Electroplated ZnNi coatings on ferrous materials

Surface protection requirements

M 3536

Dimensions in mm

This English version is a translation. In case of doubt or conflict the valid German-language original will govern.

Contents

1 Scope and purpose

This standard defines the requirements for electrolytically deposited and **Cr(VI)-free** post-treated zinc-nickel alloy coatings on ferrous materials.

The main purpose of coating application is corrosion protection.

The component group-specific application of the standard is defined in accordance with MAN 183-3.

The standard does **not** apply to components covered by the scope of the following standard:

M3514 "High-strength components (≥ 1000 N/mm^2) with electroplated ZnNi coating; qualification procedure for components **without** annealing" (in preparation)

This standard distinguishes between the component tensile strengths < 1000 N/mm^2 and ≥ 1000 N/mm^2 and for fasteners between the property classes < 10.9 / 10 and = 10.9 / 10.

The ZnNi coatings are particularly suitable for components and systems of threaded joints where, besides an increased corrosion load, a temperature load of up to 150°C is to be expected.

The standard DIN 50979 applies in full except for the following specific provisions:

- Definition of MTB-specific surface protection types in accordance with Section 3
- Restriction of application properties in accordance with Section 4
- Requirements on the coating in accordance with Section 5
- Definition of the permitted coating process in accordance with Section 7
- Heat treatment to expel hydrogen in accordance with Section 7

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Prepared by: Kluger, EAS	Release EAS: 2013-09, englisch	Replaces: 2011-05	Material group no.:

2 Release conditions

All parts of the standard series MAN 239 apply. They define the release conditions and procedures, as well as the general terms of delivery for purchased parts.

3 Surface protection types

The surface protection types listed in Table 1 apply.

Table 1: Surface protection types

Protection types	Type:
Zinc-nickel coating Passivated, silver-coloured iridescence (frequently referred to as thick-coat passivation)	S
Zinc-nickel coating Passivated, silver-coloured iridescence (frequently referred to as thick-coat passivation) Sealing	SV
Zinc-nickel coating Passivated, silver-coloured iridescence (frequently referred to as thick-coat passivation) Sealing Lubricant treatment for defined coefficient of friction	SVR
Zinc-nickel coating Passivated, black	B
Zinc-nickel coating Passivated, black Sealing	BV
Zinc-nickel coating Passivated, black Sealing Lubricant treatment for defined coefficient of friction	BVR

4 Application properties

Table 2 shows a selection of important general application properties that must be observed when using ZnNi coatings.

Function surfaces with increased requirements with respect to settling behaviour, e.g. sealing surfaces, tooth profiles or screw contact surfaces, must be tested in the respective individual case.

Table 2: Application properties of ZnNi coatings

Can characteristic	Specific information on suitability	Comment
Weldability	ZnNi without sealing: restricted suitability ZnNi with sealing: restricted suitability	The corrosion protection coating melts due to the high temperatures
Bondability *)	Without sealing better than with sealing. Low-viscosity adhesives have good bonding with the ZnNi layer	If paste adhesives are used, additionally apply a primer beforehand to improve adhesion (chemical bonding not possible, only via topography)
Vulcanisation	Outstanding suitability	With corresponding cleanness and pre-treatment requirements
Lamination	Possible if suitable primers are applied to the ZnNi surface	Resin systems must be matched for this (polyester, epoxy resin)
Embedding in thermoplastics	Joining only by form fit (in-mould lamination)	No material fit bonding
Temperature resistance	Without passivation: < 260 °C With passivation: < 230 °C With sealing: < 180 °C (peak loads)	With sealing depending on the respective sealing type Continuous load: 150 °C independent of passivation and sealing
Compatibility with operating fluids	To be agreed in individual case	
Recoatability *)	Without sealing better than with sealing	Also with sealing better than for zinc-flake coatings
Compatibility with contact partners (contact corrosion)	Contact corrosion potential is lower if sealing is present	Very good in combination with aluminium, less suitable in combination with magnesium, stainless steel Refer to information in NTM 2011.05

*) Must be tested in an individual case on an application-specific basis. No generally valid statement possible!

5 Requirements for ZnNi coating

5.1 Coating structure

The normal structure of the ZnNi coating is shown in Fig. 1:

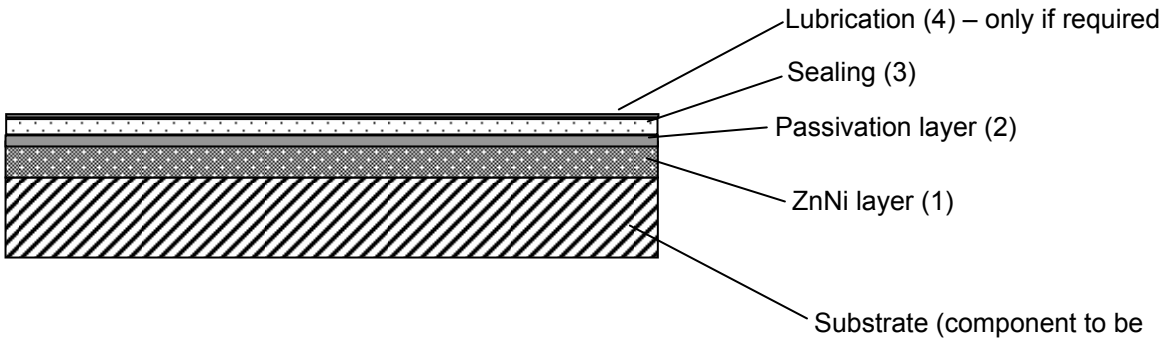

Fig. 1: Normal structure of the ZnNi coating

The coating structure is divided into corrosion and function layers.

The corrosion layers are responsible for the corrosion resistance of the coating.

The function layers are responsible for functional surface characteristics (e.g. friction behaviour, welding behaviour, recoatability, bondability, etc.).

Corrosion layers:

- ZnNi layer (1)
- Passivation layer (2)
- Sealing (3)

Function layers:

- Sealing (3) (partially also with integrated lubricant for friction coefficient adjustment)
- Lubrication (4) (for friction coefficient adjustment; normally relevant only for fasteners)

The sealing layer (3) can be assigned both to the corrosion layers and the function layers.

5.2 General coating requirements and surface topography

The entire protective coating must not have any pores, cracks, damage or other flaws that impair the corrosion protection or prescribed appearance.

The structure of the ZnNi coating must be as homogeneous as possible.

Coating-typical microcracks are permitted if these do not negatively affect the required service, corrosion and assembly characteristics.

The difference in surface roughness between an uncoated component and coated component must not exceed 5 µm referred to the R_Z value. The permitted tolerance of 5 µm designates the permitted total deviation (rougher or finer).

5.3 Coating thickness requirements and coating thickness testing

The requirements for the coating thickness of the ZnNi coating (1) in accordance with Table 3 apply.

Table 3: Coating thickness requirements

Type of component	Coating thickness of the ZnNi coating (1)	Remarks/notes
General components	8 µm to 25µm	If no specific requirements are stipulated (e.g. in component drawings), the coating thickness must be applied as uniformly as possible over the entire component surface. Component locations that are to be locally uncoated or have different coating thicknesses must be identified clearly in the component drawing.
Threaded components	8 µm to 15 µm	The requirements in accordance with DIN EN ISO 4042 apply in full. The measurement locations in accordance with DIN EN ISO 4042 apply for determination of the local coating thicknesses

The requirements for the coating thickness of the passivation layer (2) and any sealing (3) and lubrication (4) are defined in Sections 7.2 and 7.3.

The thickness of the zinc-nickel coating must be preferably determined in accordance with DIN EN ISO 3497 using the X-ray fluorescence spectrometry method. This method also permits determination of the nickel content (requirements in accordance with 4.4) in the coating.

Other coating thickness measuring methods are microscopic measurements in accordance with DIN EN ISO 1463 or the magnetic method in accordance with DIN EN ISO 2178. The passivation and sealing coating thicknesses are not taken into account.

Coating composition and adhesion requirements

The nickel content of the ZnNi coating (1) must be between 12 % and 16 %.

The coating adhesion is tested in accordance with DIN EN ISO 2819. In deviation from the provisions in accordance with DIN EN ISO 2819, the test samples are stored for 30 min at 300 ± 10 °C and then immediately quenched in water with a temperature of 15 °C to 25 °C. The coating must not flake off or form bubbles.

5.5 Corrosion requirements and tests

The corrosion resistance is tested in the neutral salt spray test in accordance with DIN EN ISO 9227 and evaluated with the help of DIN EN ISO 2081. The requirements with respect to minimum resistance apply both in delivery condition and following storage at an elevated temperature of 120 °C for 24 h.

Table 4 applies to the corrosion requirements on the component and thus for the overall coating system consisting of ZnNi coating (1) + passivation layer (2) + sealing (3) + lubrication (4).

The assessment criterion is the occurrence of red rust (base metal corrosion).

Table 4: Corrosion protection requirements for the overall system with testing in acc. with DIN EN ISO 9227 - Base metal corrosion

Type of component	Minimum test duration without red rust (base metal corrosion)	Comment
General components	720 h for all normal areas 480 h in special areas	In the case of coating-critical component geometries, component-specific agreements may be required with definition of special areas that are to be identified in the component drawing.
Fasteners (threaded components, screws and bolts, nuts)	720 h for all normal areas 480 h in special areas	Normal areas: - Bolt head - Nut body Special area: - Shank area - Thread area

The component group-specific application of the standard is defined in accordance with MAN 183-3.

The corrosion resistance against white rust (coating corrosion) is principally determined by the structure of the passivation layer (2) + sealing (3) applied to the component. The requirements in accordance with Table 5 apply.

The assessment criterion is the occurrence of white rust (coating zinc corrosion).

Table 5: Test times and requirements for assessment of passivation layers and sealing for coating zinc corrosion

Protection Type:	Test duration in h		Requirements
	Barrel-plated goods	Rack-plated goods	
S	120	144	No zinc corrosion after the prescribed test duration. Slight visual change (greying) without voluminous character permitted White rust occurs relatively soon after approx. 72 h – 240 h. There is then no further optical change up to 720 h.
SV	144	240	
SVR		240	
B	96	-	
BV	144	144	
BVR		-	

6 Basic requirements

No damage to the coating may occur during the entire logistics and assembly process that leads to impairment in the function or corrosion protection of the components.

Damage due to hydrogen embrittlement that can occur due to the coating process must be excluded. Proof must be provided by the bracing test based on DIN 50969 or in accordance with MAN 183-3 Section 7.1. If none of these standards should be suitable, a suitable bracing test must be agreed between the coating company and the MTB specialist department. (also see Section 7.5)

The surface condition of the supplied rough parts must be agreed between the coating company and the component manufacturer (rough part manufacturer). The delivery condition must permit problem-free pre-treatment (degreasing, pickling) in accordance with the defined process variants described in Section 7.

The surface concentration of adsorbed atomic hydrogen on the component surface (hydrogen coverage) must be kept as low as possible by appropriate coating process measures.

The exposure times in all process steps must be kept as short as possible on a component-specific basis and documented correspondingly.

7 Coating process and post-treatment

7.1 Pre-treatment and coating process

A typical process for an electroplated zinc-nickel coating comprises the following steps: alkaline degreasing – pickling– alkaline, electrolytic degreasing – metal deposition– post-treatment

In the case of electrolytic degreasing, only anode polarity of the component to be degreased is permitted. The use of pole reversers is expressly prohibited.

Pickling must be performed with defined, controlled pickling times (as short as possible). The pickle must be provided with suitable inhibitors.

Only alkaline baths with pH>14 are permitted. The coatings deposited from alkaline systems are particularly suitable for components with a geometrically complex shape. These coatings display a uniform nickel distribution over the whole current density range.

The ZnNi coating thickness and the growth rate of the coating must be defined by specified limit values.

The current density and electrolyte condition must be subject to permanent online monitoring with reference to defined process intervention limits during the coating process.

The ZnNi electrolyte must have a defined and component-specific chemical composition.

It must be ensured that no contact material is applied on the function surfaces since no layer can be deposited there and these areas cannot be reworked in some cases.

In addition, part-specific tests or function tests must be performed if other functional surface characteristics are required in addition to corrosion protection such as recoatability, media compatibility, sliding properties, screw fastening properties, temperature behaviour or electrical conductivity.

The requirements for edges and cut surfaces in accordance with M 3549 must be noted and observed.

7.2 Passivation

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

These layers are Cr(VI)-free conversion layers that are produced by immersion in or spraying of the components with passivation solutions. The deposited coating reacts with the passivation solution to form a thin film that protects the metal coating.

7.3 Sealing

In addition to the ZnNi coatings and passivation, it is also possible to use a sealing layer consisting of Cr(VI)-free organic polymers, inorganic protective coatings or a mixture of these (organic sealing is preferred for high-strength fasteners). This may result in a slight increase in thickness, but this must not impair the functionality of the surface. Sealing coatings usually have a coating thickness of 2 µm.

NOTE: The sealing coating usually also eliminates the interference colours produced by passivation.

7.4 Friction coefficient / lubrication

In order to reduce the friction coefficients and their scatter in the thread and under the head, the fasteners must be provided with an overall coefficient of friction of μ_{tot} = 0,09 – 0,14 (target mean value μ_{tot} = 0,11) by means of suitable lubricants or lubricants already integrated in the coatings.

The lubricants shall be tested in accordance with VDA 235-101 and M 3222 with respect to fulfilling the friction coefficients; they must be released by MAN (see MAN release list for M 3222) and may not be changed, even on a part-specific basis, without the agreement of MAN.

The lubricants must be recoatable with the coatings standardised in M 3031, M 3094, and M 3162 without any adverse visual or chemical effects.

7.5 Post-treatment

7.5.1 Components with strengths < 1000 N/mm^2 or fasteners with property classes < 10.9 / 10:

The tempering process after the treatment process may be chosen freely as long as the requirements of this standard and DIN 50979 are met and the service characteristics are not impaired.

7.5.2 Components with strengths ≥ 1000N/mm^2 or fasteners with property class 10.9 / 10:

In order to avoid hydrogen embrittlement, a heat treatment must be performed subsequently for the purpose of hydrogen effusion and where appropriate to reduce residual component stresses. However, the characteristics of the parts must not be impaired by this heat treatment. Reference values for heat treatment for hydrogen effusion are specified in Table 6 below.

Table 6: Reference values for heat treatment for hydrogen effusion after electroplating treatment in accordance with this standard

Tensile strength in N/mm^2	Heat treatment conditions in air circulating oven Minimum holding duration at part temperature (215 ± 15) °C in h
1000 to 1250	6
1251 to 1450	12
1451 to 1600	20
1601 to 2000	24

8 Testing for hydrogen embrittlement

The test for hydrogen embrittlement must be performed in accordance with MAN 183-3 Section 7.1.

Standards quoted

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 50979	Metallic coatings - Electroplated coatings of zinc and zinc alloys on iron or steel with supplementary Cr(VI)-free treatment
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
MAN 183-3	Cr(VI)-free corrosion protection coatings for components for commercial vehicle engineering
MAN 239-1 ff.	General terms of delivery for purchased parts, all parts
M 3031	Single-component top coating materials; 1K top coat
M 3094	Two-component top coating materials, 2K top coat
M 3162	2K base coating materials, primer
M 3222	Lubricants for threaded fasteners
M 3276	Lubricant coating of pipe fasteners
M 3514	Higher-strength components with electroplated ZnNi coating - Qualification procedure
M 3515	Electroplated ZnNi coatings for components with a tensile strength ≥ 1000 N/mm^2 Coating qualification requirements
M 3537-1	Functional qualification testing of higher-strength components with electroplated ZnNi coating - General requirements
M 3549	Edge and cut surface quality on components made of metallic materials
VDA 235-101	Friction coefficient adjustment of mechanical fasteners with metric thread

Previous issues M 3536 : 2011-04, 2011-05

Changes Compared to issue 2011-04 the following changes have been made:

- Application scope extended to high-strength fasteners
- Section 4: Reference to function surfaces inserted
- Table 2: Reference to NTM 2011.05
- Section 5.2: Surface roughness was revised
- Table 5: Definition of white rust inserted
- Section 7.3: Organic sealing preferred for high-strength fasteners
- Section 7.4: Friction coefficient/lubrication was added
- Section 7.5: was revised
- Section 8: was added

Compared to issue 2011-05 the following changes have been made:

- Table 2: Index * added

  In German version, term "Edelstahl" replaced by "stainless steel"
- Section 5.5: Reference to corrosion protection requirements in accordance with MAN 183-3
- Section 7.1: Note on contact material added

  Reference to M 3549 added