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TL 244

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Descriptors: zinc, nickel, passivation, sealing, chromium (VI)-free, corrosion protection, surface protection

Zinc/Nickel Alloy Coatings

Surface Protection Requirements

Previous issues

TL 244: 1987-10, 1992-05, 1993-11, 1995-12, 2002-05, 2004-12, 2006-08, 2007-02

Changes

The following changes have been made compared with TL 244: 2007-02:

- Scope supplemented by components ≤ 1 200 MPa with heat treatment
- Ofl-r647 and Ofl-r648 added
- Table of surface protection types containing Cr(VI) (formerly Table 2) removed
- Figures 1 and 2 added
- Test acc. to PV 1209, PV 1200, and PV 1210 added
- Requirement for homogeneous structure added
- Upper limit of nickel content changed
- Notes on testing regarding layer thickness measurement (formerly Section 4) added in Section 3.9
- Requirements in Section 3.11 changed
- Referenced standards updated
- Standard restructured

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1 Scope

This Technical Supply Specification (TL) specifies requirements for electrolytically deposited and Cr(VI)-free post-treated zinc/nickel alloy coatings on ferrous materials and steel parts with a tensile strength $R_m \leq 1\,000$ MPa according to code letter "r" specified in Volkswagen standard VW 13750. It furthermore defines application limits and exceptions for tensile strength values > 1 000 MPa.

The alloy coatings defined in this standard must not be used for steel parts with a tensile strength $R_m > 1\,200$ MPa and a surface hardness > 370 HV. Exceptions may be made for components with a tensile strength R_m between 1 000 MPa and 1 200 MPa. However, heat treatment acc. to DIN EN ISO 4042 is required in these cases.

These coatings, used as heavy-duty corrosion protection (protection class 6), are especially suitable for components and systems of threaded joints for which, besides an increased corrosion load, a temperature load of up to 150 °C (engine compartment and brake area) is to be expected. The silver-colored coatings Ofl-r642, Ofl-r643, Ofl-r645 and Ofl-r647 are particularly suitable for conducting connections (ground connections).

In particular, these coatings are suitable for fasteners with driving recess to avoid clogging of force application points.

Due to their electrochemical compatibility, they are also suited for use in contact with aluminum materials (but not for use in direct contact with magnesium materials).

Ofl-r647 and Ofl-r648 are particularly suitable for parts subjected to plastic deformation after surface coating (e.g., pipe systems, blind rivet nuts, blind rivet bolts, punching bolts).

2 Description

See VW 13750, Section 2.

3 Requirements

3.1 Surface protection types

The surface protection types listed in Table 1 apply.

Table 1

Surface protection type	Characteristics and appearance
Ofl-r642	Zinc/nickel coating, passivated (silver-colored to soft bluish iridescence), preferred surface protection type for adhesive coatings (MKL) and locking all-around coatings (KLR) acc. to VW 60424
Ofl-r643	Zinc/nickel coating, passivated and additionally sealed (silver-colored to soft bluish iridescence)
Ofl-r645	As for Ofl-r643, but with additional lubricant treatment acc. to TL 52132
Ofl-r647	Zinc/nickel coating, passivated (bendable zinc/nickel coating, silver-colored to soft bluish iridescence), e.g., for pipe systems

Surface protection type	Characteristics and appearance
Ofl-r648	As for Ofl-r647, but additionally with two layers of top coat which contains aluminum pigments and which is applied using the dip/spin coating method (description: Xylan 5320/F1138, silver-colored) and additional lubricant treatment acc. to TL 52132
Ofl-r649[a)]	Zinc/nickel coating, deposited from weakly acidic electrolytes, silver-colored, passivated, and additionally sealed (only for castings, e.g., brake calipers)
Ofl-r672	Zinc/nickel coating, deposited from alkaline electrolytes, black, passivated, preferred surface protection type for black adhesive coatings (MKL) and locking all-around coatings (KLR)
Ofl-r673	Zinc/nickel coating, black, passivated, and additionally sealed
Ofl-r677	As for Ofl-r673, but with additional lubricant treatment acc. to TL 52132

a) The use of weakly acidic electrolytes is to be coordinated with the departments GQL-LM/2 and/or I/GQ-32.

3.2 General requirements

Approval of first supply and changes acc. to VW 01155.

Avoidance of hazardous substances acc. to VW 91101.

10 finished parts are required for complete testing.

NOTE 1 Surface protection types with sealing may impair paintability.

These coatings are also unsuitable for sealing elements on gas-carrying systems such as the air-conditioning system, because the coatings contain micro-cracks. Subsequent plastic deformation (flaring, pinching, bending) of coated components must be avoided as this could damage the corrosion protection and thus reduce the component's corrosion resistance. Ofl-r647 or Ofl-r648 are to be used preferrentially for parts subjected to subsequent plastic deformation. Ofl-r647 is to be used preferentially for fluid-carrying systems.

Unless certain sections of a part that are marked in the drawing are excluded from the surface coating, the entire surface of the parts must comply with the required surface protection type and display the prescribed properties. The coatings must adhere firmly to the base material.

General notes on surface morphology: The surface roughness of parts with a zinc/nickel coating depends, among other things, on the characteristics of the zinc/nickel electrolyte and/or the surface finish of the component. The difference in surface roughness R_z between the uncoated and coated component must be ≤ 5 µm. Distinct nodulation on the zinc/nickel surface in connection with severe cracking as illustrated in Figure 1 are to be avoided since they have a negative influence on the coating's properties (e.g., flaking, insufficient corrosion protection, unintended welding of components due to friction during assembly). A homogeneous structure (no distinct nodulation) which may exhibit fine cracks from the surface to the base material must be ensured for the zinc/nickel coating (see Figure 2).

NOTE 2 The coatings shown in Figure 1 and Figure 2 were deposited as rack-galvanized goods. Barrel-galvanized goods may deviate slightly therefrom.

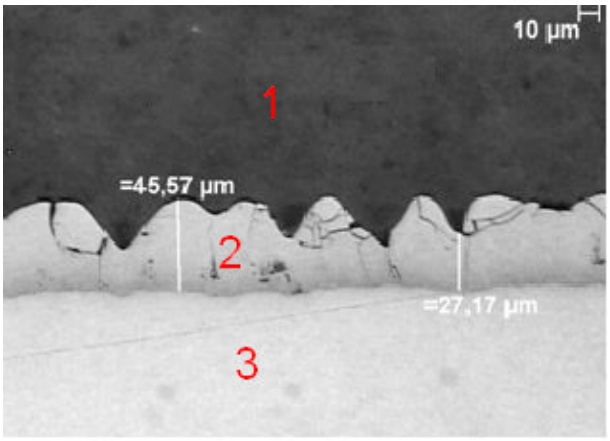

Figure 1 – Zinc/nickel coating with distinct nodulation and cracking (not OK)

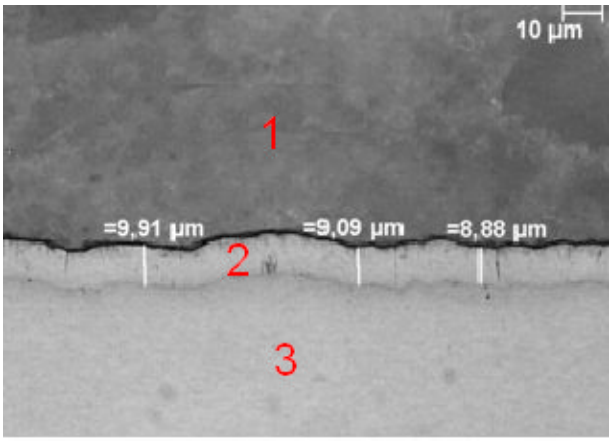

Figure 2 – Zinc/nickel coating with homogeneous structure (OK)

Legend

1	Embedding mass
2	Zinc/nickel coating
3	Steel

The production process and its control must not impair the functional characteristics of the finished part.

The protective layers must not exhibit any pores, cracks, damage or other flaws that were caused by the deposition method and which impair corrosion protection and/or specified appearance.

Given proper mounting, the coating must not exhibit any damage that would lead to impairment of function and/or decrease of the specified corrosion protection.

The surface treatment procedure is to be conducted so that damage by delayed brittle fractures (hydrogen embrittlement) can be ruled out. This must be verified in the first-sample test report by means of the bracing test according to DIN 50969.

3.3 Fasteners

In the case of metric threaded parts, the coating must not result in the h-position being exceeded in the case of external threads or the H-position being fallen below in the case of internal threads (see VW 11611).

In the case of screws, the test requirements listed below only apply to the head and/or the wrench surfaces; in the case of nuts, they apply only to the nut body without threaded area, and in the case of quick fasteners, they apply to the body. For threaded and thread-like shaped parts, such as tap end studs, the test requirements only apply to the face surfaces.

The reduced requirements according to Section 3.11 apply to process-related weak spots of the coating on fasteners such as the shank and the thread as well as to quick fasteners.

Furthermore, the specifications in DIN EN ISO 4042 concerning the maximum possible thickness of the electroplated coating in the thread profile must be taken into consideration.

Fasteners with metric threads must be treated with lubricants according to TL 52132 in order to ensure constant coefficients of friction. The coefficients of friction are tested according to VW 01129.

The surface structure of the zinc/nickel layer has a considerable impact on the coefficients of friction. It is therefore imperative to avoid nodulated parts (see Figure 1).

3.4 Zinc/nickel coating process

For components with geometrically complicated shapes, the coatings deposited from alkaline systems are especially suitable. These coatings display a uniform nickel distribution over the entire current-density range.

Except for Ofl-r649, all zinc/nickel coatings described herein are deposited from alkaline electrolytes. Ofl-r649 is deposited from weakly acidic electrolytes.

If direct deposition from alkaline zinc/nickel electrolytes, e.g. on cast materials, is possible only under unfavorable conditions, the surface may be activated by deposition of a pre-zinc coating from a weakly acidic zinc electrolyte. The use of such a 2-layer system as well as the electrolytes used must be agreed upon with the Volkswagen AG Laboratory (GQL-LM/2) and/or the Audi AG Test Laboratory (I/GQ-32).

3.5 Cr(VI)-free conversion layers

In order to improve the corrosion resistance of electrolytically deposited zinc/nickel coatings to salt water and condensed water, a post-treatment in passivation treatment solutions is required.

The passivation treatment solution must not contain any Cr(VI) compounds in order to ensure that the resultant conversion layers are likewise Cr(VI)-free.

3.6 Post-treatments

In areas visible to the customer, the appearance of the components must not be impaired by strong color variations (iridescence). Therefore, a sealing post-treatment of the conversion layer must be performed depending on the surface protection type. This results also in an improvement of the corrosion protection.

Long periods until the first occurrence of corrosion (e.g., 1 000 h and more) obtained in the salt spray test acc. to DIN EN ISO 9227 do not provide reliable information. Therefore, corrosion tests for sealed zinc/nickel coatings must be performed acc. to PV 1209 or optionally acc. to PV 1200 and PV 1210. Please refer to Section 3.11 for further notes.

Organic polymers, inorganic protective layers or mixtures of the two, which can contain additional inorganic and/or organic lubricants if necessary, can be used for sealing.

The thickness of the layer structure may be increased slightly by the additional sealing (0,1 µm to 2 µm), but this must not impair the functionality of the surface.

If besides the corrosion protection further functional surface characteristics such as paintability, compatibility with agents, sliding properties, threading behavior, vulcanizability, temperature behavior or electrical conductivity are required, part-specific tests or functional tests must be performed.

The post-treatments must not cause any impairments such as unsightly drop-like residues resulting from crystallization and/or formation of a film on the part surface.

3.7 Base material

See drawing or master data list (MDL).

3.8 Nickel content

X-ray fluorescence test using measurement devices based on DIN EN ISO 3497.

In disputed cases, the test is to be performed acc. to PV 1214 and/or PV 1216.

Requirement for Ofl-r642, Ofl-r643, Ofl-r645, Ofl-r672, Ofl-r673 and Ofl-r677: 12% to 16%

Requirement for Ofl-r647 and Ofl-r648: 10% to 15%.

Requirement for Ofl-r649: 10% to 18%.

In exceptional cases, exclusively for castings (e.g. brake caliper), a nickel content of 12% to 17% is permissible for deposits from an alkaline electrolyte system.

3.9 Thicknesses of the electroplated coating

Testing acc. to DIN EN ISO 1463, DIN EN ISO 2178, and DIN EN ISO 3497.

A coating thickness measurement device based on the X-ray fluorescence measuring method described in DIN EN ISO 3497 (e.g. Fischerscope device from Helmut Fischer GmbH & Co., Germany) that allows for the simultaneous measurement of coating thickness and nickel content is to be used.

The measuring duration is chosen so that repeat accuracy is lower than or equal to 0,5 weight percent nickel. Repeat accuracy is defined as the standard deviation of measured values under repeat conditions (same observer, same equipment, same specimen with same measuring point, short intervals between measurements).

The coating thickness is measured using the magnetic/inductive method according to DIN EN ISO 2178 by applying a test probe to the surface. For specimens with a rough surface, several individual measurements (at least 5) must be performed on the reference surface. The measuring result indicates the local coating thickness. The measuring equipment must be checked by comparative testing at regular intervals or prior to a measurement series.

Requirement:

8 µm to 25 µm (for components of a general nature),

8 µm to 15 µm (for threaded parts, measuring point according to DIN EN ISO 4042),

6 µm to 10 µm for components with Ofl-r647 and Ofl-r648.

NOTE 3 In order to meet the corrosion protection requirements set forth in Section 3.11, screws with driving recess and combined parts with black passivated zinc/nickel alloy coatings require a thicker base layer than silver-colored zinc/nickel alloy coatings. This is due to the fact that, depending on process control, the layer thickness may decrease by up to 3 µm during black passivation. Insufficient base layer thickness will thus result in insufficient corrosion protection of the driving recesses and the washers.

3.10 Adhesive strength

Thermal shock test based on DIN EN ISO 2819.

The specimen is aged for 30 minutes at (300 ± 10) °C and is then submerged in water with a temperature of 15 °C to 25 °C.

Requirement: no bubble-shaped or large-scale stripping of the zinc coating.

3.11 Corrosion behavior

The corrosion resistance of the systems must be ensured in the as-received condition and also after a 24-hour period of aging at an elevated temperature of 120 °C. These are minimum requirements which must always be adhered to.

The tests acc. to Section 3.11.1 and Section 3.11.2 must be performed for systems with passivation and sealing layers. The tests acc. to Section 3.11.1 must be performed for systems without sealing layers.

3.11.1 Test method NSS according to DIN EN ISO 9227.

The following applies to the evaluation of the zinc/nickel coatings including passivation and sealing layers:

- No base metal corrosion after a test duration of 720 h for all surface protection types according to TL 244.
- No zinc corrosion after the test durations listed in Table 2. Zinc corrosion up to a maximum degree of change of S4 acc. to DIN 34804 is permissible after a test duration of 720 h.

The following applies to the evaluation of the shank and thread areas of threaded and quick fasteners:

- No base metal corrosion after a test duration of 480 h.

Table 2 – Test durations and requirements for the evaluation including passivation and sealing layers

Protection type	Test duration in h		Requirement
	Barrel plated goods[a)]	Rack-galvanized goods	
Ofl-r642	120	144	Zinc corrosion up to a maximum degree of change of S1 acc. to DIN 34804 permissible
Ofl-r672	96	-	
Ofl-r647[b)]	-	240	
Ofl-r648	144	-	
Ofl-r649[b)]	-	120	
Ofl-r643	144	240	
Ofl-r645	144	240	
Ofl-r673	144	240	
Ofl-r677	144	-	

a) Barrel-galvanized goods are small parts which cannot be coated as rack-galvanized goods because of their shape, and which therefore are coated as bulk goods.

b) Not intended for barrel plated goods.

3.11.2 Test method acc. to PV

After 4 cycles (4 weeks) of climate corrosion cycle test acc. to PV 1209 or optionally 20 cycles acc. to PV 1210 and 16 cycles acc. to PV 1200 (5 cycles acc. to PV 1210 are followed by 4 cycles acc. to PV 1200). Evaluation acc. to DIN EN ISO 2081.

The following applies to the evaluation of passivated zinc/nickel coatings including sealing:

- No base metal corrosion after 4 cycles (4 weeks) of climate corrosion cycle test ac. to PV 1209 or optionally 20 cycles acc. to PV 1210 and 16 cycles acc. to PV 1200.

4 Other applicable documents

The following documents cited in this Standard are necessary to its application.

Some of the cited documents are translations from the German original. The translations of German terms in such documents may differ from those used in this Standard, resulting in terminological inconsistency.

Standards whose titles are given in German may be available only in German. Editions in other languages may be available from the institution issuing the standard.

PV 1200	Vehicle Parts; Testing of Resistance to Environmental Cycle Test (+80/-40) °C
PV 1209	Kondensatoren, Wasser- und Ladeluftkühler aus Al-Legierungen; Korrosionsprüfung (Klima-Korrosionswechsel-Test)
PV 1210	Body and Add-on Parts; Corrosion Test
PV 1214	Zinc or Nickel Alloy Coatings; Determination of Nickel Content
PV 1216	Determination of Nickel Content Using ICP-OES
TL 52132	Lubricant for Threaded Fastening Elements with Electrolytically Applied Coatings or those of Stainless Steel; Requirements
VW 01129	Limit Values for Coefficients of Friction; Mechanical Fasteners with Metric ISO Threads
VW 01155	Vehicle Supply Parts; Approval of First Supply and Changes
VW 11611	Metric ISO Thread; Limit Dimensions with Protective Coating for Medium Tolerance Class; External Threads 6gh / Internal Threads 6H
VW 13750	Surface Protection of Metal Parts; Surface Protection Types, Codes
VW 60424	Designation Information for Screws, Bolts, Nuts and Washers; Shapes, Types and Additional Specifications
VW 91101	Environmental Standard for Vehicles; Vehicle Parts, Materials, Operating Fluids; Avoidance of Hazardous Substances
DIN 34804	Fasteners - Change of appearance of black surfaces
DIN 50969	Testing of high-strength steel building elements for resistance to hydrogen-induced brittle fracture and advice on the prevention of such fracture
DIN EN ISO 1463	Metallic and oxide coatings - Measurement of coating thickness - Microscopical method
DIN EN ISO 2081	Metallic and other inorganic coatings - Electroplated coatings of zinc with supplementary treatments on iron or steel
DIN EN ISO 2178	Non-magnetic coatings on magnetic substrates - Measurement of coating thickness - Magnetic method
DIN EN ISO 2819	Metallic coatings on metallic substrates - Electrodeposited and chemically deposited coatings - Review of methods available for testing adhesion
DIN EN ISO 3497	Metallic coatings - Measurement of coating thickness - X-ray spectrometric methods
DIN EN ISO 4042	Fasteners - Electroplated coatings

DIN EN ISO 9227	Corrosion tests in artificial atmospheres - Salt spray tests