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Third edition
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Fasteners — Non-electrolytically applied zinc flake coating systems

Fixations — Systèmes de revêtements non électrolytiques de zinc lamellaire

Reference number
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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 2, *Fasteners*, SC 14, *Surface coatings*.

This third edition cancels and replaces the second edition (ISO 10683:2014), which has been technically revised. The main changes compared to the previous edition are as follows:

— the normative references have been updated;

— the restriction of gauging to external threads in the 2nd paragraph of 6.2.2 has been removed;

— the last column in Table B.2 with maximum clearance for tolerance position e has been removed;

— Annex C has been revised completely.

Fasteners — Non-electrolytically applied zinc flake coating systems

1 Scope

This document specifies requirements for non-electrolytically applied zinc flake coating systems for steel fasteners. It is applicable to coatings:

— with or without hexavalent chromium;

— with or without top coat;

— with or without lubricant (integral lubricant and/or subsequently added lubricant).

It is applicable to bolts, screws, studs and nuts with ISO metric thread, to fasteners with non-ISO metric thread, and to non-threaded fasteners such as washers, pins, clips, etc.

This document does not specify requirements for such fastener properties as weldability or paintability. It is not applicable to mechanically applied zinc coatings.

NOTE Coatings in accordance with this document are especially used for high strength fasteners (≥ 1 000 MPa) to avoid risk of internal hydrogen embrittlement (IHE — see 4.4).

Information for design and assembly of coated fasteners is given in Annex A.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 1463, *Metallic and oxide coatings — Measurement of coating thickness — Microscopical method*

ISO 1502, *ISO general-purpose metric screw threads — Gauges and gauging*

ISO 1891-2, *Fasteners — Terminology — Part 2: Vocabulary and definitions for coatings*

ISO 3613:2010, *Metallic and other inorganic coatings — Chromate conversion coatings on zinc, cadmium, aluminium-zinc alloys and zinc-aluminium alloys — Test methods*

ISO 6988, *Metallic and other non organic coatings — Sulfur dioxide test with general condensation of moisture*

ISO 8991, *Designation system for fasteners*

ISO 9227, *Corrosion tests in artificial atmospheres — Salt spray tests*

ISO 16047, *Fasteners — Torque/clamp force testing*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 1891-2 apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at www.electropedia.org

4 General characteristics of the coating

4.1 Zinc flake coating systems

Zinc flake coating systems are produced by applying a zinc flake dispersion to the surface of a steel fastener, usually with the addition of aluminium flakes, in a suitable medium. Under the influence of heat (curing), a bonding amongst flakes and also between flakes and substrate is generated, thus forming an inorganic surface coating sufficiently electrically conducting to ensure cathodic protection. The coating system can contain hexavalent chromium, Cr(VI).

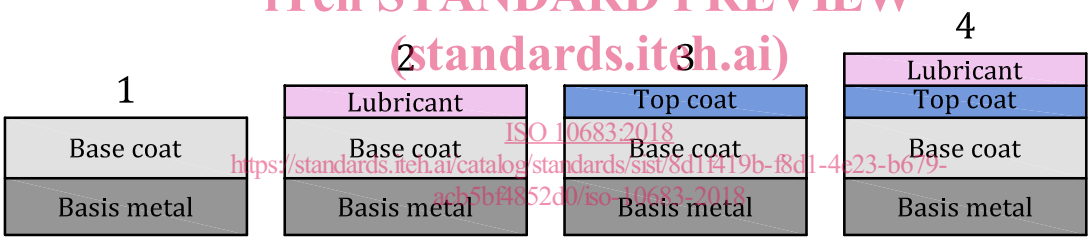
Special techniques can be necessary to avoid excessive or insufficient coating thickness.

Special techniques can be necessary to prevent lightweight and/or flat fasteners from sticking together (e.g. washers, clips, fasteners with captive washer, flanged nuts).

An additional top coat can be applied to increase corrosion resistance and/or to achieve specific properties (e.g. torque/clamp force properties, chemical resistance, aspect, colour, electrical insulation/conductivity — see A.2).

4.2 Composition of the systems

There are four basic zinc flake coating systems, as shown in Figure 1.



Key

1 only base coat
2 base coat + lubricant
3 base coat + top coat
4 base coat + top coat + lubricant

Figure 1 — Basic zinc flake coating systems

Base coat and top coat can be with integral lubricant; see detailed possible combinations in A.1.2.

4.3 Mechanical and physical properties and curing

The coating process shall not adversely influence the mechanical and physical properties of the fasteners.

NOTE Distributors who coat non-coated fasteners are considered as alteration distributors in accordance with ISO 1891-4.

Depending on the zinc flake coating system, the curing temperatures can be up to 320 °C. The curing temperature shall not be above the tempering temperature of quenched and tempered fasteners.

WARNING — The curing process (especially with higher temperature and/or longer duration) can affect the fatigue limit of fasteners with thread rolled after heat treatment. See also A.1.3 for other possible effects of curing.

4.4 Avoidance of internal hydrogen embrittlement

A characteristic of zinc flake coating systems is that hydrogen is not generated during the deposition process.

Pre-treatment processes using alkaline/solvent cleaner followed by mechanical cleaning do not generate hydrogen, thus eliminating all risk of internal hydrogen embrittlement (IHE).

When mechanical cleaning is not suitable for functional reasons (e.g. for fasteners with captive washers, fasteners with internal threads, fasteners to be rack coated), chemical cleaning (pickling) may be applied, provided that acid with suitable inhibitor and minimum cleaning cycle time are used to minimize the risk of internal hydrogen embrittlement. Fasteners with hardness greater than 390 HV or property class 12.9 and above shall not be subjected to acid cleaning. The duration between cleaning and coating shall be as short as possible.

A phosphating process is permitted as an alternative to mechanical cleaning (hydrogen may be generated during this pre-treatment process, however the curing process allows outward diffusion). The duration between phosphating and coating shall be as short as possible.

Cathodic cleaning processes are not permitted.

NOTE Zinc flake coatings have a high permeability for hydrogen which, during the curing process, allows outward diffusion of hydrogen that could have been absorbed during the pre-treatment process.

4.5 Coating systems and coating processes

The type and geometry of the fasteners shall be considered when selecting a coating system and the related coating process; see A.2.

5 Corrosion protection and testing

5.1 General

Corrosion resistance in accelerated corrosion tests cannot be directly related to corrosion protection behaviour in particular service environments. However, accelerated tests are used to evaluate the corrosion resistance of the coating.

5.2 Neutral salt spray test

The neutral salt spray test (NSS) in accordance with ISO 9227 shall be used to evaluate the corrosion resistance of the coating systems.

When evaluation of the cabinet corrosivity is requested, it should be performed in accordance with Annex C.

The neutral salt spray test shall be carried out on fasteners alone, no sooner than 24 h after coating in the “as-coated” condition, i.e. before sorting, packaging and/or assembling.

After the neutral salt spray test using a test duration of Table 1, there shall be no visible basis metal corrosion (red rust).

The contact points of fasteners with a holding fixture shall not be considered in the evaluation of corrosion protection.

NOTE Guidance for the selection of coating thickness in relation to corrosion protection is given in Annex B.

Table 1 — Standard categories for neutral salt spray test

Neutral salt spray test duration (without red rust) h	**Reference thickness of the coating system**[a] µm
240	4
480	5
600	6
720	8
960	10

[a] The reference thickness includes base coat(s) and top coat(s), if any, with or without Cr(VI). The corrosion resistance shall be decisive for acceptance; the reference thickness is given for guidance only.

The composition of the system (base coat only, base coat + top coat, etc.) shall be specified at the time of the order.

5.3 Sulfur dioxide test (Kesternich test)

This test is only intended for outdoor building fasteners.

The sulfur dioxide test with general condensation of moisture in accordance with ISO 6988 shall be used to evaluate the corrosion resistance of the coating systems; for outdoor building fasteners, the test shall be carried out with two litres of SO_2.

The sulfur dioxide test shall be carried out on fasteners alone, no sooner than 24 h after coating in the "as-coated" condition, i.e. before sorting, packaging and/or assembling.

The minimum number of cycles shall be agreed between the supplier and the purchaser at the time of the order, i.e. 2 cycles, 3, 5, 8, 10, 12, 15 cycles, etc.

The contact points of fasteners with a holding fixture shall not be considered in the evaluation of corrosion protection.

5.4 Bulk handling, automatic processes such as feeding and/or sorting, storage and transport

Bulk handling, automatic processes such as feeding and/or sorting, storage and transport can cause a significant reduction of corrosion protection depending on the coating system and type and geometry of the fasteners. This can especially occur for Cr(VI)-free coating systems where less self-healing effect takes place and/or where top coats are sensitive to impact damage and/or abrasion.

When necessary, an agreement should be reached between the supplier and the purchaser, e.g. by reducing the minimum duration of neutral salt spray test and/or by increasing the thickness of the coating system.

6 Dimensional requirements and testing

6.1 General

Before coating, fasteners shall be within the specified dimensions. For ISO metric threads, special requirements may apply; see 6.2.2, B.4 and B.5.

6.2 Fasteners with ISO metric thread

6.2.1 Coating thickness

When considering the coating thickness related to the desired corrosion resistance, the dispersion of the thickness of the coating system shall be taken into account; see B.3.

Coating thickness has a significant influence on gaugeability and assemblability, therefore thread tolerance and clearance in the thread shall be taken into account. The coating shall not cause the zero line (basic size) to be exceeded in the case of external threads, nor shall it fall below in the case of internal threads; see B.4.

NOTE For standard bolts, screws, studs and nuts not specifically manufactured to accommodate zinc flake coatings, see B.4 and B.5.

6.2.2 Gaugeability and assemblability

Coated ISO metric screw threads shall be gauged with a GO-gauge, in accordance with ISO 1502, of tolerance position h for external threads and H for internal threads.

When gauging coated threads of bolts, screws and studs, a maximum torque of 0,001 d^3 (Nm) on a length of 1d, beginning from thread end, is acceptable. When gauging coated internal threads of nuts, a maximum torque of 0,001 D^3 (Nm) is acceptable. See Table 2.

Table 2 — Maximum torque for gauging of coated ISO metric threads

Nominal thread diameter d or D mm	**Maximum torque for gauging**[a] Nm
3	0,03
4	0,06
5	0,13
6	0,22
8	0,51
10	1,0
12	1,7
14	2,7
16	4,1
18	5,8
20	8,0
22	11
24	14
27	20
30	27
33	36
36	47
39	59

[a] For other diameters, the torque shall be calculated in accordance with 0,001 d^3 or 0,001 D^3 (Nm) and rounded to 2 significant figures.

Acceptance procedures for assemblability may be applied by agreement between supplier and purchaser:

— for external thread, use of a suitable nut or the original mating fastener;

— for internal thread, use of a suitable mandrel (e.g. the mandrel specified for proof load in accordance with ISO 898-2) or the original mating fastener.

6.3 Other fasteners

After coating, there is no dimensional requirement for fasteners with non-ISO metric thread and for non-threaded fasteners specified in this document. For additional information, see A.3.

7 Mechanical and physical properties and testing

7.1 Appearance

The colour of a zinc flake coating is originally silver-grey. Other colours can be obtained by using a top coat. Variation in colour shall not be cause of rejection unless otherwise agreed; see Clause 10 g) and h).

The coated fastener shall be free from blisters and uncoated areas which can adversely affect the corrosion protection. Local excess of coating shall not impair functional properties (see Clause 6 and A.2).

7.2 Corrosion resistance related to temperature

Elevated temperature can affect the corrosion protection of the coated fasteners. This test is specified for in-process control; it is not intended to check the behaviour of the coated fasteners together with the assembled parts.

After heating the coated fasteners for 3 h at 150 °C (part temperature) the corrosion resistance requirements as specified in Clause 5 shall still be met.

Other specifications may be agreed at the time of the order.

7.3 Test methods for thickness or coating weight determination

Coating thickness or coating weight shall be determined using one of the following test methods:

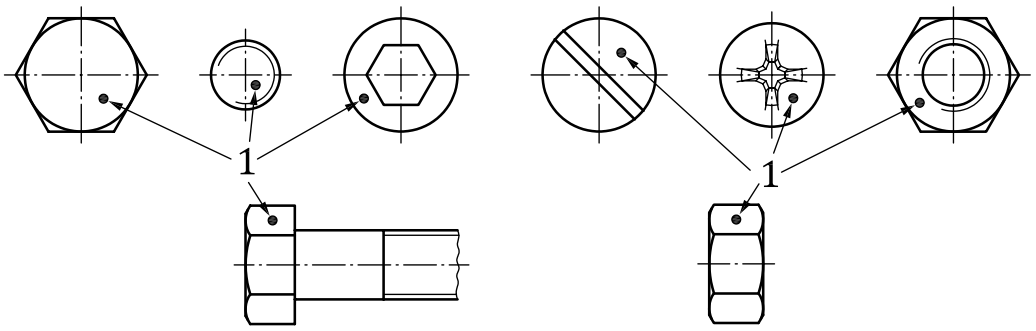
— magnetic inductive techniques (determination of the total local thickness, on measuring areas);

— X-ray techniques (this method is only capable to determine the local thickness of the base coat, on measuring areas);

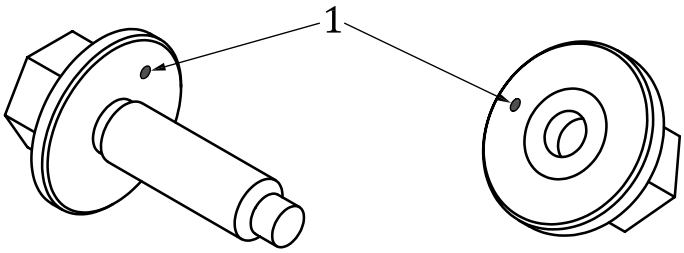
— chemical or mechanical removal of the coating system (determination of the average total coating weight of the fastener);

— microscopic method in accordance with ISO 1463 (determination of the total local thickness, on any area(s) of the fastener).

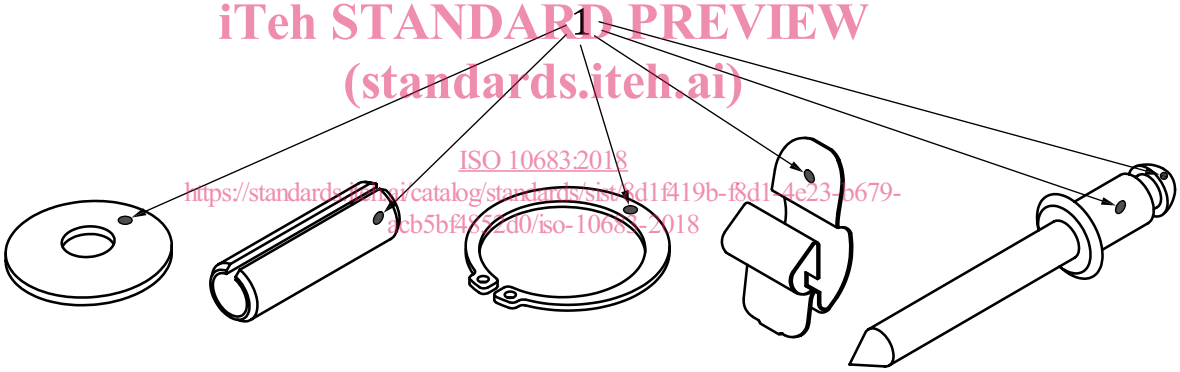
In case of dispute, the microscopic method in accordance with ISO 1463 shall be used. The thickness shall be measured on the reference areas specified in Figure 2, unless otherwise agreed.



a) Reference areas for threaded fasteners



b) Reference areas for captive washers



c) Reference areas for non-threaded fasteners (examples)

Key

1 reference area for local coating thickness determination

Figure 2 — Reference areas for fasteners

7.4 Ductility

Zinc flake coating systems are generally not very ductile, i.e. corrosion performance can be affected when deformation occurs after coating. Ductility shall be compatible with the elastic deformation occurring during assembly of the fastener, e.g. tightening of threaded fasteners, flattening for conical washers, bending for clips during installation.

The ability of the zinc flake coating system to deform should not cause impairment of the performance of the fastener, e.g. corrosion resistance, torque/clamp force relationship when specified. Therefore, suitable tests for particular applications shall be agreed between the purchaser and the supplier.

NOTE Lack of ductility can generate cracks/chips of the coating thus impairing corrosion resistance.

7.5 Adhesion/cohesion

This test may be carried out at each step of the application process.

When an adhesive tape with 25 mm width with an adhesive strength of (7 ± 1) N is firmly pressed by hand on to the surface and is subsequently pulled off rapidly and perpendicularly to the surface, the coating shall not be peeled off the basis metal. Small amounts of the coating material left sticking to the tape are acceptable.

NOTE Coating material visible on both surfaces of the fastener and adhesive tape usually results from lack of cohesion. Visible basis metal and coating material on the adhesive tape usually result from lack of adhesion.

7.6 Sacrificial cathodic protection

The sacrificial cathodic protection ability of the coating may be tested as follows:

— the fastener shall be scratched down to the basis metal, using a tool with a nominal width of 0,5 mm;

— after a neutral salt spray test of 72 h duration in accordance with Clause 5, there shall be no red rust in the scratched area.

7.7 Torque/clamp force relationship

When specified, the torque/clamp force relationship may be determined for fasteners with external ISO metric thread and nuts with zinc flake coating systems including integral lubricant and/or subsequently added lubricant.

The test method shall be agreed between the supplier and the purchaser, in accordance with ISO 16047 or other relevant technical specifications.

The requirements for torque/clamp force relationship shall be agreed between the supplier and the purchaser. See A.2 for information.

Storage conditions shall not impair the torque/clamp force performance of the coated fasteners (see A.4).

7.8 Determination of hexavalent chromium

The presence or absence of Cr(VI) may be determined. In this case, the determination shall be done in accordance with ISO 3613:2010, 5.5.2.

8 Applicability of tests

8.1 General

All requirements specified in Clauses 5, 6 and 7 apply as far as they are general characteristics of the coating or are separately specified by the purchaser.

8.2 Tests mandatory for each lot

The following tests shall be carried out for each lot of fasteners (see ISO 3269).

— Gauging of thread (see 6.2.2).

— Appearance (see 7.1).