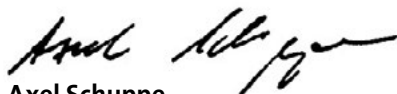
The VDB guidelines entitled “Criteria for evaluating the coated surfaces of rail vehicles” have been drawn up to rectify this. They set out criteria, stipulations, and procedures that allow objective evaluation/testing of coated surfaces, so ensuring that customer inspections are comparable. The evaluation/test criteria bring much transparency to the inspection processes, aid communication, and ultimately improve the collaboration between the relevant parties/departments. They form the basis for common understanding on all matters relating to quality.

This is why these guidelines have been drawn up by the Surface Technology working group of the VDB and approved by technical experts at DB Systemtechnik GmbH. They are directed at inspectors of the railway companies and at employees in rail vehicle manufacturing companies involved in design, coating, coating process control, and quality assurance.

These guidelines are recognized by the members of the VDB and Deutsche Bahn AG as the industry standard. The stipulations and recommendations therein improve general understanding of the inspection/approval process. The guidelines help to guarantee the quality of surfaces – and will certainly have positive effects on further collaborative developments in the railway industry.

To help users implement the guidelines and avoid misunderstandings, a supplementary document has been prepared entitled “User information”. This can be downloaded from the (VDB) website (www.bahnindustrie.info).

The guidelines and user information are regularly checked for their practicality and validity and are kept up-to-date by the Surface Technology work group of the VDB. The latter is open to receiving any comments or suggestions you may have.



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1. AREA OF APPLICATION

These guidelines regulate the procedures for customer inspection approval of the finished coated surfaces on production parts used in the rail vehicle manufacturing industry. Deviating or follow-up regulations, in particular regarding the first article inspection (FAI) process, must be separately agreed by the contract partners. These guidelines and their criteria are acknowledged by the members of the VDB (German Railway Industry Association) as the standard for the railway industry.

The procedures, tests and requirements described herein, reflect the special requirements of the rail vehicle manufacturing industry.

Quality assurance of the individual production stages in the coating process is not a feature of these guidelines.

The requirement specification on the coatings and the coating manufacturers requires that the coating system of the customer test-specimen is qualified and can satisfy those test criteria and requirements described hereafter.

2. PROCEDURE FOR CUSTOMER INSPECTIONS

The customer inspection follows the final coating process and complete assembly of the coated component. Interim inspections and random tests are also possible by arrangement. Technical defects (see Section 3.1.2) in the coated surface (e.g. craters, chips, pores) are not acceptable and must be eliminated prior to inspection.

The implementation of inspection and evaluation may only be undertaken by trained personnel. Required knowledge of the standards and correct implementation thereof are a prerequisite.

The visual inspection must always be carried out under the following conditions:

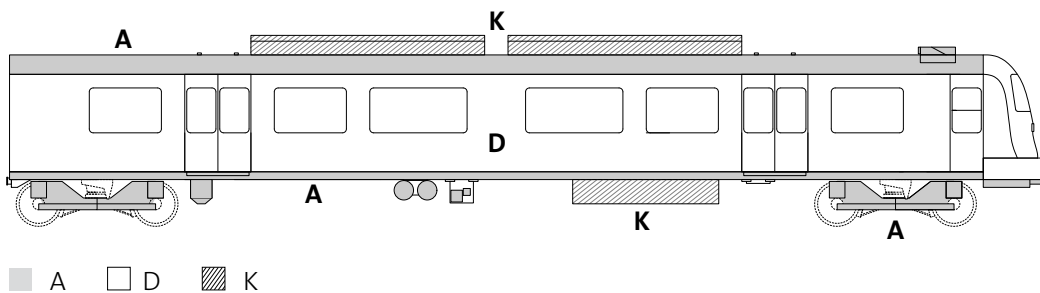
- The viewing distance must be at least 1 m.
- Viewing must be performed with the naked eye, if necessary having been corrected for normal vision. The normal acuteness of vision is the minimum criterion.
- The angle of vision must be 90° to the surface under evaluation.
- The illumination level must be at least 500 lux.
- The lighting must be diffuse and not direct.
- The lighting of the surface under evaluation must be free of surface reflections and direct sunlight whereby light distribution must be uniform and without glare.

2.1 Classification of Inspection Zones

For customer inspection of a rail vehicle body, the surface is divided into different inspection zones. These zones are largely determined by the various requirements placed on the coating for the different zones and vehicle geometries. The definition of the inspection zones is agreed beforehand, order-specific between the customer and contractor.

Zone	Definition	Rail vehicle Area / Sector
A	Exterior technical areas	e.g. undercarriage, roof, upper and lower side wall panels, and bulkhead / forehead panel
I	Interior technical areas	all surfaces not visible to passengers, such as the floor, walls, roof, reverse side cladding, brackets/ supports
D	Visible decorative areas, exterior and interior	e.g. side wall panels, front, bulkhead panels, interior trim
K	Components/parts in Zone A or I	e.g. air conditioning units

Example (zones must be order-specific agreed):



The inspection of an individual part is based on the aforementioned zone classification and the place of installation (e.g. door as in zone D).

For parts such as air conditioning units that have the same coating as the decorative area, but installed in Zones A or I, the inspection criteria for Zone K applies.

2.2 Application of Test Zone Inspection Results

Inspection	Zone A	Zone I	Zone D	Zone K	Anmerkungen
Visual Surface Defects (e.g. dust inclusions)	--	--	X*	X*	*See. 3.1.1 Visual Surface Defects
Technical Surface Defects	X*	X*	X*	X*	*Technical Surface Defects are not permitted (see 3.1.2)
Other Surface Defects (e.g. runs / sags / curtains)	X*	X*	X	X	*limited testing relevance (see 3.1.3 Other Surface Defects)
Colour	--*	--	X	X	*The colour does not have to be exactly calibrated
Dry Film Thickness	X*	X*	X*	X*	*Total Film Thickness (primer and other components of the coating system, see 3.3)
Gloss Value	--*	--	X	X	*The specified Gloss Value does not have to be strictly adhered to.
Structure and Flow	--	--	X*	--	*Evaluation using reference samples
Adhesive Strength (cross-cuttingtest / cross-section test)	X*	X*	X*	X*	*Testing on reference metal sample or directly on vehicle part.

"X" = test relevant; "--" = test irrelevant; "" = comments/ remarks*

3. EVALUATION TESTS

The inspection evaluation tests mentioned in Section 2.2 are described below in more detail.

3.1 Surface Defects

A detailed catalogue of terms for surface defects has been deliberately waived as a fully comprehensive list cannot be depicted. All possible surface defects need to be categorized to Sections 3.1.1 – 3.1.3.

3.1.1 Visual Surface Defects

Visual surface defects are those understood to occur in Zone D and Zone K and not having any effect on the properties of a coating. Essentially they are foreign matter inclusions. The following stipulations apply:

Railcar body in Zone D:

- Size of flaws < 1 mm
are permitted
- Size of flaws > 1 mm and < 2 mm
15 per 10 m² coated side wall are permitted, clusters not
more than 2 per DIN A3 surface area
- Size of flaws > 2 mm
are not permissible

Parts for Zone D:

Depending on the size of the respective part, the number of permissible flaws on the part's surface can be calculated.

- Size of flaws < 1 mm
are permitted
- Size of flaws > 1 mm and < 2 mm
2 per 1.6 m² (ca. 13 times DIN A3 area) - are permitted,
clusters not more than 2 per DIN A3 surface area,
parts smaller than 1.6 m² 1 flaw max. permitted
- Size of flaws > 2 mm
are not permissible

Parts in Zone K:

Depending on the size of the respective part, the number of permissible flaws on the part's surface can be calculated.

- Size of flaws < 1 mm
are permitted
- Size of flaws > 1 mm and < 3 mm
4 per 1.6 m² (ca. 13 times DIN A3 area) - are permitted,
clusters not more than 4 per DIN A3 surface area,
parts smaller than 1.6 m² 2 flaws max. permitted
- Size of flaws > 3 mm
are not permissible

3.1.2 Technical Surface Defects

Technical surface defects are those understood to effect or limit the properties of a coating. Such defects are not permitted. For example open pin holes, craters, surface damages, crackings, blisters belong to this group.

3.1.3 Other Surface Defects

Other surface defects are allowed in Zones A and I. These defects are understood to be those which do not effect the properties of a coating nor limit its technical functions (e.g. runs are not permissible on mounting plates or on sealing or adhesive surfaces but are permitted in other areas of Zones A and I).

3.2 Colour / Hues / Shades

Colour shade evaluation is only relevant for test procedure in Zone D and K and is a visual comparison to a master sample. The ambient illumination must comply with standard daylight (D65) in order to avoid metamerism. If color differences occur then a colour or spectrophotometer should be used for the assessment. Attention must be paid to the calibration of all measuring devices used to ensure comparability of settings and measurement geometry (illuminant, standard observer, CIELAB-colour distance formula). While the total colour distance ΔE^* gives no information about the colourmetric locus, the coatings manufacturer must insure that there is no significant shift of the colour axes L (Brightness level), a (Red-Green level), b (Yellow-Blue level) (CIELAB- Colour space Standard DIN EN ISO 11664-4) by product release.

Subsequent batches must be approved by the coating manufacturer using the design colour chart (e.g. RAL, NCS, RAL DS), the reference sample, and the previous batch.

It is recommended that all sub-suppliers receive an approved master sample as reference from the selected coating manufacturer for color approval for their internal quality assurance.

The VDB working group recommends setting the color distances individually for the respective colours, for example using coated sample metal panels with metrological support. A ΔE^* value of 1.5 has been shown to be a good guideline, however depending on the colour, fluctuation either side of this value is possible. Alternatively, use of the colour distance formula ΔE_{2000} according to Standard DIN EN ISO/CIE 11664-6 is also recommended. This uses correction factors for the calculation and leads to very good visual similarity.

Sources of error and factors influencing colour evaluation:

- Unsuitable ambient light, e.g. artificial light instead of natural light (metamerism)
- Human factors of the person performing the evaluation (metamerism, if necessary check for dyschromatopsia)
- Different instruments and instrument settings
- Different references, e.g. colour samples (RAL charts), coated sample metal panel, film/membrane samples
- Measurements on structured, rough, curved, and uneven surfaces
- Measurements on metallic and effect coatings

3.3 Dry Film Thickness

Following DIN EN ISO 2808 or ISO 19840 the dry film thickness on metals can be ascertained non-destructively.

The regulations from ISO 12944-5 for the dry thickness have to be applied including the tolerance of the specific nominal thickness which is specified in this document.

Special cases (for example surfaces where torque is applied and surfaces for bonding):

- if a film thickness range is specified, then in deviation to the ISO Standard 19840 no tolerance will be permitted (e.g. surfaces to be attached by screws/bolts subject to torque)
- if a minimum film thickness is specified, then in deviation to the ISO Standard 19840 a value below this specification is not permitted at any point
- if a maximum film thickness is specified, then in deviation to the ISO Standard 19840 a value above this specification is not permitted at any point

Because of its importance to corrosion protection it is recommended to measure the dry film thickness of the primer throughout the process.

The same applies for other parts of the coating system, when it can be suitably justified. The documentation of the dry film thickness of interlayers and top coat (layers) is generally not required. For control of process reliability random measurements of dry film thickness for the entire system are sufficient.

Sources of error and factors influencing film thickness measurement:

- Calibration in the incorrect measurement zones
- Calibration on incorrect substrates
- Measurements too close to edges / drill holes (calibration in accordance with DIN EN ISO 2360 is necessary)
- Differences in the thickness of the base material
- Differing conductivity of the base material when eddy current testing
- Surface curvature
- Surface roughness
- Incorrect contact pressure of the measuring sensor
- Temperature effects
- Measurements on composite construction (different substrates)

3.4 Gloss Value

The gloss value is measured in accordance with DIN EN ISO 2813. A minimum of five measurements must be made at representative spots and the average value is to be given. The scattering of the gloss values must be a maximum of 10 gloss units compared to the laboratory values of the coating manufacturer (e.g. measured values on average 80 GU at 20° measuring angle, single values not smaller than 70 and not larger than 90 GU at 20° measuring angle).

Sources of error and factors influencing gloss value measurement:

- Measurements on mat, silk, and high gloss surfaces at an incorrect measuring angle
- Measurement on structured, rough, and corrugated surfaces
- Measurements on curved and uneven surfaces
- Measurements on metallic and effect coatings

3.5 Structure and Flow (properties)

The evaluation of the coating structure in visible decorative areas be carried out using coated reference panels (upper and lower structure reference samples) or approved parts.

3.6 Adhesive Strength (Test)

The adhesion test is made in accordance with DIN EN ISO 2409 -cross-cut or DIN EN ISO 16276-2 – X-cut depending on the thickness of the coating. Permissible results are Gt 0-1 (cross-cut test) and 0-1 (X-cut test) respectively. The tests are performed either on metal panel samples coated simultaneously to the production process or on the object itself.

Prior to evaluation of the cross-cut test, any loose particles must be removed.

The VDB recommends using adhesive tape for this (e.g. Tesa 4124 (clear)).

4. ADDITIONAL SPECIFICATIONS

For customer inspection of the coated surfaces of rail vehicles the following additional specifications apply:

- Overspray of the top coat is acceptable provided the prescribed degree of gloss is reached
- Bold edges and tactile transition in the colour division region are permissible
- Light clouding in metallic coatings is permissible
- Repair work, spot repair, refinish/touch-up, polishing are permissible reworking processes
- Sealing- and adhesive / bonded seams with adhesives and sealants, may be over-coated but do not have to be

LIST OF STANDARDS

- **DIN EN ISO 2409**
Paint and Varnish – Cross-cut test (ISO 2409:2013)
- **DIN EN ISO 2813**
Paint and Varnish – Determination of the gloss value at 20°, 60°, and 85°
- **DIN EN ISO/CIE 11664-4**
Colorimetry - Part 4: CIE 1976 L*a*b* colour space
- **DIN EN ISO/CIE 11664-6**
Colorimetry - Part 6: ISO / CIE 2014 for the colour difference formula
- **DIN EN ISO 2178**
Non-magnetic coatings on magnetic substrates – measurement of the coating thickness – Magnetic methods ISO/DIS 2014
- **DIN EN ISO 2360**
Non-conductive coatings on non-magnetic electrically conductive basis materials metals – measurement of coating thickness – Amplitude-sensitive eddy-current method.
- **DIN EN ISO 2808**
Paint and Varnish – determination of the film thickness
- **ISO 12944-5**
Paint and Varnish- corrosion protection of steel structures by protective paint systems- Part 5: Protective paint systems
- **DIN EN ISO 16276-2**
Corrosion protection for steel structures by protective paint systems
- Assessment of and acceptance criteria for the adhesion/cohesion (fracture strength) of a coating- Part 2: Cross-cut testing and X-cut testing.
- **ISO 19840**
Paint and Varnish - Corrosion protection of steel structures by protective paint systems Measurement of, and acceptance criteria for, the thickness of dry films on rough surfaces

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