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ISO 15630-3

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Steel for the reinforcement and prestressing of concrete — Test methods —

Part 3: **Prestressing steel**

Aciers pour l'armature et la précontrainte du béton — Méthodes d'essai —

Partie 3: Aciers de précontrainte

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Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
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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 15630-3 was prepared by Technical Committee ISO/TC 17, *Steel*, Subcommittee SC 16, *Steels for the reinforcement and prestressing of concrete*.

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This second edition cancels and replaces the first edition (ISO 15630-3:2002), which has been technically revised.

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ISO 15630 consists of the following parts, under the general title *Steel for the reinforcement and prestressing of concrete — Test methods*:

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— *Part 1: Reinforcing bars, wire rod and wire*

— *Part 2: Welded fabric*

— *Part 3: Prestressing steel*

Introduction

The aim of ISO 15630 is to provide all relevant test methods for reinforcing and prestressing steels in one standard. In that context, the existing International Standards for testing these products have been revised and updated. Some further test methods have been added.

Reference is made to International Standards on the testing of metals, in general, as they are applicable. Complementary provisions have been given if needed.

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Steel for the reinforcement and prestressing of concrete — Test methods —

Part 3: Prestressing steel

1 Scope

This part of ISO 15630 specifies test methods applicable to prestressing steels (bar, wire or strand) for concrete.

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.

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ISO 4957, *Tool steels*

ISO 6508-1, *Metallic materials — Rockwell hardness test — Part 1: Test method (scales A, B, C, D, E, F, G, H, K, N, T)*

ISO 6892-1, *Metallic materials — Tensile testing — Part 1: Method of test at room temperature*

ISO 7500-1, *Metallic materials — Verification of static uniaxial testing machines — Part 1: Tension/compression testing machines — Verification and calibration of the force-measuring system*

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

ISO 9513, *Metallic materials — Calibration of extensometers used in uniaxial testing*

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3 Symbols

The symbols used in this part of ISO 15630 are given in Table 1.

Table 1 — Symbols

Symbol	Unit	Description	Reference
a_m	mm	Rib height at the mid-point	13.3, 14.2
a_{max}	mm	Maximum height of rib or depth of indentation	13.3
$a_{s,i}$	mm	Average height of a portion i of a rib subdivided into p parts of length Δl	14.2
$a_{1/4}$	mm	Rib height at the quarter-point	13.3, 14.2
$a_{3/4}$	mm	Rib height at the three-quarters point	13.3, 14.2
A	%	Percentage elongation after fracture	5.1, 5.3
A_{gt}	%	Percentage total elongation at maximum force	Clause 5
b	mm	Width of transversal rib at the mid-point	13.3.1.6
c	mm	Rib or indentation spacing	13.3
C	mm	Groove width at nominal diameter of the mandrel, d_a, used for the deflected tensile test	11.3.4
d	mm	Nominal diameter of the bar, wire or strand	5.3.1, 7.2, 9.2, 9.4.6, 10.3.4
d_a	mm	Nominal diameter of the mandrel used for the deflected tensile test	11.3.4
d_b	mm	Diameter with 2 gauge cylinders in the groove of the mandrel used for the deflected tensile test	11.3.4
d_e	mm	Diameter of the gauge cylinder used for the deflected tensile test	11.3.4
d_g	mm	Diameter of guide hole	7.2
d_i	mm	Inner diameter of the groove of the mandrel used for the deflected tensile test	11.3.4
D	%	Average coefficient of reduction of the maximum force in the deflected tensile test	11.2, 11.4
D_c	mm	Inner diameter of the cell in the stress corrosion test	10.3.4
D_i	%	Individual percentage of reduction of the maximum force in the deflected tensile test	11.4
D_m	mm	Diameter of the mandrel of the bending device in the bend test	6.2.1
e	mm	Average gap between two adjacent ribs or indentation rows	13.3.1.4, 13.3.2.5
E	MPa	Modulus of elasticity	5.2, 5.3
f	Hz	Frequency of force cycles in the axial force fatigue test	9.1, 9.4.2
f_R	—	Relative rib area	Clause 14
$F_{a,i}$	N	Individual breaking force in the deflected tensile test	11.4
F_m	N	Maximum force in the tensile test	5.3
$\bar{F}_m$	N	Mean value of the maximum force	8.2, 10.2, 11.2, 11.4
$F_{p0,1}$	N	0,1 % proof force, non-proportional extension	5.2, 5.3
$F_{p0,2}$	N	0,2 % proof force, non-proportional extension	5.2, 5.3
F_r	N	Force range in the axial force fatigue test	9.1, 9.3, 9.4.2

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Table 1 (*continued*)

Symbol	Unit	Description	Reference
F_{rt}	N	Residual force in the test piece at time t in the relaxation test	8.1
ΔF_{rt}	N	Force loss in the test piece at time t in the relaxation test	8.1
F_{R}	mm²	Area of longitudinal section of one rib	14.2
F_{up}	N	Upper force in the axial force fatigue test	9.1, 9.3, 9.4.2
F_0	N	Initial force in the isothermal stress relaxation test and the stress corrosion test	8.1, 8.2, 8.3, 8.4, 10.1, 10.2, 10.4.2
G	mm	Depth of the groove of the mandrel used for the deflected tensile test	11.3.4
h	mm	Distance from the top tangential plane of cylindrical supports to the bottom face of the guide	7.2
h_{b}	mm	Bow height in the plane of the bow	13.3.4
l	mm	Length of indentation	13.3.2.4
L_{t}	mm	Length of the test piece in the stress corrosion test	10.2
L_0	mm	Gauge length (without force on the test piece) in the isothermal stress relaxation test Length of the test piece in contact with the solution in the stress corrosion test	8.1, 8.3, 8.4 10.2, 10.3.4, 10.4.1, 10.4.3, 10.4.5
ΔL_0	mm	Elongation of the gauge length, L_0, under force, F_0, in the isothermal stress relaxation test	8.1, 8.3, 8.4
L_1	mm	Length of the passive side in the deflected tensile test	11.3.2
L_2	mm	Length of the active side in the deflected tensile test	11.3.2
m, n	—	Coefficients or numbers	8.4.9, 13.3, 14.2
P	mm	Lay length of a strand	13.3.3
r	mm	Radius of cylindrical supports	7.2
R	mm	Radius at the base of the mandrel used for the deflected tensile test	11.3.4
Ra	µm	Surface roughness of the mandrel used for the deflected tensile test	11.3.4
S_{n}	mm²	Nominal cross-sectional area of the test piece	5.3.2
t_{a}	h	Maximum agreed time for the stress corrosion test	10.4.5
$t_{\mathrm{f,\,i}}$	h	Individual lifetime to fracture in the stress corrosion test	10.4.5
$\bar{t}_{\mathrm{f}}$	h	Median lifetime to fracture in the stress corrosion test	10.4.6
t_0	s	Starting time in the isothermal stress relaxation test and in the stress corrosion test	8.4.2, 10.4
V_0	mm³	Volume of test solution to fill the test cell in the stress corrosion test	10.4.3
Z	%	Percentage reduction of area	5.3.1
α	°	Angle of deviation in the deflected tensile test	11.3.2
β	°	Rib or indentation angle to the bar or wire axis	13.3
ε_x	—	Value of the strain for a force equal to x	5.3.2
ρ	%	Relaxation	8.4.9
$\sum e_i$	mm	Part of the circumference without indentation or rib	13.3.1.4, 13.3.2.5, 14.2
NOTE 1 MPa = 1 N/mm².			

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4 General provisions concerning test pieces

Unless otherwise agreed or specified in the product standard, the pieces shall be taken from the finished product normally before packaging.

Special care should be taken when sampling is made from the packaged product (e.g. coil or bundle), in order to avoid plastic deformation which could change the properties of the samples used to provide the test pieces.

Specific complementary provisions concerning the test pieces may be indicated in the relevant clauses of this part of ISO 15630, if applicable.

5 Tensile test

5.1 Test piece

In addition to the general provisions given in Clause 4, the free length of the test piece shall be sufficient for the determination of the percentage total elongation at maximum force (A_{gt}) in accordance with 5.3.1.

If the percentage elongation after fracture (A) is determined manually, the test piece shall be marked in accordance with ISO 6892-1.

If the percentage total elongation at maximum force (A_{gt}) is determined by the manual method for bar or wire, equidistant marks shall be made on the free length of the test piece (see ISO 6892-1). The distance between the marks shall be 20 mm, 10 mm or 5 mm, depending on the test piece diameter.

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5.2 Test equipment

The test equipment shall be verified and calibrated in accordance with ISO 7500-1 and shall be at least of class 1.

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If an extensometer is used, it shall be of class 1 in accordance with ISO 9513 for the determination of E, $F_{p0,1}$ or $F_{p0,2}$; for the determination of A_{gt}, a class 2 extensometer (see ISO 9513) may be used.

Grips shall be such as to avoid breaks in or very near the grips.

5.3 Test procedure

5.3.1 General

The tensile test for the determination of the modulus of elasticity (E), 0,1 % and 0,2 % proof force ($F_{p0,1}$ and $F_{p0,2}$), percentage total elongation at maximum force (A_{gt}) and/or percentage elongation after fracture (A) and percentage reduction of area (Z) shall be carried out in accordance with ISO 6892-1.

An extensometer shall be used for the determination of the modulus of elasticity (E), 0,1 % and 0,2 % proof force ($F_{p0,1}$ and $F_{p0,2}$) and percentage total elongation at maximum force (A_{gt}). The extensometer gauge length shall be as given in the relevant product standard.

Accurate values of A_{gt} can only be obtained with an extensometer. If it is not possible to leave the extensometer on the test piece to fracture, the elongation may be measured as follows.

— Continue loading until the extensometer records an elongation just greater than the elongation corresponding to $F_{p0,2}$, at which the extensometer is removed and the distance between the testing machine cross-heads is noted. The loading is continued until fracture occurs. The final distance between the cross-heads is noted.

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— The difference between the cross-head measurements is calculated as a percentage of the original distance between the cross-heads and this value is added to the percentage obtained by an extensometer.

For wire and bars, it is also permissible to determine A_{gt} by the manual method (see ISO 6892-1).

It is preferable to apply a preliminary force to the test piece, e.g. to about 10 % of the expected maximum force before placing the extensometer.

If A_{gt} is not completely determined with an extensometer, this shall be indicated in the test report[1)].

Tensile properties, $F_{p0,1}$, $F_{p0,2}$, F_m, are recorded in force units.

For the determination of percentage elongation after fracture (A), the original gauge length shall be 8 times the nominal diameter (d), unless otherwise specified in the relevant product standard. In case of dispute, A shall be determined manually.

If the rupture occurs within a distance of 3 mm from the grips, the test shall, in principle, be considered as invalid and it shall be permissible to carry out a retest. However, it shall be permitted to take into account the test results if all values meet the relevant specified values.

5.3.2 Determination of the modulus of elasticity

The modulus of elasticity (E) shall be determined from the slope of the linear portion of the force-extension diagram in the range between $0{,}2F_m$ and $0{,}7F_m$, divided by the nominal cross-sectional area of the test piece (S_n).

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$$E = \left[(0{,}7F_m - 0{,}2F_m)/(\varepsilon_{0{,}7F_m} - \varepsilon_{0{,}2F_m})\right]/S_n \qquad (1)$$

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The slope may be calculated either by a linear regression of the measured data stored in a data storage facility or by a best-fit visual technique over the above-defined portion of the registered curve.

In some special cases, e.g. hot-rolled and stretched bars, the above-mentioned method cannot be applied; a secant modulus between $0{,}05F_m$ and $0{,}7F_m$ may then be determined as follows:

$$\left[(0{,}7F_m - 0{,}05F_m)/(\varepsilon_{0{,}7F_m} - \varepsilon_{0{,}05F_m})\right]/S_n$$

In addition to the provisions given in 5.3.1, it shall be ensured that the stress rate shall not be changed within the force range over which the modulus of elasticity is determined.

6 Bend test

6.1 Test piece

The general provisions given in Clause 4 apply.

1) For routine tests conducted by prestressing steel producers, the test information should be contained within internal documentation.

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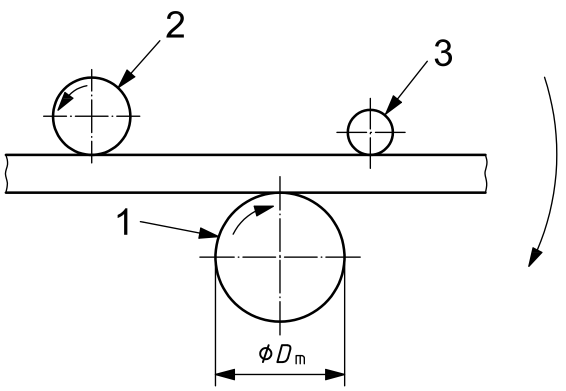
6.2 Test equipment

6.2.1 A bending device, the principle of which is shown in Figure 1, shall be used.

NOTE Figure 1 shows a configuration where the mandrel and support rotate and the carrier is locked. It is also possible that the carrier rotates and the support or mandrel is locked.



Key
1 mandrel
2 support
3 carrier

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Figure 1 — Principle of a bending device

6.2.2 The bend test may also be carried out by using a device with supports and a mandrel (e.g. see ISO 7438).

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6.3 Test procedure

The bend test shall be carried out at a temperature between 10 °C and 35 °C. The test piece shall be bent over a mandrel.

The angle of bend and the diameter of the mandrel shall be in accordance with the relevant product standard.

6.4 Interpretation of test results

The interpretation of the bend test shall be carried out in accordance with the requirements of the relevant product standard.

If these requirements are not specified, the absence of cracks visible to a person with normal or corrected vision is considered as evidence that the test piece withstood the bend test.

A superficial ductile tear may occur at the base of the ribs or indentations and is not considered to be a failure. The tear may be considered superficial when the depth of the tear is not greater than the width of the tear.

7 Reverse bend test

7.1 Test piece

In addition to the general provisions given in Clause 4, the test piece shall comply with ISO 7801.

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