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Metallic coatings — Physical vapour-deposited coatings of cadmium on iron and steel — Specification and test methods

Revêtements métalliques — Revêtements de cadmium appliqués par vide sur fer et acier — Spécification et méthodes d'essai

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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.

ISO 22778 was prepared by Technical Committee ISO/TC 107, *Metallic and other inorganic coatings*, Subcommittee SC 3, *Electrodeposited coatings and related finishes*.

Introduction

Cadmium coatings are applied by physical vapour-deposition techniques to iron, steel and other substrates to enhance appearance and improve resistance to corrosion. Unlike electroplating, physical vapour deposition does not introduce hydrogen into the basis material. Hence, vapour-deposited cadmium coatings are especially beneficial for protecting high-strength steels that are susceptible to hydrogen embrittlement. Hydrogen, however, can be introduced into the substrate during fabrication, cleaning, pickling and other treatments, and care must still be exercised to prevent the introduction of hydrogen prior to vapour deposition.

Cadmium is toxic and health, safety and environmental concerns are now eliminating its non-essential uses. There remain, nevertheless, critical applications, often aerospace-related, where the unique properties of cadmium coatings, for example, their corrosion resistance, intrinsic lubricity, ductility, electrical conductivity and low contact resistance, make continued use necessary. One benefit of depositing cadmium by physical deposition techniques is that the process is conducted in a sealed vacuum chamber and exposure to cadmium is at an absolute minimum.

The corrosion resistance of physical vapour-deposited cadmium coatings may be further enhanced by the use of chromate conversion coatings and other supplementary treatments.

Metallic coatings — Physical vapour-deposited coatings of cadmium on iron and steel — Specification and test methods

WARNING — The use of this International Standard may involve hazardous materials, operations and equipment. This standard does not address all the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices, and to determine the applicability of regulatory limitations prior to use.

1 Scope

This International Standard specifies requirements for high-purity cadmium coatings produced by physical vapour deposition on iron, steel, and other substrates. It provides test methods to determine that the requirements have been met, and a method for designating the cadmium and chromate conversion coatings and other supplementary treatments.

Cadmium coatings are not suitable for production items that will reach a temperature of 225 °C or higher in service, or that will come into contact with other parts that will reach that temperature.

2 Normative references

The following referenced documents are indispensable for the application 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 2064, *Metallic and other inorganic coatings — Definitions and conventions concerning the measurement of thickness*

ISO 2080, *Electroplating and related processes — Vocabulary*

ISO 2177, *Metallic coatings — Measurement of coating thickness — Coulometric method by anodic dissolution*

ISO 2360, *Non-conductive coatings on non-magnetic electrically conductive basis materials — Measurement of coating thickness — Amplitude-sensitive eddy-current method*

ISO 2819, *Metallic coatings on metallic substrates — Electrodeposited and chemically deposited coatings — Review of methods available for testing adhesion*

ISO 2859 (all parts), *Sampling procedures for inspection by attributes*

ISO 3497, *Metallic coatings — Measurement of coating thickness — X-ray spectrometric methods*

ISO 3543, *Metallic and non-metallic coatings — Measurement of thickness — Beta backscatter method*

ISO 3882, *Metallic and other inorganic coatings — Review of methods of measurement of thickness*

ISO 3892, *Conversion coatings on metallic materials — Determination of coating mass per unit area — Gravimetric methods*

ISO 4518, *Metallic coatings — Measurement of coating thickness — Profilometric method*

ISO 4519, *Electrodeposited metallic coatings and related finishes — Sampling procedures for inspection by attributes*

ISO 4520, *Chromate conversion coatings on electroplated zinc and cadmium coatings*

ISO 9220, *Metallic coatings — Measurement of coating thickness — Scanning electron microscope method*

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

ISO 9587, *Metallic and other inorganic coatings — Pretreatments of iron or steel to reduce the risk of hydrogen embrittlement*

ISO 9588, *Metallic and other inorganic coatings — Post-coating treatments of iron or steel to reduce the risk of hydrogen embrittlement*

ISO 12686, *Metallic and other inorganic coatings — Automated controlled shot-peening of metallic articles prior to nickel, autocatalytic nickel or chromium plating, or as a final finish*

ISO 16348, *Metallic and other inorganic coatings — Definitions and conventions concerning appearance*

EN 12508, *Corrosion protection of metal and alloys — Surface treatment, metallic, and other inorganic coatings — Vocabulary*

IEC 60454, *Specifications for pressure-sensitive adhesive tapes for electrical purposes — Part 2: Methods of test*

3 Terms and definitions

For the purposes of this document, the terms and definitions in ISO 2064, ISO 2080, ISO 2859, ISO 4519 and EN 12508 apply.

4 Information to be supplied by the purchaser to the processor

When ordering articles for physical vapour deposition of cadmium in accordance with this International Standard, the purchaser shall provide the following information in writing in the contract or purchase order, or in the engineering drawing:

a) the designation (see Clause 5);

b) the specification and metallurgical condition of the basis metal, any process-temperature limitations (see 6.1.2) and shot-peening requirements [see 6.1.3 c)];

c) the significant surface, including the coating of holes, recesses and presence of rack marks (see 6.1.1 and 6.3.1);

d) details of any sensitive material and whether ultra high-purity argon is required (see 6.1.2);

e) the requirement for any consolidation, for example, by glass bead peening (see 6.4.1);

f) the requirement for coating thickness (see 5.4 and Table 1) and a chromate conversion coating (see 5.5 and 6.4.2);

g) the requirement for a supplementary treatment, such as paint, and details of the specification involving the organic finish (see 5.5 and 6.4.3);

h) the requirement for coating adhesion (see 6.3.3 and Annex C).

i) the requirement for special test specimens and for the type of test method, for example, destructive or non-destructive (see 6.6);

j) sampling and inspection requirements (see Clause 7 and Annex D).

5 Designation

The designation shall appear on engineering drawings, in the purchase order, the contract or in the detailed product specification. The designation specifies the basis material, the requirements for stress relief before vapour deposition, the nominal composition and thickness of the vapour-deposited cadmium coating, the type of chromate conversion coating and other supplementary treatment, and the heat treatment to reduce susceptibility to hydrogen embrittlement.

5.1 General

The designation shall comprise the following:

a) the term: vapour-deposited coating;

b) the number of this International Standard, ISO 22778;

c) a hyphen;

d) the chemical symbol of the basis metal;

e) a stroke (/); symbols for the cadmium coating, as well as any coatings that may be applied prior to and after deposition, separated by strokes for each stage in the coating sequence in the order of application. The coating designation shall include the thickness of the coating, in micrometres.

5.2 Basis metal

The basis metal shall be designated by its chemical symbol, or its principal constituent, if it is an alloy. For example:

— Fe for iron and steel;

— Zn for zinc alloys;

— Cu for copper and copper alloys;

— Al for aluminium and aluminium alloys.

The specific alloy may be identified by its standard designation (for example, its UNS number, or its national or regional equivalent) placed between the symbols, < >, for example, Fe<G434000>. See Reference [3] in the Bibliography.

5.3 Pre-process stress-relief heat treatment

Stress-relief heat treatment prior to coating may be required for some basis materials. Brackets shall be placed around the letters SR, the temperature in degrees Celsius, and the time in hours. The temperature shall be in parentheses after the letters SR; for example [SR(210)1].

5.4 Type and thickness of cadmium

The cadmium coating shall be designated by its chemical symbol, Cd, followed by a number giving the minimum local thickness of the coating in micrometres. For example, Cd5, designates a cadmium coating that is 5 µm thick. The minimum thickness of the vapour-deposited cadmium coatings shall be selected in accordance with Table 1.

Allowances for the thickness of the coating should be made by adjusting the dimensional tolerances during the manufacture of threaded items, and those with close tolerances.

Table 1 — Minimum thickness requirements for physical vapour-deposited cadmium coatings

Application	Minimum local thickness µm
Steels, normal requirements	15
Threaded articles of less than 20 mm nominal diameter, as follows:	
< 3 mm	4
3 to < 6 mm	5
6 to < 10 mm	6
10 mm and over	8
Articles with bore dimensions, as follows:	
< 3 mm	5
3 mm and over	8
Other small articles	8

5.5 Chromate conversion coatings and other supplementary treatments

The type of chromate conversion coating and other supplementary treatments shall be designated by the symbols given in Tables 2 and 3.

Table 2 — Symbols for chromate conversion coatings

Code	Type	Typical appearance	Coating mass per unit area
	Name		g/m^2
A [a]	Clear	Transparent, clear to bluish	⩽ 0,5
C	Iridescent	Yellow iridescent	< 0,5 to < 1,5
D	Opaque	Olive-green	> 1,5
F	Black	Black	⩽ 0,5 to ⩽ 1,0

[a] Chromium in hexavalent form may or may not be present.

Table 3 — Supplementary treatments other than conversion coatings

Code	Type of treatment
T1	Application of paints, varnishes, powder coatings or similar coating materials
T2	Application of organic or inorganic sealants.
T3	Dyeing
T4	Application of grease or oil, or other lubricants
T5	Application of wax

NOTE The function of chromate conversion coatings and other supplementary treatments is to retard or prevent the formation of white corrosion products on surfaces exposed to corrosive atmospheres, and to delay the appearance of red corrosion of cadmium coatings on steel. The iridescent yellow to olive drab chromate films are satisfactory for the application of subsequent paint coatings, but bleached or leached chromate films are not recommended as a supplementary finish with vapour-deposited cadmium coatings.

Chemical conversion coatings that do not contain hexavalent chromium are commercially available. Some contain trivalent chromium; others are chromium-free. Substitutes shall meet the corrosion requirements given in Table 4.

5.6 Post-coating heat treatment

Heat treatment to reduce the susceptibility of high-strength steels to hydrogen embrittlement may be required in some circumstances (see Clause 8). Brackets shall be placed around the letters ER, the temperature in degrees Celsius, and the time in hours. The temperature shall be in parentheses after the letters ER; for example [ER(400)12].

5.7 Examples of coating designations

Example of a physical vapour-deposited cadmium coating 8 µm thick on steel (Fe), with a supplementary chromate conversion coating that is iridescent yellow (C):

Physical vapour-deposited coating ISO 22778 – Fe/Cd8/C

Example of a coating 5 µm thick on steel, with a supplementary chromate conversion coating that is transparent or colourless (A) and that shall receive a subsequent organic sealant (T2):

Physical vapour-deposited coating ISO 22778 – Fe/Cd5/A/T2

Example of a coating on high-strength steel that is to be stress relieved at 150 °C for 2 h before applying a cadmium coating 5 µm thick, with a supplementary black chromate conversion (F):

Physical vapour-deposited coating ISO 22778 – Fe/[SR(150)2]/Cd5/F

6 Requirements

6.1 General

6.1.1 Basis material

This International Standard does not specify requirements for the condition, finish and surface roughness of the basis metal prior to physical vapour deposition of cadmium. Surfaces to be coated, however, shall be smooth and free from oxides, tool marks, pitting, intergranular attack, or other defects.