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

## Part 1: Reinforcing bars, rods and wire

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

*Partie 1: Barres, fils machine et fils pour béton armé*



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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).

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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 15630-1:2010), which has been technically revised. Changes have been introduced in the Introduction, Clause 2, Clause 3, Clause 4, Clause 5 (only the title), 5.3, 6.3, 8.3, 8.4.5, 10.3.1.1, 10.3.1.2, 10.3.3 and 11.3.2 and Figure 6. A new Clause 13 has been added for "specialized" tests. The Bibliography has been updated and the dated references have been replaced by undated references.

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.

# 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 (see Clauses 5 to 12), as well as specialized test methods (gathered in Clause 13) 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 1: Reinforcing bars, rods and wire

## 1 Scope

This document specifies chemical and mechanical test methods and measurement methods of geometrical characteristics applicable to reinforcing bars, rods and wire 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 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 6892-1, *Metallic materials — Tensile testing — Part 1: Method of test at room temperature*

ISO 6892-2, *Metallic materials — Tensile testing — Part 2: Method of test at elevated temperature*

ISO 6892-3, *Metallic materials — Tensile testing — Part 3: Method of test at low 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 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 |
|---|---|---|---|
| $a'$ | mm | Height of longitudinal rib | 10.3.2, 11.3 |
| $a_m$ | mm | Rib height at the mid-point or indentation depth in the centre | 10.3.1.2, Figure 6, 11.3.2, 11.4.1, 11.4.2 |
| $a_{max}$[a] | mm | Maximum height of transverse rib or maximum indentation depth | 10.3.1.1 |
| $a_{s,i}$ | mm | Average height of a portion $i$ of a rib subdivided into $p$ parts of length $\Delta l$, or average depth of a portion $i$ of an indentation subdivided into $p$ parts of length $\Delta x$ | Figure 6, 11.3.1, 11.4.1 |
| $a_{1/4}$ | mm | Rib height at the quarter-point or indentation depth at the quarter of their length | 10.3.1.2, 11.3.2, 11.4.2 |
| $a_{3/4}$ | mm | Rib height at the three-quarters point or indentation depth at the three-quarters of their length | 10.3.1.2, 11.3.2, 11.4.2 |
| $A$ | % | Percentage elongation after fracture | 5.1, 5.3 |
| $A_g$ | % | Percentage plastic extension at maximum force ($F_m$) | 5.3 |
| $A_{gt}$ | % | Percentage total extension at maximum force ($F_m$) | Clause 5 |
| $A_r$ | % | Percentage uniform elongation after fracture | 5.3 |
| $b$ | mm | Width of transverse rib at the mid-point or width of indentation | 10.3.8 |
| $c$ | mm | Transverse rib or indentation spacing | Figure 6, 10.3.3, 11.3 |
| $d$ | mm | Nominal diameter of the bar, rod or wire | 5.3, Figure 3, 8.2, 8.4.7, 11.3, 11.4, Table 1, 13.3.4.8 |
| $D$ | mm | Diameter of the mandrel of the bending device in the bend or rebend test | Figure 2, 6.3, 7.3.2 |
| $e$ | mm | Average gap between two adjacent rib or indentation rows | 10.3.5, Figure 6, 11.3.2, Figure 7 |
| $f$ | Hz | Frequency of force cycles in the axial force fatigue test | 8.1, 8.4.3, Table 1 |
| $f_P$ | — | Relative indentation area | Clause 11 |
| $f_R$ | — | Relative rib area | Clause 11 |
| $F_m$ | N | Maximum force in the tensile test | 5.3 |
| $F_P$ | mm² | Area of the longitudinal section of one indentation | 11.4.1 |
| $F_r$ | N | Force range in the axial force fatigue test | 8.1, 8.3, 8.4.2, 8.4.3 |
| $F_R$ | mm² | Area of the longitudinal section of one rib | Figure 6, 11.3.1 |
| $F_{up}$ | N | Upper force in the axial force fatigue test | 8.1, 8.3, 8.4.2, 8.4.3 |
| $l$ | mm | Length of the transverse rib at the rib-core interface | Figure 6 |
| $n$, $m$, $q$, $p$ | — | Quantities used in formulae defining $f_R$, $f_P$, $F_R$ and $F_P$ | 11.3, 11.4 |
| $P$ | mm | Pitch for cold-twisted bars | 10.3.4, 11.3 |
| $r_1$ | 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 |
| $R_{eH}$ | MPa | Upper yield strength | 5.3 |
| $R_m$ | MPa | Tensile strength | 5.3 |
| $R_{p0,2}$ | MPa | 0,2 % proof strength, plastic extension | 5.2, 5.3 |
| $S_n$ | mm² | Nominal cross-sectional area of the bar, rod or wire | 8.4.2 |
| $x$ | mm | Length of an indentation | Figure 7 |

NOTE 1 MPa = 1 N/mm².

[a] In some product standards, the symbol $h$ is also used for this parameter.

| Symbol | Unit | Description | Reference |
|---|---|---|---|
| $\alpha$ | ° | Transverse rib flank inclination | 10.3.7 |
| $\beta$ | ° | Angle between the axis of a transverse rib or indentation and the bar, rod or wire axis | 10.3.1, 10.3.6, Figure 6, 11.3, 11.4 |
| $\gamma$ | ° | Angle of bend in the bend or rebend test | 6.3, Figure 4, 7.3.2 |
| $\Delta l$ | mm | Incremental part of the length of the transverse rib at the rib-core interface | 11.3.1, Figure 6 |
| $\Delta x$ | mm | Incremental part of the length of an indentation | 11.4.1 |
| $\delta$ | ° | Angle of rebend in the rebend test | Figure 4, 7.3.4 |
| $\lambda$ | — | Empirical factor in empirical formulae of $f_R$ and $f_P$ | 11.3.2, 11.4.2 |
| $\varphi$ | — | Empirical factor in formula of $f_R$ for ribs of constant height | 11.3.2 |
| $2\sigma_a$ | MPa | Stress range in the axial force fatigue test | 8.4.2 |
| $\sigma_{max}$ | MPa | Maximum stress in the axial force fatigue test | 8.4.2 |
| $\sum e_i$ | mm | Part of the circumference without indentation or rib | 10.3.5, 11.3.2, 11.4.2 |
| NOTE 1 MPa = 1 N/mm². | | | |
| [a] In some product standards, the symbol $h$ is also used for this parameter. | | | |

## 4 General provisions concerning test pieces

Unless otherwise agreed or specified in the product standard, the test piece shall be taken from the bar, rod or wire in the as-delivered condition.



In the case of a test piece taken from a coil (rod or wire), the test piece shall be straightened prior to any testing by a bend operation with a minimum amount of plastic deformation.

NOTE 1 The straightness of the test piece is critical for the tensile test at room temperature, the tensile test at low temperature, the axial force fatigue test and the cyclic inelastic load test.



The means of straightening the test piece (manual, machine) shall be indicated in the test report.

For routine tests conducted by the manufacturers of reinforcing steels, the test information, including the test piece condition and method of straightening, should be described within internal documentation.

For the determination of the mechanical properties in the tensile test at room temperature, the tensile test at low temperature, the axial force fatigue test and the cyclic inelastic load test, the test piece may be artificially aged (after straightening if applicable), depending on the requirements of the product standard.

If ageing is specified but the product standard does not specify the ageing treatment, the following conditions should be applied: heating the test piece to 100 °C, maintaining at this temperature ±10 °C for a period between 60 min and 75 min and then cooling in still air to ambient temperature.

NOTE 2 Depending on the conditions (number of test pieces, diameter of test pieces, type of heating device), different heating times can be required for the test piece to reach the temperature of 100 °C. Unless otherwise proven, a minimum heating time of 40 min can be assumed for the test pieces to reach the oven/bath operating temperature.

If an ageing treatment is applied to the test piece, the conditions of the ageing treatment shall be stated in the test report.

## 5 Tensile test at room temperature

### 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 elongation after fracture or the percentage total extension at maximum force in accordance with 5.3.

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, 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 testing machine 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 $R_{p0,2}$; for the determination of $A_{gt}$, a class 2 extensometer (see ISO 9513) may be used.

Any extensometer used for the determination of the percentage total extension at maximum force ($A_{gt}$) shall have a gauge length of at least 100 mm. The gauge length shall be indicated in the test report.



### 5.3 Test procedure

The tensile test shall be performed in accordance with ISO 6892-1. For the determination of $R_{p0,2}$, if the straight portion of the force-extension diagram is limited or not clearly defined, one of the following methods shall be applied:



— the procedure recommended in ISO 6892-1;

— the straight portion of the force-extension diagram shall be considered as the line joining the points corresponding to $0{,}2F_m$ and $0{,}5F_m$.

  $F_m$ may be predefined as the force corresponding to the nominal tensile strength given in the applicable product standard.

  For stainless steels, other values than the ones mentioned above, applicable to carbon steels, may be replaced by the appropriate values given in the product standard or agreed between the parties involved.

In case of dispute, the second procedure shall be applied.

The test may be considered invalid if the slope of this line differs by more than 10 % from the theoretical value of the modulus of elasticity.

For the calculation of tensile properties ($R_{eH}$ or $R_{p0,2}$, $R_m$), the nominal cross-sectional area shall be used, unless otherwise specified in the relevant product standard.

Where fracture occurs in the grips or at a distance from the grips less than 20 mm or $d$ (whichever is the greater), the test may be considered as invalid.

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

The percentage total extension at maximum force ($A_{gt}$) shall be determined either by using an extensometer or by the manual method described in this document.

If $A_{gt}$ is measured by using an extensometer, ISO 6892-1 shall be applied with the following modification. $A_{gt}$ shall be recorded before the force has dropped more than 0,2 % from its maximum value.

NOTE This provision is aimed at avoiding different values with different methods (manual vs. extensometer). It is recognized that the use of extensometers tends to give on average a lower value of $A_{gt}$ than the one measured manually.

If $A_{gt}$ is determined by the manual method after fracture, $A_{gt}$ shall be calculated from Formula (1):

$$A_{gt} = A_r + R_m / 2\,000 \tag{1}$$

where $A_r$ is the percentage uniform elongation after fracture.

For stainless steels, the value 2 000 in Formula (1) should be replaced by the appropriate value given in the product standard or agreed between the parties involved.

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.

In case of dispute, the manual method shall apply.




a Grip length.

b Gauge length 100 mm.

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

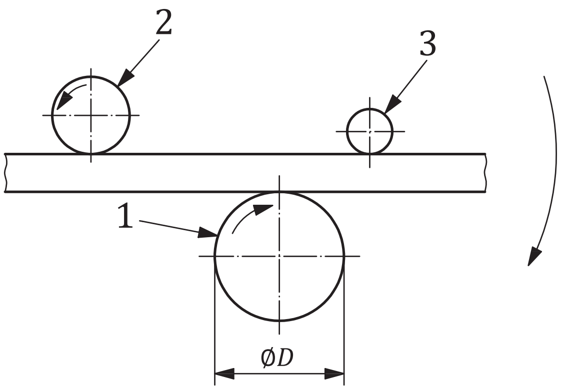
# 6 Bend test

## 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.




**Key**

1 mandrel
2 support
3 carrier

**Figure 2 — Principle of a bending device**



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.

**6.2.2** The bend test may also be performed by 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, unless otherwise agreed by the parties involved.

For testing at a low temperature, if the agreement between the parties involved does not specify all the testing conditions, a deviation of ±2 °C on the agreed temperature should be applied. The test piece should be immersed in the cooling medium for a sufficient time to ensure that the required temperature is reached throughout the test piece (for example, at least 10 min in a liquid medium or at least 30 min in a gaseous medium). The bend test should start within 5 s from removal from the medium. The transfer device should be designed and used in such a way that the temperature of the test piece is maintained within the temperature range.

The test piece shall be bent over a mandrel.

In the case of hot-rolled threaded bars, the mandrel shall be placed on the longitudinal flat part of the bar unless otherwise stated in the product standard or agreed between the parties involved.

The angle of bend ($\gamma$) and the diameter of the mandrel ($D$) shall be in accordance with the relevant product standard.

### 6.4 Interpretation of test results

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