



ERWA GUIDELINE FOR AXLE COATING

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1 Preface

ERWA is the “European Railway Wheelset manufacturers Association” and it is a Working Group of UNIFE, whose members are the following companies/groups:

- Bochumer Verein Verkehrstechnik
- CAF Miira
- GHH-Bonatrans Group
- Lucchini RS Group

In order to contribute to enhance the performance of axle protection, with the final aim of increasing the reliability and competitiveness of railway service, the Members of ERWA decided to combine their experience and knowledge about axle coating and, by their joint effort, prepare and publish this “ERWA Guideline For Axle Coating” (hereinafter the “Guideline”) based on the return of experience of the last decades of direct relationship with European and non-European railway operators, car builders and maintenance companies.

The Guideline is public, available, and free to use for everybody in every sector. The recommendations contained in this Guideline should not be interpreted as a standard or approval. This Guideline and its conclusions only provide and reflect the best available information at the time it was prepared.

The Guideline is available for all and can be applied partially or to a full extent by any company – within or outside of UNIFE – without any need of credit but under the full responsibility of the company using the Guideline in any manner.

Neither ERWA nor any of its Members make any claim on intellectual property rights arising from this Guideline. Any change of the contents and their adaptation and application to actual needs and situations are incumbent to the individual company making free use of the Guideline. There is no duty of update and management of the Guideline by ERWA or ERWA Members, but it could be revised by ERWA in any moment, at its sole discretion whenever new experience from the service will be available.

2 Scope

The scope of the Guideline is to indicate the relevant technical parameters for railway axles coating systems. The Guideline also indicates the suggested tests to be performed in order to verify such specified parameters.

3 Technical conditions of component to be coated and environment conditions

The Guideline refers to railway axles manufactured and qualified according to the EN13261.

The axle surface finishing is obtained by lathe turning with a maximum roughness of 1.6 (μm) Ra but in some areas (transitions and grooves) it can be polished to a roughness below 0.8 (μm) Ra (requirements defined in EN 13261).

ERWA has considered axles subject to the following main environment conditions:

- Temperature ranges from about -45°C to $+50^{\circ}\text{C}$; on powered axles the temperature of the axle steel may be higher due to the heating coming from the gear box and the temperature ranges from about -45°C to 80°C . Moreover, there may be for short time thermal radiation from the disc brakes.
- Humidity ranges from 15 to 100 %.
- Presence of ice and snow.
- Salt and other corrosive products and or marine environment shall be considered.
- Depending on the application the wheelset different maximum speeds are defined: 120, 160, 200, 350 km/h.

- For the higher speed ranges axles may be subjected to stone impacts and impact resistance may be required. Similar damages can be generated by ice that can accumulate around the vehicle bogie structure.
- Axles in normal operation may be subjected to particle abrasion (for example sand, brake dust, ferrite dust and other) for this reason a level of resistance to gritting or abrasion may be required.
- Axles are subjected to cyclic bending; maximum strain level amplitudes on the surface are in the range of $\pm 1000 \mu\text{m/m}$.
- The axle maintenance period (that means when the axle coating can be restored to new condition), depending on the application and maintenance policy can range from about 5 to 15 years.
- Axles can come into contact with oil and grease.
- Axles can come into contact with chemical products used for example during cleaning of the vehicles for example from 2 to 5 days. During cleaning often high-pressure washing will be used.
- Ice and snow will be removed with hot water, e.g. 55°C at a pressure of about 5 bar.

4 Requirements for sample preparation

The test shall be performed in order to be applicable to railway axles manufactured according to EN13261; for this reason, whenever possible, the test samples shall be slices of axles manufactured according to this standard. The above is required, because the specific surface finishing may affect, for example, the coating adhesion and general performance of the paint.

When for a certain test, axle samples can't be used, standard reference samples, for example steel plates Q-panel type R, shall be used instead.

Axle specimens for testing shall be obtained from a serial production manufacturing process, machined with the surface requirements according to EN 13261 but with a roughness $\leq 1.6 (\mu\text{m}) \text{ Ra}$.

Samples shall be cut from axles; approximate dimensions shall be: diameter 150-220mm, length 100-150 mm.

The cleaning and the coating application process for the samples shall be the same as the one that is used during the normal serial manufacturing process as defined in point 5 of the present document.

Preferably, the preparation of the samples and the coating should be done at a wheelset manufacturing site, instructed and supervised by the coating manufacturer / supplier.

The tests shall be carried out several days after the application of the coating, depending on the paint system and the recommendations of the paint supplier. In the absence of any information, a period of 14 days after the application of the coating may be adopted.

5 Coating application process

The coating application process shall be equivalent to the one that will be used in serial production at wheelset manufacture plant or railway operator maintenance shops and according the application instructions from the coating manufacturer / supplier.

The main characteristics of this process are:

- Cleaning process, surface degreasing and cleaning solvents. Surface tension
- Pot life
- Coating application type (airless, high pressure, air mix)
- Air pressure supply, depending on the coating system
- Application conditions, temperature, humidity, film thickness

- Curing time, air and forced drying, room temperature or heat hardening in the case of heated room (it is preferable that the coating manufacturer / suppliers provides a curing time chart dependent on the temperature providing also the possibility of curing at room temperature).
- Working viscosity

The coating manufacturer / supplier shall describe and document in a report all the above relevant parameters used in the preparation of the samples. This preparation report will be part of the coating qualification documentation.

6 Test program and requirements

6.1 Classification of coatings (with reference to classification of EN 13261)

Some characteristics of coatings may change depending on the application. Three classes are identified:

- Class 1: this coating is able to protect the axle surface from impact indentations generated for example by flying stones or ice. Usually the thickness of the coating is relatively high (for example 4 to 10 mm) and it should be mainly used for protecting high speed axles.
- Class 2: even if this coating is not resistant to impacts, it is a high-performance coating having to stand contact with typical strong chemicals used during the cleaning of vehicles and having a high performance in presence of salty environment and abrasion or gritting conditions.
- Class 3: this coating has no specific requirements in terms of chemical resistance and it is less demanding in terms of salty environment and abrasion conditions.

6.2 Requirements to be obtained

A list of tests is required for qualifying a coating (see table 1).

Some tests are to be repeated at different temperatures (-40, 20, 60°C) and after an artificial aging cycle, as defined in 6.3.

Table 1 summarizes the qualification tests to be performed.

6.3 Artificial aging

The reference for the aging cycle is the Test Specification PV1200 from Volkswagen AG to be repeated 100 times:

The temperature shall be regulated with a tolerance of ± 2 °C and the relative air humidity (rel. humidity in the following) with a tolerance of $\pm 5\%$.

The climatic chamber shall be set to room temperature (23 °C) and 30% rel. humidity before the test specimen is inserted.

The holding times must always be maintained. The heating and cooling phases can be varied according to the performance capability of the climatic chambers used. Deviations shall be specified in the test report.

One cycle (see Figure 1) lasts for 720 min (12 h) and comprises the following temperature and humidity profiles:

- 60 min heating phase to +80 °C and 80% rel. humidity,
- 240 min holding time at +80 °C and 80% rel. humidity,
- 120 min cooling phase to -40 °C, when freezing point is reached: approx. 30% rel. humidity, the air humidity remains unregulated as of $T < 0$ °C (depending on the system, humidity regulation can also be suspended as of $T < 10$ °C),
- 240 min holding time at -40 °C, air humidity remains uncontrolled,
- 60 min heating phase to +23 °C, rel. humidity is regulated to 30% as of $T = 0$ °C

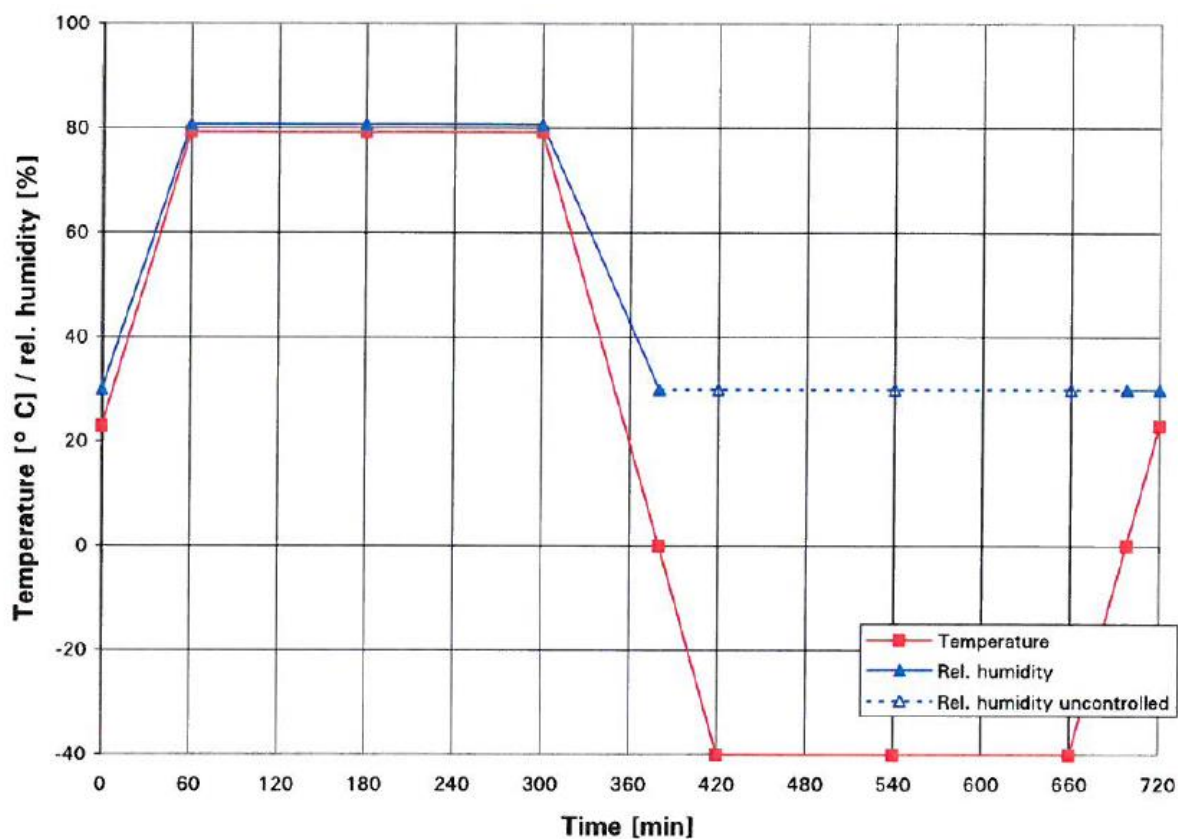


Figure 1 – Test cycle for PV 1200

				Samples per class			New condition (without aging)			Aged condition (according to chapter 5.3)			
				Class 1	Class 2	Class 3	-40°C	20°C	60°C	-40°C	20°C	60°C	
Coating property to be verified	Test method and reference standards	Sample type	N° of samples / tests per class (1, 2, 3)	Class 1	Class 2	Class 3	-40°C	20°C	60°C	-40°C	20°C	60°C	Results to be achieved
Coating thickness	The thickness is to be measured according to EN ISO2808, provided that the thickness of the coating permits this. If not, it is to be agreed in the technical specification. Method 7C is recommended for conventional coatings.	All samples has to be tested for this and the following tests	all	all	all	all		x					According EN 13261:2020-09. Measure all samples and verify that the measured values are in agreement with the requirements of the coating application procedure
Resistance to salt spray	Salt spray test according to EN ISO 9227.	slices of axle (The test sample could be also a steel plate (e.g. 5-10 mm thickness). This is useful for thick coatings class1.	3	3	3	3		x					According EN 13261:2020-09 (Corrosion propagation from the cut < 2 mm) ; Evaluation according ISO 4628 - 2, -3, -4, -8. Possible to evaluate the minimum duration in steps of: 240, 480, 720, 1000 hours. Requirements: Class 1 ≥ 480 hours Class 2 ≥ 1000 hours Class 3 ≥ 480 hours
Resistance specific corrosive products	Immersion test according to EN13261:2020-09 (Annex I) The immersion test shall be followed 24 h after by the adhesion test defined in EN ISO 2409:2013 or EN 16276-2 or EN ISO 4624.	slices of axle	3		3			x					According EN 13261:2020-09
Determination of ignitibility and lateral flame spread, of smoke toxicity and density and of the heat releases	EN45545-2 -Requirements for fire behavior of materials and components, EN ISO 5659-2, ISO 5660-1), ISO 5658-2 (only required for TSI WAG applications)	defined in EN 45545-2: steel plates, dimensions length*width*thickness: 100*100*1 (ignitibility and lateral spread), 75*75*1 smoke toxicity and density), 800*155*1-3 max. heat relapses [mm] Coating thickness: at the upper thickness of the coating and their application.	3 steel plates per class and test, dimensions length*width*thickness: 3 plates 100*100*1, 3 plates 75*75*1, 3 plates 800*155*1-3 mm	9	9	9		x					According TSI Loc & Pas COMMISSION REGULATION (EU) No 1302/2014 of 18 November 2014: Tests according : EN 45545-2 R9 (HL2). According TSI WAG COMMISSION REGULATION (EU) No 321/2013 of 13 March 2013: Test according ISO 5658-2 with: ignitibility and lateral flame spread: CFE ≥ 18 kW/m²

				Samples per class			New condition (without aging)			Aged condition (according to chapter 5.3)			
				Class 1	Class 2	Class 3	-40°C	20°C	60°C	-40°C	20°C	60°C	
Coating property to be verified	Test method and reference standards	Sample type	N° of samples / tests per class (1, 2, 3)	Class 1	Class 2	Class 3	-40°C	20°C	60°C	-40°C	20°C	60°C	Results to be achieved
Coating adhesion	Usually for thickness above 1 mm: Pull off test – ISO 4624. But it is recommended according EN 13261:2020-09. The pull-off test is recommended as an additional test for all coating thicknesses in assessment of the coating and assessment of a manufacturer of a coated axle.	slice of axle	3 samples new condition, 3 samples aged condition. Notes: 1): Measurement made first at 20°C and then at 60°C on the same samples 2): it is possible to use the same samples as for the pull off tests.	3 ;Note 1)	3 ;Note 1)	3 ;Note 1)		x	x		x	x	According EN 13261:2020-09 P ≥ 4 MPa at 20°C; at 60°C for information. The Pull – off test classification B or n (cohesion break greater than 90%) of clause 8.5 of EN ISO 4624.
	For thickness up to 250 µm: Cross-cut test EN ISO 2409 For thickness from 250 to 1000 µm: X-cut test EN 16276-2.	slice of axle			3 ;Note 2)	3 ;Note 2)			x			x	
Resistance to bending (coating elasticity)	Bending test according EN ISO 1519, Type 2 mandrel tester. Determination of the diameter of the first mandrel to cause failure.	Steel plate 0.5 - 1mm thick, not blasted Coating thickness: average or nominal range of application.	6 plates (Q-Panels type R, 0,5-1mm thickness		6	6	x	x	x	x	x	x	No coating damage with mandrel diameter of 32 mm
Resistance to impact	According EN 13261:2020-09 (with a energy of 90J).	slice of axle, It is possible to use one sample for more tests	18	18			x	x	x	x	x	x	According EN 13261:2020-09 (no damage of the axle metal surface)
Stone chip resistance	Stone chip - EN ISO 20567-1 method B.	steel plate 203x102x(0.7 to 1 mm) not blasted; lower thickness range of coating application	18 plates		18	18	x	x	x	x	x	x	Class 2 ≤ Rating 3 Class 3 ≤ Rating 4
Gritting resistance	Gritting test according EN 13261:2020-09	slice of axle	3		3	3		x					Class 2 ≤ Level 3 Class 3 ≤ Level 4

Table 1 – List of qualification tests and requirements for the three classes of coatings.

7 General requirements

- All coating proposed shall comply with the REACH regulation (REGULATION (EC) No 1907/2006 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency amending Directive 1999/45/EC and repealing Council Regulation (EEC) No 793/93 and Commission Regulation (EC) No 1488/94 as well as Council Directive 76/769/EEC and Commission Directives 91/155/EEC, 93/67/EEC, 93/105/EC and 2000/21/EC)
If there are revisions or amendments: the actual documents has to be considered
- VOC value shall be documented. (DIRECTIVE 2004/42/CE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 21 April 2004 on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain paints and varnishes and vehicle refinishing products and amending Directive 1999/13/EC) *If there are revisions or amendments: the actual documents has to be considered*
- Coating manufacturers / suppliers shall document and be able to demonstrate the constant quality of their product complying with the requirements stipulated in this document continuously.

8 Disclaimer

This Guideline is provided for information and educational purposes only. It is intended to offer the users a guidance deriving from developed data and experience. Adherence to this Guideline does not guarantee any successful outcome nor approval from third parties.

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