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# ISO 10683

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

*Fixations — Systèmes de revêtements non électrolytiques de zinc lamellaire*

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# Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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).

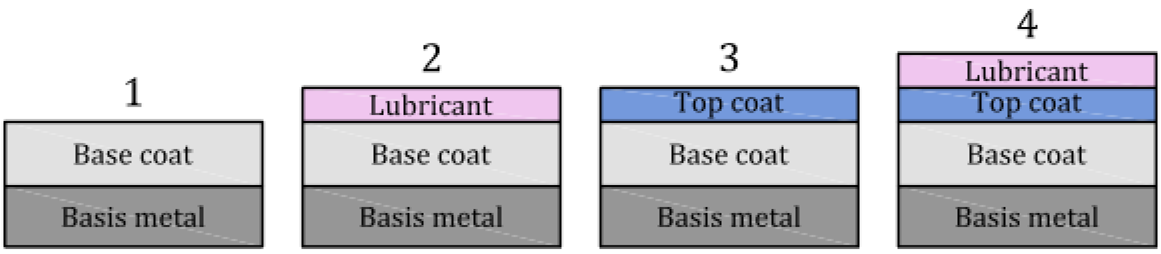
Special techniques can be necessary to avoid excessive or insufficient coating thickness.

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)<br>h | **Reference thickness of the coating system**[a]<br>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 1$d$, 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:

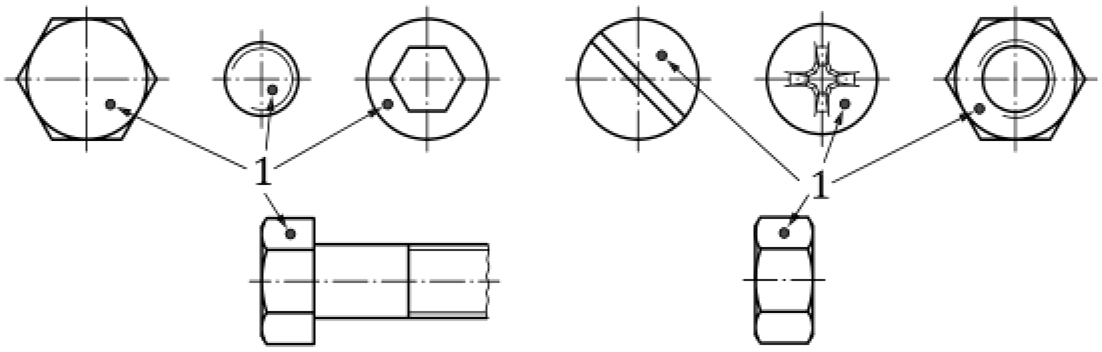
— magnetic inductive techniques (determination of the total local thickness, on measuring areas);

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

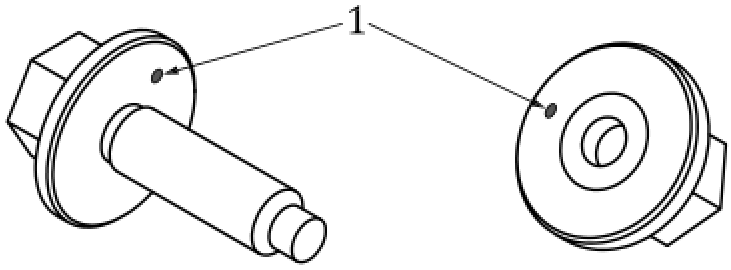
— chemical or mechanical removal of the coating system (determination of the average total coating weight of the fastener);

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

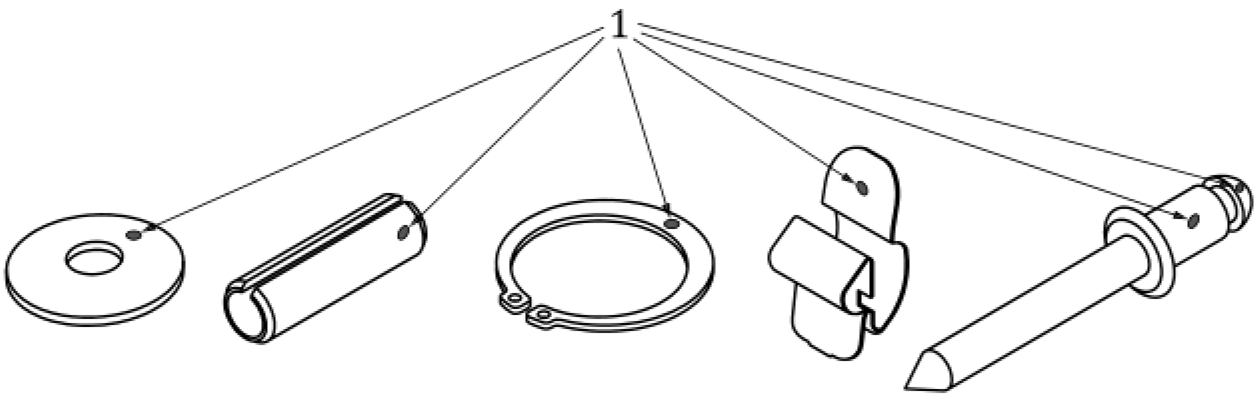
In case of dispute, the microscopic method in accordance with ISO 1463 shall be used. The thickness shall be measured on the reference areas specified in Figure 2, unless otherwise agreed.




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).

### 8.3 Tests for in-process control

The following tests are not intended to be applied for each fastener lot, but shall be used for in-process control (see ISO 16426), when relevant.

— Corrosion resistance: neutral salt spray test (see 5.2) or, alternatively and only when specifically required, sulfur dioxide test (see 5.3).

— Temperature resistance (see 7.2).

— Coating thickness or coating weight (see 7.3).

— Adhesion/cohesion (see 7.5).

### 8.4 Tests to be performed when specified by the purchaser

The following tests are performed when specifically required by the purchaser; see ISO 3269. In-process test results for that lot (see 8.3) may be used to supply test results to the purchaser.

— Corrosion resistance: neutral salt spray test (see 5.2) or, alternatively and only when specifically required, sulfur dioxide test (see 5.3). Significant areas may be specified for the evaluation of the corrosion resistance.

— Coating thickness or coating weight (see 7.3).

— Torque/clamp force relationship (see 7.7 and Table 3).

— Ductility (see 7.4).

— Cathodic protection (see 7.6).

— Presence or absence of Cr(VI) (see 7.8).

## 9 Designation

### 9.1 Designation of zinc flake coating systems for the order

The designation of the coating shall be added to the fastener designation in accordance with the designation system specified in ISO 8991. The zinc flake coating system shall be designated in accordance with Table 3 and in the same order. A slash (/) shall be used to separate data fields in the coating designation.

**Table 3 — Designation for zinc flake coating systems for the order**

| Zinc flake coating system | | | | Neutral salt spray test duration (red rust) | Torque/clamp force requirement, if any |
|---|---|---|---|---|---|
| **Base coat** | **Hexavalent chromium Cr(VI)** | **Organic or inorganic top coat** | **Additional lubricant, if any** | | |
| Without integral lubricant = **flZn**<br>or<br>With integral lubricant = **flZnL** | **No specification:** may be delivered with or without Cr(VI) at the choice of the supplier<br>or<br>With Cr(VI) = **yc**<br>or<br>Without Cr(VI) = **nc** | With integral lubricant in the top coat = **TL**<br>or<br>Without integral lubricant in the top coat = **Tn** | **L** | e.g. **480 h** | **C**[a] |

[a] Range of $\mu$ or $K$ values to be specified at the time of the order, see also A.2.1.

Examples 1 to 4 provide examples of coating designation for the order:

EXAMPLE 1 Fastener with a non-electrolytically applied zinc flake coating (flZn), with a required minimum corrosion resistance (neutral salt spray test) of 240 h is designated as follows:

[fastener designation] – **flZn/240h**

EXAMPLE 2 Fastener with a non-electrolytically applied zinc flake coating with integral lubricant (flZnL), without Cr(VI) (nc), without top coat, with a required minimum corrosion resistance (neutral salt spray test) of 480 h, lubricated but without specific torque/clamp force requirement is designated as follows:

[fastener designation] – **flZnL/nc/480h**

EXAMPLE 3 Fastener with a non-electrolytically applied zinc flake coating (flZn) with Cr(VI) (yc), with a top coat with integral lubricant (TL), with a required minimum corrosion resistance (neutral salt spray test) of 720 h, and with a coefficient of friction $\mu$ within the range of [0,10 to 0,20] (C) is designated as follows:

[fastener designation] – **flZn/yc/TL/720h/C**

EXAMPLE 4 Fastener with a non-electrolytically applied zinc flake coating (flZn) without Cr(VI) (nc), without integral lubricant, with a top coat without integral lubricant (Tn), with additional lubricant (L), with a required minimum corrosion resistance (neutral salt spray test) of 960 h, and with a coefficient of friction $\mu$ equal to 0,17 ± 0,03 (C) is designated as follows:

[fastener designation] – **flZn/nc/Tn/L/960h/C**

### 9.2 Designation of zinc flake coating systems for labelling

At least the following information shall be added on the label, separated by a slash (/):

— **flZn** for the zinc flake coating (base coat);

— **yc** for coating with Cr(VI), or **nc** for Cr(VI) free coating;

— minimum duration of corrosion resistance (neutral salt spray) in hours.

Examples 1 to 3 provide examples for labelling.

EXAMPLE 1 Hexagon head bolt ISO 4014 – M12×80 – 10.9 – **flZn/nc/720h**

EXAMPLE 2 Hexagon regular nut ISO 4032 – M12 – 10 – **flZn/yc/480h**

EXAMPLE 3 Plain washer ISO 7089 – 12 – 300HV – **flZn/nc/240h**

## 10 Ordering requirements

When ordering a zinc flake coating system for fasteners in accordance with this document, the following information shall be supplied:

a) reference to this document;

b) the coating designation (see Clause 9);

c) the material properties of the fastener that may be influenced by the coating process, e.g. tempering temperature, hardness or other properties;

d) torque/clamp force requirements, if any, including specification and related test method (e.g. ISO 16047);

e) other requirements, if any (e.g. resistance to chemicals, suitability for adhesives, electrical conductivity/insulation);

f) tests to be carried out, if any (see Clause 8);

g) sampling;

h) colour if different from silver-grey;

i) cosmetic appearance, if any.

# Annex A
(informative)

# Design aspects and assembly of coated fasteners

## A.1 Design

### A.1.1 General

Before selecting a coating system, all functions and conditions of the assembly should be considered and not just the fastener; see A.2.2. The purchaser should consult the supplier to determine the appropriate choices for a given application.

### A.1.2 Description of zinc flake coating systems

Figure A.1 shows typical zinc flake coating systems.

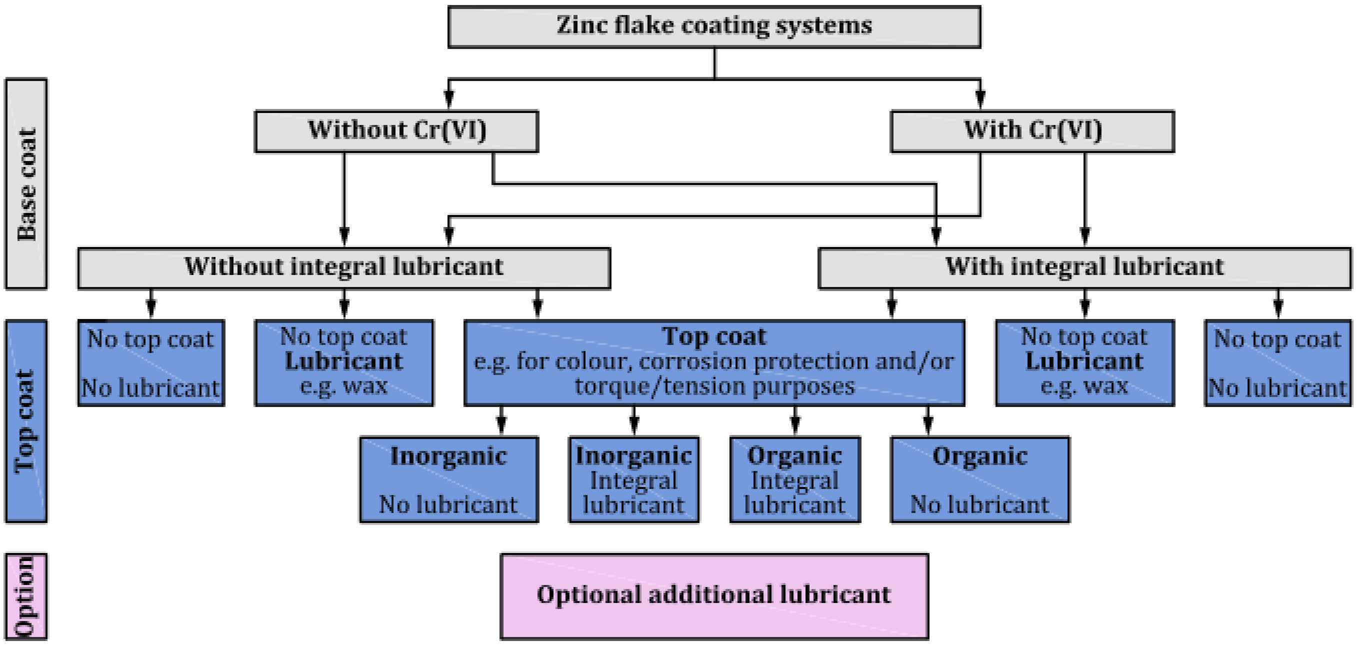



**Figure A.1 — Typical zinc flake coating systems**

An integral lubricant may be chosen to achieve torque/clamp force properties.

An additional top coat may be chosen to increase corrosion resistance and to achieve other specific properties (e.g. torque/clamp force properties, resistance to chemicals, mechanical resistance, aspect, colour, thermal resistance, electrical insulation/conductivity, UV resistance).

The selection of the nature of the top coat should be based on desired additional properties:

— organic top coat: electrical insulation, high resistance to chemicals or colouring possibilities, etc.;

— inorganic top coat: impact/abrasion resistance or thermal resistance, etc.

An additional lubricant may be chosen to adjust torque/clamp force relationship.

### A.1.3 Coating process

Zinc flake coating systems can be applied in bulk or rack process using dip-spin or spray process.

Zinc flake coating is generally a mass process. When lots of small quantities have to be coated, a suitable coating line and/or process can be necessary in order to achieve the required properties and performances for the coated fasteners. For fasteners of large size or mass or when the risk of thread damage has to be reduced, rack instead of bulk process may be considered.

Curing process (especially with higher temperature and/or longer duration) can have an effect on the properties/performances of fasteners:

— when the curing temperature is above the tempering temperature, reduction of hardness can affect the performances of case hardened or nitrocarburised fasteners (e.g. for thread forming or self-drilling screws), or elastic and plastic deformation (e.g. for clips);

— for cold worked fasteners or fasteners with thread rolled after heat treatment, residual stresses may be reduced.

## A.2 Functional properties

### A.2.1 Assemblability and mountability

Clearance between assembly components (e.g. clearance hole), dimensional tolerances of the functional parts of the fasteners, tool gripping (e.g. for retaining rings), tool insertion (e.g. for recess and internal drives) and driving should not be impaired.

For dimensional requirements after coating for threaded fasteners, see 6.2 and Annex B.

The compatibility of the coating system with the tightening process, especially when high speed tightening is foreseen (risk of overheating, stick/slip, etc.) should be considered.

The compatibility of the coated fasteners with the clamped parts, e.g. tapped holes, clamped parts in aluminium, magnesium, stainless steel, electrophoreticaly coated parts, hot dip galvanized parts, plastic, wood should be considered.

To achieve a specific clamp force and a consistent torque/clamp force relationship for fasteners with ISO metric thread, at least one of the mating threaded fasteners should be lubricated. Zinc flake coating systems provide lubricated solutions (see A.1.2). Torque/clamp force relationship can be determined in accordance with ISO 16047 and expressed as a coefficient of friction $\mu$ (or by $K$-factor).

### A.2.2 Other properties of the assembly with coated fasteners

#### A.2.2.1 Chemical resistance

Organic top coats applied on zinc flake base coats are more resistant to acidic and alkaline chemicals than inorganic top coats.

#### A.2.2.2 Electrical conductivity

The electrical conductivity of zinc flake base coats with inorganic top coat is generally suitable for application of electrophoretic coatings and antistatic purposes. Zinc flake coating systems are not suitable for electrical grounding.

#### A.2.2.3 Galvanic corrosion

In order to reduce the risk of galvanic corrosion, all of the parts of the assembly should be considered (coated fasteners and clamped parts). A direct metal contact with non-coated clamped parts should be avoided, especially e.g. for stainless steel, magnesium, copper or copper alloys. Due to their insulating effect, organic top coats improve the resistance against galvanic corrosion.

The items listed in A.2.2 are not exhaustive. All the specific service conditions should be considered when selecting a coating system.

#### A.2.2.4 Cleanliness

For cleanliness requirements, the suitability of the zinc flake coating system should be checked (e.g. dust, particle size, particle type, number of particles).

## A.3 Particular issues related to fasteners and coating processes

### A.3.1 General

The type of fasteners should be considered when choosing a coating system and related coating process: A.3.2 to A.3.9 list the main issues for each type of fasteners. When 100 % sorting is required for specific characteristic(s), agreement should be reached between the supplier and the purchaser at the time of the order. Suitable measures should be taken into account for the following potential issues.

### A.3.2 Fasteners with ISO metric thread

— Thread damages (the heavier the part, the more sensitive it is).

— Filling of drive/recess.

— Retention of particles in threads.

— For fasteners to be coated and with pitch $P < 1$ mm, a special agreement between supplier and purchaser should be reached.

— Contamination with foreign parts.

### A.3.3 Fasteners with captive washers

— Retention of particles (e.g. when shot blasting is used).

— Free rotation of the washer.

— Contamination with foreign parts.

### A.3.4 Fasteners with adhesive or patch

Applicability on zinc flake coating systems and functional properties should be evaluated.

### A.3.5 Nuts

— Retention of particles in threads.

— For fasteners to be coated and with pitch $P < 1$ mm, a special agreement between supplier and purchaser should be reached.

— Contamination with foreign parts.

### A.3.6 Prevailing torque nuts

For all metal prevailing torque nuts, zinc flake coating systems in combination with silicate based top coat may cause scratching of the coating, fouling or even galling during tightening. In this case, an alternative top coat or additional lubricant should be used.

For prevailing torque nuts with non-metallic insert, the effect of the curing temperature should be considered.

### A.3.7 Fasteners with recess, internal drive or cavities

Special techniques can be necessary to prevent retention of particles (e.g. when shot blasting is used as pre-treatment) and excess of coating in recesses or internal drives or cavities.

### A.3.8 Screws which form their own mating threads

When selecting zinc flake coating systems, the requirements for thread-forming properties should be considered.

NOTE It includes thread forming and thread cutting screws, tapping screws, drilling screws, chip board screws, screws for plastics and similar fasteners.

### A.3.9 Clips and retaining rings

Plastic deformation and tangling of clips and retaining rings should be avoided during the coating process.

Special techniques can be necessary to prevent excess of coating in retention zones.

## A.4 Storage of coated fasteners

During storage and before installation, direct contact with water or other liquid, condensation, exposure to dust, etc. should be avoided; such conditions can impair torque/clamp force relationship and/or corrosion resistance.

# Annex B
(informative)

# Coating thickness and thread clearance for ISO metric screw threads

## B.1 General

Dimensional requirements and testing for fasteners with ISO metric screw thread are specified in 6.2.

Zinc flake coating processes usually do not produce a uniform distribution of the coating thickness on the whole surface of the fasteners. As coating thickness has a significant influence on gaugeability, it is necessary to consider thread tolerance and clearance in the thread.

When designing fasteners to be coated for corrosion resistance purpose, at least the following should be taken into consideration:

— type and size of the fastener;

— tolerance class of the thread;

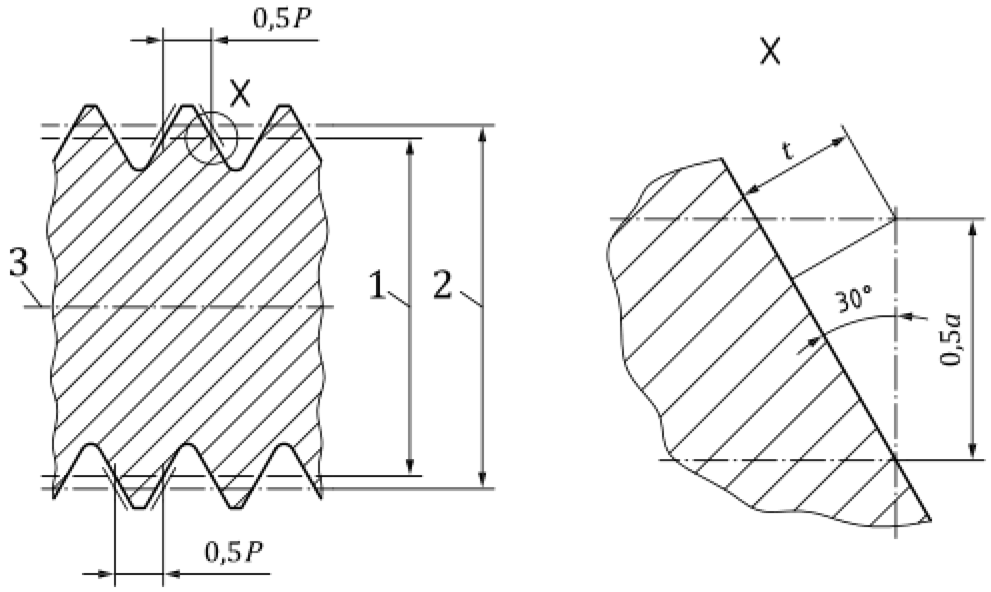
— typical dispersion of the thickness from the coating process (see B.3);

— clearance available in the thread (see B.4).

Examples are given in B.6 to explain how these aspects could be considered.

## B.2 Geometrical relationship between coating thickness and pitch diameter

When a coating with a theoretical/reference thickness $t$ is applied on an external thread in order to achieve a specified corrosion resistance (see Clause 5), the pitch diameter $d_2$ increases by $4t$ as illustrated in Figure B.1; see Table B.1.




**Key**

*a* change of pitch diameter due to coating

*P* pitch of the thread

*t* thickness of the coating

1 pitch diameter of the bolt before coating, $d_2$

2 pitch diameter of the bolt after coating

3 thread axis

$$\frac{t}{0,5a} = \sin 30^\circ = 0,5 \qquad 0,25a = t \qquad a = 4t$$

**Figure B.1 — Geometrical relationship between coating thickness and pitch diameter**

**Table B.1 — Geometrical relationship between coating thickness and pitch diameter**

Dimensions in micrometres

| Coating thickness<br>*t* | Pitch diameter increase<br>4*t*[a] |
|---|---|
| 3 | 12 |
| 4 | 16 |
| 5 | 20 |
| 6 | 24 |
| 8 | 32 |
| 10 | 40 |
| 12 | 48 |

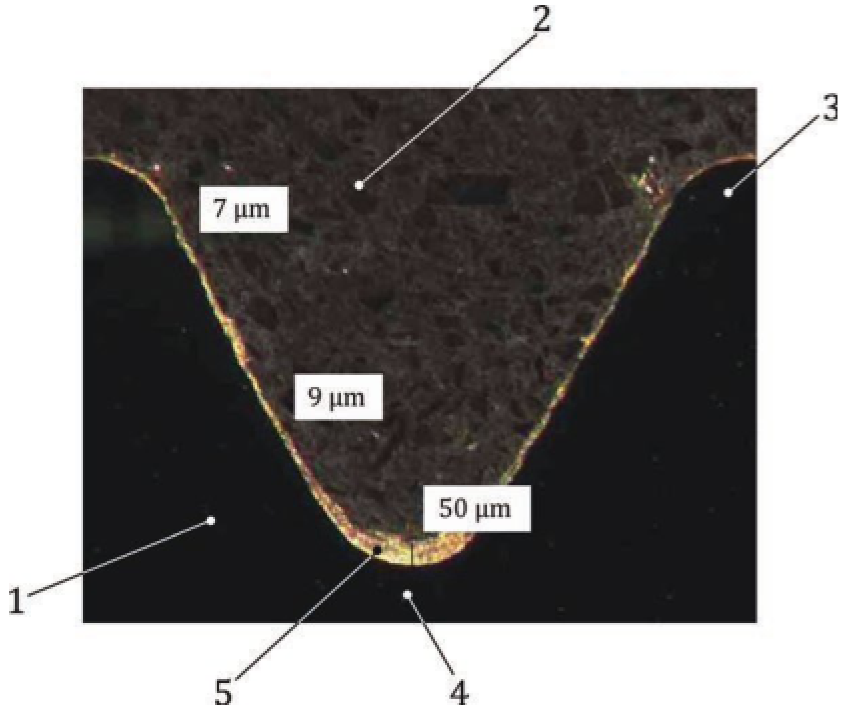
[a] This pitch diameter increase corresponds to the fundamental deviation (clearance), which is needed for the coating thickness *t*.

## B.3 Variability of coating thickness

Zinc flake coatings for fasteners are typically applied by the dip spin process, which results in non-uniform coating thickness.

The dip spin coating process can generate significant variation in local thickness, exceeding the coating thickness *t* by as much as one third to half of the coating thickness. This variability of coating thickness does not typically impair thread fit. The effect of coating thickness on the pitch diameter should be carefully considered in order to achieve thread fit and gaugeability. Excessive thickness at the thread root (see Figure B.2) does not typically impair thread fit and gaugeability, and the zinc flake coating process does not typically result in excessive thickness at the thread crest.

NOTE Large diameters, long or heavy fasteners are usually rack coated.




**Key**

1 bolt

2 resin

3 thread crest

4 thread root

5 coating

**Figure B.2 — Example of typical variation of coating thickness on a bolt thread (M12 × 1,5) resulting from a dip spin coating process**

## B.4 Clearance for coating thickness

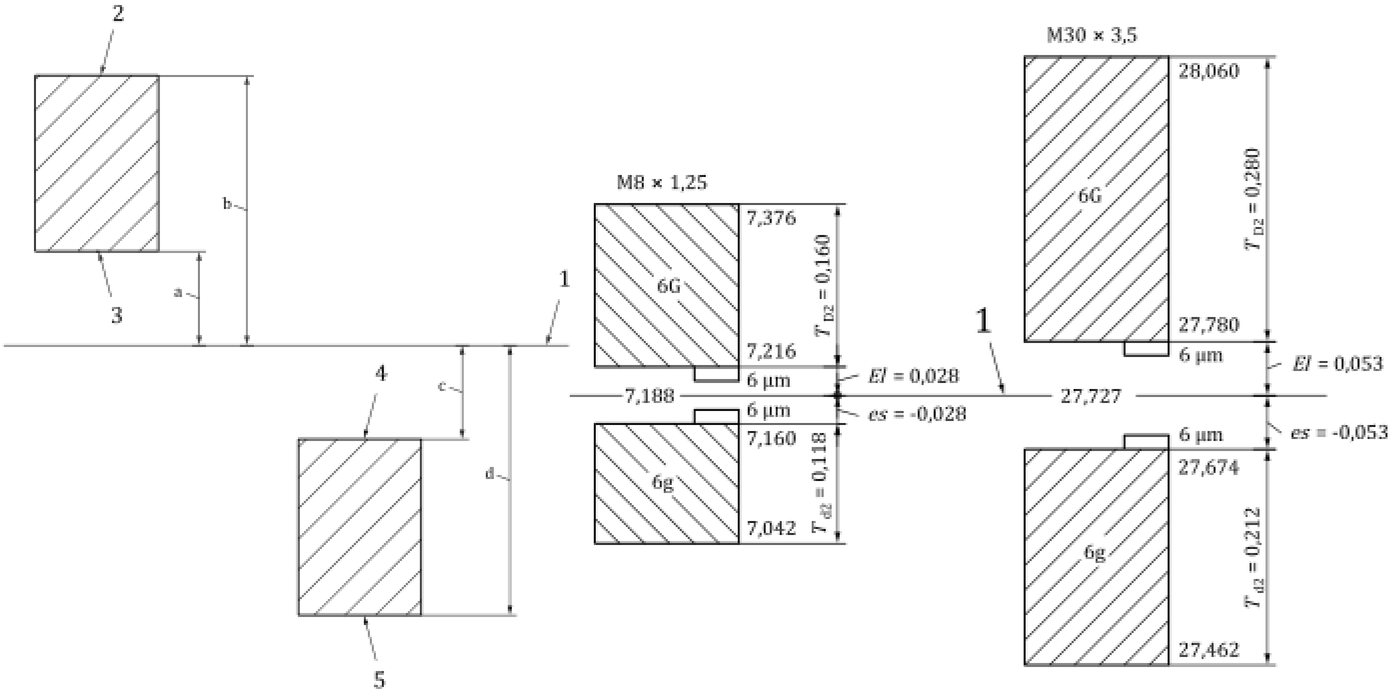
Fasteners should be manufactured to provide for sufficient clearance at the pitch diameter in order to accommodate the coating thickness.

Coating thickness which can be applied on ISO metric threads in accordance with ISO 965-1, ISO 965-2 or ISO 965-3 depends on the fundamental deviation at the pitch diameter as given in Table B.2, which itself depends on the screw thread and the following tolerance positions:

— g, f, e for external threads;

— G for internal threads.

Dimensions in millimetres




**a) Internal thread/ External thread** **b) Examples for M8×1,25 and M30×3,5**

**Key**

1 zero line

2 maximum pitch diameter of the nut thread before coating

3 minimum pitch diameter of the nut thread before coating

4 maximum pitch diameter of the bolt thread before coating

5 minimum pitch diameter of the bolt thread before coating

$T_{D2}$ tolerance for $D_2$

$T_{d2}$ tolerance for $d_2$

*EI* lower limit of the fundamental deviation of the nut thread with respect to zero line

*es* upper limit of the fundamental deviation of the bolt thread with respect to zero line

[a,c] The minimum clearance corresponds to the fundamental deviation.

[b,d] The maximum clearance corresponds to the absolute value of the fundamental deviation plus the tolerance grade value.

**Figure B.3 — Pitch diameter tolerance position and clearance for coating**

Table B.2 indicates the clearance at the pitch diameter, in function of the thread tolerance grade value of the non-coated fasteners, for a given thread pitch dimension. The minimum and maximum clearances are theoretical values limiting the range of available space for coating (see Figure B.3). They are given in order to check that the thickness of the coating system is in the given range.

The clearance should be divided by 4 in accordance with Table B.1 in order to get the maximum possible coating thickness.

**Table B.2 — Theoretical limits of clearance for ISO metric threads**

| Thread pitch *P* | Nominal thread diameter[a] *d* or *D* | | Internal thread | External thread | | |
|---|---|---|---|---|---|---|
| | | | Tolerance position **G** | Tolerance position **g** | Tolerance position **f** | Tolerance position **e** |
| | Coarse pitch | Fine pitch | Minimum clearance[b] | Minimum clearance[b] | Minimum clearance[b] | Minimum clearance[b] |
| mm | mm | mm | µm | µm | µm | µm |
| 0,25 | 1 and 1,2 | — | +18 | −18 | — | — |
| 0,3 | 1,4 | — | +18 | −18 | — | — |
| 0,35 | 1,5 and 1,8 | — | +19 | −19 | −34 | — |
| 0,4 | 2 | — | +19 | −19 | −34 | — |
| 0,45 | 2,2 and 2,5 | — | +20 | −20 | −35 | — |
| 0,5 | 3 | — | +20 | −20 | −36 | −50 |
| 0,6 | 3,5 | — | +21 | −21 | −36 | −53 |
| 0,7 | 4 | — | +22 | −22 | −38 | −56 |
| 0,75 | 4,5 | — | +22 | −22 | −38 | −56 |
| 0,8 | 5 | — | +24 | −24 | −38 | −60 |
| 1 | 6 and 7 | 8 and 10 | +26 | −26 | −40 | −60 |
| 1,25 | 8 | 10 and 12 | +28 | −28 | −42 | −63 |
| 1,5 | 10 | 12 to 22 | +32 | −32 | −45 | −67 |
| 1,75 | 12 | — | +34 | −34 | −48 | −71 |
| 2 | 14 and 16 | 20 to 33 | +38 | −38 | −52 | −71 |
| 2,5 | 18, 20 and 22 | — | +42 | −42 | −58 | −80 |
| 3 | 24 and 27 | 36 to 48 | +48 | −48 | −63 | −85 |
| 3,5 | 30 and 33 | — | +53 | −53 | −70 | −90 |
| 4 | 36 and 39 | 52 to 64 | +60 | −60 | −75 | −95 |
| 4,5 | 42 and 45 | — | +63 | −63 | −80 | −100 |
| 5 | 48 and 52 | — | +71 | −71 | −85 | −106 |
| 5,5 | 56 and 60 | — | +75 | −75 | −90 | −112 |
| 6 | 64 | — | +80 | −80 | −95 | −118 |

[a] Nominal thread diameters are given for information; the determining characteristic is the thread pitch.

[b] The minimum clearance corresponds to the fundamental deviation.

## B.5 Compatibility between corrosion resistance and clearance

For compatibility between corrosion resistance and clearance, see Figure B.4.

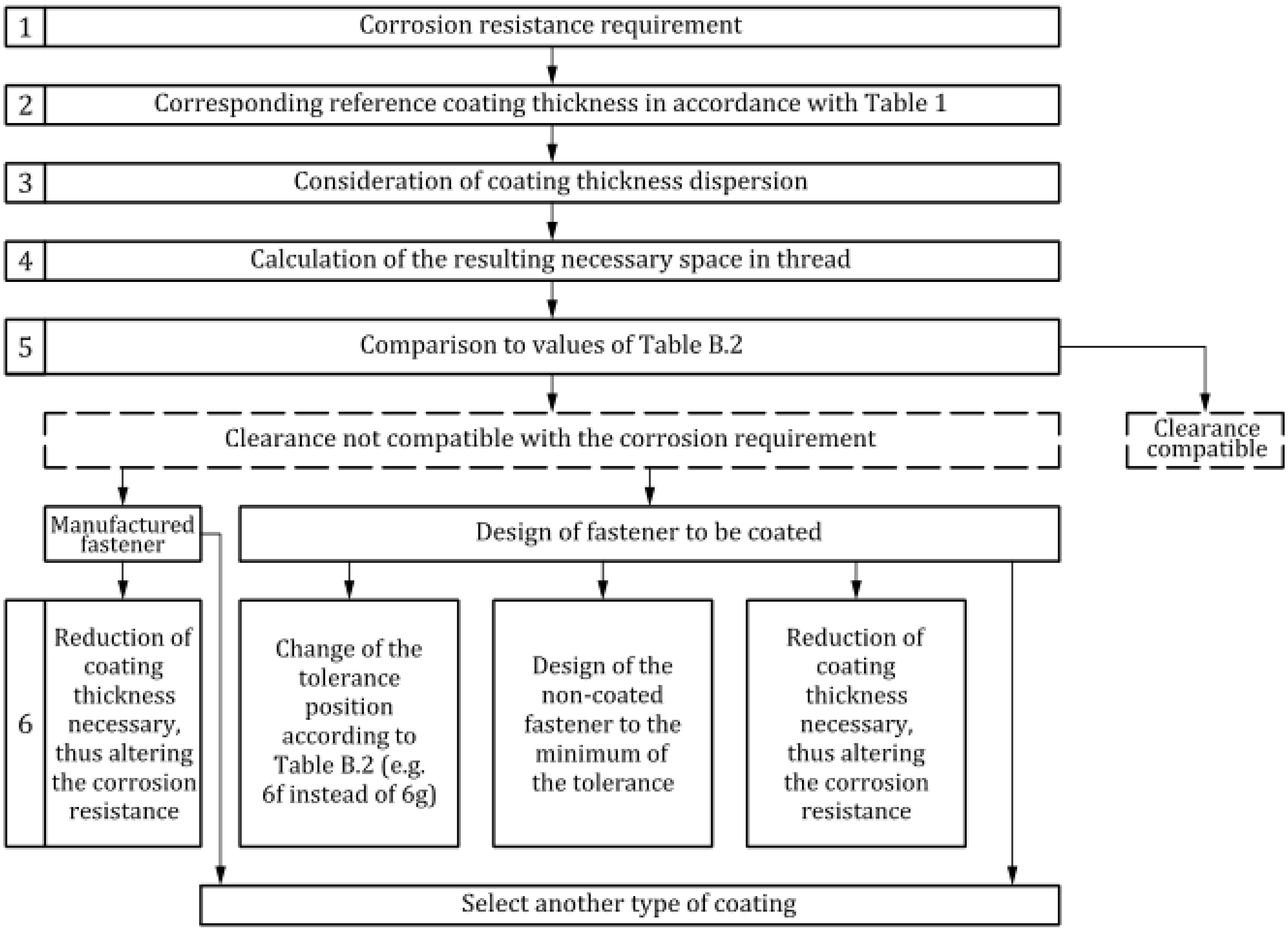



**Figure B.4 — Check of compatibility between corrosion resistance and clearance**

## B.6 Examples of application

### B.6.1 Example of a bolt with thread tolerance class 6g

| | |
|---|---|
| Fastener | ISO metric bolts M12 in accordance with ISO 4014, coarse pitch of 1,75 mm |
| Corrosion resistance requirement | 480 h |
| From Table 1 | Reference coating thickness: 5 µm |
| Influence of the possible dispersion (see B.3) | 5 µm + 2,5 µm for maximum thickness at pitch diameter, rounded to 8 µm |
| From Table B.1 (8 µm × 4) | 32 µm |
| From Table B.2 (tolerance class 6g) | Minimum clearance: 34 µm |

Result: When the calculated value (32 µm) is less or equal to the minimum clearance defined in Table B.2 (34 µm), whatever the dimension of the thread is within tolerance class 6g before coating, the thickness of the coating system is compatible with the requirement.

### B.6.2 Example of a screw with thread tolerance class 6g

| | |
|---|---|
| Fastener | ISO metric screw M6 in accordance with ISO 4017, coarse pitch of 1 mm |
| Corrosion resistance requirement | 600 h |
| From Table 1 | Reference coating thickness: 6 µm |
| Influence of the possible dispersion (see B.3) | 6 µm + 3 µm for maximum thickness at pitch diameter |
| From Table B.1 (9 µm × 4) | 36 µm |
| From Table B.2 (tolerance class 6g) | Minimum clearance: 26 µm |

Result: The calculated value (36 µm) exceeds the minimum clearance defined in Table B.2 (26 µm), the thickness of the coating system is not compatible with the requirement.

### B.6.3 Example of the same screw as in B.6.2 but with thread tolerance class changed to 6f

| | |
|---|---|
| Fastener | ISO metric screw M6 in accordance with ISO 4017, coarse pitch of 1 mm |
| Corrosion resistance requirement | 600 h |
| From Table 1 | Reference coating thickness: 6 µm |
| Influence of the possible dispersion (see B.3) | 6 µm + 3 µm for maximum thickness at pitch diameter |
| From Table B.1 (9 µm × 4) | 36 µm |
| From Table B.2 (tolerance class 6f) | Minimum clearance: 40 µm |

Result: The calculated value (36 µm) is now less than the minimum clearance defined in Table B.2 (40 µm). Whatever the dimension of the thread is within tolerance class 6f before coating, the thickness of the coating system is compatible with the requirement.

# Annex C
(informative)

# Coating systems tested in accordance with ISO 9227, NSS — Evaluation of cabinet corrosivity for the neutral salt spray test

## C.1 Introduction

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

This annex is designed to be used in addition to the test method specified in ISO 9227 for neutral salt spray test. It has been established for the evaluation of steel fasteners with zinc based coatings, for the purpose of controlling manufacturing lots.

The main reason for this development as a complement to ISO 9227 was the necessary improvement in terms of reliability, reproducibility and reduction of dispersion of test results, as neutral salt spray test is used for acceptance of fastener production by:

— using the same evaluation mode (appearance of red rust on zinc based coated steel reference panels rather than weight loss evaluation) and

— periodic controls of the corrosivity of the test cabinet.

This method is successfully used in the fastener industry and significantly improves the reproducibility of results of different salt spray cabinets.

## C.2 Purpose

This annex is a complement to ISO 9227 that specifies a methodology for evaluating the corrosivity of the test cabinet for neutral salt spray test (NSS), for steel fasteners with non-electrolytically applied zinc flake coatings in accordance with this document.

Two types of tests are defined in order to:

— determine the corrosivity level as a grade and the conditions under which the cabinet is considered compliant, by controlling the cabinet corrosivity throughout the useful volume, independent of specimens to be tested;

— monitor the cabinet corrosivity between periodic controls.

## C.3 Frequency of controls

The determination of the corrosivity level shall be carried out at least once a year, and also prior to the use of the cabinet following major maintenance or repair work on the equipment.

The corrosivity monitoring shall be carried out at least once a month.

## C.4 Operating conditions

### C.4.1 Parameters

All parameters specified in ISO 9227 shall be checked, except the method for evaluating the cabinet corrosivity.

### C.4.2 Reference panels

The reference panels shall be made of steel, e.g. CR24 in accordance with ISO 6932, coated at least on one surface with a layer of zinc obtained by high-speed continuous hot dip galvanizing. The zinc thickness shall be (11 ± 1) µm.

The dimensions of the reference panels shall be 190 mm × 90 mm, see Figure C.4.

The reference panels may be oiled for better protection in storage.

The reference panels shall be accompanied by an inspection certificate containing at least the following:

— the identification of the supplier;

— the identification of the reference panels: coil and cast number;

— the chemical composition and mechanical properties of the substrate metal;

— the measured thickness of the zinc deposit;

— the reference of the protective oil, if any.

### C.4.3 Preparation of the reference panels

#### C.4.3.1 Degreasing procedure

The reference panels shall be used within 24 h after the degreasing procedure has been completed. They shall be degreased as follows:

a) Pre-degreasing with acetone using a soft cloth.

b) Degreasing with ultrasonics in a cleaning solution make-up of the following:

   — sodium bicarbonate ($NaHCO_3$) (15 ± 2) g/l;

   — sodium carbonate ($Na_2CO_3$) (10 ± 2) g/l;

   — trisodium phosphate ($Na_3PO_4$) (20 ± 2) g/l;

   — volume adjusted to one litre with distilled or deionized water.

   **Ultrasonic conditions:**

   — temperature (45 ± 2) °C;

   — duration (7 ± 1) minutes.

   The service life of this degreasing solution is 36 months in an opaque container and in storage conditions ranging from 0 °C to 40 °C. This solution shall be stored in a sealed container between uses (one litre of this solution is sufficient for a maximum of 5 panels).

c) Remove the panel with tongs before turning off the ultrasonics. Rinse in distilled or deionized water, then in a clean solvent (ethanol or acetone) and finally leave to dry in the air.

#### C.4.3.2 Panel protection

Degreased panels should be handled wearing gloves. Edges and back of panels should be protected with a suitable adhesive tape (e.g. the brown-coloured PVC tape with a width of 38 mm or 50 mm, or similar adhesive removable protection), as specified in Figure C.4, so that the total exposed surface is 160 mm × 80 mm.

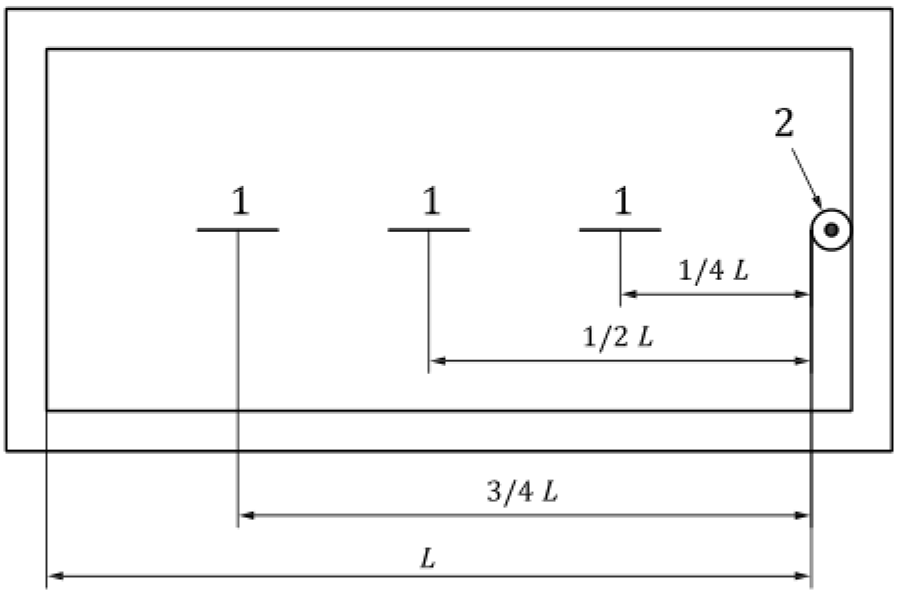
#### C.4.3.3 Position of reference panels and collectors

The support shall be made of chemically inert material. It shall enable positioning of the panels in line with an angle of (20 ± 5)° from the vertical, with the unprotected face upwards. The centre of each panel shall be levelled at the mean specimen exposure height. The number and relative position of the panels vary in accordance with the test method and cabinet design; see Figures C.1 to C.3:

— at least three panels shall be used for the annual control. The panels shall be positioned 1/4, 1/2 and 3/4 of the distance between the spray nozzle and the most distant cabinet wall;

— at least one panel shall be used during the monthly monitoring. This panel shall be positioned halfway between the spray and the most distant cabinet wall.

The collecting devices shall be placed in accordance with ISO 9227. For annual control, the number of collecting devices shall be the same as the number of panels, and located as close as possible to the panels.



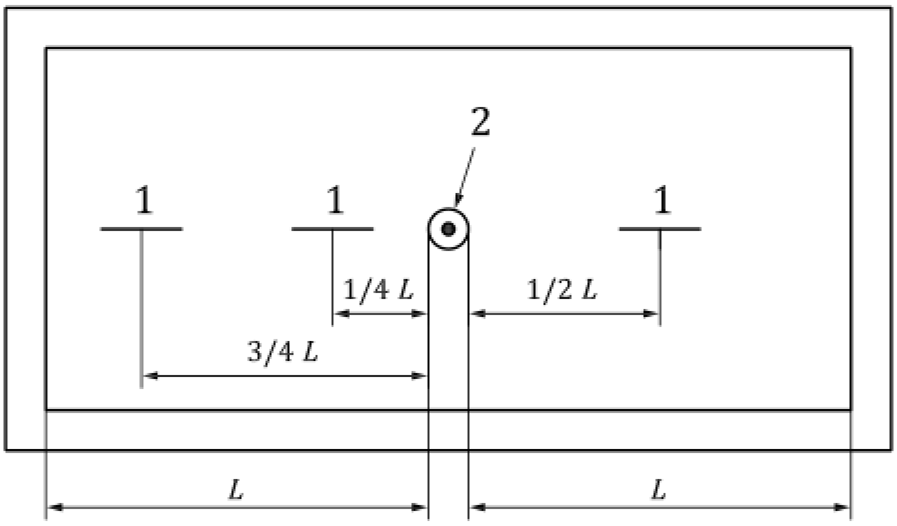

**Key**

*L* distance between spray nozzle and the most distant cabinet wall

1 panel

2 spray nozzle

**Figure C.1 — Off-centred spray cabinet**



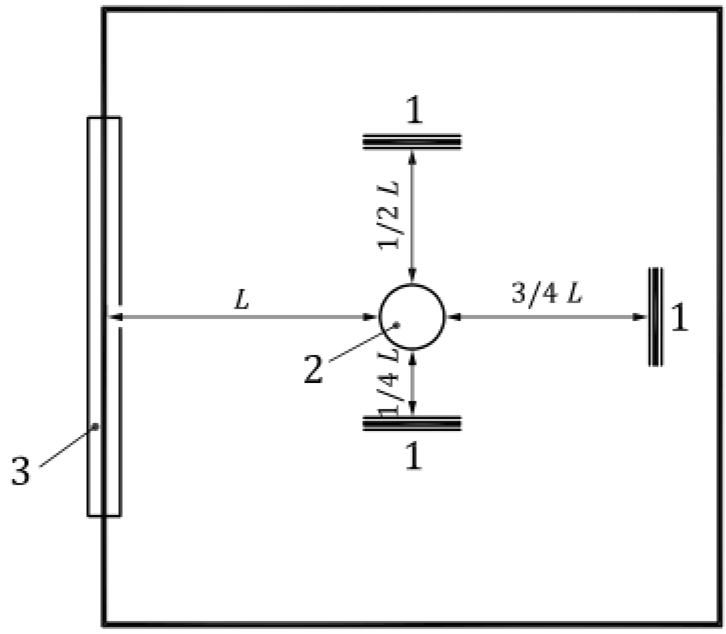

**Key**

*L* distance between spray nozzle and the most distant cabinet wall

1 panel

2 spray nozzle

**Figure C.2 — Centred spray cabinet**




**Key**

*L* distance between spray nozzle and the most distant cabinet wall

1 panel

2 spray nozzle

3 door

**Figure C.3 — Square centred spray cabinet**

### C.4.3.4 Filling of the cabinet

The test panels shall be arranged so that they do not come into contact with the cabinet, and so that their surfaces are exposed to free circulation of salt spray.

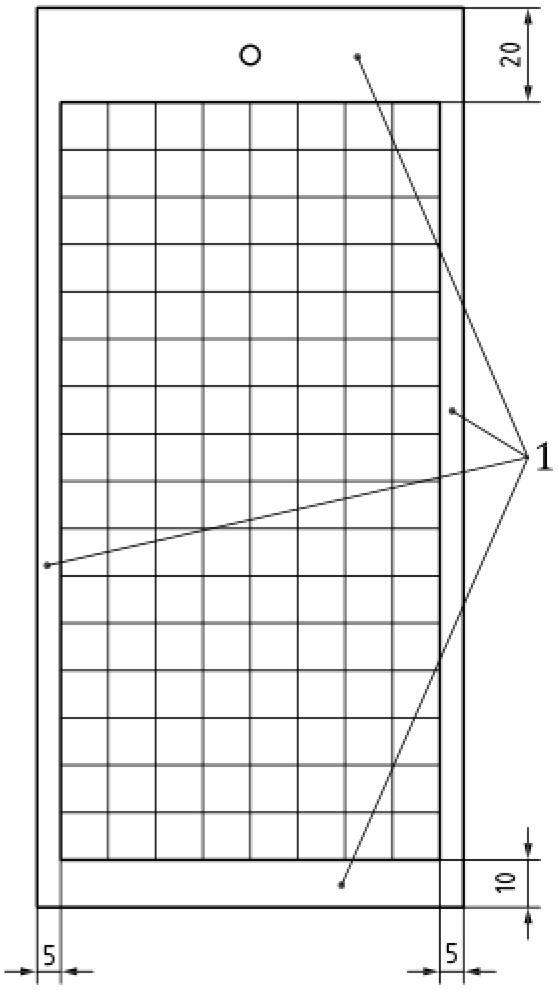
During the annual control, the cabinet shall only contain the reference panels.

Monthly monitoring may be conducted during normal operation of the cabinet. The other exposed specimens shall not obstruct the reference panel.

### C.4.4 Control mask

The control mask specified in Figure C.4 shall be reproduced on a transparent foil. The mask shall be placed on the reference panel.

Dimensions in millimetres




Hot dip galvanized panel: 190 mm × 90 mm

Surface area of one square: 1 $cm^2$

Number of squares: 128

% corroded = $n$ squares × 0,78

**Key**

1 protected zone (see C.4.3.2)

**Figure C.4 — Protection and control mask for reference panels**

### C.4.5 Determination of the corroded surface

A square is reported to be corroded as soon as it shows one point of red rust (flow included). See examples in Figure C.5.

All visual checks shall be made on non-rinsed, still wet panels.

The final check shall be made after a period of 70 h to 72 h and then every (24 ± 1) h. For practical aspects, it is recommended to start the test on Friday.

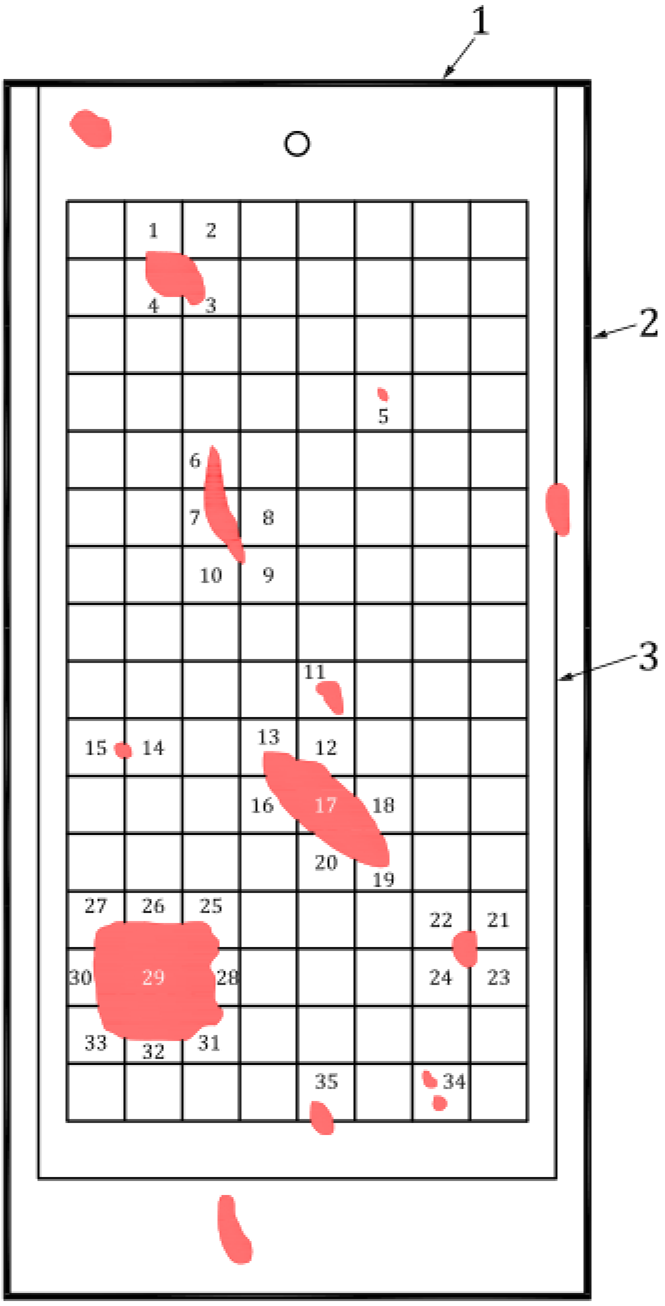
If one of the panels shows evidence of red rust during the 72 h check, repeat the test (e.g. the following Monday) and check it every 24 h.

For the annual control, the cabinet shall be open during 30 min per day after the initial period of 72 h. For the monthly monitoring, each opening shall not exceed 60 min. The open duration shall not be deducted.

### C.4.6 Quantification of corrosivity

The top of the mask shall be placed exactly at the top of the reference panel in accordance with its orientation in the cabinet during the test.

An example of quantification of corrosivity is shown in Figure C.5.




**Key**

1 top of the mask and top of the panel

2 reference panel

3 control mask

35 squares showing red rust: the percentage of corrosion (Red Rust Rate — RRR) is 27,3 % (35 × 0,78)

**Figure C.5 — Example of quantification of the corrosivity**

## C.5 Corrosivity results

Red Rust Time (RRT) is the time taken for the rusting level to exceed 5 % (i.e. a minimum of seven squares showing red rust).

RRT for each test panel and the corresponding grade shall be expressed in accordance with Table C.1. See also examples in C.6.5.

**Table C.1 — Grading system for the evaluation of the corrosivity level**

| Red Rust Time (RRT)<br>h | Grade | Corrosivity evaluation |
|---|---|---|
| RRT ≤ 72 | A | Not compliant |
| 72 < RRT ≤ 96 | B | Compliant |
| 96 < RRT ≤ 120 | C | |
| RRT > 120 | D | Not compliant |

For corrosivity evaluation, the cabinet is compliant for the purpose of testing steel fasteners with zinc and zinc-based coating systems, when the grade of each panel is equal to B or C in accordance with Table C.1.

The cabinet corrosivity is expressed by using the same grading system of A to D in accordance with Table C.1.

NOTE When testing coated fasteners with several cabinets (e.g. at purchaser's and supplier's places), reliable consistent results can only be achieved when the corrosivity level is compliant in accordance with Table C.1.

## C.6 Example of report format for annual control and monthly monitoring of the cabinet

### C.6.1 Annual control and monthly monitoring of the cabinet corrosivity level

| | | | |
|---|---|---|---|
| Type of test: Monthly monitoring | ☐ | Annual control | ☐ |
| Test start date: | Cabinet identification number: | | |
| Reference panel batch number: | | | |

### C.6.2 Condensate check

| Volume collected<br>ml/h [a] | | |
|---|---|---|
| **Collector 1** | **Collector 2** | **Collector 3** |
| | | |

NOTE The collector device number is the same as the panel number.

[a] Average measurement over the entire test duration (opening time included); in accordance with ISO 9227, (1,5 ± 0,5) ml/h for a horizontal collecting area of 80 $cm^2$ (which corresponds to three collecting devices of 10 cm in diameter each).

### C.6.3 Determination of the corrosivity level

| | | Evidence of red rust: % quantified on the control mask | | |
|---|---|---|---|---|
| **Red Rust Time (RRT)**<br>h | **Grade** | **Panel 1** | **Panel 2** | **Panel 3** |
| RRT ≤ 72 | A | | | |
| 72 < RRT ≤ 96 | B | | | |
| 96 < RRT ≤ 120 | C | | | |
| RRT > 120 | D | | | |
| Result (grade when Red Rust Rate RRR ≥ 5 %) | | | | |

### C.6.4 Conclusion for the corrosivity of the cabinet

| | | |
|---|---|---|
| Conformity of all parameters ☐ | Non conformity ☐ | |
| Comments: | | |
| Operator name: | Date: | Signature: |

### C.6.5 Examples for the determination of the corrosivity level

Examples of determination of the corrosivity level are given in Tables C.2 and C.3.

**Table C.2 — Example 1: Compliant cabinet**

| | | Evidence of red rust: % quantified on the control mask | | |
|---|---|---|---|---|
| **Red Rust Time (RRT)**<br>h | **Grade** | **Panel 1** | **Panel 2** | **Panel 3** |
| RRT ≤ 72 | A | Red Rust : 0 square<br>— | Red Rust : 1 square<br>0,78 % | Red Rust : 0 square<br>— |
| 72 < RRT ≤ 96 | B | Red Rust : 3 squares<br>(3 × 0,78 =) 2,3 % | Red Rust : 8 squares<br>(8 × 0,78 =) 6,2 % | Red Rust : 10 squares<br>(10 × 0,78 =) 7,8 % |
| 96 < RRT ≤ 120 | C | Red Rust : 7 squares<br>(7 × 0,78 =) 5,5 % | Red Rust : 12 squares<br>(12 × 0,78 =) 9,4 % | Red Rust : 20 squares<br>(20 × 0,78 =) 15,6 % |
| RRT > 120 | D | — | — | — |
| Result (grade when Red Rust Rate RRR ≥ 5 %) | | C | B | B |
| | | Corrosivity level : COMPLIANT | | |

**Table C.3 — Example 2: Non-compliant cabinet**

| | | Evidence of red rust: % quantified on the control mask | | |
|---|---|---|---|---|
| **Red Rust Time (RRT)**<br>h | **Grade** | **Panel 1** | **Panel 2** | **Panel 3** |
| RRT ≤ 72 | A | Red Rust : 0 square<br>— | Red Rust : 0 square<br>— | Red Rust : 0 square<br>— |
| 72 < RRT ≤ 96 | B | Red Rust : 1 square<br>0,78 % | Red Rust : 3 squares<br>(3 × 0,78 =) 2,3 % | Red Rust : 10 squares<br>(10 × 0,78 =) 7,8 % |
| 96 < RRT ≤ 120 | C | Red Rust : 3 squares<br>(3 × 0,78 =) 2,3 % | Red Rust : 7 squares<br>(7 × 0,78 =) 5,5 % | Red Rust : 20 squares<br>(20 × 0,78 =) 15,6 % |
| RRT > 120 | D | Red Rust : 7 squares<br>(7 × 0,78 =) 5,5 % | Red Rust : 15 squares<br>(15 × 0,78 =) 11,7 % | Red Rust : 35 squares<br>(35 × 0,78 =) 27,3 % |
| Result (grade when Red Rust Rate RRR ≥ 5 %) | | D | C | B |
| | | Corrosivity level : not compliant | | |

# Bibliography


[1] ISO 898-2, *Mechanical properties of fasteners made of carbon steel and alloy steel — Part 2: Nuts with specified property classes — Coarse thread and fine pitch thread*

[2] ISO 965-1, *ISO general purpose metric screw threads — Tolerances — Part 1: Principles and basic data*

[3] ISO 965-2, *ISO general purpose metric screw threads — Tolerances — Part 2: Limits of sizes for general purpose external and internal screw threads — Medium quality*

[4] ISO 965-3, *ISO general purpose metric screw threads — Tolerances — Part 3: Deviations for constructional screw threads*

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

[6] ISO 1891-4, *Fasteners — Terminology — Part 4: Control, inspection, delivery, acceptance and quality*

[7] ISO 3269, *Fasteners — Acceptance inspection*

[8] ISO 4014, *Hexagon head bolts — Product grades A and B*

[9] ISO 4017, *Fasteners — Hexagon head screws — Product grades A and B*

[10] ISO 4032, *Hexagon regular nuts (style 1) — Product grades A and B*

[11] ISO 6932, *Cold-reduced carbon steel strip with a maximum carbon content of 0,25 %*

[12] ISO 7089, *Plain washers — Normal series — Product grade A*

[13] ISO 16426, *Fasteners — Quality assurance system*

**ICS 21.060.01; 25.220.40**

Price based on 31 pages