INTERNATIONAL STANDARD

ISO 14655

First edition
1999-12-15

Epoxy-coated strand for the prestressing of concrete

Toron pour la précontrainte du béton avec revêtement époxy

Reference number
ISO 14655:1999(E)

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Printed in Switzerland

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 14655 was prepared by Technical Committee ISO/TC 17, *Steel*, Subcommittee SC 16, *Steels for the reinforcement and prestressing of concrete*.

Annexes A and B form a normative part of this International Standard. Annex C is for information only.

Epoxy-coated strand for the prestressing of concrete

1 Scope

This International Standard specifies requirements for fusion-bonded, epoxy-coated, or epoxy-coated and filled, seven-wire prestressing steel strand for the prestressing of concrete.

NOTE Use of epoxy-coated strand in pre-tensioned applications such as fire-rated construction should be approached with caution.

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 documents indicated below. For undated references, the latest edition of the 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*.

ISO 6272:1993, *Paints and varnishes — Falling weight test.*

ISO 6892:1998, *Metallic materials — Tensile testing at ambient temperature.*

ISO 6934-4:1991, *Steel for the prestressing of concrete — Part 4: Strand*.

ISO 9227:1990, *Corrosion tests in artificial atmospheres — Salt spray tests*.

3 Terms and definitions

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

3.1
coated and filled strand
epoxy-coated seven-wire strand in which the void spaces between the wires are completely filled with the epoxy coating to prevent migration of corrosive media, either by capillary action or other hydrostatic forces

3.2
coated strand
seven-wire prestressing steel strand which has been coated with a fusion-bonded epoxy coating

3.3
disbonding
loss of adhesion between the fusion-bonded epoxy coating and the strand

3.4
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

3.5
grit
inert particles that are impregnated into the surface of the coating

3.6
grit-impregnated strand
coated strand with grit impregnated into the surface of the coating

3.7
holiday
discontinuity in a coating which is not discernible to a person with normal or corrected vision

3.8
manufacturer
any organization which produces coated strand

3.9
sealing material
a coating system, formulated to be compatible with the fusion-bonded epoxy coating, used to repair damaged areas and cut ends

3.10
test unit
the quantity of coated strand 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.

4 Materials

4.1 Prestressing steel strand

Prestressing steel strand to be coated shall be in accordance with ISO 6934-4 or any other product standard as specified by the purchaser, and shall be free of contaminants such as oil, grease or paint.

4.2 Epoxy powder

The epoxy powder shall comply with the requirements listed in annex B. The material shall be of organic composition except for the pigment, or grit if applicable, which may be inorganic if used.

The purchaser shall be furnished a written certification that properly identifies the batch designation of the epoxy powder used in the order, quantity represented, date of manufacture, name and address of the powder manufacturer and a statement that the supplied epoxy powder is the same composition as that which was qualified under the requirements of annex B.

If specified in the order, a representative 0,25 kg sample of the epoxy powder material shall be supplied to the purchaser. The sample shall be packaged in an airtight container and identified by batch designation.

4.3 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 repairs at the manufacturer or at the site. The material shall comply with the requirements of annex B.

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

5 Surface preparation of prestressing steel strand

The surface of the prestressing steel strand to be coated shall be cleaned chemically or by other methods that will not impair the prestressing steel strand.

6 Application of coating

The coating shall be applied to the cleaned surface as soon as possible after cleaning and before re-oxidation of the surface occurs as discernible to a person with normal or corrected vision. However, in no case shall application of the coating be delayed more than 10 min after cleaning.

The fusion-bonded epoxy powder coating shall be applied in accordance with the written recommendations of the manufacturer of the coating material for initial steel surface temperature range and post-application cure requirements. The temperature of the surface immediately prior to coating shall be measured using infrared guns and/or temperature-indicating crayons at least once every 10 min during continuous operations.

NOTE 1 The use of infrared guns and temperature-indicating crayon measurement of the coated prestressing steel strand is recommended.

The coating shall be applied by electrostatic deposition or other suitable method.

NOTE 2 Periodic checks of the coating's cure by Differential Scanning Calorimetry is recommended.

The surface of the coating may be smooth or grit-impregnated.

Inert particles (grit) shall be impregnated into the surface of the coating when grit-impregnated strand is ordered. Such particles shall not cause the coating to fail the requirements of clause 7. The particles shall be inert in concrete and non-reactive with concrete additives and soluble salts.

The epoxy coating on the surface of grit-impregnated strand shall be capable of reaching a temperature of 66 °C without reducing the transfer of prestressing due to the strand bonding to the surrounding concrete.

WARNING At temperatures above 74 °C, currently available epoxy powder coatings begin to soften and lose ability to transfer load from strand to concrete by bond. At 93 °C practically all transfer capacity will be lost.

7 Requirements for coated prestressing steel strands

7.1 Coating thickness

For coated strand, the coating thickness after curing shall be between 650 µm and 1 150 µm.

A coating thickness less than 650 µm may be agreed upon between purchaser and manufacturer.

NOTE If a coating thickness less than 650 µm is agreed upon, the manufacturer should submit test data to demonstrate performance in accordance with this International Standard.

7.2 Mechanical properties

The coated strand shall satisfy the requirements for characteristic maximum force, 0,1 % proof force and elongation described in ISO 6934-4 or any other product standard as specified by the purchaser.

Epoxy-coated strand shall have relaxation losses of not more than 4 % after 1 000 h when initially loaded to 70 % of specified characteristic maximum force of the strand.

7.3 Coating continuity

After curing, the coating shall be free of holes, voids, cracks and damaged areas discernible to a person with normal or corrected vision.

Continuous holiday detection of the coated strand shall be performed. If more than two holidays per 30 m are detected, the strand shall be rejected and corrective action shall be instituted. Coated strand with two holidays or less per 30 m shall be repaired in accordance with the sealing material manufacturer's recommendation.

7.4 Coating adhesion

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

Except as specified in A.2, evidence of cracking or disbonding of the coating shall be considered cause for rejection of the coated strand represented by the bend test sample.

The coating adhesion shall also be evaluated by a tensile test. The test temperature shall be 23 °C ± 2 °C, and the rate of stressing shall be between 6 N/(mm^2·s) and 60 N/(mm^2·s). No cracks visible to a person with normal or corrected vision shall occur in the coating up to an elongation of 1 %.

7.5 Bond with concrete or grout

Pull-out tests shall be conducted on grit-impregnated coated strand to assure proper bond properties. See A.1.4.

8 Permissible coating damage and repair of damaged coating

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

Coating damage discernible to a person with normal or corrected vision shall be repaired with sealing material meeting the requirements of 4.3 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 coating at repared areas shall have a minimum thickness of 650 μm.

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.

The manufacturer shall, when requested in the order, furnish a representative load-elongation curve for each size and grade of strand shipped and a copy of the manufacturer's quality control tests.

10 Handling and identification

All strapping bands shall be padded or suitable banding shall be used to prevent damage to the coating. All reels of coated strand shall be handled in such a manner as not to damage the coating on the strand. Coating damage due to handling shall be repaired in accordance with the written recommendations of the sealing material manufacturer. The repaired coating shall conform to the requirements of clause 7.

The reel number shall be maintained throughout the fabrication and coating process to the point of shipment for traceability.

11 Coated and filled strand

If specified in the order, or agreed upon between purchaser and manufacturer, the delivered strand shall be coated and filled.

For coated and filled strand, all requirements given in this International Standard shall apply, except for the following:

— the coating thickness after curing shall be 400 µm to 900 µm;

— epoxy-coated and filled strand shall have a relaxation loss of not more than 6,5 % after 1 000 hours when initially loaded to 70 % of the specified characteristic maximum force of the strand.

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 Method of test

Measurements shall be made in accordance with method No. 6 of ISO 2808:1997 following the instructions for calibration and use 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. The coating thickness shall be determined within a ± 5 % allowable error with a gauge capable of measuring along a curved surface.

The coating thickness shall be measured on the crown of the wires, on a straight length of the strand. The magnetic gauge shall be placed at one section on the strand and readings taken at the crown of each outer wire and averaged.

A.1.1.2 Frequency of tests

For each reel of strand, thickness measurements shall be conducted at five locations spaced approximately evenly along the manufactured length of the strand. Records of inspection during manufacturing shall be available when requested. It shall be permissible to reduce the frequency of thickness measurements if the manufacturer can demonstrate small coating thickness standard deviations to the satisfaction of the purchaser.

A.1.2 Coating continuity

During the coating process, a continuous holiday detection procedure shall be employed using an appropriate holiday detector. The procedure shall follow the written instructions furnished by the manufacturer of the holiday detector.

Holiday checks to determine the acceptability of the coated prestressing steel strand shall be made at the manufacturer's plant with an in-line minimum 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 verify that it is correct. The detector shall be equipped with indicators such as a lamp and/or a buzzer for indicating discontinuities.

NOTE 1 Hand-held holiday detector checks should be performed regularly to verify the accuracy of the in-line system.

NOTE 2 To obtain an accurate holiday count, care should be taken to ensure that contact of the sponge along the entire steel surface being tested is maintained.

A.1.3 Coating adhesion

A.1.3.1 Method of test

The adhesion and shear strength of the coating shall be evaluated by bending a sample from a finished reel of coated strand 180° around a mandrel diameter equal to 32 times the nominal diameter of the strand. The test specimens shall be between 20 °C and 30 °C.

Fracture of a steel wire or the strand in the bend test for adhesion of coating shall not be considered as an adhesion failure of the coating, and another specimen from the same production shift may be substituted.

The coating adhesion shall also be evaluated by a tensile test in accordance with ISO 6892.

Sample length for the bend test shall be at least 1 500 mm. Sample length for the tensile test shall follow the requirements of ISO 6892.

A.1.3.2 Frequency of tests

Tests for coating adhesion shall be conducted at the end of each manufactured length.

A.1.4 Bond with concrete or grout

A.1.4.1 Method of test

Pull-out specimens shall be cast in concrete cylinders with the dimensions shown in Table A.1. The untensioned strand shall be embedded concentrically along the longitudinal axis of the specimen. The test shall be conducted when the concrete reaches a compressive strength between 30 MPa and 35 MPa. Padding material shall be applied to provide a uniform support to the specimen and to make the strand perpendicular to the supporting surface. The loading shall be applied as shown in Figure A.1, by a hydraulic or mechanical jack. The load should be measured using a calibrated load indicator. A dial gauge shall be used at the unloaded end of the strand to indicate slip. Minimum force at 0,025 mm slip shall be at least equal to or greater than the values shown in Table A.1.

A.1.4.2 Frequency of tests

Pull-out tests shall be conducted once every 15 000 m of grit-impregnated strand produced. It shall be permissible to reduce the frequency of pull-out tests if the manufacturer can demonstrate small standard deviations to the satisfaction of the purchaser.

Table A.1 — Requirements for pull-out tests

Strand diameter mm	Cylinder diameter mm	Embedment length mm	Minimum force at 0,025 mm slip kN
9,3	150	195	9,7
9,5	150	190	9,7
10,8	150	170	9,8
11,1	150	165	9,9
12,4	150	155	10,2
12,7	150	150	10,5
15,2	150	140	11,5