British Standard

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Incorporating Corrigendum No. 1

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

Part 1: Reinforcing bars, wire rod and wire

The European Standard EN ISO 15630-1:2002 has the status of a British Standard

ICS 77.140.60; 77.140.65; 91.080.40

National foreword

This British Standard is the official English language version of EN ISO 15630-1:2002. It is identical with ISO 15630-1:2002.

The UK participation in its preparation was entrusted by Technical Committee ISE/9, Steel for concrete reinforcement, to Subcommittee ISE/9/1, Bars, wire and fabric for concrete reinforcement, which has the responsibility to:

- aid enquirers to understand the text;
- present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
- monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this subcommittee can be obtained on request to its secretary.

Cross-references

The British Standards which implement international or European publications referred to in this document may be found in the BSI Standards Catalogue under the section entitled "International Standards Correspondence Index", or by using the "Find" facility of the BSI Standards Electronic Catalogue.

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Summary of pages.
This document comprises a front cover, an inside front cover, the EN ISO title page, the EN ISO foreword page, the ISO title page, pages ii to v, a blank page, pages 1 to 15, the Annex ZA page, an inside back cover and a back cover.

The BSI copyright date displayed in this document indicates when the document was last issued.

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EUROPEAN STANDARD

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EUROPÄISCHE NORM

EN ISO 15630-1

April 2002

ICS 77.140.60; 77.140.65; 91.080.40

Supersedes ENV 10080:1995

English version

Steel for the reinforcement and prestressing of concrete - Test methods - Part 1: Reinforcing bars, wire rod and wire (ISO 15630-1:2002)

Aciers pour l'armature et la précontrainte du béton - Méthodes d'essai - Partie 1: Barres, fils machine et fils pour béton armé (ISO 15630-1:2002)

Stähle für die Bewehrung und das Vorspannen von Beton - Prüfverfahren - Teil 1: Bewehrungsstäbe, -walzdraht und -draht (ISO 15630-1:2002)

This European Standard was approved by CEN on 11 April 2002.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Management Centre has the same status as the official versions.

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Foreword

This document (ISO 15630-1:2002) has been prepared by Technical Committee ISO/TC 17 "Steel" in collaboration with Technical Committee ECISS/TC 19 "Concrete reinforcing and prestressing steels - Properties, dimensions, tolerances and specific tests", the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by October 2002, and conflicting national standards shall be withdrawn at the latest by October 2002.

This document supersedes ENV 10080:1995.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

Endorsement notice

The text of the International Standard ISO 15630-1:2002 has been approved by CEN as a European Standard without any modifications.

NOTE Normative references to International Standards are listed in annex ZA (normative).

INTERNATIONAL STANDARD

ISO 15630-1

First edition
2002-04-15

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

Part 1: Reinforcing bars, wire rod and wire

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

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

Reference number
ISO 15630-1:2002(E)

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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 3.

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 part of ISO 15630 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 15630-1 was prepared by Technical Committee ISO/TC 17, *Steel*, Subcommittee SC 16, *Steels for the reinforcement and prestressing of concrete*.

This part of ISO 15630, together with parts 2 and 3, cancels and replaces ISO 10065:1990, ISO 10287:1992 and ISO 10606:1995.

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

— *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 testing of metals in general as they are applicable. Complementary provisions have been given if needed.

Test methods which do not form the subject of an existing International Standard on metal testing are fully described in ISO 15630.

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

Part 1:
Reinforcing bars, wire rod and wire

1 Scope

This part of ISO 15630 specifies test methods applicable to reinforcing bars, wire rod and wire.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 15630. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 15630 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 4965:1979, *Axial load fatigue testing machines — Dynamic force calibration — Strain gauge technique*

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

ISO 7438:1985, *Metallic materials — Bend test*

ISO 7500-1:1999, *Metallic materials — Verification of static uniaxial testing machines — Part 1: Tension/compression testing machines — Verification and calibration of the force-measuring system*

ISO 9513:1999, *Metallic materials — Calibration of extensometers used in uniaxial testing*

ISO/TR 9769:1991, *Steel and iron — Review of available methods of analysis*

3 Symbols

See Table 1.

Table 1 — Symbols

Symbol	Unit	Description	Reference
a'	mm	Height of longitudinal rib	10.3.2, 11.3
a_m	mm	Rib height at the mid-point	10.3.1.2, 11.3.3
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 in p parts of length Δl	11.3.1
$a_{1/4}$	mm	Rib height at the quarter-point	10.3.1.2, 11.3.3
$a_{3/4}$	mm	Rib height at the three-quarters point	10.3.1.2, 11.3.3
A	%	Percentage elongation after fracture	5.1, 5.3
A_g	%	Percentage non-proportional elongation at maximum force (F_m)	5.3
A_{gt}	%	Percentage total elongation at maximum force (F_m)	5
A_n	mm^2	Nominal cross-sectional area of the bar, rod or wire rod	8.4.2
c	mm	Transverse rib or indentation spacing	10.3.3, 11.3
d	mm	Nominal diameter of the bar, wire rod or wire	5.3, 8.2, 8.4.8, 11.3
D	mm	Diameter of the mandrel of the bending device in the bend or rebend test	6.3, 7.3.2
e	mm	Average gap between two adjacent rib or indentation rows	10.3.5
f	Hz	Frequency of load cycles in the fatigue test	8.1, 8.4.3
f_P	1	Relative indentation area	Clause 11
f_R	1	Relative rib area	Clause 11
F_m	N	Maximum force in the tensile test	5.3
F_P	mm^2	Area of the longitudinal section of one indentation	11.3.2
F_r	N	Force range in the axial load fatigue test	8.1, 8.3, 8.4.2, 8.4.3
F_R	mm^2	Area of the longitudinal section of one rib	11.3.1
F_{up}	N	Upper force in the axial load fatigue test	8.1, 8.3, 8.4.2, 8.4.3
n, m, q, p	1	Quantities used in formulae defining f_R, f_P, F_R and F_P	11.3
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}	N/mm^2	Upper yield strength	5.2, 5.3
R_m	N/mm^2	Tensile strength	5.3
$R_{p0,2}$	N/mm^2	0,2 % proof strength, non-proportional extension	5.2, 5.3
α	°	Transverse rib flank inclination	10.3.7
β	°	Angle between the axis of a transverse rib or indentation and the bar, wire rod or wire axis	10.3.6, 11.3

Table 1 (*continued*)

Symbol	Unit	Description	Reference
γ	°	Angle of bend in the bend or rebend test	6.3, 7.3.1 (Figure 4), 7.3.2
δ	°	Angle of rebend in the rebend test	7.3.1 (Figure 4), 7.3.4
λ	1	Empirical factor in empirical formulae of f_R and f_P	11.3.3
$2\sigma_a$	N/mm²	Stress range in the axial load fatigue test	8.4.2
σ_{max}	N/mm²	Maximum stress in the axial load fatigue test	8.4.2
Σe_i	mm	Part of the circumference without indentation or rib	10.3.5, 11.3.3

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

NOTE 1 N/mm² = 1 MPa.

4 General provisions concerning test pieces

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

In the case of a test piece taken from coil, the test piece shall be straightened prior to any tests by a simple bend operation with a minimum amount of plastic deformation.

For the determination of the mechanical properties in the tensile test and the fatigue test, the test piece may be artificially aged (after straightening if applicable) depending on the requirements of the product standard.

NOTE When the product standard does not specify any ageing treatment, the following conditions may be applied: Heating the test piece to 100 °C, maintaining at this temperature ± 10 °C for a period of 1 hour $^{+15}_{0}$ min and then free cooling in still air to ambient temperature.

When 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

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 elongations in accordance with 5.3.

When percentage elongation after fracture (A) is determined, the test piece shall be marked according to clause 8 of ISO 6892:1998.

When percentage total elongation 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 annex H of ISO 6892:1998). The distance between the marks shall be 20 mm, 10 mm or 5 mm, depending on bar, wire rod or wire 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.

When an extensometer is used, it shall be of class 1 (see ISO 9513) for the determination of R_{eH} or $R_{p0,2}$; for the determination of A_{gt}, a class 2 extensometer (see ISO 9513) can be used.

The extensometer which may be used to determine the percentage total elongation 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 carried out in accordance with ISO 6892. 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 13.1 of ISO 6892:1998;

— the straight portion of the force-extension diagram shall be considered as the line joining the points corresponding to 0,1 F_m and 0,3 F_m.

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

NOTE The test should be considered invalid when 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 5 times the nominal diameter (d), unless otherwise specified in the relevant product standard.

For the determination of the percentage total elongation at maximum force (A_{gt}), ISO 6892 shall be applied with the following modifications or complements:

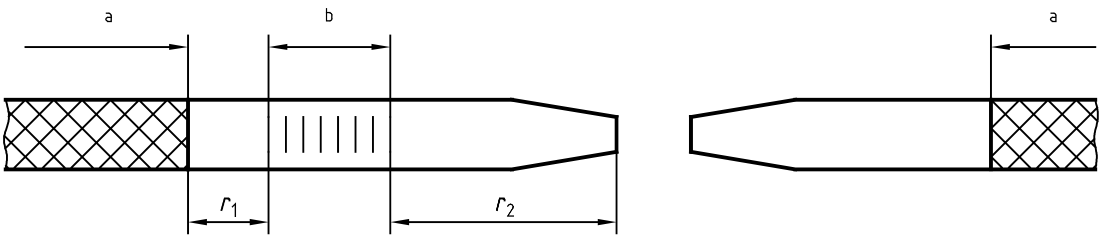
— if A_{gt} is measured by using an extensometer, A_{gt} shall be recorded before the force has dropped more than 0,5 % from its maximum value;

— if A_{gt} is determined by the manual method after fracture, A_{gt} shall be calculated from the following formula:

$$A_{gt} = A_g + R_m / 2\,000$$

where A_g is the percentage non-proportional elongation at maximum force. The measurement of A_g shall be made on a gauge length of 100 mm 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

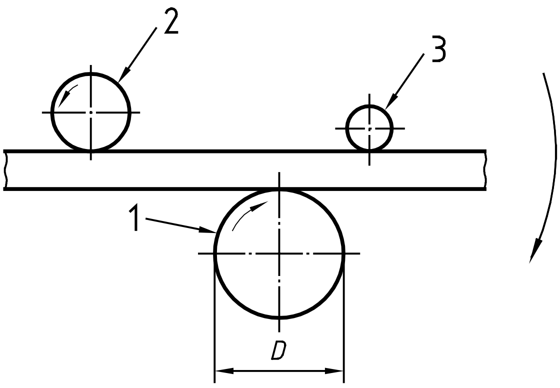
The general provisions in clause 4 apply.

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.

6.2.2 The bend test may also be carried out by using a device with supports and a mandrel (see 4.1 of ISO 7438:1985).



Key

1 Mandrel

2 Support

3 Carrier

Figure 2 — Principle of a bending device

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.

NOTE The bending rate should be about 60 °/s.

The angle of bend (γ) 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 carried out according to the requirements of the relevant product standard.

When 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.

7 Rebend test

7.1 Test piece

The general provisions given in clause 4 apply.

7.2 Test equipment

7.2.1 Bending device

A bending device as specified in 6.2 shall be used.

7.2.2 Rebending device

Rebending can be performed on a bending device as shown in Figure 2. An example of an alternative rebending device is shown in Figure 3.

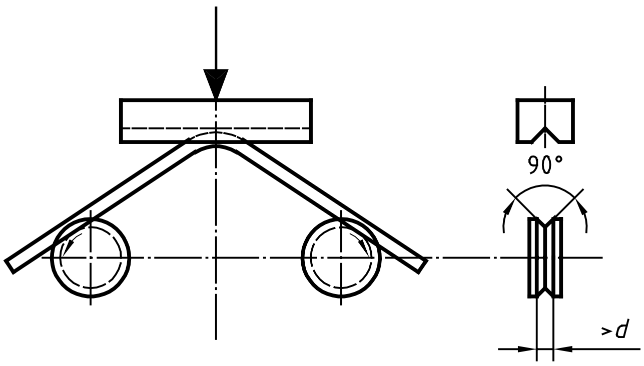


Figure 3 — Example of a rebending device

7.3 Test procedure

7.3.1 General

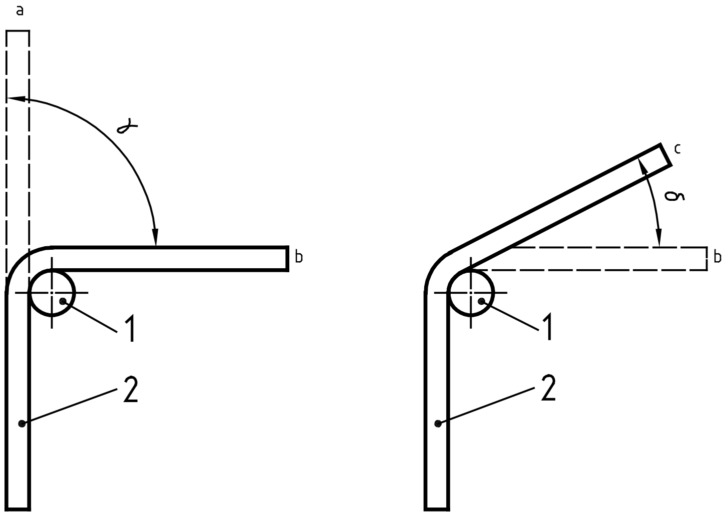
The test procedure consists of three steps:

a) bending;

b) artificial ageing;

c) rebending.

The test procedure is illustrated by Figure 4.



Key

1 Mandrel

2 Test piece

a Initial position

b Position after operation described in 7.3.2

c Position after operation described in 7.3.4

Figure 4 — Illustration of the test procedure for rebend tests

7.3.2 Bending

Bending shall be performed at a temperature between 10 °C and 35 °C. The test piece shall be bent over a mandrel.

NOTE The bending rate should be about 60°/s.

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

The test piece shall be carefully inspected for cracks and fissures visible to a person with a normal or corrected vision.

7.3.3 Artificial ageing

The temperature and time of artificial ageing shall be in accordance with the relevant product standard.

NOTE When the product standard does not specify any ageing treatment, the following conditions may be applied: heating the bent test piece to 100 °C, maintaining at this temperature ± 10 °C for a period of 1 hour $^{+15}_{0}$ min and then free cooling in still air to the ambient temperature.

7.3.4 Rebending

After free cooling in still air to a temperature between 10 °C and 35 °C, the test piece shall be bent back by a specified angle (δ) in accordance with the relevant product standard.

NOTE The rebending should be performed at a rate of about 60°/s.

7.4 Interpretation of test results

The interpretation of the rebend test shall be carried out according to the requirements of the relevant product standard.

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

8 Axial load fatigue test

8.1 Principle of test

The axial load fatigue test consists of submitting the test piece to an axial tensile force, which varies cyclically according to a sinusoidal wave-form of constant frequency f (see Figure 5) in the elastic range. The test is carried out until failure of the test piece, or until reaching the number of load cycles specified in the relevant product standard, without failure.

8.2 Test piece

The general provisions given in clause 4 apply.

NOTE The straightness of the test piece is critical for the fatigue test. To achieve satisfactory straightness, a production straightening machine may be used.

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

The surface of the free length between the grips shall not be subjected to any surface treatment of any kind and shall not contain identification marks. The free length shall be at least 140 mm or 14d, whichever is the greater.

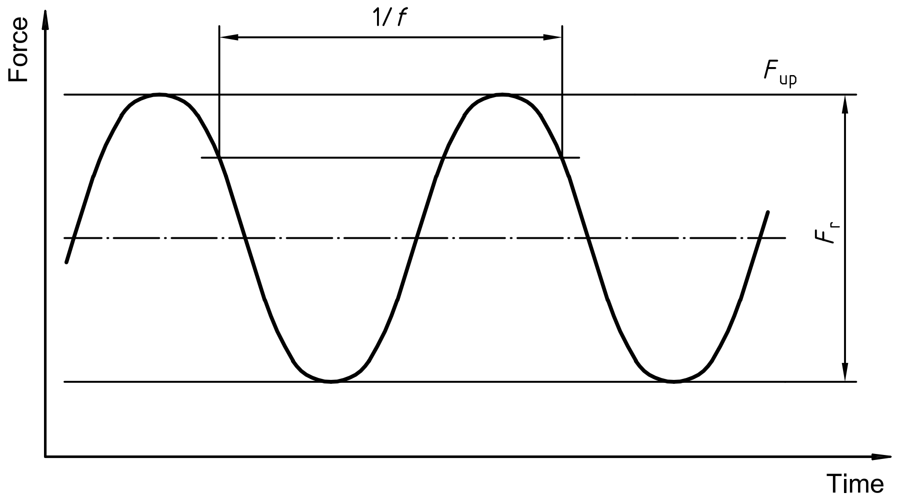


Figure 5 — Load cycle diagram

8.3 Test equipment

The fatigue testing machine shall be calibrated in accordance with ISO 4965. The accuracy shall be at least ± 1 %. The testing machine shall be capable of maintaining the upper force, F_{up}, within ± 2 % of the specified value and the force range, F_r, within ± 4 % of the specified value.

8.4 Test procedure

8.4.1 Provisions concerning the test piece

The test piece shall be gripped in the test equipment in such a way that force is transmitted axially and free of any bending moment along the test piece.

8.4.2 Upper force (F_{up}) and force range (F_r)

The upper force (F_{up}) and the force range (F_r) shall be as given in the relevant product standard.

NOTE F_{up} and F_r can be deduced from the maximum stress (σ_{max}) and the stress range ($2\sigma_a$) given in the relevant product standard as follows:

$$F_{up} = \sigma_{max} \times A_n$$

$$F_r = 2\sigma_a \times A_n$$

where A_n is the nominal cross-sectional area of the bar, wire rod or wire.

8.4.3 Stability of force and frequency

The test shall be carried out under conditions of stable upper force (F_{up}), force range (F_r) and frequency (f). There shall be no interruptions in the cyclic loading throughout the test. However, it is permissible to continue a test which is accidentally interrupted. Any interruption shall be reported.

8.4.4 Counting of load cycles

The number of load cycles shall be counted inclusively from the first full load range cycle.

8.4.5 Frequency

The frequency of load cycles shall be stable during the test and also during test series. It shall be between 1 Hz and 200 Hz.

8.4.6 Temperature

The temperature of the test piece shall not exceed 40 °C throughout the test. The temperature of the testing laboratory shall be between 10 °C and 35 °C, unless otherwise specified. For tests carried out under controlled conditions, the temperature of the testing laboratory shall be (23 ± 5) °C.

8.4.7 Termination of the test

The test shall be terminated upon failure of the test piece before reaching the specified number of cycles, or on completion of the specified number of cycles without failure.

8.4.8 Validity of the test

If failure occurs in the grips or within a distance of $2d$ of the grips or initiates at an exceptional feature of the test piece, the test may be considered as invalid.

9 Chemical analysis

In general, the chemical composition is determined by spectrometric methods.

In case of dispute about analytical methods, the chemical composition shall be determined by an appropriate referee method specified in one of the International Standards listed in ISO/TR 9769:1991.

10 Measurement of the geometrical characteristics

10.1 Test piece

The general provisions given in clause 4 apply.

The length of the test piece shall be sufficient to allow the measurements in accordance with 10.3.

10.2 Test equipment

The geometrical characteristics shall be measured with an instrument of a resolution of at least:

— 0,01 mm for the depth of indentations;

— 0,02 mm for the height of transverse or longitudinal ribs;

— 0,05 mm for the gap between the transverse ribs or indentations of two adjacent transverse rib or indentation rows;

— 0,5 mm for the measurement of the distance between transverse ribs (or indentations) when determining the transverse rib spacing (or indentation spacing) (see 10.3.3) or for the measurement of the distance between two corresponding points of a longitudinal rib of cold-twisted products when determining the pitch (see 10.3.4);

— one degree for the inclination between the transverse rib or indentation and the longitudinal axis of the bar, wire rod or wire or the measurement of rib flank inclination.

10.3 Test procedure

10.3.1 Heights of transverse ribs or depths of indentations

10.3.1.1 Maximum value (a_{max})

The maximum height of transverse ribs or depth of indentations (a_{max}) shall be determined as the mean of at least three measurements per row of the maximum height of individual transverse ribs or maximum depth of individual indentations not used for the identification of the bar, wire rod or wire.

10.3.1.2 Value at a given position

The height of transverse ribs or depth of indentations at a given position, e.g. at the quarter-point or at the mid-point or at the three-quarters point, respectively designated $a_{1/4}$, a_m and $a_{3/4}$, shall be determined as the mean of at least three measurements in this position per row on different transverse ribs or indentations not used for the identification of the bar, wire rod or wire.

10.3.2 Height of longitudinal ribs (a')

The height of longitudinal ribs (a') shall be determined as the mean of at least three measurements of the height of each longitudinal rib at three different positions.

10.3.3 Transverse rib or indentation spacing (c)

The spacing of the transverse ribs or indentations (c) shall be determined from the measured length divided by the number of the rib gaps or protrusions between indentations included in it.

The measured length is deemed to be the interval between the centre of a rib or indentation and the centre of another rib or indentation on the same row of the product determined in a straight line and parallel to the longitudinal axis of the product. The measured length shall be:

— at least 10 rib gaps or protrusions between indentations,

— one pitch length for cold-twisted products.

10.3.4 Pitch (P)

The pitch (P) for cold-twisted bars shall be determined as the mean of the distances between two consecutive corresponding points of a longitudinal rib on the same longitudinal line, for each longitudinal rib.

10.3.5 Part of the circumference without ribs or indentations (Σe_i)

The part of the circumference without ribs or indentations (Σe_i) shall be determined as the sum of the average gap (e) between each pair of two adjacent ribs or indentation rows, for each rib or indentation row. e shall be determined from at least three measurements.

10.3.6 Transverse rib or indentation angle (β)

The transverse rib or indentation angle (β) to the bar, wire rod or wire axis shall be determined as the mean of the individual angles measured for each row of ribs or indentations with the same nominal angle.

10.3.7 Transverse rib flank inclination (α)

Each transverse rib flank inclination (α) shall be determined as the mean of the individual inclinations on the same side of the ribs, measured as indicated in Figure 6 on at least two different transverse ribs per row not used for the identification of the bar, wire rod or wire.

11 Determination of the relative rib or indentation area (f_R or f_P)

11.1 Introduction

The interaction between steel and concrete permits mutual load transfer.

The main effect on bond is given by shear bond caused by ribs or indentations on the surface of the reinforcing steel.

In the case of ribbed or indented reinforcing steel, the bond behaviour can be determined by different methods:

— measurement of the geometric characteristics of the ribs or indentations;

— measurement of the interaction between the concrete and reinforcing steel in a pull-out test or beam test.

On the basis of the geometric data, a bond factor, called relative rib area (f_R) or relative indentation area (f_P) can be computed.

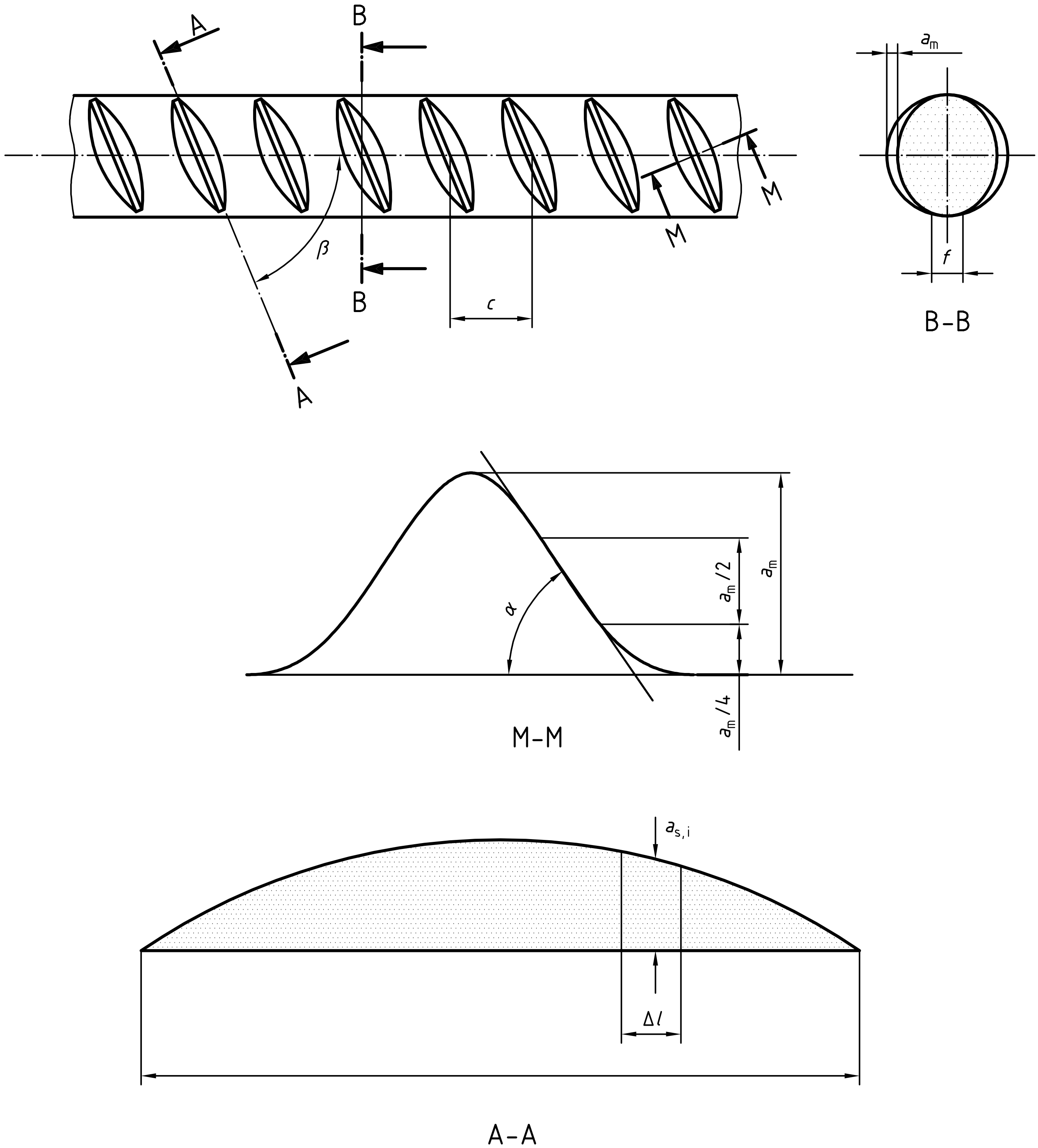


Figure 6 — Determination of the rib flank inclination (α) and determination of the area of the longitudinal section F_R

11.2 Measurements

The determination of the relative rib or indentation area (f_R or f_P) shall be carried out using the results of measurements of the geometrical characteristics made in accordance with clause 10.

11.3 Calculation of f_R or f_P

11.3.1 Relative rib area

The relative rib area is defined by the following formula:

$$f_R = \frac{1}{\pi d} \sum_{i=1}^{n} \frac{\frac{1}{m} \sum_{j=1}^{m} F_{R,i,j} \sin \beta_{i,j}}{c_i} + \frac{1}{P} \sum_{k=1}^{q} a'_k$$

The second summand applies only for cold-twisted bars and should only be taken into account up to a value of 30 % of the total value of f_R.

In the above formula:

— n is the number of rows of transverse ribs on the circumference;

— m is the number of different transverse rib inclinations per row;

— q is the number of longitudinal ribs for cold-twisted bars;

$F_R = \sum_{i=1}^{p} (a_{s,i} \Delta l)$ is the area of the longitudinal section of one rib (see Figure 6), where $a_{s,i}$ is the average height of a portion i of a rib subdivided in p parts of length Δl.

11.3.2 Relative indentation area

The relative indentation area is defined by the following formula:

$$f_P = \frac{1}{\pi d} \sum_{i=1}^{n} \frac{F_{P,i} \sin \beta_i}{c_i}$$

In this formula, n is the number of indentation rows.

11.3.3 Simplified formulae

Where the general formulae given in 11.3.1 and 11.3.2 are not strictly applied by using special devices, a simplified formula may be used.

Examples of simplified formulae are as follows:

a) Trapezium formulae:

$$f_R = (a_{1/4} + a_m + a_{3/4})(\pi d - \sum e_i)\frac{1}{4\pi d c} + \frac{1}{P} q a'$$

$$f_P = (a_{1/4} + a_m + a_{3/4})(\pi d - \sum e_i)\frac{1}{4\pi d c}$$

b) Simpson's rule formulae:

$$f_{\mathrm{R}} = (2a_{1/4} + a_{\mathrm{m}} + 2a_{3/4})(\pi d - \Sigma e_i)\frac{1}{6\pi dc} + \frac{1}{P}qa'$$

$$f_{\mathrm{P}} = (2a_{1/4} + a_{\mathrm{m}} + 2a_{3/4})(\pi d - \Sigma e_i)\frac{1}{6\pi dc}$$

c) Parabola formulae:

$$f_{\mathrm{R}} = \frac{2a_{\mathrm{m}}}{3\pi dc}(\pi d - \Sigma e_i) + \frac{1}{P}qa'$$

$$f_{\mathrm{P}} = \frac{2a_{\mathrm{m}}}{3\pi dc}(\pi d - \Sigma e_i)$$

d) Empirical formulae:

$$f_{\mathrm{R}} \text{ or } f_{\mathrm{P}} = \lambda \frac{a_{\mathrm{m}}}{c}$$

where λ is an empirical factor, which may be shown to relate f_{R} or f_{P} to a_{m}/c for a particular bar, wire rod or wire profile.

The values $a_{1/4}$, a_{m} and $a_{3/4}$ shall be determined in accordance with 10.3.1.2.

Σf_i and Σe_i shall be determined in accordance with 10.3.5.

11.3.4 Formula used for the calculation of f_{R} or f_{P}

The formula used for the calculation of f_{R} or f_{P} shall be stated in the test report.

12 Determination of deviation from nominal mass per metre

12.1 Test piece

The determination of the deviation from nominal mass per metre shall be carried out on a test piece which shall have square cut ends.

12.2 Accuracy of measurement

The length and the mass of the test piece shall be measured with an accuracy of at least ± 0,5 %.

12.3 Test procedure

The percentage deviation from nominal mass per metre shall be determined from the difference between the actual mass per metre of the test piece deduced from its mass and length and its nominal mass per metre as given by the relevant product standard.

13 Test report

The test report shall include at least the following information:

a) reference to this part of ISO 15630, i.e. ISO 15630-1;

b) identification of the test piece (including the nominal diameter of the bar, wire rod or wire);

c) length of the test piece;

d) the type of test and the relevant test results;

e) the relevant product standard, when applicable;

f) any complementary useful information concerning the test piece, test equipment and procedure.

Annex ZA
(normative)

Normative references to international publications with their relevant European publications

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

NOTE Where an International Publication has been modified by common modifications, indicated by (mod.), the relevant EN/HD applies.

Publication	Year	Title	EN	Year
ISO 7438	1985	Metallic materials - Bend test	EN ISO 7438	2000
ISO 7500-1	1999	Metallic materials - Verification of static uniaxial testing machines - Part 1: Tension/compression testing machines	EN ISO 7500-1	1999

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