INTERNATIONAL STANDARD

ISO 15630-3

Third edition
2019-02

Corrected version
2019-10

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

Reference number
ISO 15630-3:2019(E)

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Published in Switzerland

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

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

This third edition cancels and replaces the second edition (ISO 15630-3:2010), which has been technically revised. Changes have been introduced in the Introduction, Clauses 1 and 2, 5.3.1, 5.3.2, 9.3, 9.4.4, 10.4.3, 11.4 (now 10.3, 10.4.4, 11.4.3, 12.4) and Figure 8. The Bibliography has been updated and the dated references have been replaced by undated references. A new Clause 8 on the wrapping test has been added.

A list of all parts in the ISO 15360 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

This corrected version of ISO 15630-3:2019 incorporates the following corrections:

— in Figure 8, 60° ± 12° has been corrected to 60° ± 12′.

Introduction

The aim of ISO 15630 (all parts) is to provide all relevant test methods for reinforcing and prestressing steels in one standard series.

This document covers standard test methods, as well as specialized test methods that are not commonly used in routine testing and that should only be considered where relevant (or specified) in the applicable product standard.

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

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

Part 3: **Prestressing steel**

1 Scope

This document specifies test methods applicable to prestressing steel (bar, wire or strand) for concrete.

This document does not cover the sampling conditions that are dealt with in the product standards.

A list of options for agreement between the parties involved is provided in Annex A.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 4957, *Tool steels*

ISO 4965-1, *Metallic materials — Dynamic force calibration for uniaxial fatigue testing — Part 1: Testing systems*

ISO 4965-2, *Metallic materials — Dynamic force calibration for uniaxial fatigue testing — Part 2: Dynamic calibration device (DCD) instrumentation*

ISO 6508-1, *Metallic materials — Rockwell hardness test — Part 1: Test method*

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

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

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

ISO 7802, *Metallic materials — Wire — Wrapping test*

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

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

3 Terms, definitions and symbols

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

For the purposes of this document, the following symbols apply.

Symbol	Unit	Description	Reference
a_m	mm	Rib height at the mid-point	14.3, 15.2
a_{max}	mm	Maximum height of rib or depth of indentation	14.3
$a_{s,i}$	mm	Average height of a portion i of a rib subdivided into p parts of length Δl	15.2
$a_{1/4}$	mm	Rib height at the quarter-point	14.3, 15.2
$a_{3/4}$	mm	Rib height at the three-quarters point	14.3, 15.2
A	%	Percentage elongation after fracture	5.1, 5.3
A_{gt}	%	Percentage total extension at maximum force	Clause 5
A_r	%	Percentage uniform elongation after fracture	5.3
b	mm	Width of transverse rib at the mid-point	14.3.1.6
c	mm	Rib or indentation spacing	14.3
C	mm	Groove width at nominal diameter of the mandrel, d_a, used for the deflected tensile test	12.3.4
d	mm	Nominal diameter of the bar, wire or strand	5.3.1, 7.2, Table 3, 10.4.6, Table 4
d_a	mm	Nominal diameter of the mandrel used for the deflected tensile test	12.3.4
d_b	mm	Diameter to be obtained after placing two gauge cylinders in the groove of the mandrel used for the deflected tensile test	12.3.4
d_e	mm	Diameter of the gauge cylinder used for the deflected tensile test	12.3.4
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	12.3.4
D	%	Average coefficient of reduction of the maximum force in the deflected tensile test	12.2, 12.4
D_c	mm	Inner diameter of the test cell in the stress corrosion test	11.3.4
D_i	%	Individual percentage of reduction of the maximum force in the deflected tensile test	12.4
D_m	mm	Diameter of the mandrel of the bending device in the bend test	Figure 2
e	mm	Average gap between two adjacent ribs or indentation rows	14.3.1.4, 14.3.2.5
E	MPa	Modulus of elasticity	5.2, 5.3
f	Hz	Frequency of force cycles in the axial force fatigue test	10.1, 10.4.2
f_R	—	Relative rib area	Clause 15
$F_{a,i}$	N	Individual breaking force in the deflected tensile test	12.4
F_m	N	Maximum force in the tensile test	5.3
$\overline{F}_m$	N	Mean value of the maximum force	9.2, 11.2, 12.2, 12.4
$F_{p0,1}$	N	0,1 % proof force, plastic extension	5.2, 5.3
$F_{p0,2}$	N	0,2 % proof force, plastic extension	5.2, 5.3
F_r	N	Force range in the axial force fatigue test	Figure 6, 10.3, 10.4.2
F_{rt}	N	Residual force in the test piece at time t in the isothermal stress relaxation test	9.1
ΔF_{rt}	N	Force loss in the test piece at time t in the isothermal stress relaxation test	9.1
F_R	mm^2	Area of longitudinal section of one rib	15.2
NOTE 1 MPa = 1 N/mm^2.			

Symbol	Unit	Description	Reference
F_{up}	N	Upper force in the axial force fatigue test	Figure 6, 10.3, 10.4.2
F_0	N	Initial force in the isothermal stress relaxation test and the stress corrosion test	9.1, 9.2, 9.3, 9.4, 11.1, 11.2, 11.4.2
G	mm	Depth of the groove of the mandrel used for the deflected tensile test	12.3.4
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	14.3.4
l	mm	Length of indentation	14.3.2.4
L_t	mm	Length of the test piece in the stress corrosion test	11.2
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	9.1, 9.3, 9.4 11.2, 11.3.4, 11.4.1, 11.4.3, 11.4.5
L_1	mm	Length of the passive side in the deflected tensile test	12.3.2
L_2	mm	Length of the active side in the deflected tensile test	12.3.2
m, n	—	Coefficients or numbers	9.4.9, 14.3, 15.2
P	mm	Lay length of a strand	14.3.3
r	mm	Radius of cylindrical supports	7.2
R	mm	Radius at the base of the mandrel used for the deflected tensile test	12.3.4
r_1	mm	Distance between the grips and the gauge length for the manual measurement of A_{gt}	5.3
r_2	mm	Distance between the fracture and the gauge length for the manual measurement of A_{gt}	5.3
R_a	µm	Surface roughness of the mandrel used for the deflected tensile test	12.3.4
S_n	mm^2	Nominal cross-sectional area of the test piece	5.3.2
t_a	h	Maximum agreed time for the stress corrosion test	11.4.5
$t_{f,i}$	h	Individual lifetime to fracture in the stress corrosion test	11.4.5
$t_{f,m}$	h	Median lifetime to fracture in the stress corrosion test	11.4.6
t_0	s	Starting time in the isothermal stress relaxation test and in the stress corrosion test	9.4.2, 11.4
y	mm	Distance from a plane, defined by the axes of the cylindrical supports, to the nearest point of contact with the test piece	Figure 3
V_0	mm^3	Volume of test solution to fill the test cell in the stress corrosion test	11.4.3
Z	%	Percentage reduction of area	5.3.1
α	°	Angle of deviation in the deflected tensile test	12.3.2
β	°	Rib or indentation angle to the bar or wire axis	14.3
ε_{xF_m}	—	Value of the strain for a force equal to $x\ F_m$	5.3.2
ρ	%	Relaxation	9.4.9
$\sum e_i$	mm	Part of the circumference without indentation or rib	14.3.1.4, 14.3.2.5, 15.2
NOTE 1 MPa = 1 N/mm^2.			

4 General provisions concerning test pieces

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

Special care should be taken when samples are taken 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 are indicated in the relevant clauses of this document, if needed.

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 extension 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 extension at maximum force (A_{gt}) is determined by the manual method for a 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.

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.

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 $F_{p0,2}$), maximum force (F_m), percentage total extension at maximum force (A_{gt}) and/or percentage elongation after fracture (A) and percentage reduction of area (Z) shall be performed 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 extension at maximum force (A_{gt}). The extensometer gauge length shall be as specified 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 or until the maximum force has been passed, the extension may be measured as follows.

— Continue loading until the extensometer records an extension just greater than the extension corresponding to $F_{p0,2}$, at which the extensometer is removed; 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.

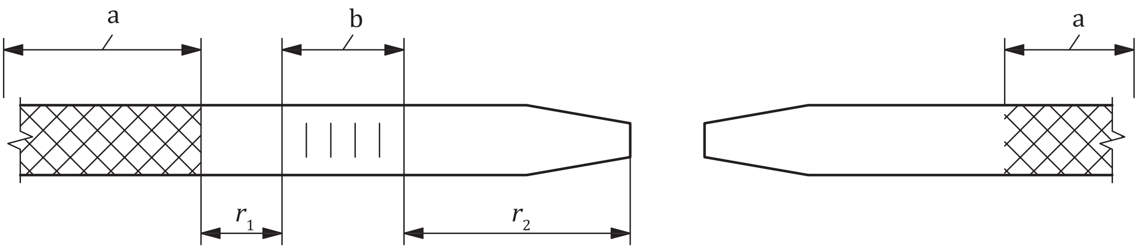
— The difference between the cross-head measurements is calculated as a percentage of the original distance between the cross-heads and this value is added to the percentage obtained by the extensometer.

For wire and bars, it is also permissible to determine A_{gt} by the manual method. If A_{gt} is determined by the manual method after fracture, A_{gt} shall be calculated from Formula (1):

$$A_{gt} = A_r + R_m / 2\ 000 \quad (1)$$

where A_r is the percentage uniform elongation after fracture.

The measurement of A_r shall be made, as the measurement of A (see ISO 6892-1), on the longer of the two fractured parts of the test piece on a gauge length of 100 mm, as close as possible to the fracture but at a distance, r_2, of at least 50 mm or $2d$ (whichever is the greater) away from the fracture. This measurement may be considered as invalid if the distance, r_1, between the grips and the gauge length is less than 20 mm or d (whichever is the greater). See Figure 1.



[a] Grip length.

[b] Gauge length 100 mm.

Figure 1 — Measurement of A_{gt} by the manual method

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.

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

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 eight times the nominal diameter (d), unless otherwise specified in the relevant product standard. In case of dispute, A shall be determined manually.

If the fracture 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 perform 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 divided by the nominal cross-sectional area of the test piece (S_n).

In general, for cold-drawn prestressing products (e.g. strands and plain wires), the slope can be determined in the range between $0{,}2F_m$ and $0{,}7F_m$, as shown by Formula (2):

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

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 recorded 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 shown by Formula (3):

$$\left[(0,7F_{\mathrm{m}} - 0,05F_{\mathrm{m}}) / (\varepsilon_{0,7F_{\mathrm{m}}} - \varepsilon_{0,05F_{\mathrm{m}}})\right] / S_{\mathrm{n}} \qquad (3)$$

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

6 Bend test

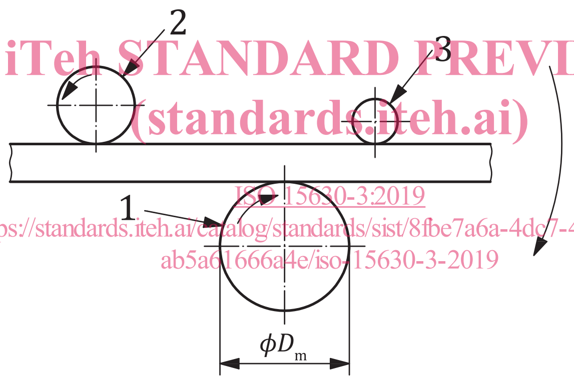
6.1 Test piece

The general provisions given in Clause 4 apply.

6.2 Test equipment

6.2.1 A bending device, the principle of which is shown in Figure 2, shall be used.

NOTE Figure 2 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

Figure 2 — Principle of a bending device

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

6.3 Test procedure

The bend test shall be performed 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.

