INTERNATIONAL STANDARD

ISO 6935-1

Second edition
2007-01-15

Steel for the reinforcement of concrete —

Part 1: Plain bars

Aciers pour l'armature du béton —

Partie 1: Barres lisses

Reference number
ISO 6935-1:2007(E)

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

Contents

Page

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 6935-1 was prepared by Technical Committee ISO/TC 17, *Steel*, Subcommittee SC 16, *Steels for the reinforcement and prestressing of concrete*.

This second edition cancels and replaces the first edition (ISO 6935-1:1991), which has been technically revised.

ISO 6935 consists of the following parts, under the general title *Steel for the reinforcement of concrete*:

— *Part 1: Plain bars*

— *Part 2: Ribbed bars*

— *Part 3: Welded fabric*

Steel for the reinforcement of concrete —

Part 1:
Plain bars

1 Scope

This part of ISO 6935 specifies technical requirements for plain bars to be used as reinforcement in concrete.

This part of ISO 6935 covers nine steel grades not intended for welding which are B240A-P, B240B-P, B240C-P, B240D-P, B300A-P, B300B-P, B300C-P, B300D-P and B420D-P, and one steel grade intended for welding which is B420DWP. The production process is at the discretion of the manufacturer. It also applies to plain bars supplied in coil form. The requirements of this part of ISO 6935 apply to straightened product. The steel grades are designated with steel names allocated in accordance with ISO/TS 4949.

NOTE The first "B" stands for steel for reinforcing concrete. The next 3 digits represent the specified characteristic value of upper yield strength. The fifth letter stands for ductility class (4.4). The next symbol relates to welding; "-" means not intended for welding and "W" means intended for welding. The last "P" stands for plain bar.

This part of ISO 6935 covers products delivered in straight lengths.

Plain bars produced from finished products, such as plates and railway rails, are excluded.

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.

ISO 404, *Steel and steel products — General technical delivery requirements*

ISO/TS 4949, *Steel names based on letter symbols*

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

ISO 10144, *Certification scheme for steel bars and wires for the reinforcement of concrete structures*

ISO 14284, *Steel and iron — Sampling and preparation of samples for the determination of chemical composition*

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

3 Symbols

The symbols used in this part of ISO 6935 are listed in Table 1.

Table 1 — Symbols

Symbol	Unit	Description	Reference
A_5	%	Percentage elongation after fracture	7.1, 8.1
A_{gt}	%	Percentage total elongation at maximum force	7.1, 8.1
A_n	mm^2	Nominal cross-sectional area	Clause 5, 8.1
d	mm	Nominal diameter of the bar	Clause 5, 8.1, 8.2, Clause 9
f_k	—	Required characteristic value	11.3.2.3.1
k, k'	—	Indices	11.3.2.3.1
m_n	—	Mean value of n individual values	11.3.2.3.1
n	—	Number of individual values	11.3.2.3.1
R_{eH}	N/mm^2	Upper yield strength	7.1
R_m	N/mm^2	Tensile strength	7.1
$R_{p0,2}$	N/mm^2	0,2 % proof strength, non-proportional extension	7.1
s_n	—	Standard deviation for n individual values	11.3.2.3.1
x_i	—	Individual value	11.3.2.3.1

4 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

4.1
cast analysis
chemical analysis representative of the cast determined by the steelmaker in accordance with his own procedures

[ISO 16020:2005]

4.2
certification scheme
certification system as related to specified products, processes or services to which the same particular standards and rules, and the same procedure, apply

4.3
characteristic value
value having a prescribed probability of not being attained in a hypothetical unlimited test series

[ISO 16020:2005]

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

NOTE 2 A nominal value is used as the characteristic value in some circumstances.

4.4
ductility class
classification of the ductility properties of reinforcing steels based on the value of the ratio of tensile strength to yield strength, as well as the elongation measured either as A_{gt} or as A_5

NOTE See Table 5.

4.5
product analysis
chemical analysis carried out on the product

[ISO 16020:2005]

5 Dimensions, masses per unit length and permissible deviations

Dimensions, mass per unit length and permissible deviations are given in Table 2. By agreement between the the manufacturer and purchaser, plain bars whose nominal diameters are other than those shown in Table 2 may be used. By agreement between the manufacturer and purchaser, the permissible deviation on mass per length may be replaced by tolerances on diameters.

Delivery length should be agreed between the manufacturer and purchaser. The preferred delivery length of straight bars is 6 m or 12 m. Unless otherwise agreed, permissible deviation on delivery length from rolling mill shall be $^{+100}_{0}$ mm.

Table 2 — Dimensions, mass per unit length and permissible deviations

Nominal bar diameter	Nominal cross-sectional area [a]	Mass per unit length	
		Requirement [b]	Permissible deviation [c]
d	A_n		
mm	mm^2	kg/m	%
6	28,3	0,222	± 8
8	50,3	0,395	± 8
10	78,5	0,617	± 5
12	113	0,888	± 5
14	154	1,21	± 5
16	201	1,58	± 5
20	314	2,47	± 5
22	380	2,98	± 5

a $A_n = 0{,}785\,4 \times d^2$

b Mass per unit length = $7{,}85 \times 10^{-3} \times A_n$

c Permissible deviation refers to a single bar.

6 Chemical composition

The chemical composition of the steel, as determined by cast analysis, shall conform to Table 3.

The carbon equivalent, CEV, is calculated according to the following formula.

$$CEV = C + \frac{Mn}{6} + \frac{(Cr + V + Mo)}{5} + \frac{(Cu + Ni)}{15} \quad (1)$$

where C, Mn, Cr, V, Mo, Cu and Ni are the mass fractions, expressed as percentages, of the respective chemical elements of the steel.

The permissible deviation of the product analysis relative to the cast analysis as specified in Table 3 are given in Table 4.

Table 3 — Chemical composition based on cast analysis — Maximum values of mass fractions, in percentage

Steel grade	C	Si	Mn	P	S	N	CEV [a]
B240A-P B240B-P B240C-P B300A-P B300B-P B300C-P	—	—	—	0,060	0,060	—	—
B240D-P B300D-P	—	—	—	0,050	0,050	—	—
B420D-P B420DWP [b]	0,30	0,55	1,50	0,040	0,040	0,012	0,56

[a] Other CEV formulae and values may be used by agreement between the manufacturer and purchaser.

[b] Alloy elements, such as Cu, Ni, Cr, Mo, V, Nb, Ti and Zr, may be added by agreement between the manufacturer and purchaser.

Table 4 — Chemical composition based on product analysis — Permissible deviation of the product analysis in percentage by mass

Elements	Specified maximum value in cast analysis in Table 3 %	Permissible deviation in product analysis from the specified limits of the cast analysis in Table 3 %
C	> 0,25	+ 0,03
Si	⩽ 0,60	+ 0,05
Mn	⩽ 1,65	+ 0,06
P	⩽ 0,05	+ 0,008
	> 0,05	+ 0,010
S	⩽ 0,05	+ 0,008
	> 0,05	+ 0,010

7 Mechanical properties

7.1 Tensile properties

The tensile test shall be performed in accordance with 8.1.

The material shall conform to the requirements for tensile properties specified in Table 5.

In the context of this part of ISO 6935, the characteristic value is (unless otherwise indicated) the lower or upper limit of the statistical tolerance interval at which there is a 90 % probability ($1 - \alpha = 0{,}90$) that 95 % ($p = 0{,}95$) of the values are at or above this lower limit, or are at or below this upper limit, respectively. This definition refers to the long-term quality level of production.

By agreement between the manufacturer and purchaser, the values shown in Table 5 may be used as specified minimum and/or maximum values.

Table 5 — Tensile properties

Ductility class	Steel grade	Specified characteristic value of upper yield strength R_{eH} N/mm²		Specified characteristic value of tensile strength R_m N/mm²	Ductility properties		
					Specified characteristic value of R_m/R_{eH}	Specified characteristic value of elongation [a] %	
		Minimum	Maximum	Maximum	Minimum	A_5 Minimum	A_{gt} Minimum
A	B240A-P	240	—	—	1,02	20	2
	B300A-P	300	—			16	
B	B240B-P	240	—	—	1,08	20	5
	B300B-P	300	—			16	
C	B240C-P	240	—	—	1,15	20	7
	B300C-P	300	—			16	
D	B240D-P	240	—	520	1,25	22	8
	B300D-P	300	—	600		19	
	B420D-P	420	540	—		16	
	B420DWP						

[a] By agreement between the manufacturer and purchaser, the type of elongation shall be selected between A_5 and A_{gt}. If the type of elongation is not specified by agreement, A_{gt} should be used.

If a yield phenomenon is not present, the 0,2 % proof strength ($R_{p0,2}$) shall be determined.

7.2 Bending properties

After testing in accordance with 8.2, the bar shall show neither rupture nor cracks visible to a person of normal or corrected vision.

8 Testing

8.1 Tensile test

The tensile test shall be carried out in accordance with ISO 15630-1.

For the determination of percentage elongation after fracture, A_5, the original gauge length shall be 5 times the nominal diameter.

For the determination of percentage total elongation at maximum force, A_{gt}, equidistant marks shall be made on the free length of the test piece. The distance between the marks shall be 20 mm, 10 mm or 5 mm, depending on the bar diameter.

For determination of tensile properties, the nominal cross-sectional area of the bar shall be used.

8.2 Bend test

The bend test shall be carried out in accordance with ISO 15630-1.

The test piece shall be bent to an angle between 160° and 180° over a mandrel of the diameter specified in Table 6.

Table 6 — Mandrel diameter to be used for the bend test

Dimensions in millimetres

Nominal diameter d	**Mandrel diameter** (max.) [a] [b]
$\leqslant 16$	$3d$
$16 < d \leqslant 22$	$6d$

[a] By agreement between the manufacturer and purchaser, larger mandrel diameters may be used.

[b] For nominal diameters larger than 22 mm, the mandrel diameters in bend tests shall be agreed between the manufacturer and purchaser.

8.3 Chemical analysis

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

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

9 Designation

Plain bars according to this part of ISO 6935 shall be designated in the following order:

a) reinforcing steel;

b) a reference to this part of ISO 6935 (i.e. ISO 6935-1);

c) nominal diameter, in millimetres, according to Table 1;

d) steel grade.

EXAMPLE Reinforcing steel ISO 6935-1 — 12 B240A-P.

10 Marking

Each bundle of bars shall have a label stating the name of the manufacturer, a reference to this part of ISO 6935 (i.e. ISO 6935-1), the steel grade, the nominal diameter, the cast number or reference related to test record and country of origin.

11 Evaluation of conformity

11.1 General

Certification and inspection of reinforcement shall be performed

a) in accordance with a certification scheme monitored by an external body, or

b) according to acceptance testing of a specific delivery.

11.2 Certification scheme

In the case of a certification scheme, certification and inspection shall be performed in accordance with ISO 10144.

11.3 Acceptance testing of a specific delivery

11.3.1 General

Provisions regarding the nature, extent and evaluation of acceptance testing on deliveries of reinforcing steel not subject to a certification scheme are given in 11.3.2 and 11.3.3.

Acceptance testing of a specific delivery shall be performed according to 11.3.2.

By agreement between the manufacturer and purchaser, 11.3.3 may be used.

11.3.2 Verification of characteristic values

11.3.2.1 Organization

The tests shall be organized and carried out according to an agreement between the purchaser and manufacturer, taking into consideration the national rules of the receiving country.

11.3.2.2 Extent of sampling and testing

For the purpose of testing, the delivery shall be subdivided into test units with a maximum mass of 50 t or a fraction thereof. Each test unit shall consist of products of the same steel grade and the same nominal diameter from the same cast. The manufacturer shall confirm in the test report that all samples in the test unit originate from the same cast. The chemical composition (cast analysis) shall be stated in this test report.

Test pieces shall be taken from each test unit as follows:

a) two test pieces from various bars, for testing the chemical composition (product analysis);

b) a minimum of 15 test pieces (if appropriate, 60 test pieces, see 11.3.2.3.1) from various bars for testing all other properties specified in this part of ISO 6935.

11.3.2.3 Evaluation of the results

11.3.2.3.1 Inspection by variables

For properties which are specified as characteristic values, the following shall be determined:

a) all individual values x_i of the 15 test pieces (n = 15);

b) the mean value m_{15} (for n = 15);

c) the standard deviation s_{15} (for n = 15).

The test unit corresponds to the requirements, if the condition stated below is fulfilled for all properties:

$$m_{15} - 2{,}33 \times s_{15} \geqslant f_k \tag{2}$$

where

f_k is the specified characteristic value;

2,33 is the value for the acceptability index k for n = 15 for a failure rate of 5 % (p = 0,95) at a probability of 90 % (1 − α = 0,90).

$$s_{15} = \sqrt{\frac{\sum (x_i - m_{15})^2}{14}} \tag{3}$$

If the condition stated above is not fulfilled, the index

$$k' = \frac{m_{15} - f_k}{s_{15}} \tag{4}$$

is determined from the test results available. Where $k' \geqslant 2$, testing can be continued. In this case, 45 further test pieces shall be taken and tested from different bars in the test unit, so that a total of 60 test results are available (n = 60).

The test unit shall be considered to comply with the requirements, if the condition stated below is fulfilled for all properties:

$$m_{60} - 1{,}93 \times s_{60} > f_k \tag{5}$$

where 1,93 is the value for the acceptability index k for n = 60 for a failure rate of 5 % (p = 0,95) at a probability of 90 % (1 − α = 0,90).

11.3.2.3.2 Inspection by attributes

When testing properties are specified as maximum or minimum values, all results determined on the 15 test pieces shall comply with the requirements of the product standard. In this case, the test unit shall be considered to comply with the requirements.

The tests may be continued when at most 2 results not conforming to the conditions occur. In this case, 45 further test pieces from various bars in the test unit shall be tested, so that a total of 60 test results are available. The test unit complies with the requirements, if not more than 2 of the 60 results do not conform to the conditions.