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Zinc-coated steel for the reinforcement of concrete

Aciers revêtus de zinc pour l'armature du béton

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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 14657 was prepared by Technical Committee ISO/TC 17, *Steel*, Subcommittee SC 16, *Steels for the reinforcement and prestressing of concrete*.

Zinc-coated steel for the reinforcement of concrete

1 Scope

This International Standard specifies requirements for hot-dip zinc (galvanized) coating on steel reinforcing bars, wire and welded fabric used in the reinforcement of concrete.

It specifies three classes, class A, class B and class C coatings, which differ in coating mass (see 6.2.3).

This International Standard does not apply to hot-dip zinc-coated reinforcements for prestressing or components of these reinforcements.

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 752:2004, *Zinc ingots*

ISO 1460:1992, *Metallic coatings — Hot dip galvanized coatings on ferrous materials — Gravimetric determination of the mass per unit area*

ISO 1461:1999, *Hot dip galvanized coatings on fabricated iron and steel articles — Specifications and test methods*

ISO 2178:1982, *Non-magnetic coatings on magnetic substrates — Measurement of coating thickness — Magnetic method*

ISO 6935-1:1991, *Steel for the reinforcement of concrete — Part 1: Plain bars*

ISO 6935-2:1991, *Steel for the reinforcement of concrete — Part 2: Ribbed bars*

ISO 6935-3:1992, *Steel for the reinforcement of concrete — Part 3: Welded fabric*

ISO 10474, *Steel and steel products — Inspection documents*

ISO 10544:1992, *Cold-reduced steel wire for the reinforcement of concrete and the manufacture of welded fabric*

ISO 15630-1:2002, *Steel for the reinforcement and prestressing of concrete — Test methods — Part 1: Reinforcing bars, wire rod and wire*

ISO 15630-2:2002, *Steel for the reinforcement and prestressing of concrete — Test methods — Part 2: Welded fabric*

ISO 16020:2004, *Steel for the reinforcement and prestressing of concrete — Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 16020 and the following apply.

3.1
hot-dip galvanizing
any process in which the product is immersed in a molten zinc bath

3.2
bundle
two or more bars or sheets of welded fabric properly bound together

3.3
manufacturer
any organization that produces coated steel reinforcing bar, wire or welded fabric

4 Materials

4.1 Reinforcing steel

Reinforcing steel to be coated with zinc shall comply with the product standard as specified by the purchaser. If a product standard is not specified by the purchaser, the reinforcing steel shall comply with ISO 6935-1, ISO 6935-2, ISO 6935-3 or ISO 10544.

4.2 Zinc for coating

The zinc used for coating shall conform to ISO 752.

4.3 Repair material

Material for repairing damaged coating and renovating uncoated areas shall be an appropriate zinc-rich formulation.

NOTE Appropriate types of materials, for repairing damaged coatings and renovating uncoated areas, are prescribed in e.g. ASTM A780.

5 Process of manufacture (galvanizing)

It shall be the responsibility of the manufacturer to maintain identity of the steel reinforcement throughout the galvanizing process and to the point of shipment.

If specified by the purchaser, the galvanized coating shall be chromate treated (see Annex A).

NOTE The manufacturer should exercise due care: (1) to avoid distortion or cracking of the steel reinforcement likely to occur during galvanizing; (2) when galvanizing steel reinforcement that is susceptible to embrittlement.

6 Requirements for zinc-coated steel reinforcing bars, wire and welded fabric

6.1 Mechanical and geometrical properties

For the geometrical and mechanical properties of the steel, the requirements of the applicable product standard for uncoated steel also apply to the steel after zinc-coating.

6.2 Zinc coating characteristics

6.2.1 Finish and appearance

Finish and appearance shall conform to 6.1 in ISO 1461:1999.

Reinforcement that sticks together after galvanizing shall be rejected. In addition, the presence of tears or sharp spikes, which make the reinforcement hazardous to handle, shall be cause for rejection.

6.2.2 Adherence

For steel reinforcement that is galvanized as an integral phase of the steel-making process, the adherence of the zinc coating shall be evaluated by a bend test or rebend test depending on the specified product standard. After the test, the coating shall not show flaking on the outside radius of the bent bar, visible to a person with normal or corrected vision. In addition, the coating shall be adherent so it cannot be removed by any reasonable process of handling.

For steel reinforcement that is produced, tested and complies with the applicable product standard, and is subsequently galvanized, the adherence of the coating shall be evaluated by a knife test (see B.1.2). In addition, the coating shall be adherent so it cannot be removed by any reasonable process of handling.

6.2.3 Mass of zinc deposited per unit area

The mass of zinc deposited per unit area shall not be less than:

— for class A coating: 600 g/m^2 for reinforcement with $d > 6$ mm, and 500 g/m^2 for $d \leqslant 6$ mm, where d is the nominal diameter of the bar or wire;

— for class B coating: 300 g/m^2 for all nominal diameters;

— for class C coating: 140 g/m^2 for all nominal diameters.

NOTE Coating masses greater than 600 g/m^2 may be mutually agreed upon by the manufacturer and purchaser.

If the coating thickness correspondence is requested in micrometres, it shall be calculated by the formula:

$$\{e\} = \{m\} / 7{,}14$$

where

$\{e\}$ is the numerical value of the thickness, expressed in micrometres (μm);

$\{m\}$ is the numerical value of the mass of zinc per unit area, expressed in grams per square metre (g/m^2).

The mass shall be determined using the provisions given in B.1.3.

7 Inspection of zinc-coated steel

7.1 Applicability

Unless otherwise agreed, this clause shall apply to the final inspection of the zinc-coated steel reinforcement before it is released. For steel reinforcement that is galvanized as an integral phase of the steel-making process, the provisions here shall take precedence over any conflicting provisions in the applicable product standard for the uncoated steel. For steel reinforcement that has been produced, tested and confirmed to be in accordance with the applicable product standard prior to zinc-coating, 7.4 shall not apply.

NOTE Some national or regional certification schemes have rules for the evaluation of conformity, which deviate from those in Clause 7.

7.2 Batching

The inspection can be done either by cast or by batch. The batching mode shall be defined in the order.

7.3 Test unit

The test unit shall consist of zinc-coated products made using the same process starting from reinforcement of the same grade, nominal diameter and source, the mass of each test unit being:

— for inspection by cast, 40 tonnes or the remaining fraction of less than 40 tonnes;

— for inspection by batch, 20 tonnes or the remaining fraction of less than 20 tonnes.

7.4 Inspection of mechanical and geometrical properties

Twelve test series shall be carried out for each test unit, and each series shall include:

— one tensile test;

— one bend or rebend test;

— one check of reinforcement shape parameters and mass per unit length;

— one determination of the weld shear force for welded fabric.

No result shall be less than the limit. Furthermore for R_{eH} and R_m, $m_{12} - 2{,}74\,s$ shall not be less than the specified value, where

$$m_{12} = \frac{1}{12}\sum_{i=1}^{12} x_i$$

$$s = \sqrt{\frac{\sum_{i=1}^{12}(x_i - m_{12})^2}{11}}$$

where x_i denotes individual values for R_{eH} or R_m.

The batch shall be considered as non-conforming if these conditions are not met.

NOTE R_{eH} is the upper yield strength in N/mm^2 and R_m is the tensile strength in N/mm^2. (1 N/mm^2 = 1 MPa.)

7.5 Inspection of mass of zinc per unit area

A zinc coating check (thickness) shall be carried out for each test unit on at least three samples from different production units (bars or coils). For no sample, the result shall be less than the requirement, see 6.2.3.

8 Permissible amount of damaged coating and repair of damaged coating

Damaged coating discernible to a person with normal or corrected vision shall be repaired using an appropriate zinc-rich formulation.

The total damaged surface area, prior to repair with the zinc-rich formulation, shall not exceed 0,5 % of the surface area in any 1 m length of the bar or wire. This limit on repaired damage does not include sheared or cut ends that are coated with the zinc-rich formulation.

When coated steel reinforcing bars, wire and welded fabric are sheared, saw-cut, or cut by other means during the fabrication process, the cut ends shall be repaired using the same zinc-rich formulation that is used for the repair of damaged coating.

The coating at repaired areas shall have a minimum thickness of 80 μm for class A coating, 50 μm for class B coating, and 25 μm for class C coating.

NOTE These requirements apply to the coated product before the coated steel reinforcement is accepted from the manufacturer by the purchaser and are not site acceptance criteria. See Annex C.

9 Packing, handling, storage, transport

The product shall be delivered in the form of bars or coils or sheets of welded fabric, subject to agreement between manufacturer and purchaser.

Arrangements shall be made such that the coating is not significantly altered during handling, storage or transport.

10 Labelling

Labelling shall be sufficient to ensure product traceability. At least the following information shall be marked on each bundle of bars or sheets of welded fabric, or on each coil:

— name or address of manufacturer's factory;

— product identification (grade, diameter, length or configuration as appropriate);

— bundle or coil mass;

— batch number or equivalent information for cross reference to inspection documents.

11 Information to be provided by the purchaser

The purchaser shall provide the following information at the time of the enquiry and order:

— product designation;

— nominal dimensions;

— quantity ordered;

— class of coating (see 6.2.3);

— whether chromate treatment is required (see Clause 5);

— type of inspection document (see ISO 10474);

— the batching mode to be used by the inspection (see Clause 7).

Annex A
(informative)

Chromate treatment of galvanized coating

The aim of chromate treatment of the galvanized coating is to preclude a reaction between the zinc-coated reinforcement and fresh portland cement paste. The standard ASTM A767/A767M-00b includes requirements for chromate treatment. These requirements are

a) If the chromate treatment is performed immediately after galvanizing, the chromate treatment may be accomplished by quenching the steel reinforcement in a solution containing a mass fraction of at least 0,2 % of sodium dichromate in water (such as 2 kg/m^3 of quench water) or by quench chromating in a minimum of 0,2 % chromic acid solution. The solution shall be at a temperature of least 32 °C. The zinc-coated reinforcement shall be immersed in the solution for at least 20 s.

b) If the zinc-coated reinforcement is at ambient temperature, the chromate treatment shall be the same as specified in a) except that 0,5 % to 1,0 % concentration of sulfuric acid shall be added as an activator of the chromate solution. In this case, there is no temperature requirement for the activated chromate solution.

Proprietary chromating solutions of equivalent strength are permitted in place of the generic chemical treatment specified in a) and b) .

Annex B
(normative)

Test methods and retests

B.1 Test methods

B.1.1 Geometrical and mechanical tests

The geometrical and mechanical properties shall be determined by the test methods to which the standard for the uncoated reinforcing steel refers. If, for some property, no test method is given in the standard or is otherwise agreed, ISO 15630-1 and ISO 15630-2 shall be used.

B.1.2 Adherence of zinc coating

Determine the adherence properties of the zinc coating to the surface of the base metal by cutting or prising with the point of a stout knife, applied with considerable pressure in a manner tending to remove a portion of the coating. Adherence shall be considered inadequate if the coating flakes off in the form of a layer of coating so as to expose the base metal in advance of the knife point. Do not use testing carried out at edges or corners, which are points of lowest coating adherence. Likewise, do not use removal of small particles of the coating by paring or whittling to determine failure.

B.1.3 Determination of the zinc mass per area unit

B.1.3.1 General

It shall be permissible to use either of two methods to determine the zinc mass per unit area:

— the gravimetric determination method, which is a destructive method;

— the magnetic coating thickness measurement method, which is a non-destructive method and is frequently easier to use.

In case of dispute, the results obtained by the gravimetric determination method shall apply.

B.1.3.2 Gravimetric determination method

B.1.3.2.1 General

The zinc mass deposited on a sample with a given area shall be determined as a hot dip galvanized coating in accordance with ISO 1460.

B.1.3.2.2 Sample

A sample of length given in Table B.1 shall be used. Both ends of the sample shall be cut before testing in order to avoid galvanized faces.

Table B.1 — Sample length as a function of the nominal reinforcement diameter, d_n

Dimensions in millimetres

Nominal diameter d_n	Sample length L_o
$d_n \leqslant 12$	300
$12 < d_n \leqslant 20$	200
$d_n > 20$	100

B.1.3.3 Thickness measurement by magnetic method

B.1.3.3.1 Principle

Various apparati may be used to determine the thickness of non-magnetic coatings on a magnetic base metal. These apparati make a magnetic circuit in which the coating acts as a separation, and translate either the variation in the magnetic attraction force, or the variation of the magnetic flux due to the intermediate coating metal, into a coating thickness.

These apparati can measure the thickness of coatings on ferrous metal, deposited by hot-dip galvanizing.

These measurements have the advantage of being fast and non-destructive, hence their use in routine inspection. The measurements shall be carried out in accordance with the general requirements of ISO 2178.

NOTE Measuring the coating thickness on curved surfaces is difficult. It is essential that the tool be positioned exactly perpendicular to the surface to determine the coating thickness. If the position of the tool is not perpendicular to the surface, the thickness measurement will be erroneously high.

B.1.3.3.2 Apparatus and calibration

No special type of instrument is recommended. It is essential to ensure that all instruments are in good working condition and produce reproducible results by carrying out systematic calibrations with standard sheets of thicknesses similar to those to be measured, even if the instrument readout is graduated in micrometres.

This calibration shall be carried out using standard sheets placed on the uncoated base metal of the lot to be inspected.

In order to plot a calibration curve (Figure B.1), at least three measurements of known thicknesses e_1, e_2 and e_3 are made on standard sheets using the instrument covering the range of thicknesses to be measured.

Obtain the corresponding readouts L_1, L_2 and L_3, and plot the calibration curve T.

A thickness e is then obtained corresponding to each readout L of the instrument, as shown in Figure B.1.

B.1.3.3.3 Procedure

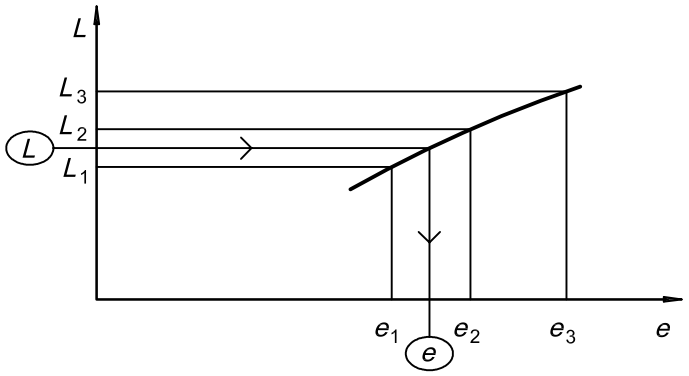
A minimum of 30 judiciously distributed measurements shall be carried out on the sample.

It is assumed that the distribution of measurement points is judicious if these measurement points are distributed in practically equal numbers for each series of ribs or indentations:

— at the summit of ribs or at the bottom of indentations;

— in the area between ribs or indentations;

— in the area of the reinforcement without any ribs or indentations (see Figure B.2).

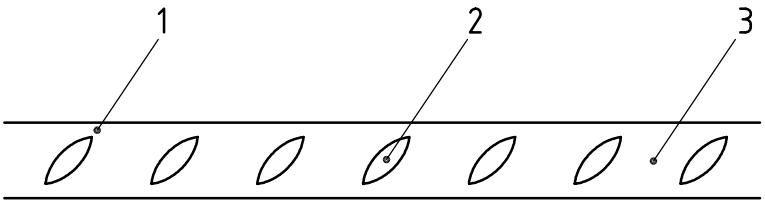


Key

e thickness

L readout

Figure B.1 — Calibration curve



Key

1 area without ribs or indentations

2 summit of rib or bottom of indentation

3 area between ribs or indentations

Figure B.2 — Position of measurement points

B.1.3.3.4 Interpretation of results

The zinc mass per unit area expressed in grams per square metres (g/m^2) is equal to the product of the arithmetic mean of the measured thickness expressed in micrometres (μm) multiplied by 7,14.

B.2 Cancellation of test

In case of incorrect procedure, the test shall not be taken into account. Incorrect procedure means defective preparation, incorrect mounting in the test machine, malfunctioning of the machine, or any other similar problem.

B.3 Retests

B.3.1 If any specimen used in testing for geometrical and mechanical properties, adherence of the zinc coating and zinc mass per unit area fails to meet the specified requirements, it shall be discarded.

For coated steel reinforcing bars, two further coated steel reinforcing bars from the same bundle shall be subjected to the test or tests in which the original bar failed. If both additional coated bars pass the retest, the bundle from which they were taken shall be deemed to comply with this International Standard. If either of them fails, the bundle shall be deemed not to comply with this International Standard.

For coated steel wire in coil and for coated welded fabric, two further samples of coated wire or welded fabric from the same test unit shall be subjected to the test or tests in which the original sample failed. If both additional coated samples pass the retest, the test unit from which they were taken shall be deemed to meet the requirements of this International Standard. If either of them fails, the test unit shall be deemed not to comply with this International Standard.

B.3.2 For coated steel reinforcing bars, if the bundle does not comply with this International Standard, two bars shall be selected from the bundle immediately preceding and from the untested bundle immediately following the non-compliant bundle and be subjected to the test or tests in which the original bars failed. If all bars pass the retest, then the bundles shall be deemed to comply with this International Standard. If any bar fails a retest, the bundle from which it originated shall be deemed not to comply with this International Standard.

For coated steel wire in coil and for coated welded fabric, if the test unit does not comply with this International Standard, two samples shall be selected from the test unit immediately preceding and from the test unit immediately following the non-compliant test unit and be subjected to the test or tests in which the original samples failed. If all samples pass the retest, then the test unit shall be deemed to comply with this International Standard. If any sample fails a retest, the test unit from which it originated shall be deemed not to comply with this International Standard.

B.3.3 For coated steel reinforcing bars, in the case of a second non-compliant bundle, the untested bundle immediately next to it, which may be preceding or following, shall be subjected to retest. This procedure shall be repeated until a compliant bundle is tested.

For coated steel wire in coil and for coated welded fabric, in the case of a second non-compliant test unit, the untested test unit immediately next to it which may be preceding or following, shall be subjected to retest. This procedure shall be repeated until a compliant test unit is tested.

B.3.4 A certain number of coated reinforcing steel specimens will have been produced since the last acceptance test was performed and accepted. The reinforcing steel that has been coated since the last test shall be divided into four equal time period groups according to when they were produced. Each test unit shall then be further defined as the coated reinforcing steel that has been produced in a given time period since the last accepted test.

Annex C
(informative)

Guidelines for site practice

This International Standard is a product standard. Its requirements cease when the purchaser accepts the zinc-coated (galvanized) steel reinforcing bars, wire and welded fabric from the manufacturer. As a product standard, it does not delineate requirements for subsequent practices at the site.

The project specifications should prescribe requirements for the zinc-coated steel reinforcing bars, wire or welded fabric from the time the purchaser accepts the zinc-coated bars, wire or welded fabric from the manufacturer, and subsequent practices at the site. In the absence of such requirements in the project specifications, the following guidelines for site practices are recommended.

a) Exercise care when handling coated steel reinforcing bars, wire and welded fabric. Avoid bundle-to-bundle abrasion or bar-to-bar abrasion resulting from sagging bundles.

b) Equipment for handling coated steel reinforcing bars, wire and welded fabric should have protected contact areas.

c) Coated steel reinforcing bars, wire and welded fabric should be off-loaded as close as possible to their fixing area in order to minimize rehandling.

d) Coated steel reinforcing bars, wire and welded fabric should be stored off the ground on protective bearers, and timbers placed between bundles when stacking is necessary. The supports should be spaced sufficiently close to prevent sags in the bundles.

e) Coated and uncoated steel reinforcing bars, wire and welded fabric should be stored separately.

f) Coated and uncoated reinforcement should not be used in combination in reinforced concrete members.

g) The maximum amount of repaired damaged areas of coating, including areas repaired at the manufacturer's facility, should not exceed 1 % in any one metre length of the coated bar, or of each coated wire.

   — When the extent of damaged coating exceeds 1 % of the surface area in any one metre length of the coated steel reinforcing bar, or of each coated steel wire, the coated bar or wire or welded fabric should be discarded.

   — When the extent of damaged coating does not exceed 1 % of the surface area in any one metre length of the coated bar, or of each coated wire, all damaged coating discernible to a person with normal or corrected vision should be repaired with a zinc-rich formulation complying with this International Standard.

h) Fixed coated steel reinforcing bars, wire or welded fabric should be inspected for damaged coating prior to pouring the concrete. Particular attention should be paid to sheared ends of coated bars. Where damage exists, it should be repaired with an appropriate zinc-rich formulation.

i) When fixing coated steel reinforcing bars, wire and welded fabric, all wire bar supports and spacers, and tying wire should be coated with zinc or with dielectric material.

j) After fixing, walking on coated steel reinforcing bars, wire and welded fabric should be avoided. The positioning of mobile equipment should be planned to avoid damage to the coated reinforcement.

k) When immersion-type vibrators are used to consolidate concrete around coated steel reinforcing bars, wire and welded fabric, the vibrators should be equipped with non-metallic, resilient heads.

Bibliography

[1] ASTM A767/A767M-00b, *Standard Specification for Zinc-Coated (Galvanized) Steel Bars for Concrete Reinforcement*

[2] ASTM A780-01, *Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings*

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