
**Metallic and other inorganic coatings —
Electroplated coatings of cadmium with
supplementary treatments on iron or
steel**

*Revêtements métalliques et autres revêtements inorganiques — Dépôts
électrolytiques de cadmium avec traitements supplémentaires sur fer ou
acier*

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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 2082 was prepared by Technical Committee ISO/TC 107, *Metallic and other inorganic coatings*, Subcommittee SC 3, *Electrodeposited coatings and related finishes*.

This third edition cancels and replaces the second edition (ISO 2082:1986), which has been technically revised.

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Introduction

Electrodeposits of cadmium are used to protect iron and steel from corrosion. Cadmium is anodic and corrodes sacrificially, thus protecting ferrous basis metals even when exposed through pores or pits in the cadmium. Electrodeposited cadmium coatings have traditionally been applied to iron or steel from alkaline cyanide solutions, but in recent years, environmental concerns and regulations have led to increased use of acid sulphate, neutral chloride and acid fluoborate cadmium solutions.

Because the appearance and serviceability of electroplated cadmium coatings are influenced by the surface condition of the basis metal, agreement should be reached between the interested parties that the surface of the basis metal is satisfactory for electroplating.

Cadmium is highly toxic and health, safety and environmental concerns are eliminating its non-essential uses. There remain, nevertheless, critical applications, often aerospace-related, where the unique properties of electrodeposited cadmium coatings, for example, their corrosion resistance, intrinsic lubricity, ductility, electrical conductivity and low contact resistance, make continued use of cadmium coatings necessary.

The corrosion resistance of electroplated cadmium coatings and their tendency to tarnish when handled can be improved by applying chromate conversion and other supplementary coatings.

Chemical conversion coatings that do not contain hexavalent chromium are commercially available and their use is becoming more and more popular. The appearance of these substitutes may be different from those produced with hexavalent chromium. Other conversion coatings that are chromium-free are also available. Substitutes are required to satisfy the corrosion requirements given in this International Standard.

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Metallic and other inorganic coatings — Electroplated coatings of cadmium with supplementary treatments on iron or steel

DANGER — Cadmium vapour is highly toxic by inhalation. During heat treatment, all precautions should be taken to ensure that no person is exposed to it. Attention is also drawn to the danger arising from welding, soldering or heating and other operations, in which the possibility that cadmium will be vaporised exists. Because of its toxicity, cadmium should not be employed as a coating for any article that will come in contact with food or beverages or containers in contact with these items or any household goods.

WARNING — This International Standard may not be compliant with some countries' health, safety and environmental legislations and calls for the use of substances and/or procedures that may be injurious to health if adequate safety measures are not taken. This International Standard does not address any health hazards, safety or environmental matters and legislations associated with its use. It is the responsibility of the producers, purchasers and/or user of this International Standard to establish appropriate health, safety and environmentally acceptable practices and take appropriate actions to comply with any national, regional and/or international rules and regulations. Compliance with this International Standard does not, of itself, confer immunity from legal obligations.

1 Scope

This International Standard specifies the requirements of electroplated coatings of cadmium with supplementary treatments on iron and steel. It includes information that is to be supplied by the purchaser to the electroplater, and describes coating requirements, including those for heat treatment before and after electroplating.

It is not applicable to coatings applied

- to sheet, strip or wire in the non-fabricated form,
- to close-coiled springs, or
- for purposes other than protective, intrinsic lubricity, ductility, electrical conductivity and low contact resistance use.

This International Standard does not specify requirements for the surface condition of the basis metal prior to electrodeposition with cadmium.

The coating thickness that can be applied to threaded components can be limited by dimensional requirements, including class or fit.

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, *Metallic and other inorganic coatings — Surface treatment, metallic and other inorganic coatings — Vocabulary*

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

ISO 2178, *Non-magnetic coatings on magnetic substrates — Measurement of coating thickness — Magnetic method*

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

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 3613, *Chromate conversion coatings on zinc, cadmium, aluminium-zinc alloys and zinc-aluminium alloys — Test methods*

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 9587, *Metallic and other inorganic coatings — Pretreatment 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 10289, *Methods for corrosion testing of metallic and other inorganic coatings on metallic substrates — Rating of test specimens and manufactured articles subjected to corrosion tests*

ISO 10587, *Metallic and other inorganic coatings — Test for residual embrittlement in both metallic-coated and uncoated externally-threaded articles and rods — Inclined wedge method*

ISO 15724, *Metallic and other inorganic coatings — Electrochemical measurement of diffusible hydrogen in steels — Barnacle electrode method*

ASTM B117, *Standard Practice for Operating Salt Spray (Fog) Apparatus*

3 Terms, definitions, abbreviated terms and symbols

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 2064 and ISO 2080 apply.

3.2 Abbreviated terms

C	iridescent conversion coating
D	opaque chromate conversion coating
ER	hydrogen-embrittlement-relief heat treatment
NM	non-metallic materials
PL	plateable plastics materials
SR	stress relief heat treatment
T2	organic sealant

3.3 Symbols

Cd	chemical symbol for cadmium
Fe	chemical symbol for iron

4 Information to be supplied by the purchaser to the electroplater

4.1 Essential information

The following information shall be supplied to the electroplater in writing, for example, in the contract or purchase order or on engineering drawings:

- the reference to this International Standard, ISO 2082, and the designation (see Clause 5);
- the significant surface indicated, for example, by drawings or by the provision of suitably marked samples;
- the nature, condition and finish of the basis metal if they are likely to affect the serviceability and/or the appearance of the coating (see Clause 1);
- the position on the surface for unavoidable defects, such as rack marks (see 6.1);
- the finish required, for example, bright, dull or other finish, preferably accompanied by approved samples of the finish (see 6.1);
- the type of chromate conversion coating or supplementary treatment (see 6.3 and Annex A); chromate conversion coatings shall only be omitted, and alternative conversion coatings and/or other supplementary treatments (see Table A.2) or conformal coatings, such as lacquers, applied over the chromate coating, at the specific request of the purchaser;
- the requirements for thickness, adhesion and accelerated corrosion test requirements (see 6.2, 6.4, 6.5 and Annex B);
- the tensile strength of parts and the requirements for heat treatment before and/or after electrodeposition (see 6.6 and 6.7);
- sampling methods, acceptance levels or any other inspection requirements if inspection is different from that given in ISO 4519 (see Clause 7).

4.2 Additional information

The following additional information shall also be supplied to the electroplater:

- a) any special requirements for, or restrictions on, preparation of the article to be coated (see Bibliography);
- b) any other requirements, such as for articles of complex shape, an area for testing and rating.

5 Designation

5.1 General

The designation shall appear on engineering drawings, in the purchase order, in the contract or in the detailed product specification. The designation specifies, in the following order, the basis metal, stress relief requirements, the type and thickness of undercoats, if present, the thickness of the cadmium coating, heat treatment requirements after electroplating, and the type of conversion coating and/or supplementary treatment (see Bibliography).

5.2 Designation specification

The designation shall comprise the following:

- a) the term "Electrodeposited coating";
- b) the reference to this International Standard, ISO 2082;
- c) a hyphen;
- d) the chemical symbol of the basis material, Fe, (iron or steel) followed by its standard designation;
- e) a solidus (/);
- f) the SR designation, if necessary, followed by a solidus;
- g) the chemical symbol for cadmium, "Cd";
- h) a number indicating the minimum local thickness, in micrometres, of the cadmium coating followed by a solidus;
- i) the ER designation, if necessary, followed by a solidus;
- j) if appropriate, codes indicating the type of chromate conversion coating (see Annex A), followed by a solidus;
- k) if appropriate, codes designating any supplementary treatments (see Annex A).

Solidi (/) shall be used to separate data fields in the designation corresponding to the different sequential processing steps. Double separators or solidi indicate that a step in the process is either not required or has been omitted (see ISO 27830).

If other supplementary treatments other than or in addition to chromate conversion coating are used, the designation for a coating thickness of 25 µm of cadmium shall be

Fe/Cd25/X/Y

where

X represents one of the chromate conversion coating codes given in Table A.1;

Y represents one of the codes for other supplementary coatings given in Table A.2.

5.3 Designation of heat treatment requirements

The heat treatment requirements shall be designated as follows:

- the letters SR for stress relief heat treatment prior to electroplating, and/or the letters ER for hydrogen-embrittlement-relief heat treatment after electroplating;
- in parentheses, the minimum temperature, expressed in degrees Celsius (°C);
- the duration, expressed in hours (h), of the heat treatment.

For example, SR(210)1 designates stress relief heat treatment at 210 °C for 1 h.

5.4 Examples

The following are examples of coating designations.

EXAMPLE 1 Designation of an electrodeposited coating of 12 µm cadmium (Cd12) on iron or steel (Fe) which has had an iridescent conversion coating (C) applied:

Electrodeposited coating ISO 2082 – Fe/Cd12/C

EXAMPLE 2 Designation of an electrodeposited coating of 25 µm cadmium (Cd25) on iron or steel (Fe) which is to be heat-treated after electroplating for hydrogen embrittlement relief for 8 h at 190 °C, designated as ER(190)8, and has been given a supplementary opaque chromate conversion coating (D) followed by a sealing treatment consisting of the application of an organic sealant (T2).

Electrodeposited coating ISO 2082 – Fe/Cd25/ER(190)8/D/T2

EXAMPLE 3 Same as Example 2, but in addition the articles are heat-treated prior to electroplating for stress relief purposes at 200 °C for a minimum of 3 h, designated as SR(200)3:

Electrodeposited coating ISO 2082 – Fe/SR(200)3/Cd25/ER(190)8/D/T2

6 Requirements

6.1 Appearance

Although this International Standard does not specify the condition, finish or surface roughness of the basis material prior to electroplating, the appearance of electroplated coatings depends on the condition of the basis material (see the Bibliography for surface preparation). The electroplated article on its significant surface shall be free from clearly visible plating defects such as blisters, pits, roughness, cracks or non-plated areas other than those arising from defects in the basis metal. On articles where a contact mark is unavoidable, its position shall be the subject of agreement between the interested parties (see 4.1). The articles shall be clean and free from damage.

Unless the purchaser specifies otherwise, the cadmium coating shall be bright. If necessary, a sample showing the required finish shall be supplied or approved by the purchaser [see 4.1 e)].

6.2 Thickness

The thickness of the cadmium coating specified in the designation shall be the minimum local thickness. The minimum local thickness of the coating shall be measured at any point on the significant surface that can be touched by a ball 20 mm in diameter, unless otherwise specified by the purchaser (see 4.1 and 4.2).

Methods for the measurement of the thickness of cadmium coatings on steel are specified in ISO 1463, ISO 2177, ISO 2178, ISO 3497, ISO 3543 and ISO 4518.

In case of dispute, the method specified in ISO 2177 shall be used for articles having a significant surface area greater than 100 mm². In the case of articles having a significant surface area less than 100 mm², the minimum local thickness shall be deemed to be the minimum value of the average thickness determined by the method specified in Annex B.

Prior to the use of the method specified in ISO 2177, it is necessary to remove the chromate or other conversion coating using a very mild abrasive, for example, a paste of levigated alumina. In the case of heavy conversion coatings, the results will, therefore, be slightly lower.

If the coatings are rough or matte, the microscopical (ISO 1463) and profilometric (ISO 4518) methods may give unreliable results, and magnetic methods may give measurements which are somewhat greater than those obtained on smooth coatings of the same mass per unit area.

Table 1 provides thickness requirements for corrosion protection under various conditions of service.

6.3 Conversion coatings and other supplementary treatments

Conversion coatings, shall only be omitted, or replaced by other conversion coatings, at the specific request of the purchaser [see 4.1 f)]. Annex A provides the codes for chromate conversion and other supplementary coatings.

Chemical conversion coatings that do not contain hexavalent chromium, such as trivalent chromium, or are chromium free, conforming to the requirements of this International Standard, are commercially available. All forms of chromate conversion coatings, alternative conversion coatings or substitutes, with the exception of phosphate coatings, that may be used shall meet the corrosion requirements of this International Standard. Conversion coatings containing trivalent chromium are available for all codes in Table A.1. However, the appearance of these substitutes may be different from those produced with hexavalent chromium conversion coatings. Table 1, Table 2, Table A.1, Table A.2 and Table C.1 in this International Standard reflect the requirements and products that have been used and accepted in practice universally over several decades by producers, purchasers and users in metal finishing industry worldwide.

6.4 Adhesion of cadmium and chromate coatings

The cadmium coating shall continue to adhere to the basis metal when subjected to the burnishing test specified in ISO 2819. The chromate conversion coating shall be tested for adhesion in accordance with ISO 3613.

6.5 Accelerated corrosion testing

6.5.1 Neutral salt spray test

DANGER — Cadmium vapour is highly toxic by inhalation. During heat treatment, all precautions should be taken to ensure that no person is exposed to it. Attention is also drawn to the danger arising from welding, soldering or heating and other operations, in which the possibility that cadmium will be vaporised exists. Because of its toxicity, cadmium should not be employed as a coating for any article that will come in contact with food or beverages or containers in contact with these items or any household goods.

When tested in accordance with the neutral salt spray (NSS) test specified in ASTM B117 for the times given in Tables 1 and 2, the test surface shall remain free from red corrosion products (see Table 1) and from white corrosion products (see Table 2) when examined by the unaided eye or corrected vision. Slight staining shall not be a cause for rejection.

The partial coating designation given in Table 1 and Table C.1 gives the minimum local thickness of cadmium after chromate treatment, if carried out. The required thickness of the cadmium coating to ensure resistance to corrosion depends on the severity of the service conditions. Coating designation, Fe/Cd5 for example, is recommended only for dry, indoor conditions. As the service conditions become more severe, it is necessary to increase the thickness of the cadmium coating to ensure resistance to corrosion, and to specify cadmium coating required with respect to the service conditions (see Table C.1).

It is recommended that coatings with classification codes Fe/Cd12 and Fe/Cd25 receive a coloured chromate conversion coating.

The duration and results of artificial atmosphere corrosion tests may bear little relationship to the service life of the coated article and, therefore, the results obtained are not to be regarded as a direct guide to the corrosion resistance of the tested coatings in all environments where these coatings may be used.

Table 1 — Neutral salt spray corrosion resistance of cadmium plus chromate conversion coatings before basis metal corrosion (red rust) begins

Coating designation (partial)	Neutral salt spray test duration h
Cd5/A Cd5/F	48
Cd5/C Cd5/D Cd8/A Cd8/F	72
Cd8/C Cd8/D Cd12/A Cd12/F	120
Cd12/C Cd12/D Cd25/A Cd25/F	192
Cd25/C Cd25/D	360

Table 2 — Corrosion resistance of the chromate conversion coating before corrosion of the underlying cadmium coating

Chromate conversion coating code ^a	Neutral salt spray test time h	
	Barrel electroplated	Vat electroplated
A	8	16
C	72	96
D	72	96
F	24	48

^a See Annex A.

6.5.2 Corrosion rating

After testing, samples shall be rated in accordance with ISO 10289. The acceptance rating shall be specified by the purchaser.

6.6 Stress relief heat treatment before cleaning and metal deposition

When specified by the purchaser, steel parts that have an ultimate tensile strength equal to or greater than 1 000 MPa and that contain tensile stresses caused by machining, grinding, straightening or cold forming operations shall be given a stress relief heat treatment prior to cleaning and metal deposition. The procedures and classes for stress relief heat treatment shall be as specified by the purchaser or the purchaser shall specify appropriate procedures and classes from ISO 9587.

When heat treatment for stress relief prior to electroplating or for hydrogen embrittlement relief after electroplating (see 6.7) are specified, the time and temperature of the heat treatment process shall be included in the coating designation as illustrated in 5.3 and 5.4.

Steels with oxide or scale have to be cleaned before application of the coatings. For high strength steels (equal to or greater than 1 000 MPa), non-electrolytic alkaline and anodic alkaline cleaners as well as mechanical cleaning procedures are preferred to avoid the risk of producing hydrogen embrittlement during cleaning procedures (see Bibliography).

6.7 Hydrogen-embrittlement-relief heat treatment after electroplating

Steel parts having an ultimate tensile strength equal to or greater than 1 000 MPa as well as surface-hardened parts shall receive hydrogen-embrittlement-relief heat treatment in accordance with the procedures and classes of ISO 9588 or as specified by the purchaser.

When heat treatment for stress relief prior to electroplating (see 6.6) or for hydrogen embrittlement relief after electroplating is specified, the time and temperature of the heat treatment process shall be included in the coating designation as illustrated in 5.3 and 5.4. The effectiveness of the hydrogen-embrittlement-relief heat treatment shall be determined in accordance with ISO 10587 for testing threaded articles for residual hydrogen relief heat treatment, and with ISO 15724 for measuring relative, diffusible hydrogen concentration in steels unless otherwise specified by the purchaser.

Any heat treatment for the relief of hydrogen embrittlement shall be carried out before a chromate conversion coating is applied.

7 Sampling

A random sample of the size as specified in ISO 4519 shall be selected from the inspection lot. The articles in the sample shall be inspected for conformance to the requirements of this specification and the lot shall be classified as conforming or not conforming to each requirement according to the criteria of the sampling plans in ISO 4519. If other form of sampling plan is selected [see 4.1 i)], a random sample shall be selected and the articles in the sample shall be inspected for conformance to the requirements of this International Standard.

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Annex A (normative)

Designation of chromate conversion coatings and other supplementary treatments

A.1 General

Chromating solutions are usually acidic and might contain hexavalent or trivalent chromium salts, together with other salts which can be varied to affect the appearance and hardness of the film. Clear, iridescent, olive-green and black films on cadmium coating can be obtained by processing in appropriate solutions. Transparent films can also be obtained by bleaching iridescent films in alkaline solutions or in phosphoric acid. See Table C.1 for guidance on the appropriate coating. Table A.1 gives the approximate surface density (mass per unit area) for each type of chromate conversion coating when measured in accordance with ISO 3892.

Table A.1 — Chromate conversion coating type, appearance and surface density

Type		Typical appearance	Coating surface density ρ_A g/m ²
Code	Name		
A	Clear	Transparent, clear to bluish	$\rho_A \leq 0,5$
C	Iridescent	Yellow iridescent	$0,5 < \rho_A < 1,5$
D	Opaque	Olive-green	$\rho_A > 1,5$
F	Black	Black	$0,5 \leq \rho_A \leq 1,0$
NOTE Chromate coatings described in this table might not necessarily be specified for the improvement of the adhesion of paints and varnishes.			
^a This chromate coating may or may not contain hexavalent chromium ions.			

A.2 Sealing

In order to give better protection against corrosion, chromate conversion coatings can be post-treated with sealing agents, by introducing organic or inorganic products into the chromate film. This operation also enhances the resistance of the chromate conversion coating to higher temperatures.

Sealing can be carried out by dipping or spraying the conversion coating with polymers in aqueous solutions. A similar process is based on the addition of suitable organic products to the chromating solution.

A.3 Supplementary treatments other than conversion coatings

If a supplementary treatment other than conversion coatings is required, the type of treatment shall be designated in accordance with the codes in Table A.2.

Table A.2 — Supplementary treatments other than conversion coatings

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

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