Cr(VI)-free corrosion protection systems for components for commercial vehicle engineering

MAN 183-3

Dimensions in mm

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

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The MAN 183-3 standard shall be applied for the following applications:

- **Higher-strength fasteners (screws, bolts and nuts) of property class ≥ 8.8/8**
- **Fasteners (screws, bolts and nuts) of property class ≤ 6.8/6**
- **Fasteners with increased temperature requirements**
- **Wheel bolts and nuts**
- **Screws for thermoplastics**
- **Self-tapping screws**
- **Wood screws**
- **Thread rolling and thread cutting screws**
- **Pipe/hose fittings, hose mounts, and hose ferrules**
- **Washers**
- **General components**
- **Wheel bolts and nuts**

MAN 183-2 continues to apply to the following application:

Higher-strength fasteners (screws, bolts and nuts of property class ≥ 8.8/8) with surface protection containing Cr(VI)

- **Wheel bolts and nuts (containing Cr(VI))**

Continued on Page 2 to 25

Co-sponsors: EPTA

Technical responsibility:	Standardization:	Replaces:
Knott, EZAS	Jürgens, EZAS	MAN 183-3: 2017-06

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1 Scope and purpose

The Cr(VI)-free corrosion protection systems as per this standard replace the previous systems containing Cr(VI) as per MAN 183-2 and DIN EN ISO 4042.

If a Cr(VI)-free corrosion protection system in accordance with this norm is documented for a component, **in agreement with MAN** a corrosion protection containing Cr(VI) of the same type as per MAN 183-2 may be supplied for a certain transition period (except for pipe fittings).

If the supplier-specific approval for the Cr(VI)-free systems in accordance with Section 2 is not yet available, the coatings must be reported to MAN as per Section 5 before use and must be approved by MAN.

If there is already a supplier-specific approval as per Section 2 for a Cr(VI)-free corrosion protection system and **if MAN agrees**, the Cr(VI)-free system as per this standard can be delivered even if systems containing Cr(VI) (e.g. A3C) are specified in the standard designations in the master data or drawings. In such cases, MAN must agree to a test exemption. This only applies to the applications approved as per this standard.

This standard describes Cr(VI)-free corrosion protection systems for various applications on iron materials and steel parts. The specific application characteristics are combined in corresponding requirement profiles by a code.

By stipulating additional requirements over and beyond generic standards, the purpose of this standard is to ensure the following for high-tensile drawing screws:

- the quality of the corrosion protection systems,
- resistance to hydrogen-induced brittle fracture and
- reduction in friction values and their distribution

2 Release conditions

All parts of the standard series MAN 239 apply. In these standards the release conditions and procedures as well as the general terms of delivery for purchased parts are laid down.

High-strength components with corrosion protection systems and lubricants in accordance with this standard may be purchased only from manufacturers/coating companies that have been approved by MAN.

In the case of the initial release of corrosion protection systems/coating companies for electroplated coatings for parts with strengths of $R_m \geq 1000$ N/mm^2 and for other systems for parts with strengths of $R_m \geq 1200$ N/mm^2, proof must be produced of measures to protect against hydrogen-induced brittle fracture as per DIN 50969-1 /-2 and, if requested by MAN, of a bracing test carried out as per Section 6.9.

The corrosion protection properties of the systems in accordance with Section 6.10 are verified with approval of the corrosion protections systems and coating companies by the Materials Technology department. Corrosion-related approval of these systems is documented via the system/material item numbers (also see Appendix A) in host screen T127A. Verification of other functional characteristics (e.g. friction coefficients, electrical conductivity, etc.) is not part of this corrosion-related approval inspection.

For this purpose, the corrosion protection system must be presented in good time for material approval to the Materials Technology department in the form of coated series components, **including a report as confirmation of compliance with the requirements in accordance with Section 6.10 issued by an accredited test laboratory (DIN EN ISO / IEC 17025)**. In addition to the test report relating to the respective requirements, a detailed description of the corrosion protection system must also be submitted.

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Process control and the process technologies used for the coating process (pretreatment, coating, heat treatment and post-treatment processes) must be checked and evaluated as part of the initial sample release.

The released corrosion protection system/coating company must be used for all series deliveries and may only be changed with the agreement of MAN and after a new initial sample inspection.

Any change to the corrosion protection system and processes will necessitate a new release by MAN.

3 Designation of the corrosion protection systems

- In technical documentation (drawings): e.g. **Corrosion protection MAN 183-B1**
  or **MAN 183-PHR**
- In the designation of standard parts: e.g. **Hex bolt DIN 931-M10x40-10.9-MAN 183-B1**
  Self-tapping screw M 3296 ST4,2x22-MAN 183- B4 - OS
  MAN 183- B1 -finish-rolled

Number of this standard

Code for the corrosion protection system in accordance with Table 1

Without lubrication, see Section 6.6

There is no need to specify -OS in the standard designations in assembly drawings

Finish rolling only in special cases in accordance with Section 6.11

4 Corrosion protection systems

Table 1 of this standard specifies the properties and requirements for standard type codes that can be met with different Cr(VI)-free corrosion protection systems. Thus, electroplated coatings can be used in parallel with zinc flake coatings for some type codes.

Table 2 defines which Cr(VI)-free corrosion protection systems are released for particular application areas with specific application characteristics.

Explanation of the footnotes in Table 1

[0]) The provisions in Sections 1 and 6 must be observed for non-high-strength components with a strength of PC ≤6.8 / 6 or $R_m \leq 600$ N/mm^2

[1]) For mechanical fasteners with property class ≥ 8.8/8 as per VDA 235-104.10.

[2]) Only for strengths $R_{m \geq}$ 1000 N/mm^2/PC 10.9.

[3]) With or without lubrication as per Table 2 and -OS specification.

[4]) Coating B4 or B16 is permitted only if the colour black is required for design reasons or as a distinguishing feature for pipe fittings.

[5]) For coatings B1 and B4, suitable coating procedures are required, in particular for internal threads, small external threads, and internal drives with scooping areas.

[6]) The coating of fasteners of property class 12/12.9 with electroplating systems is not permitted.

[7]) Higher strengths must be released separately.

[8]) Since zinc-flake coating is not permitted for thread diameters of less than M6 for B1 and B4, thread diameters of ≤ M5 are coated with electroplated ZnNi with passivation and where appropriate sealing.

[9]) See M 3536 Table 4 for definition of normal area and special area

[10]) The tolerance position must be taken into account if a red rust resistance of 720 h is required for higher-strength fasteners. The tolerance position of the uncoated component must be specified in the initial sample report.

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Table 1 Corrosion protection systems; type codes, properties, and requirements

Code of the corrosion protection system	**PHR** [1])	**B1** [5])[8])	**B4** [4])[5])[8])	**B7**	**B11**
Time until red rust occurs, test as per DIN EN ISO 9227-NNS	6 h	480 h 720 h: - higher-strength fasteners [10]) - screws for thermoplastics - self-tapping screws	480 h	120 h	720 h (normal area) 480 h (special area) [9])
Approved for tensile strengths R_m in N/mm^2 or PC [0])	--	The following applies for electroplated coatings: $R_m \leq 1000$ or PC $\leq$ 10.9/10		--	$R_m \leq 1000$ [7])
Type of system (without lubricant) For lubricants, see Section 6.6	Phosphating, oiled [1])	Coating system consisting of metal pigment layer or electroplated coating (+ passivation) as base layer and, if appropriate, sealing [6])		Metal pigment layer with top coat	Electroplated ZnNi coating with thick-coat passivation
Colour of system	**Grey/black**	**Silver-grey**	**black**	**Grey**	**Silver-grey**
Recommended layer thicknesses	max. 5 µm [1]) Otherwise min. 5 µm	Min. 8 µm			
General requirements	DIN EN ISO 9717	Section 6.2, VDA 235-104, for pipe fittings VDMA 24576		Section 6.2, VDA 235-104	Section 6.2, VDA 235-104, for pipe fittings VDMA 24576
Additional requirements:	See Section:	See Section:		See Section:	See Section:
- Component condition	6.1	6.1		6.1	6.1
- Preliminary treatment	6.3	6.3		6.3	6.3
- Corrosion protection system	6.4.1	6.4.2 or 6.4.3		6.4.3	6.4.2
- Heat treatment/annealing	6.5.1 [2])	6.5.1		--	6.5.2
- Lubricant/friction values [3])	6.6/6.7	6.6/6.7		--	--
- Coating thickness	6.8	6.8		6.8	6.8
- Bracing test	6.9	6.9		6.9	6.9
- Corrosion resistance	6.10	6.10		6.10	6.10
- Electrical conductivity	Good	None		None	Good
- Contact corrosion	see M 3539	see M 3539		see M 3539	see M 3539
- Finish rolling (special case)	6.11	6.11	6.11	6.11	--

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Table 1 Corrosion protection systems; type codes, properties, and requirements (continued)

Code for coating	**B12**	**B13** [6])	**B15** [6])	**B16** [4])[6])	**B31**	**B32**
Time until red rust occurs, test as per DIN EN ISO 9227-NNS	720 h (normal area) 480 h (special area) [9])	120 h	240 h	240 h	720 h	720 h
Approved for tensile strengths R_m in N/mm^2 or PC [0])	$R_m \leq 1000$	$R_m \leq 1000$ or PC ≤ 10.9/10				
Type of system (without lubricant) For lubricants, see Section 6.6	Electroplated ZnNi coating with thick-coat passivation and sealing	Electroplated Zn coat-ing with thick-coat passivation	Electroplated ZnFe coating with thick-coat passivation	Electroplated ZnFe coating with thick-coat passivation and seal-ing	Metal pigment layer	Metal pigment layer
Colour of system	**Silver-grey**	**Silver grey iridescent** (guide value)	**Silver grey irides-cent** (guide value)	**black**	**Silver-grey**	**Silver-grey**
Recommended layer thickness-es	Min. 8 µm					
General requirements	Section 6.2, VDA 235-104, for pipe fittings VDMA 24576	Section 6.2, VDA 235-104				
Additional requirements:	See Section:					
- Component condition	6.1	6.1	6.1	6.1	6.1	6.1
- Preliminary treatment	6.3	6.3	6.3	6.3	6.3	6.3
- Corrosion protection system	6.4.2	6.4.2	6.4.2	6.4.2	6.4.3	6.4.3
- Heat treatment/annealing	6.5.2	6.5	6.5	6.5	6.5	6.5
- Lubricant/friction values [3])	--	6.6/6.7	6.6/6.7	6.6/6.7	6.6/6.7	6.6/6.7
- Coating thickness	6.8	6.8	6.8	6.8	6.8	6.8
- Bracing test	6.9	6.9	6.9	6.9	6.9	6.9
- Corrosion resistance	6.10	6.10	6.10	6.10	6.10	6.10
- Electrical conductivity	None	Good	Good	None	None	None
- Contact corrosion	see M 3539	see M 3539	see M 3539	see M 3539	see M 3539	see M 3539
- Finish rolling (special case)	--	6.11	6.11	6.11	6.11	6.11

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Table 2 Applications

	Code	Corrosion protection system	Lubrication/subsequent treatment	Released systems **)	Comments
1.	**Higher-strength fasteners (screws, bolts and nuts) of property class ≥ 8.8/8** The coating of fasteners with property class 12/12.9 with electroplating systems is not permitted.				
	B1	Zinc-flake coating without top coat	Normal case: with lubricant according to M 3222 Lubrication with Delta-Lube 10 green is omitted for micro-encapsulated screws	Delta Protekt KL 100 + Delta-Lube 10 green	The max. layer thickness must not restrict screwability. Only for thread diameters ≥ M6
		Electroplated coating		ZnNi as per M 3536 Type SVR	**Only for thread diameters < M6**
	B4 *)	Zinc-flake coating	Lubricant coating to achieve the friction coefficients in Section 6.7	(Normal case) Delta Tone/Delta Seal	Colour black due to design requirements Fasteners in visible area Only for thread diameters ≥ M6
		Electroplated coating		ZnNi as per M 3536 Type BVR	**Only for thread diameters < M6**
	PHR	Phosphating	Subsequent treatment with silicone-free corrosion protection oils on all sides Lubrication with lubricant oil emulsions (e.g. Parkerol) on all sides	Znph/r/5/T4	Application only inside units The washing off of lubricant oil emulsions is not permitted.

*) Not to be used for fasteners with ribs (hexagonal flange nuts/ribbed bolts) since no assembly parameters have been defined up to the present time.

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Table 2 continued - Applications

	Code	Corrosion protection system	Lubrication/subsequent treatment	Released systems **)	Comments
2.	**Fasteners (screws, bolts and nuts) of property class ≤ 6.8/6** *)				
Normal case	**B1**	Electroplated coating	Friction coefficients as per Section 6.7 do not apply	ZnNi as per M 3536 Type SV	In the event of procurement problems for ZnNi in non-European locations, a zinc-flake coating can be procured in deviation from this. The max. layer thickness must not restrict screwability.
	B4	Zinc-flake coating with top coat		Delta Tone + Delta Seal Black (normal case) (Geoblack) blocked for new designs	Colour black due to design requirements Fasteners in visible area Reduction of the risk of contact corrosion
		Electroplated coating		ZnNi as per M 3536 Type BV	
	B11			ZnNi as per M 3536 Type S	For conductive contact points which were previously coated with A2C/A3C
	B13			Zn in accordance with DIN EN ISO 19598	Use only in the interior and engine
	B15			ZnFe in accordance with DIN EN ISO 19598	
	B16				Colour black due to design requirements Fasteners in visible area Use only in the interior and engine
	PHR	Phosphating	Subsequent treatment with silicone-free corrosion protection oils on all sides	Znph/r/5/T4	Application only inside units The washing off of lubricant oil emulsions is not permitted.

*) Components with lower-strength threads (≤ 600 MPa) for which no property class in accordance with ISO 898 is specified and that cannot be assigned to Sections 3 to 9 are coated in accordance with Table 2.11 (e.g. plug screws)

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Table 2 continued - Applications

	Code	Corrosion protection system	Lubrication/subsequent treatment	Released systems **)	Comments
3.	**Fasteners (screws, bolts and nuts) for higher temperature requirements**				
	B7	Zinc-flake coating with top coat	Friction coefficients as per Section 6.7 do not apply	Delta-Protekt KL 120 + Delta-Heat Zinktek 200 + 2x Techseal Silver S-HAT Geomet 321A + 2x Plus 10	For increased requirements with respect to heat resistance and unfastening capability up to 400 °C For material, see DIN 267-13 (e.g.: DIN 267-13-GA)

*) The unfastening capability must remain guaranteed for fasteners. Copper-plated fasteners serve as a reference here which are used at MTB as standard in higher temperature ranges (see MAN 183-1, Table 4)

Table 2 continued - Applications

	Code	Corrosion protection system	Lubrication/subsequent treatment	Released systems **)	Comments
4.	**Wheel bolts and nuts**				
Normal case Bolts	**B31**	Zinc-flake coating without top coat	Lubricant coating	Geomet 500 + Dacrolub 10	In the case of wheel bolts, a maximum layer thickness of 12 µm on the fitting surface must not be exceeded.
Normal case Nuts	**B32**	Zinc-flake coating with top coat	Integrated lubrication, Lubricant coating	Geomet 500 + Plus VL + microGleit DF 902	

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Table 2 continued - Applications

	Code	Corrosion protection system	Lubrication/subsequent treatment	Released systems **)	Comments
5.	**Screws for thermoplastics**				
Normal case	**B1**	Electroplated coating	No lubricant additives (integrated or additional)	ZnNi as per M 3536 Type SV	In the case of plastic screws, the screws can come loose if there are reduced coefficients of friction.
	B4			ZnNi as per M 3536 Type BV	In the case of plastic screws, the screws can come loose if there are reduced coefficients of friction. Colour black due to design requirements

Table 2 continued - Applications

	Code	Corrosion protection system	Lubrication/subsequent treat-ment	Released systems **)	Comments
6.	**Self-tapping screws**				
Normal case	**B1**	Electroplated coating	No lubricant additives (integrated or additional)	ZnNi as per M 3536 Type SV	The max. layer thickness must not restrict screwability.
	B4	Zinc-flake coating with top coat	No lubricant additives (integrated or additional)	Delta Tone + Delta Seal Black (Geoblack) blocked for new designs	Colour black due to design requirements
		Electroplated coating		ZnNi in accordance with M 3536 Type BV	
	B13	Electroplated coating		Zn in accordance with DIN EN ISO 19598	Use only in the interior and engine

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Table 2 continued - Applications

	Code	Corrosion protection system	Lubrication/subsequent treatment	Released systems **)	Comments
7.	**Wood screws**				
Normal case	**B1**	Zinc-flake coating Electroplated coating	No lubricant additives (integrated or additional)	Geomet 321 Delta Protekt KL 100 ZnNi as per M 3536 Type SV	The max. layer thickness must not restrict screwability. In the event of procurement problems, it is possible to procure an alternative surface protection system: MAN 183-B15
	B4	Zinc-flake coating with top coat		Delta Tone + Delta Seal Black (Geoblack) blocked for new designs	Colour black due to design requirements In the event of procurement problems, it is possible to procure an alternative surface protection system: MAN 183-B16
	B13	Electroplated coating		Zn in accordance with DIN EN ISO 19598	Use only in the interior and engine
	B15			ZnFe in accordance with DIN EN ISO 19598	
	B16				Colour black due to design requirements Use only in the interior and engine

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Table 2 continued - Applications

	Code	Corrosion protection system	Lubrication/subsequent treatment	Released systems **)	Comments
8.	**Thread rolling and thread cutting screws**				
Normal case	**B1**	Zinc-flake coating	Lubrication appropriate for assembly	Geomet 321 Delta Protekt KL 100	DIN 7500-1 (for thread rolling screws) or DIN 7513 and DIN 7516 (for thread cutting screws) Electroplated coating only for thread diameter < M6
		Electroplated coating		ZnNi in accordance with DIN EN ISO 19598 ZnNi8//Cn//T2	
	B4	Zinc-flake coating with top coat		Delta Tone + Delta Seal Black	

Table 2 continued - Applications

	Code	Corrosion protection system	Lubrication/subsequent treatment	Released systems **)	Comments
9.	**Pipe fittings and pipe and hose fasteners** *)				
Normal case	**B1**	Electroplated coating	No friction coefficient optimisation (normal case) Exception: Union nuts as per DIN 3870, lubrication on all sides as per M 3276, M 3222	ZnNi, passivated, with inorganic sealing ZnNi, passivated, with organic sealing Zn, passivated, with organic sealing	Supplier-specific coating as per VDMA 24576 Corrosion resistance K4 or K5 as per VDMA 24576
	B4		No friction coefficient optimisation (normal case)	ZnNi, passivated, with inorganic sealing	Colour black only for cutting rings as per MAN 195 Supplier-specific coating as per VDMA 24576 Corrosion resistance K4 or K5 as per VDMA 24576

*) Among other things, this includes hose fittings and ferrules, sealing nuts, lock nuts, measuring connections, flange connections, adapters, pneumatic and hydraulic couplings (e.g. plug-in and screw couplings), hydraulic valves (e.g. throttle valves, pressure limiting valves, directional control valves, and non-return valves), and valve control blocks.

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Table 2 continued - Applications

	Code	Corrosion protection system	Lubrication/subsequent treatment	Released systems **)	Comments
10.	**Washers**				
Normal case	**B1**	Zinc-flake coating Electroplated coating	No lubricant additives (integrated or additional)	Geomet 321 Delta Protekt KL 100 ZnNi as per M 3536 Type SV	At least 5 µm Zinc flake coatings in normal case for nominal size ≥ 7. Also possible for smaller nominal sizes for some forms.
	B4	Zinc-flake coating with top coat		Delta Tone + Delta Seal Black (Geoblack) blocked for new designs	At least 5 µm Colour black due to design requirements Reduction of the risk of contact corrosion
	B11	Electroplated coating		ZnNi as per M 3536 Type S	For conductive contact points which were previously coated with A2C/A3C For higher conductivity requirements, stainless steel is recommended.
	B12			ZnNi as per M 3536 Type SV	For higher abrasion resistance requirements
	B13			Zn in accordance with DIN EN ISO 19598	Use only in the interior and engine
	B15			ZnFe in accordance with DIN EN ISO 19598	
	B16				Colour black due to design requirements Use only in the interior and engine
	B7	Zinc-flake coating with top coat		Delta-Protekt KL 120 + Delta-Heat Zinktek 200 + 2x Techseal Silver S-HAT Geomet 321A + 2x Plus 10	For increased requirements with respect to heat resistance up to 400 °C
	PHR	Phosphating	Subsequent treatment on all sides as per DIN EN ISO 9717 No lubrication	Znph/r/5/T4	**Special case** Very low corrosion resistance

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Table 2 continued - Applications

	Code	Corrosion protection system	Lubrication/subsequent treatment	Released systems **)	Comments
11.	**General components (components that are not covered by the application areas 1 to 10)**				
Normal case	**B1**	Zinc-flake coating Electroplated coating	No lubricant additives *) (integrated or additional)	Geomet 321 Delta-Protekt KL 100 Magni B 46 ZnNi as per M 3536 Type SV etc.	Zinc-flake coatings are not suitable for adhesive bonding Exception: Micro-encapsulation to secure fasteners in accordance with MAN 222
	B4	Zinc-flake coating Electroplated coating		Delta Tone + Delta Seal Black ZnNi as per M 3536 Type BV (Geoblack) blocked for new designs etc.	Colour black due to design requirements
	B11	Electroplated coating	No lubricant additives *) (integrated or additional)	ZnNi as per M 3536 Type S	For higher abrasion resistance requirements For conductive contact points which were previously coated with A2C/A3C
	B12			ZnNi as per M 3536 Type SV	For higher abrasion resistance requirements
	PHR	Phosphating	Subsequent treatment on all sides as per DIN EN ISO 9717 No lubrication	Znph/r/5/T4	**Special case** Very low corrosion resistance

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Table 2 continued - Applications

	Code	Corrosion protection system	Lubrication/subsequent treatment	Released systems **)	Comments
11.	**General components (components that are not covered by the application areas 1 to 10)**				
	B13	Electroplated coating	No lubricant additives *) (integrated or additional)	Zn in accordance with DIN EN ISO 19598	Use only in the interior and engine
	B15			ZnFe in accordance with DIN EN ISO 19598	
	B16				Colour black due to design requirements Use only in the interior and engine
	B7	Zinc-flake coating with top coat		Delta-Protekt KL 120 + Delta-Heat Zinktek 200 + 2x Techseal Silver S-HAT Geomet 321A + 2x Plus 10	For increased requirements with respect to heat resistance up to 400 °C

*) In cases with special functional requirements (e.g. for plate nuts), lubrication is permitted after consultation with the specialist department.
**) Other corrosion protection systems will be added to Table 2 following approval.

5 Changeover

Due to the end-of-life vehicles directive, many suppliers are no longer able to offer corrosion protection systems that contain Cr(VI), which means that these have to be replaced by corresponding alternatives.

The following procedure is used for the selection and introduction of alternative systems:

Table 3

1.	Inquire as to which alternative corrosion protection systems are offered. If the system is unknown, organise test via the Materials Technology department if necessary.	
2.	Add the corresponding application (part type, Table 2) to MAN 183-3.	
3	First article inspection:	Positive test must confirm usability. Entry of date of first article inspection Determination of when changeover is to take place Use
4.	Enter corrosion protection system into T127A release list. Create material number for Cr(VI)-free system. Add part type to release list if necessary.	

6 Requirements

The general requirements as per the standards stated in Tables 1 and 2 apply, together with the following requirements:

6.1 Requirements to be met by the components before coating (see also DIN EN 26157-3)

The components to be coated must not have any material, heat treatment, processing, or surface defects which could have an unfavourable influence on the corrosion resistance and quality of the corrosion protection systems. Examples of such defects include cracks, pore pockets, foreign matter inclusions, laminations or sink marks and cold corrosion spots, shrinkage and notch cracks, swirls and shrink holes.

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

Components with high residual tensile stresses must be annealed or stress-relieved immediately after the stresses are introduced or, at the latest, before a chemical or electroplating treatment. When doing so, the highest possible temperature is to be selected although this temperature must not exceed the temperature of any preceding heat treatment.

For case-hardened or selectively surface hardened components, a duration of at least 2 hours at 180 °C to 200 °C applies, other than in the case of finish-rolled screws.

The dimensions and permissible deviations must conform to the requirements in the applicable standards or drawings. This applies in particular for the threads.

Before application of the corrosion protection systems, the components must be free from corrosion products of any kind as well as from dirt, grease, oils, and fingerprints.

6.2 General process requirements

All the treatments shall be carried out so that as little hydrogen as possible can be absorbed.

High-strength phosphated raw materials must be dephosphated, particularly for component strengths of $R_m \geq 1000$ N/mm^2, prior to the relevant heat treatment.

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The treatment, coating, and lubricating materials applied must not contain any chlorinated hydrocarbons, heavy metals, or other materials requiring identification in accordance with the dangerous goods regulations, must not cause any skin irritation, and must not be harmful to the environment.

The corrosion protection systems and lubricants must be recoatable with the coatings named in M 3031, M 3094, and M 3162 without any adverse optical or chemical effects.

6.3 Preliminary treatment to activate the surfaces

Pickling treatments, in particular in cathodic baths, should be avoided where possible and mechanical or other cleaning procedures used instead.

Pickling must occur in highly-effective electrolytes with suitable inhibitors which do not contain any promoters that favour an increase in hydrogen absorption. Pickling treatments in acids without inhibitors are not permitted.

The time between the preliminary treatment and application of the corrosion protection system shall be kept as short as possible.

If longer pickling periods cannot be avoided, a heat treatment suitable for high-strength components, for example 1 hour at 150 °C, shall be carried out in between.

6.4 Application of the corrosion protection systems

6.4.1 Phosphating

The phosphate coating must be applied evenly with a structure as finely crystalline as possible and without any smudges and dirt residue, and it must adhere securely to the surface of the component.

For high-strength mechanical fasteners of property class ≥ 8.8/8, a micro-crystalline thin phosphate coating with a zinc phosphate base accordance with VDA 235-104.10 shall normally be applied in layer thicknesses of max. 5 µm.

In addition, the process, maximum permissible layer thickness and phosphate base must be selected so that - after lubrication in accordance with Section 6.6 - the friction coefficients in Section 6.7 can be achieved reliably and no stick-slip effects can occur during tightening, even after long storage periods.

For other high-strength components, Znph/r/5/T4 in accordance with DIN EN ISO 9717 normally applies.

6.4.2 Electroplated coatings

Requirements for electroplated zinc and zinc-iron coatings are defined in DIN EN ISO 19598, and the requirements for electroplated zinc-nickel coatings are documented in M 3536.

The coated components must have a thick, even, and matt-finished coating with good adhesion and which does not flake off even when the component is twisted. They must not have any large pores, cracks, rough areas, or spots.

6.4.3 Zinc-flake coatings

The general requirements in accordance with VDA 235-104.40 apply for coating B1 (higher-strength fasteners in accordance with VDA 235-104.42). The requirements specified in VDA 235-104.50 apply to coating B4. The requirements VDA 235-104.43 apply for wheel bolts (B31) and the requirements VDA 235-104.42 for wheel nuts (B32). The stated standards apply in full if the standard MAN 183-3 does not define any deviating, limiting or supplementary requirements. The general requirements in accordance with VDA 235-104 also apply for B7.

For coatings B1, B4 and B7, suitable application procedures are to be used, in particular in the case of internal threads, small external threads, and internal drives with scooping areas, to ensure that function and mountability are not adversely affected.

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6.5 Heat treatment (annealing)

In order to expel the hydrogen absorbed during the coating procedure, or to make it ineffective, the following heat treatments shall be carried out on high-strength components if required.

6.5.1 Components with strengths of $R_m \geq 1200$ N/mm^2 are to be subjected to a heat treatment of approximately 2 hours at 130 °C to 150 °C after phosphating in any case of doubt.

6.5.2 The heat treatment of electroplated (Zn, ZnFe) components with strength $R_m \geq 1000$ N/mm^2 must take place immediately and no more than 4 hours after electroplating and in all cases prior to passivation. Guide values with respect to temperature and holding periods as a function of the tensile strength of components are documented in DIN EN ISO 19598.

The heat treatment of electroplated ZnNi components is described in M 3536.

6.6 Lubrication, subsequent treatment

For certain corrosion protection systems, it is necessary to carry out an additional lubrication in order to fulfil the friction coefficients in accordance with Section 6.7. In general, the requirements in Table 2 apply.

However, if "-OS" is stated in the designation after the code for the corrosion protection system, e.g. MAN 183-B4-OS, in deviation from the requirements in Table 2 no lubrication is required with a lubrication agent and therefore the friction values do not have to be met in accordance with Section 6.7.

The lubricants shall be tested in accordance with VDA 235-101 and M 3222 or M 3276 with respect to fulfilling the friction coefficients in accordance with Section 6.7; they must be approved by MAN (see MAN approval list for M 3222) and may not be changed, even for one specific part, without the agreement of MAN.

A visible greenish colouring of the lubricant film in accordance with M 3222 is required as proof of lubrication on higher- and high-strength fasteners with silver-grey Zn-flake coatings.

The greenish colouring of the lubrication does not apply to wheel fasteners with the surface protection B31 and B32. Transparent lubrication in accordance with M 3222 is required in these cases.

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

Micro-encapsulated screws in accordance with MAN 222 are not lubricated.

6.7 Friction coefficients

In order to reduce the friction coefficients and their spread in the thread and under the head, components with threads and corrosion protection systems as per this standard must - to the extent required in Table 2, Section 6.6 - be treated with suitable lubricants as per Section 6.6 or by means of the lubricants already integrated into the systems (e.g. Teflon ®) to achieve an overall friction coefficient of $\boldsymbol{\mu_{Total}}$ **= 0,09 to 0,14** (target average value of $\boldsymbol{\mu_{Total}}$ **= 0,11**).

Checking of the friction coefficients is part of the first article inspection. A maximum value of $\mu_{Total} = 0{,}15$ is permitted on mating surfaces of bright steel.

The test is performed as per VDA 235-203 or M 3222 in accordance with DIN EN ISO 16047 or if necessary in accordance with DIN 946.

6.8 Coating thicknesses of the corrosion protection systems

The layer thicknesses of the corrosion protection systems (recommended minimum values as per Table 1) including lubricant must fall within the limit values laid down in the applicable standards (DIN EN ISO 9717, VDA 235-104, and VDMA 24576) or in the drawings.

For the layer thicknesses in the thread, GO gauges of tolerance position 6h or 6H apply. The requirements of DIN ISO 1502 or VDA 235-104 apply.

For nuts with the systems B1, B4 B7 and B32, appropriate measures shall to be taken to ensure compliance with the specified layer thicknesses at the base of the thread and in scooping areas.

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In the case of wheel bolts, the maximum layer thickness on the fitting surface in the finished coated condition must not exceed 12 µm.

6.9 Resistance to hydrogen-induced brittle fracture

The proof of resistance to hydrogen-induced brittle fracture must be provided in accordance with DIN 50969-1 /-2 or, if requested by MAN, by means of a bracing test as per Section 7.1 on at least 10 parts from a coating batch. The parts must not have any incipient cracks or fractures.

6.10 Corrosion resistance and other requirements placed on the corrosion protection system

The required corrosion protection properties must be achieved both when the part is in lubricated and unlubricated condition in accordance with Section 6.6. This does not apply to PHR.

The requirements in M 3018 apply with regard to resistance to media. The adhesive strength must be assessed in accordance with DIN EN ISO 10683 for non-electroplated systems and in accordance with DIN EN ISO 19598 for electroplated systems.

The requirements in M 3018 apply with regard to recoatability of corrosion protection systems without lubrication. Corrosion protection systems with lubrication cannot normally meet the requirements for recoatability in accordance with M 3018. It is possible to assess the recoatability of corrosion protection systems with lubrication on the basis of their resistance to steam jet in accordance with M 3018 in recoated condition.

Table 4 Corrosion resistance

Test load	Corrosion protection system/test requirement				
	PHR	**B1** [2)]	**B4** [2)]	**B11** [3)]	**B12** [3)]
Salt spray test DIN EN ISO 9227 - NSS (h)	6	480/720 [1)]	480	720 (normal area) / 480 (special area)	720 (normal area) / 480 (special area)

Test load	Corrosion protection system/test requirement					
	B13	**B15**	**B16**	**B31** [2)]	**B32** [2)]	**B7** [2)]
Salt spray test DIN EN ISO 9227 - NSS (h)	120	240	240	720	720	120

[1)] Applies only to higher-strength fasteners

[2)] The corrosion resistance for fasteners must be met independently of dimensions and, in deviation from VDA 235-104 (for zinc flakes), both at locations without thread and locations with thread.

[3)] See M 3536 Table 4 for definition of normal area and special area

The components must not have any base metal corrosion (red rust) after the test load.

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6.11 Finish rolling

If the term FINISH ROLLED is entered in the designation in the item master data (purchase order and delivery call-off), this means that special requirements are placed on the coated threads in the case of external threads (screws) in deviation from DIN EN 26157-1 and 3.

Any damage to the thread caused by production and/or coating processes (knocks or localised coating concentrations on the thread root) must be rectified by means of a finish rolling procedure in order to avoid stressing leading to thread seizure.

The finish rolling process must be such that a GO screw ring gauge with tolerance position 6h as per DIN ISO 1502 can be screwed onto the entire length of the thread by hand without particular force.

The thread geometry, corrosion protection, and friction coefficients (lubrication) may not be restricted to an impermissible extent by the finish rolling process.

If the production process is set up in such a way that no damage can occur in the thread root and/or there can be no local coating concentrations on the thread root, then finish rolling is not required.

Finish rolling shall be required only in proven individual **problematic cases**, in particularly for M 16 and higher, and may be initiated **only** by the **assembly department** due to **problems** in the assembly process.

The term FINISH ROLLED is entered in the designation in the item master data by the Standardization department.

FINISH ROLLED cannot be defined as a standard requirement in assembly drawings. Entry of the term FINISH ROLLED in the item master data is not permitted for newly documented screws and bolts.

If screws and bolts are already documented with the suffix FINISH ROLLED in the item master data, these may also then be entered correspondingly in the assembly drawings.

7 Tests

The provisions laid down in the quoted standards apply.

When testing new corrosion protection systems, the adhesive strength, recoatability, and resistance to media as per M 3018 must be examined in addition to the corrosion resistance (also see Section 6.10).

The positions to be used for corrosion resistance and to determine the layer thicknesses shall be selected in consultation with the MAN quality departments. In cases of doubt, the microscopic determination of the local layer thickness in accordance with DIN EN ISO 1463 shall apply, e.g. on the head or key surfaces.

7.1 Bracing test

In deviation from DIN 50969, the following test conditions apply for the bracing test:

The bracing test must be carried out at the latest 24 hours after the components have been removed from the coating bath.

The components (if applicable, replacement test parts) shall be braced until there is a plastic deformation of 1% minimum and 10% maximum of the elastic spring travel. They must be kept in this bracing condition at 20 °C for 96 hours.

Threaded parts are to be lubricated before bracing to an overall friction value of μ_{Total} = 0,09 - 0,14.

After dismantling, the components shall be checked visually for incipient cracks and fractures.

In any case of doubt, a bending test and a magnetic crack test shall be carried out.

The results shall be documented in line with Section 2 and DIN 50969 -1/-2.

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Appendix A **Corrosion release of the systems in accordance with MAN 183-3; System/material item numbers**

(The released systems are listed only by way of example in Appendix A. The entries in the host screen T127A are decisive.)

System/material item number	Designation of system/material item number	Code	Released systems	Comment
04.10006-0601	MAN 183 - B1 with lubrication (720h NSS)	B1	Delta Protekt KL 100 + Delta-Lube 10	
			ZnNi as per M 3536 Type SVR	
04.10006-0602	MAN 183 - B1 without lubrication (720h NSS)		Delta Protekt KL 100	
			ZnNi as per M 3536 Type SV	
04.10006-0603	MAN 183 - B1 with lubrication (480h NSS)		Geomet 321 + lubrication appropriate for assembly	
			Delta Protekt KL 100 + lubrication appropriate for assembly	
			ZnNi in accordance with DIN EN ISO 19598 ZnNi8//CN//T2 + lubrication appropriate for assembly	
04.10006-0604	MAN 183 - B1 without lubrication (480h NSS)		Geomet 321	
			Delta Protekt KL 100	
			Magni B 46	
			ZnNi as per M 3536 Type SV	
			ZnNi passivated – as per VDMA 24576	

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System/material item number	Designation of system/material item number	Code	Released systems	Comment
04.10006-0605	MAN 183 - B4 with lubrication (480h NSS)	B4	Delta Tone + Delta Seal with lubrication	
			ZnNi as per M 3536 Type BVR	
04.10006-0606	MAN 183 - B4 without lubrication (480h NSS)		Delta Tone + Delta Seal	
			ZnNi as per M 3536 Type BV	
04.10006-0610	MAN 183 - B11 without lubrication (720h NSS)	B11	ZnNi as per M 3536 Type S	
04.10006-0614	MAN 183 - B12 without lubrication (720h NSS)	B12	ZnNi as per M 3536 Type SV	
04.10006-0618	MAN 183 - B13 without lubrication (120h NSS)	B13	Zn in accordance with DIN EN ISO 19598	
04.10006-0617	MAN 183 - B13 with lubrication (120h NSS)	B13	Zn in accordance with DIN EN ISO 19598 + lubrication	
04.10006-0622	MAN 183 - B15 without lubrication (240h NSS)	B15	ZnFe in accordance with DIN EN ISO 19598	
04.10006-0621	MAN 183 - B15 with lubrication (240h NSS)	B15	ZnFe in accordance with DIN EN ISO 19598 + lubrication	
04.10006-0626	MAN 183 - B16 without lubrication (240h NSS)	B16	ZnFe in accordance with DIN EN ISO 19598	
04.10006-0625	MAN 183 - B16 with lubrication (240h NSS)	B16	ZnFe in accordance with DIN EN ISO 19598 + lubrication	
04.10006-0629	MAN 183 – PHR with oiling (6h NSS)	PHR	Znph/r5/T4	
04.10006-0635	MAN 183 - B31 with lubrication (720h NSS)	B31	Geomet 500 + Dacrolub 10	
04.10006-0639	MAN 183 - B32 with lubrication (720h NSS)	B32	Geomet 500 + Plus VL + microGleit DF 902	

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System/material item number	Designation of system/material item number	Code	Released systems	Comment
04.10006-0643	MAN 183 – B7 without lubrication (120h NSS)	B7	Delta-Protekt KL 120 + Delta-Heat Zinktek 200 + 2x Techseal Silver S-HAT Geomet 321A + 2x Plus 10	

Applicable documents

DIN 267-13	Fasteners - Technical specifications - Part 13: Parts for bolted connections with specific mechanical properties for use at temperatures ranging from -200 °C to +700 °C
DIN 3870	Non-soldering and soldering compression fittings - Union nuts
DIN 50969-1	Prevention of hydrogen-induced brittle fracture of high-strength steel components - Part 1: Preventive measures
DIN 50969-2	Prevention of hydrogen-induced brittle fracture of high-strength steel building elements - Part 2: Tests
DIN 931	Hexagon head bolts, metric thread
DIN 946	Determination of coefficient of friction of bolt/nut assemblies under specified conditions
DIN EN ISO 1463	Metallic and oxide coatings - Measurement of coating thickness - Microscopical method
DIN EN 26157-1	Fasteners; surface discontinuities; bolts, screws and studs subject to general requirements
DIN EN 26157-3	Fasteners; surface discontinuities; bolts, screws and studs subject to special requirements
DIN EN ISO 16047	Fasteners - Torque/clamp force testing
DIN EN ISO 19598	Metallic coatings - Electroplated coatings of zinc and zinc alloys on iron or steel with supplementary Cr(VI)-free treatment
DIN EN ISO 4042	Parts with threads - Electroplated coatings
DIN EN ISO 6270-2	Paints and varnishes - Determination of resistance to humidity - Part 2: Procedure for exposing test specimens in condensation-water atmospheres
DIN EN ISO 9717	Metallic and other inorganic coatings - Phosphate conversion coating of metals
DIN EN ISO 9227	Corrosion tests in artificial atmospheres - Salt spray tests
DIN ISO 1502	ISO general purpose metric screw threads - Gauges and gauging
M 3018	Corrosion protection and coating systems for purchased parts
M 3031	One-component top coating materials, 1K top coat; technical terms of delivery
M 3094	Two-component top coating materials, 2K top coat; technical terms of delivery
M 3162	2K base coating materials, primer; technical terms of delivery
M 3222	Lubricants for screw connections; technical terms of delivery
M 3276	Lubricant coating of pipe fasteners
M 3296	Pan-head tapping screws with hexalobular socket
M 3536	Electroplated ZnNi coating on ferrous materials, surface protection requirements
M 3539	Contact corrosion – influencing variables and measures
M 3549	Edge and cut surface quality on components made of metallic materials
MAN 183-2	Corrosion protection coatings for high-strength fasteners and other components
MAN 239-1 ff.	General terms of delivery for purchased parts, all parts
VDA 235-101	Lubrication of mechanical fasteners with threads
VDA 235-104	Cr(VI)-free types of surface protection for fasteners with metric threads
VDA 235-203	Screw fastening behaviour, friction coefficients - Practical and assembly-oriented testing
VDMA 24576	VDMA standard sheet: Fluid technology; requirements and designations for corrosion protection layers without hexavalent chromium

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Previous issues: E MAN 183-3/2008-09
MAN 183-3/2010-03, 2010-04, 2010-11, 2011-04; 2011-06; 2011-09; 2012-05; 2013-06, 2014-01, 2014-08, 2015-09, 2015-10; 2015-12; 2016-06; 2016-10; 2016-12, 2017-06

Changes: Compared to issue 2014-08 the following changes have been made:

- Table 1: B13, B15 colour definition serves as guide value
  B31, B32 added
- Table 2.2: B11 added
- Table 2.3: B31 and B32 added
- Table 2.5: ZnNi as per M 3536 Type BV added under B4
- Section 6.4.3: Reference to B31, B32 added
- Section 6.8: Permitted layer thickness on fitting surface of wheel bolts added

Compared to issue 2015-09 the following changes have been made:

- Table 1: B7 added for requirements related to higher temperatures
- Table 2.3: added
- Tables 2.3 to 2.12 re-numbered
- Table 2.10: B7 added
- Table 2.12: B7 added

Compared to issue 2015-12 the following changes have been made:

- B20 and B21 removed from MAN 183-3

Compared to issue 2016-06 the following changes have been made:

- Table 2.6: B13 added
- Index under Table 2.2 corrected (reference to Table 2.11 instead of 2.10)
- EAS is now EZAS

Compared to issue 2016-10 the following changes have been made:

- Section 6.6: Reference to transparent lubrication of wheel fasteners added
  Reference to greenish lubrication extended by higher-strength fasteners

Compared to issue 2016-12 the following changes have been made:

- Table 2: Dacrolube corrected to Dacrolub
- Appendix: Dacrolube corrected to Dacrolub
- DIN 50979 replaced by DIN EN ISO 19598
- Section 6.11 Information on documentation of finish-rolled screws and bolts supplemented

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Compared to issue 2017-06 the following changes have been made:

- Application notes on cover page adapted
- Section 2: Editorial revision of release conditions
  Inclusion of requirement for submission of test results by supplier
- Table 2: Released systems adapted for coating system B7
  Application 3, term "substrate" replaced by "material" in comments
  In application 10. specification of nominal size for use of zinc flakes qualified
- Section 6.8: Change in layer thickness to recommended minimum values
- Section 6.10: Revision of not on corrosion protection requirements without lubricant
  Revision of requirements on recoatability
- Table 4: Index for definition of normal and special areas for B11 and B12 added
- Section 7: Reference to Section 6.10 added
  Reference to DIN EN ISO 1463 added
- Appendix A Coating system for B7 added

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