
**Epoxy-coated steel for the reinforcement of
concrete**

Armatures en acier pour béton armé avec revêtement époxy

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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 3.

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 International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 14654 was prepared by Technical Committee ISO/TC 17, *Steel*, Subcommittee SC 16, *Steel for the reinforcement and prestressing of concrete*.

Annex A forms a normative part of this International Standard. Annexes B, C, and D are for information only.

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Epoxy-coated steel for the reinforcement of concrete

1 Scope

This International Standard specifies requirements for fusion-bonded epoxy-coated post-fabricated and pre-fabricated steel bar, wire and welded fabric for the reinforcement of concrete.

This International Standard permits the application of either flexible (type A) or nonflexible (type B) coatings. Steel reinforcing bar, wire and welded fabric coated with a nonflexible (type B) coating shall not be fabricated after coating.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative document indicated below. For undated references, the latest edition of normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 2808:1997, *Paints and varnishes — Determination of film thickness.*

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ISO 4287:1997, *Geometrical Product Specifications (GPS) — Surface texture: Profile method — Terms, definitions and surface texture parameters.*

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

ISO 14656:—¹⁾, *Epoxy powder and sealing material for the coating of steel for the reinforcement of concrete.*

3 Terms and definitions

For the purposes of this International Standard, the following terms and definitions apply.

3.1

batch

production unit of epoxy powder

1) To be published.

3.2

bundle

two or more lengths properly bound together

3.3

coated bar

steel reinforcing bar which has been coated with a fusion-bonded epoxy coating

3.4

coated wire

straightened steel wire which has been coated with a fusion-bonded epoxy coating

3.5

coated welded fabric

sheet of steel welded fabric which has been coated with a fusion-bonded epoxy coating

3.6

coating line

strand (deprecated)

one length-coating process line in a multiple-line steel reinforcing bar coating plant

3.7

conversion coating

preparation of the blasted metal surface prior to coating application which is designed to pretreat the metal, promote coating adhesion, improve corrosion resistance and increase blister resistance

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3.8

disbonding

loss of adhesion between the fusion-bonded epoxy coating and the steel reinforcing bar, wire or welded fabric

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3.9

fabricator

any organization which cuts and/or bends coated steel reinforcing bar, wire or welded fabric

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3.10

fusion-bonded epoxy coating

coating containing pigments, thermosetting epoxy resins, crosslinking agents and other additives, which have been applied in the form of a powder on to a clean, heated metallic substrate and fused to form a continuous barrier

3.11

holiday

discontinuity in a coating which is not discernible to a person with normal or corrected vision

3.12

length

piece of nominally straight steel reinforcing bar cut to a specified length

3.13

longitudinal rib

uniform continuous rib parallel to the axis of the steel reinforcing bar

3.14

manufacturer

any organization which produces coated steel reinforcing bars, wire or welded fabric

3.15

post-fabricated reinforcement

steel reinforcing bar, wire or welded fabric that is fabricated after being coated with a fusion-bonded epoxy coating

3.16**pre-fabricated reinforcement**

steel reinforcing bar, wire or welded fabric that is fabricated before being cleaned and coated with a fusion-bonded epoxy coating

3.17**sealing material**

a coating system, formulated to be compatible with the fusion-bonded epoxy coating, used to repair damaged areas and cut ends

3.18**test unit**

the quantity of coated reinforcing steel to be accepted or rejected together, on the basis of the tests to be carried out on sample products in accordance with the requirements of the product standard or order

NOTE Adapted from ISO 404:1992.

3.19**transverse rib**

any rib on the surface of the steel reinforcing bar or wire other than a longitudinal rib

3.20**wetting agent**

material that lowers the surface tension of water allowing it to penetrate more effectively into small discontinuities in the coating giving a more accurate indication of the holiday count

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4 Materials**4.1 Steel reinforcing bars**

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Steel reinforcing bars to be coated shall be in accordance with ISO 6935-1 or ISO 6935-2 or any other product standard as specified by the purchaser, and shall be free of contaminants such as oil, grease or paint.

NOTE Prior to coating, the steel reinforcing bars should be inspected for their suitability for coating. Steel reinforcing bars with sharp edges on the ribs, rolled-in slivers or other surface imperfections are difficult to coat properly. The coating will tend to flow away from sharp edges on the ribs, rolled-in slivers or other surface imperfections, and could result in inadequate coating thickness at these points.

4.2 Steel wire or welded fabric

Steel wire or welded fabric to be coated shall be in accordance with ISO 10544 or ISO 6935-3 or any other product standard as specified by the purchaser, and shall be free of contaminants such as oil, grease or paint.

4.3 Epoxy powder

The epoxy powder upon application shall be in accordance with ISO 14656. Upon request, the purchaser shall be provided with test data for review.

The purchaser shall be furnished with a written certificate that properly identifies the batch designation of the epoxy powder used in the order, states quantity, date of manufacture, name and address of the powder manufacturer and a statement that the supplied epoxy powder is the same composition as that prequalified in accordance with ISO 14656. The manufacturer of the epoxy powder shall furnish an infrared trace and a differential scanning calorimetry trace of the powder batches used in preparing the coated steel reinforcing bars, wire and welded fabric as part of the certificate.

If specified in the order, a representative 0,2 kg sample of the epoxy powder shall be supplied to the purchaser from each batch. The sample shall be packaged in an airtight container and identified by batch designation.

The epoxy powder shall be maintained in a temperature-controlled environment following the written recommendations of the powder manufacturer until ready for use, at which point the epoxy powder will be given sufficient time to reach the approximate plant ambient temperature. The epoxy powder shall be used within the powder manufacturer's written recommended shelf life.

4.4 Sealing material

The coating system, for use as sealing material, shall be compatible with the fusion-bonded epoxy coating, inert in concrete, and recommended by the epoxy powder manufacturer. The sealing material shall be suitable for repairing damaged coatings at the manufacturer, fabricator or at the site, and shall be in accordance with ISO 14656.

When specified in the order, sealing material shall be supplied to the purchaser.

5 Surface preparation of steel reinforcing bar, wire and welded fabric

The surface of the steel reinforcing bar, wire and welded fabric shall be cleaned by abrasive blast steel grit. The amount of residual mill scale on the cleaned surface shall not exceed 5 % when tested in accordance with C.10.

Average blast profile roughness depth readings of 50 μm to 70 μm , defined as the arithmetic mean deviation of the assessed profile, R_a , in ISO 4287:1997, shall be considered suitable as an anchor pattern.

NOTE 1 The use of a "profilometer" type surface measurement instrument which measures the peak count as well as the maximum profile depth is recommended.

A steel grit of Rockwell hardness C 55 or higher, such as GL-25, shall be used. Preferably 100 % grit shall be used.

NOTE 2 Recycled steel grit abrasive should be maintained so as to minimize contaminants such as oil, salt and dust caused by the blasting operation.

Multidirectional, high-pressure dry air knives shall be used after blast cleaning to remove dust, grit and other foreign matter from the steel surface. The air knives shall not deposit oil on the steel reinforcing bars, wire and welded fabric.

NOTE 3 Steel reinforcing bar, wire and welded fabric found to be salt contaminated should be cleaned by acid washing or other suitable methods to remove contaminants from the surface prior to preheating. Washed surfaces should not be allowed to flash rust.

It shall be permissible for a chemical wash and/or conversion coating of the steel reinforcing bar, wire and welded fabric surface to be used to enhance coating adhesion.

NOTE 4 Some powder coatings may require pretreatment of the steel in accordance with the powder manufacturer's instructions.

The pretreatment shall be applied after abrasive cleaning and before coating, in accordance with the written application instructions specified by the pretreatment manufacturer.

Alternative surface preparation criteria to the foregoing may be applied provided:

- a) they can be shown to give a good or better performance with respect to clause 7 and C.8 to C.11;
- b) the preparation procedures and critical measures are documented, including tolerance limits which can be shown not to compromise overall quality;
- c) the product is produced under a quality assurance scheme which validates a) and b) above.

6 Application of powder

The epoxy powder shall be applied to the cleaned and pretreated (if applicable) surface as soon as possible after surface treatments have been completed, and before any visible (to a person with normal or corrected vision) surface rusting occurs. The maximum time to application of coating shall be based on the relative humidity (RH) in the coating plant according to Table 1:

Table 1 — Maximum time between surface treatment and application of powder

Relative humidity RH	Maximum time min
$RH \leq 55 \%$	180
$55 \% < RH \leq 65 \%$	90
$65 \% < RH \leq 75 \%$	60
$75 \% < RH \leq 85 \%$	30

If the relative humidity is in excess of 85 %, coating application shall cease, except where the surface preparation, heating and coating process is a continuous operation.

The powder shall be applied in accordance with the written recommendations of the manufacturer of the powder in the case of initial steel surface temperature range and post application cure requirements. During continuous operations, the temperature of the surface immediately prior to coating shall be measured using infrared guns and/or temperature-indicating crayons at least once every 30 min.

NOTE 1 The use of infrared guns and temperature-indicating crayon measurement of the coated steel reinforcing bar, wire or welded fabric is recommended. <https://standards.iteh.ai/catalog/standards/sist/4e13bc99-0abb-4b57-a0a9-83596a540a31/iso-14654-1999>

NOTE 2 Periodic checks of the coating's cure by differential scanning calorimetry is recommended.

NOTE 3 When twin wire types of welded fabric are to be coated, an appropriate method of coating application should be considered.

7 Requirements for coated steel reinforcing bar, wire and welded fabric

7.1 General

Nonflexible (type B) coatings shall be required to meet the performance requirements of flexible (type A) coatings with the exception of the requirements for coating flexibility (7.4).

NOTE Some national standards include a qualification test to determine the relative bond strength of ribbed steel reinforcing bars in concrete. In the USA, for example, relative bond strength is determined with beam-end test specimens in accordance with ASTM A 944. In the qualification testing, the relative bond strength of the coated bars is required to be at least 85 % of the relative bond strength of the uncoated bars. For more information see ASTM A 944.

When specifying epoxy coated reinforcing steel according to this International Standard, the need for a bond strength specification should also be considered.

7.2 Coating thickness

The coating thickness after curing shall be 170 μm to 300 μm . The upper thickness limit does not apply to repaired areas of damaged coating.

7.3 Coating continuity

There shall not be more than four holidays per linear metre of the coated steel reinforcing bar or coated wire (spool and individual lengths). For coated bars or wires less than 300 mm in length, the maximum shall be one holiday.

In welded fabric, the number of holidays shall not exceed the values given in Table 2.

Table 2 — Coating continuity in welded fabric

Wire spacing ^a	Number of intersections to be checked ^b	Maximum number of holidays
b_L and $b_C \leq 100$ mm	10	20 holidays/m ²
b_L or $b_C > 100$ mm	5	10 holidays/m ²

^a b_L is the spacing of longitudinal wires; b_C is the spacing of transverse wires.
^b One intersection is a welding point including 13 mm wire in each direction.

Damage at cut ends shall not be counted.

7.4 Coating flexibility

No cracking or disbonding of the coating shall be visible to a person with normal or corrected vision on the outside radius of the bent test piece.

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7.5 Coating adhesion

The coating adhesion shall be evaluated by cathodic disbondment and salt spray testing in accordance with procedures described in ISO 14656.

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The manufacturer shall be able to demonstrate a disbondment radius on cathodic disbondment testing of less than 2 mm on greater than 95 % of the samples tested on a three-month rolling average.

The manufacturer shall be able to demonstrate a disbondment radius on salt spray testing of less than 3 mm on greater than 95 % of the samples tested on a three-month rolling average.

8 Permissible coating damage and repair of damaged coating

Coating damage discernible to a person with normal or corrected vision shall be repaired with sealing material meeting the requirements of 4.4 in accordance with the written recommendations of the sealing material manufacturer. Any rust shall be removed by suitable means before application of the sealing material.

The total damaged surface area, prior to repair with sealing material, shall not exceed 0,5 % of the surface area in any one metre length of the bar or wire. This limit on repaired damage does not include sheared or cut ends that are coated with sealing material.

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 sealed with the same sealant that is used for the repair of damaged coating.

The coating at repaired areas shall have a minimum thickness of 180 µm.

NOTE 1 These requirements apply to the coated product before the coated steel is accepted from the supplier by the purchaser and are not site acceptance criteria, see annex B.

NOTE 2 Process limitations on straight-bar coating lines can result in inadequate coating for approximately 200 mm at each end of the steel reinforcing bar. It is recommended that these ends be either removed or repaired during subsequent fabrication.

NOTE 3 If the coating damage in any one metre length of the bar or wire exceeds 0,5 % of the surface area, that section should be removed from the coated bar or wire and discarded. In repairing coating damage, care should be taken not to apply the sealing material to an excessive amount of intact coating during the repair process.

9 Manufacturer's certificate

The manufacturer shall make available, when requested by the purchaser, a certificate of testing stating:

- a) that the material supplied complies with the requirements of this International Standard;
- b) the address at which the record of test results is available for inspection;
- c) the identification symbol of the certification body, where applicable.

10 Handling, storage and identification

Coated steel reinforcing bars, wire and welded fabric shall be transported and handled with care. All systems for handling coated bars, wire and welded fabric shall have padded contact areas. All bundling bands shall be padded or suitable banding shall be used to prevent damage to the coating. All bundles of coated reinforcement shall be lifted in such a way as to prevent bar-to-bar abrasion from sags in the bundles. The coated reinforcement shall not be dropped or dragged.

If circumstances require that coated steel reinforcing bars, wire and welded fabric be stored outdoors for more than two months, protective storage measures shall be implemented to protect the material from sunlight, salt spray and weather exposure. Coated reinforcement stored in corrosive environments shall require protection sooner. If the coated reinforcements are stored outdoors without cover, the date on which the coated reinforcements are placed outdoors shall be recorded on the identification tag on the bundled steel. Coated reinforcement shall be covered with opaque polyethylene sheeting or other suitable opaque protective material. For stacked bundles, the protective covering shall be draped around the perimeter of the stack. The covering shall be secured adequately, and allowance for air circulation around the coated reinforcement be made in orders to minimize condensation under the covering.

All coated reinforcement shall be stored off the ground on protective bearers.

Quality assurance codes shall be placed on all identification tags of the coated steel reinforcing bars, wire and welded fabric. These codes shall certify compliance to this International Standard and include references to the date of fabrication, the date of coating, the powder lot designation and the quality assurance testing performed. The identification of all steel reinforcing bars, wire and welded fabric shall be maintained throughout the coating and fabrication processes up to the point of shipment.

Annex A (normative)

Test methods and frequency of tests, and retests

A.1 Test methods and frequency of tests

A.1.1 Coating thickness

A.1.1.1 Test method

For acceptance purposes, at least 95 % of all recorded coating thickness measurements shall be within the specified range. Thickness measurements less than 130 µm shall be considered cause for rejection.

A single recorded coating thickness measurement is the average of three individual readings obtained between three consecutive transverse ribs of the steel reinforcing bar, or between three consecutive indentations or ribs of the wire or welded fabric wires. A minimum of five recorded measurements shall be obtained approximately evenly-spaced along each side of the test specimen (a minimum of ten recorded measurements per specimen).

Measurements shall be made in accordance with method No. 6 of ISO 2808:1997 following the instructions for calibration and use issued by the thickness gauge manufacturer. Pull-off and fixed probe gauges may be utilized. "Pencil-type" pull-off gauges that require the operator to observe the readings at the instant the magnet is pulled from the surface shall not be used.

For ribbed bars and ribbed or indented wire, the thickness of the coating shall be measured on the body of a straight length of bar or wire between the transverse ribs or indentations.

Measurements of coating thickness for plain bars and plain wire shall follow the preceding procedure for ribbed bars and ribbed or indented wire, except for the location of the three individual readings. The three individual readings, the average of which is a single recorded coating thickness measurement, shall be obtained at three consecutive points. The spacing between the three consecutive points shall be approximately equal to the nominal diameter of the bar or wire.

A.1.1.2 Frequency of tests

For steel reinforcing bars, tests for coating thickness shall be made on a minimum of two bars of each size from each production hour.

For wire and welded fabric, tests shall be made on a minimum of 0,3 m length of each size wire or welded fabric coated during each production hour.

A.1.2 Coating continuity

A.1.2.1 Test method

Holiday checks to determine the acceptability of the coated steel reinforcing bars prior to shipment shall be made at the manufacturer's plant with a hand-held 67,5 V, 80 000 Ω, wet-sponge type, direct-current holiday detector or equivalent method. The testing voltage shall be fixed and the detector designed so that an external instrument can indicate that it is correct. The detector shall be equipped with indicators such as a lamp and/or a buzzer for indicating discontinuities. The probe shall be capable of covering all surfaces of the coated bars, wire and welded fabric of the shapes and dimensions being tested.

The sponge shall be soaked in tap water to which a wetting agent has been added.