

Specification
MK 06 000 – 6
Safety-relevant fasteners

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1 Area of application

This specification defines the technical requirements and necessary quality-assurance measures for suppliers of high-strength fasteners, provided this specification is explicitly referred to in the purchase order.

It applies to high-strength screws and bolts of property classes 8.8, 10.9 and 12.9 according to ISO 898-1, as well as nuts and similar components in property classes 8, 10 and 12 according to ISO 898-2. The present specification can also be valid for other high-strength components with similar strength if so indicated in the respective drawing.

Non-compliances with the requirements of this specification can be admissible, provided it can be demonstrated that they are equivalent. Any non-compliances shall be communicated to client and require written approval from client.

2 Other applicable standards and documents

The respective product standards and product drawings are valid wherever applicable:

- ~ DIN 13 ISO metric screw threads
- ~ DIN 18800-1 Steel structures – Part 1: Design and construction, or EN 1993 – EC 3
- ~ DIN 18800-7 Steel structures – Part 7: Execution and constructor's qualification, or EN 1090-2
- ~ DIN 50602 Metallographic examination; microscopic examination of special steels using standard diagrams to assess the content of non-metallic inclusions
- ~ EN 14399-4, -6 System HV – Hexagon bolt and nut assemblies
- ~ DAST 021 Schraubenverbindungen aus feuerverzinkten Garnituren M39 bis M64 (Fasteners made from HDG assemblies, M39 to M64)

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- ~ DIN EN ISO 148-1 Metallic materials – Charpy pendulum impact test
- ~ ISO 898-1 Mechanical properties of fasteners made of carbon steel and alloy steel – Part 1: Bolts
- ~ ISO 898-2 Mechanical properties of fasteners made of carbon steel and alloy steel – Part 2: Nuts
- ~ ISO 965 ISO general purpose metric screw threads – Tolerances
- ~ ISO 4042 Fasteners – Electroplated coatings
- ~ ISO 4759 Tolerances for fasteners
- ~ ISO 6157 Fasteners – Surface discontinuities
- ~ ISO 9001 Quality management systems
- ~ DIN EN ISO 9227 Corrosion tests in artificial atmospheres – Salt spray tests
- ~ EN 10204 Metallic products – Types of inspection documents
- ~ DIN EN ISO 9443 Surface quality classes for hot-rolled bars and wire rod – Technical delivery requirements for the surface quality of round bars and wire rod in the hot-rolled condition
- ~ ISO 10683 Fasteners – Non-electrolytically applied zinc flake coating systems
- ~ ISO 10684 Fasteners – Hot-dip galvanized coatings
- ~ ISO 15330 Fasteners – Preloading test for the detection of hydrogen embrittlement – Parallel bearing surface method
- ~ DIN EN ISO 16047 Fasteners – Torque/clamp force testing
- ~ ISO 16426 Fasteners – Quality assurance system
- ~ DASt 022 Feuerverzinken von tragenden Stahlbauteilen (Hot-dip galvanising of load-bearing steel components)
- ~ Richtlinie für die Herstellung feuerverzinkter Schrauben, Juli 2009, DSV/GAV (Guideline for manufacturing HDG bolts, July 2009, DSV/GAV)

3 Requirements for screws and bolts

3.1 Material selection

The chemical composition of the material used shall meet the requirements of ISO 898-1. This is restricted to carbon steel with additives or alloyed steel. The phosphorus and sulphur content shall each be restricted to a maximum of 0.02 %. The total combined phosphorus and sulphur content is not permitted to exceed 0.03 %. With regard to material purity, the following applies: Overall characteristic value according to DIN 50602 K3 < 20.

With respect to primary-material surface discontinuities, grade D applies to bars and rolled rods according to DIN EN ISO 9443. If hardened and tempered material is used (for $D \geq M16$), this material shall be stripped in the thread area. Otherwise, a 100 % crack inspection shall need to be performed. Carburisation in accordance with Section 3.3 shall be taken into account (for $D < M16$, the values in ISO 898-1 apply).

3.2 Mechanical and physical properties

In addition to the requirements of DIN EN ISO 898-1, ISO 10684 applies to hot-dip galvanized parts. The minimum value for the notched-bar impact determined at -40 °C from the V-notch sam-

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ple to DIN EN ISO 148-1 for property classes 8.8 and 10.9 is 27 J, while the minimum value is 20 J for property class 12.9.

3.3 Carburation

The surface-decarburation limit values specified for property class 12.9 in ISO 898-1 also apply to property classes 8.8 and 10.9. A slight increase in hardness caused by rolling after heat treatment is acceptable.

Surface carburation detectable by metallographic section or microhardness measurement is not admissible. Carburation is defined as follows:

- ~ Threads \geq M16: When the surface hardness is more than 20 Vickers points higher than the core hardness (measured in HV 0.3)
- ~ Threads $<$ M16: ISO 898-1

A metallographically detectable white layer on the surface (δ ferrite) is not permitted.

3.4 Surface defects

Only surface discontinuities according to ISO 6157-3 for screws and bolts with special requirements are admissible for all property classes.

3.5 Manufacturing-process requirements

The upper third of the admissible strength and hardness scatter range should be avoided for property classes 10.9 and 12.9 through appropriate regulation of the hardening and tempering processes.

Hardening and tempering systems, regardless of whether they are pass-through or chamber ovens, shall be equipped with a carbon-level and temperature-regulation system, as well as continuous temperature and carbon-level recording.

Inductive systems shall have a closed-loop control system and constant temperature, pass-through speed and quench-quantity monitoring.

Furthermore, thorough cleaning before heat treatment is required to avoid the formation of delta (δ) ferrites.

Fundamentally, only rolled threads are admissible. The thread runout on set screws shall be accurately rounded.

If not otherwise explicitly specified in the purchase order, the supplier may provide bolts with threads rolled before or after heat treatment, at the manufacturer's discretion.

Threaded rods/parts shall always be 'rolled after heat treatment', even if this is not explicitly stipulated in the purchase order.

The size of damage or surface discontinuities on the thread, e.g. dents, notches, scratches, nicks or geometric divergences caused by the coating, is only admissible if a true-to-gauge nut can be screwed on by hand to a torque (in Nm) of $0.0001 \cdot d^3$ (d in mm).

3.5.1 Additional purchase-order specifications

The purchase order might also include other specifications.

Definitions/explanations of terms:

- ~ If **'rolled after heat treatment'** is specified in the purchase order: The threads shall be rolled after hardening and tempering of the parts. (By contrast, for 'rolled before heat treatment', the thread is rolled in the blank before heat treatment.)
- ~ If **'rolled after coating'** is specified in the purchase order: The threads are lightly rolled after the surface protection coating has been applied in order to even out the surface and obtain a smooth thread
- ~ If **'100 % crack inspection'** is specified in the purchase order: Before applying the surface protection, 100 % of the parts shall be subjected to a magnetic crack inspection

4 Requirements for nuts and similar components

4.1 Material selection

The material shall be selected according to ISO 898-2. Free-cutting steel is not admissible. Compliance with minimum hardness requirements is **mandatory**.

4.2 Mechanical and physical properties

In addition to the requirements of ISO 898-2, nuts that have not been hardened and tempered are not admissible.

4.3 Surface defects

ISO 6157-2 tolerates surface discontinuities.

4.4 Manufacturing-process requirements

Hardening and tempering systems, regardless of whether they are pass-through or chamber ovens, shall be equipped with a carbon-level and temperature-regulation system, as well as continuous temperature and carbon-level recording.

Inductive systems shall have a closed-loop control system and constant temperature, pass-through speed and quench-quantity monitoring.

5 Surface protection

Temporary corrosion-protection measures are not permitted to lead to hydrogen absorption (for example, black after hardening and tempering; lubricated, not phosphated).

Considering the surface activation required before coating, the entire hardening and tempering process shall be optimised so that surfaces are as clean as possible. In particular, adhesive residue from the quench bath should be avoided.

5.1 Surface protection – Electroplated

ISO 4042 applies with regard to electroplated surface protection. Electroplating surface treatment is not permissible for property classes 12 and 12.9. Components in property classes 10 and 10.9 shall be appropriately heated after the coating has been applied. For threads rolled after heat treatment, this heat treatment should not exceed 250 °C and shall be commenced 4 hours after completion of the electroplating treatment at the latest.

5.2 Surface protection – Hot-dip galvanised

ISO 10684 applies to hot-dip galvanised fasteners, in addition to the requirements described in the DAST 022 guideline for the composition and monitoring of the zinc melt.

ISO 965 (→ thread tolerance 6az before hot-dip galvanising, if not otherwise specified) applies to hot-dip galvanised bolts not ordered as HSFG bolts according to EN 14399-4 or DAST 021. The base line of the thread is not permitted to be exceeded through galvanising. Subsequent machining of any type is not admissible.

Unless otherwise specified, nuts not ordered according to EN 14399-4 or DAST 021 shall be manufactured with position tolerance 6H.

Because of the high procedural risks, extreme care shall be taken when preparing, carrying out and monitoring the hot-dip galvanising process of high-strength fasteners. It may only be carried out by verified hot-dip galvanising plants known to the customer. Hot-dip galvanising is not admissible for property classes 12 and 12.9.

Only baths where the concentration of free hydrochloric acid is constantly monitored are permitted to be used for pickling. The HCl concentration in these baths shall be between 15 % (freshly prepared) and 8 %. When a bath reaches the lower concentration limit, it shall be discarded. Regeneration by adding acid is not admissible.

Only pickle liquor with an added inhibitor is permitted to be used. This inhibitor shall be disclosed to the customer, and proof of its suitability shall be provided. The inhibitor shall be dosed according to the manufacturer's instructions for the freshly prepared bath. Subsequent addition of inhibitor to the pickle liquor during its period of use is not admissible.

In coordination with client, and after written approval, testing of the effectiveness of the inhibited pickle liquor can be carried out (e.g. by means of 'circlip tensioning tests') in accordance with Annex A1 in the 'Richtlinie für die Herstellung feuerverzinkter Schrauben, DSV/GAV' (Guideline for manufacturing HDG bolts) in the context of the manufacturer's in-house production quality control. This eliminates the prohibition of regenerating the pickle liquor by adding acid and corrosion-inhibitor additives.

The maximum admissible pickling duration without subsequent heating is 15 minutes. If the maximum pickling duration (< 30 minutes) is exceeded, the fasteners shall be heat-treated at 220 °C before galvanising. The holding duration shall be a minimum of 2 hours for fasteners that have been completely heated.

All heat-treated fasteners shall be pickled again for < 1 minute immediately before galvanising in order to activate the surface.

High-temperature galvanising (530–560 °C) is admissible for dimensions up to M24. From M27 onwards, only normal-temperature galvanising (445–470 °C) may be used.

5.3 Surface protection – Inorganic

ISO 10683 applies with regard to inorganic surface protection.

Only coating systems approved by client, in combination with processing facilities approved by client, are permitted to be used. Modifications without the approval of client are not permissible.

- ~ An audit conducted by client or its authorised representatives is required for approval of the processing facility (refer to Section 7.1)
- ~ Among other things, the approval of the coating system requires representative initial samples for suitably collated product groups, friction-coefficient investigations and confirmation of adherence to the friction-coefficient range, also in combination with corresponding competitor products

Designation of the coating system as per DIN EN ISO 10683: fIZn/nc/TL/x/720h/[0.09–0.14]

- ~ Cr(VI)-free base coat without integrated lubricant: nominal layer thickness 12 µm, individual values at least 8 µm
- ~ Organic top coat with integrated lubricant (refer to Section 6): nominal layer thickness 6 µm, matt green colouring
- ~ The total layer thickness comprising the base coat and top coat is not permitted to be less than 14 µm
- ~ In addition to the 720-h salt spray test (NSS), adherence to the minimum coat thicknesses is required and shall be documented
- ~ Subsequently applied lubricant and additional coatings, e.g. wax, are not permissible

The maximum curing temperature is not permitted to exceed 250 °C.

For fasteners in property class 10 or 10.9 and above, pickling in acid during pre-treatment is impermissible. Alkaline, solvent-based and/or mechanical pre-treatments should be used.

In order to take consideration of the required free space for the coat thickness, the uncoated fasteners may conform to tolerance position 6e for external threads and 6E for internal threads.

After applying the coating, the actual profile of the thread is not permitted to exceed tolerance position H for internal threads and h for external threads.

Separate tolerance agreements, combined with pull-out tests to guarantee the resistance to stripping, might be required for small pitches ($P < 3$ mm).

6 Lubricant coating

For all initial orders or changes, the lubricant coating used shall be agreed with client. Client shall specify the respectively required type of lubricant coating (and/or integrated lubricant) in the purchase order or designation of the parts.

6.1 Requirements and conditions

The following requirements and test conditions shall be complied with for lubricated parts:

- ~ For HSFG fasteners according to EN 14399-4/-6, k-Class K1 applies for 'extended assembly lots'. 'Extended assembly lot' means that the bolts, washers and nuts in the lot can be from different batches from one supplier
- ~ For HSFG fasteners > M36, the specifications according to DAST 021 apply with the addition for 'extended assembly lots'

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- ~ Friction-coefficient range: Overall friction-coefficient value 0.09–0.14 (unless otherwise specified in the purchase order, or in the case of HSFSG fasteners)
- ~ The friction coefficient shall be continually checked and recorded
- ~ The label (or package insert) shall indicate the friction-coefficient range/k-Class
- ~ Production batches are not permitted to be mixed in the coating process
- ~ Lubricant coatings on screws and bolts shall be 'dry tack-free'
- ~ A lubricant coating such as 'Torque 'n' Tension' shall be visibly recognisable (e.g. blue colouring) and shall be agreed as necessary when the purchase order is placed
- ~ No further colouring is required for nuts treated with a lubricant coating such as Molykote

6.2 Determining friction coefficients

The friction coefficient shall be determined on the basis of DIN EN ISO 16047.

The overall friction coefficient shall be determined on assembly parts in accordance with the specified property class, surface coating, and with washers featuring a hardness of 300 HV.

- ~ Hot-dip galvanised and moly-coated (HDG MoS₂/HDG moly-coated)
Anti-seize spray only on specified component, all assembly parts hot-dip galvanised
- ~ Hot-dip galvanised with 'Torque 'n' Tension' (HDG TnT)
Anti-seize spray only on specified part, all assembly parts hot-dip galvanised
- ~ Zinc flake coating without chromate (fIZnnc)
Lubricant coating on all assembly parts

7 Quality-assurance measures

7.1 Manufacturer qualification

The quality-management system of the supplier and the fastener manufacturer, and that of its sub-contractors and service providers, shall be certified according to at least ISO 9001 or a more highly developed quality-management system such as ISO/TS 16949 or VDA 6.1.

The manufacturer shall create product drawings for each product. The manufacturer and the surface-coating facility commissioned by the manufacturer shall provide quality-management plans and process flow charts with appropriately detailed process, work and inspection instructions for the manufactured components.

All quality-relevant documents shall be archived for at least 20 years by the supplier if no other agreements have been made.

Only manufacturers and suppliers approved by client Product and Quality Management are permitted. Minimum requirements for manufacturer approval:

- ~ Auditing of the manufacturer by client Product and Quality Management or an authorised representative of the customer. This can be dispensed with for long-term suppliers with whom technical information is exchanged ('trusted manufacturers')
- ~ Representative initial samples for suitably combined groups of products shall be submitted in collaboration with client Product and Quality Management, together with complete initial-sample inspection reports
- ~ Submission of quality-management plans

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Client shall be notified in the event of significant manufacturing-process changes. Client shall then decide whether renewed initial sampling is necessary.

Client can assign responsibility for approving a manufacturer to an intermediary if the product is supplied by that intermediary. This requires a written agreement for each individual case. The intermediary shall provide client with a list of approved manufacturers in accordance with this specification.

7.2 Inspections and certificates

7.2.1 General

The manufacturer shall request manufacturer's test certificate 3.1 from its steel suppliers.

If specified in the purchase order, a copy of manufacturer's test certificate 3.1 according to EN 10204 shall be prepared for each production batch.

Otherwise, it shall be ensured that the full required test certificate can also be issued subsequently based on the bolt marking.

The manufacturer shall carry out appropriate inspections according to ISO 898-1 as part of its in-house production quality control for screws and bolts. Nuts and similar components shall be inspected according to ISO 898-2.

The test certificate shall contain the following as a minimum:

- ~ Item designation
- ~ Test requirements (e.g. according to ISO 898-1 and corresponding specification for safety-relevant fasteners)
- ~ Material used/melt
- ~ Markings and identifiers on the product
- ~ Sample values as per Section 7.2.2 and Section 7.2.3
- ~ Friction coefficients as per Section 6 and Section 6.2
- ~ Tolerance zone of the blank
- ~ Coating layer thickness, with adhesive strength
- ~ Batch number

7.2.2 Bolts

7.2.2.1 For hardened and tempered material:

- ~ Core- and surface-hardness values from manufacturer's acceptance test
- ~ Mechanical (tensile strength; 0.2 % proof stress; elongation at break; constriction; notched-bar impact test at -40 °C) and chemical values (particularly Mn, C, P and S) according to the steel mill's test certificate

7.2.2.2 For subsequent heat treatment:

- ~ Chemical values according to steel mill's test certificate
- ~ Mechanical values after heat treatment according to in-house testing or testing performed by an institute commissioned by the manufacturer:
 - ~ Tensile strength (tensile test on whole specimens or angular tensile test). If, contrary to the requirements of Section 3.5, the tensile strength is in the upper third of the admissible

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range, the 0.2 % proof stress limit, the elongation at break and the constriction also need to be determined and listed

- ~ Hardness values
- ~ Notched-bar impact at -40 °C
- ~ Carburisation as described in Section 3.3 (confirmation that carburisation was determined and has passed inspection)
- ~ Confirmation of positive material identification (PMI) analysis (atomic emission spectroscopy or similar)
- ~ Confirmation of visual inspection for surface discontinuities as per Section 3.4
- ~ For hot-dip galvanised threaded bolts, the effective diameter (and/or the tolerance zone) of the non-galvanised component shall also be indicated

7.2.3 Nuts

7.2.3.1 For hardened and tempered material:

- ~ Hardness values from manufacturer's acceptance test
- ~ Mechanical (tensile strength; 0.2 % proof stress; elongation at break; constriction) and chemical values (particularly Mn, C, P and S) according to the steel mill's test certificate

7.2.3.2 For subsequent heat treatment:

- ~ Chemical values according to steel mill's test certificate
- ~ Mechanical values according to in-house testing or testing performed by an institute commissioned by the manufacturer: proof-load test, hardness values
- ~ Confirmation of positive material identification (PMI) analysis (atomic emission spectroscopy or similar)
- ~ Confirmation of visual inspection for surface discontinuities as per Section 4.3

7.3 Traceability and component identification

To ensure traceability of the material and heat-treatment batch, screws and bolts shall be marked with an identification number beyond the obligatory identification according to ISO 898-1/-2 and individual product standards. The identification number shall be changed if a new material batch (new melt or new heat-treatment batch) is used.

Fasteners covered by this specification should preferably be marked with an additional 'S' for the sake of differentiation, if there is space to do so.

8 Packaging and delivery

The supplier is responsible for packaging and shipping. This shall be carried out in such a way as to ensure careful transport. This especially applies to threaded areas, which shall be provided with extra protection against damage if requested by the customer.

The packaging shall protect the components appropriately against mechanical damage, dirt ingress, and moisture.

Further requirements regarding packaging can be specified in the purchase order.

9 Actions in the event of non-compliance

Client Product and Quality Management shall be informed about any non-compliance with the quality standards defined in this specification in writing at once and before delivery of the lot. The customer and client Product and Quality Management shall decide jointly about approval, reworking or rejection of the lot.

If any non-compliances with the quality standards defined in this specification remain unnoticed until the bolts have been installed, the identification number required under Section 7.3 shall facilitate immediate replacement of all bolts affected by the aforementioned non-compliance, should this be necessary.

Any complaints concerning a non-compliance shall include the following information:

- ~ Cause of defect
- ~ Actions taken to remedy defects and/or avoid defects in future (with implementation date)
- ~ Extent of the defect (e.g. limitation to particular batches/deliveries, number of components/batches affected, verification of isolated cases)
- ~ Potential effects on previously installed fasteners from the affected batch/delivery (risk evaluation)
- ~ The complaint is technically processed between the customer and the manufacturer in close cooperation with the service provider

Complaints concerning fasteners under this specification shall be responded to promptly (within a few days) with appropriate solutions to ensure safe WEC operation.