

INTERNATIONAL STANDARD

ISO
6934-1

First edition
1991-07-01

Steel for the prestressing of concrete —

Part 1: General requirements

*Acier pour armatures de précontrainte —
Partie 1: Spécifications générales*



Reference number
ISO 6934-1:1991(E)

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.

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.

International Standard ISO 6934-1 was prepared by Technical Committee ISO/TC 17, *Steel*.

ISO 6934 consists of the following parts, under the general title *Steel for the prestressing of concrete*:

- *Part 1: General requirements*
- *Part 2: Cold-drawn wire*
- *Part 3: Quenched and tempered wire*
- *Part 4: Strand*
- *Part 5: Hot-rolled steel bars with or without subsequent processing*

Annex A forms an integral part of this part of ISO 6934. Annexes B and C are for information only.

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Case Postale 56 • CH-1211 Genève 20 • Switzerland

Printed in Switzerland

Steel for the prestressing of concrete —

Part 1: General requirements

1 Scope

1.1 ISO 6934 specifies requirements for high tensile strength steel to be used in prestressed concrete. It applies only to material in the condition as supplied by the manufacturer. It does not cover requirements for materials and anchorage devices used in conjunction with the prestressing steel in structural components.

1.2 The specific properties for each type of prestressing steel are given in ISO 6934-2 to ISO 6934-5.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 6934. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 6934 are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 1099:1975, *Metals — Axial load fatigue testing*.

ISO 6892:1984, *Metallic materials — Tensile testing*.

ISO 7801:1984, *Metallic materials — Wire — Reverse bend test*.

ISO 10065:1990, *Steel bars for reinforcement of concrete — Bend and rebend tests*.

3 Definitions

For the purposes of this part of ISO 6934, the following definitions apply.

3.1 cast analysis: Chemical analysis of a sample of the molten steel during casting.

3.2 characteristic value: Value having a prescribed probability of not being attained in a hypothetical unlimited test series. [ISO 8930]

NOTE 1 Equivalent to *fractile*, which is defined in ISO 3534.

3.3 nominal cross-sectional area: The cross-sectional area equivalent to the area of a circular plain bar of nominal diameter.

3.4 relaxation: Time-dependent stress loss for a constant length. Relaxation is stated as a percentage of the initial stress applied to the steel.

4 Manufacturing process

Steel according to ISO 6934 may be made by any process except the air or mixed air/oxygen bottom blown processes.

5 Types of prestressing steel

5.1 Cold-drawn wire

A solid product obtained from a rod by cold working through dies or rollers. The product is supplied in coils of diameter approximately equal to that of the wiredrawing machine capstan (mill coils) or in larger diameter coils of straightened wire.

The wire is defined by its surface configuration (5.1.1 to 5.1.4) and method of treatment (5.1.5 and 5.1.6).

5.1.1 plain wire: Wire with a surface as obtained in the drawing die. The wire has a constant nominal

cross-section and does not show periodical irregularities along the length in either the surface or axis.

5.1.2 ribbed wire: Wire whose surface has ribs at regular intervals along the length.

5.1.3 indented wire: Wire whose surface has indentations at regular intervals along the length.

5.1.4 crimped wire: Wire which has a regular deformation of the wire axis in either a single plane or in helical form produced by a subsequent mechanical process.

5.1.5 mill coil wire: Wire in the condition after cold drawing. It may be covered by a residue of drawing lubricant.

5.1.6 stress relieved wire: Cold-drawn wire that has been subjected to one of the following treatments in a continuous linear manner:

- a) the wire passes through a sequence of flexures followed by a short-term heat treatment;
- b) the wire is given a short-term heat treatment under plastic deformation (under conditions of longitudinal strain).

Both treatments improve certain mechanical properties and relaxation characteristics, method b) giving lower stress relaxation.

5.2 Quenched and tempered wire

A hot-rolled rod or wire, which is heated to a high temperature, rapidly cooled to produce a martensitic structure and then tempered at a suitable temperature. The product is delivered in coils. The surface of the wire may be covered with a thin film of scale. The wire may be plain, ribbed, grooved or indented.

5.3 Strand

A linear product consisting of two or more wires spun together in helical form. The pitch and direction of spinning are the same for all the helical wires in the same layer. The pitch is appropriate to the size and type of strand.

The strand is given a final stress-relieving treatment, in the same way as cold-drawn wire, and is delivered in coil form.

Compacted strand is a strand which has been compressed (e.g. by cold working after stranding) and given a stress-relieving treatment before winding into coil form.

Strand is classified as follows.

5.3.1 2 and 3-wire strand: Two or three wires, respectively, spun together over a theoretical common axis.

5.3.2 7 wire-strand: A straight-core wire around which are spun 6 helical wires in one layer.

5.3.3 19 wire-strand: A straight-core wire around which are spun two layers of wires.

5.4 Bar

Bar is produced by hot rolling of steel and is supplied in straight lengths. It may be plain or ribbed. Processed bars are bars which are cold worked or heat treated. Such bars may have an additional heat treatment, to give the required properties.

6 Requirements

6.1 Chemical composition

The chemical composition shall be related to the type of product and its size and tensile strength. If requested by the purchaser the cast analysis of the steel shall be given. In cast analyses, the content of both sulfur and phosphorus shall not exceed 0,04 %.

6.2 Geometrical properties

6.2.1 The geometrical properties are based upon nominal diameters.

6.2.2 Where the delineation of geometrical properties by nominal diameters is insufficient or not appropriate, the geometrical properties may be defined by nominal cross-sectional area with specified tolerances and appropriate details of the configuration of the wire, strand or bar (see ISO 6934-2 to ISO 6934-5).

6.3 Mechanical properties

ISO 6934 contains requirements for the following mechanical properties of the products covered:

- maximum force;
- proof force;
- percentage total elongation at maximum force;
- ductility;
- isothermal relaxation.

The relevant tests and required values for each product are given in the corresponding part of ISO 6934.

6.3.1 Tensile properties

6.3.1.1 The values for maximum force, proof force and percentage total elongation at maximum force shall be specified as characteristic values. At least 95 % of the population under consideration shall have tensile properties equal to or above the characteristic value specified.

By agreement between manufacturer and purchaser, the characteristic values specified in the relevant part of ISO 6934 may be used as guaranteed minimum values.

The values given for all other properties shall be considered either as a maximum or a minimum value, as appropriate.

6.3.1.2 The specified proof force value is the proof force of 0,1 % non-proportional elongation and it shall be the mandatory requirement. In the relevant parts of ISO 6934, the 0,2 % proof force is also given, and this may be required in the order.

6.3.1.3 The percentage total elongation at maximum force shall be determined as specified in the relevant parts of ISO 6934.

6.3.2 Bending properties

Prestressing steel shall be proved to have suitable ductility by means of bend tests or reverse bend tests. Test methods depend upon the product, as specified in the relevant parts of ISO 6934.

6.3.3 Long-term behaviour

6.3.3.1 Isothermal relaxation

Values for relaxation of stress shall be established at a nominal temperature of 20°C for a period of 1000 h from initial stresses of 60 %, 70 % and 80 % of the nominal tensile strength. The values of 60 % and 80 % shall not be mandatory but shall be provided if requested by the purchaser.

6.3.3.2 Fatigue behaviour

If requested by the purchaser, fatigue behaviour shall be demonstrated according to annex A.

6.4 Surface condition

The finished product shall be free from defects, which may impair the performance of the product.

Unless otherwise specified, longitudinal seams or discontinuities shall not be considered as defects if their depth is less than 4 % of the nominal diameter of a bar or a wire.

Prestressing steel shall be free from rust. Slight rusting shall not be a reason for rejection, provided it does not cause pits visible to the naked eye.

Additional coating for specific purposes shall only be applied to the surface of the steel if previously agreed between purchaser and manufacturer.

7 Testing of properties

7.1 Scope of testing

Inspection and testing shall be performed

- in accordance with a certification scheme monitored by an external body;

or

- by testing of a specific delivery according to column 3 in table 1.

7.2 Tensile testing of strand

7.2.1 Maximum force

The strand shall be held in strand or rope-testing machine grips, which shall not cause excessive damage to the strand wires. If any wire break occurs within a distance of 3 mm from the grips, and the breaking load is below the specified characteristic value, the test shall be discarded.

7.2.2 Percentage total elongation at maximum force

The percentage total elongation at maximum force of the strand shall be measured on a gauge length of not less than 500 mm by means of a suitable extensometer. The elongation shall be measured prior to fracture of any of the component wires.

The extensometer may be removed from the specimen prior to rupture after the specified minimum elongation has been exceeded.

7.3 Reverse bend

The reverse bend test shall be conducted in accordance with ISO 7801 except where amended for the type of product.

Table 1 — Testing of properties

1 Property	2 Test method	3 Extent of testing
Chemical composition	ISO-standards as applicable	One test for each cast of steel for the delivery
Surface condition	ISO 6934	One test for each type of steel ¹⁾ for the delivery
Maximum force	ISO 6892	Characteristic value ²⁾
Proof force	ISO 6892	Characteristic value
Percentage total elongation at maximum force	ISO 6892	Characteristic value
Bend	ISO 10065	One test for each type of steel for the delivery
Reverse bend	ISO 7801	
Relaxation	ISO 6934	Properties typical of the steel shall be demonstrated
Fatigue strength	ISO 1099	Properties typical of the type of steel shall be demonstrated if requested

1) "Type of steel" refers to each product with its particular production process and diameter.

The acceptance criteria are described in the various parts of ISO 6934.

2) "Characteristic value" indicates that the extent of testing shall be sufficient to determine such values.

In the case of inspection by guaranteed minimum values, the extent of testing shall be in accordance with the agreement between the manufacturer and purchaser.

8 Delivery conditions

8.1 Identification

Unless otherwise agreed, each coil of wire or strand or quantity of bars shall carry a label giving

- a) the number of the relevant part of ISO 6934;
- b) the nominal diameter;
- c) the nominal tensile strength;
- d) relaxation properties;
- e) coil number or bar batch number related to the test certificate;
- f) manufacturer's name and plant.

8.2 Coil size

Unless otherwise agreed, the coil size shall meet the requirements given in the relevant part of ISO 6934 for each product.

The diameter of the coil for wire and strand shall be sufficiently large to ensure that the material can be uncoiled without difficulty, and without affecting the mechanical properties and the straightness of the product. Where appropriate, a maximum curvature of the prestressing steel is given in the relevant part of ISO 6934 for the product.

8.3 Transport and storage

Prestressing steels in transit and storage shall be protected against damage and contamination, particularly from substances or liquids which are likely to produce or encourage corrosion.

9 Information to be supplied by the purchaser

When ordering products according to ISO 6934, the purchaser shall state

- a) the designation according to the relevant part of ISO 6934;
- b) the type of material: wire, strand or bar;
- c) packing and protection requirements;
- d) whether cast analyses of the steel should be given.

Annex A
(normative)

Fatigue behaviour

If requested by the purchaser, the material shall withstand, without failure, 2×10^6 cycles of a stress fluctuating down from a maximum stress of 70 % of the nominal tensile strength. The fluctuating stress

range, i.e. twice the stress amplitude, is defined in the relevant part of ISO 6934. The fatigue test shall be carried out for each type of steel and an appropriate number of diameters.

Annex B
(informative)

Options for agreement between purchaser and supplier

For convenience, the provisions for which this part of ISO 6934 indicates that additional or deviating requirements can be agreed between purchaser and supplier, or requested by the purchaser, are listed below. The list does not imply any restriction on agreements concerning other provisions.

- Cast analysis (6.1).
- Guaranteed minimum values (6.3.1.1 and table 1).
- 0,2 % proof force (6.3.1.2).
- Relaxation from 60 % or 80 % of nominal stress (6.3.3.1).
- Fatigue behaviour (6.3.3.2).
- Longitudinal seams or discontinuities (6.4).
- Additional coating (6.4).
- Identification label (8.1).
- Coil size (8.2).

Annex C
(informative)

Bibliography

[1] ISO 3534:1977, *Statistics — Vocabulary and symbols.*

[2] ISO 8930:1987, *General principles on reliability for structures — List of equivalent terms.*

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UDC 669.14:691.714:691.328

Descriptors: concrete, prestressed concrete, steels, prestressing steels, specifications, tests, delivery condition.

Price based on 7 pages
