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Steel for the reinforcement of concrete —

Part 2:
Ribbed bars

Aciers pour l'armature du béton —

Partie 2: Barres à verrous

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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 Technical Committee ISO/TC 17, *Steel*, Subcommittee SC 16, *Steels for the reinforcement and prestressing of concrete*.

This fourth edition cancels and replaces the third edition (ISO 6935-2:2015), which has been technically revised. The main changes compared to the previous edition are as follows:

— Figures 1, 2, 3 have been revised;

— Figure 5, A.3, A.4 have been newly added;

— introduction of hot-rolled threaded reinforcing bar in Clause 3, 4, 6 and A.7.

A list of all parts in the ISO 6935 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.

Steel for the reinforcement of concrete —

Part 2:
Ribbed bars

1   Scope

This document specifies technical requirements for ribbed bars to be used as reinforcement in concrete. It is applicable to steel delivered in the form of bars, coils and de-coiled products. This document covers both weldable and non-weldable steels. It does not apply to ribbed bars produced from finished products, such as plates and railway rails.

The production process is at the discretion of the manufacturer.

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

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

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

3   Terms and definitions

For the purposes of this document, the following terms and definitions 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/

3.1
cast analysis
chemical analysis representative of the cast determined by the manufacturer in accordance with its own procedures

[SOURCE: ISO 16020:2005, 2.4.3, modified — "manufacturer" has replaced "steelmaker".]

3.2
conformity assessment scheme
conformity assessment system related to specific objects of conformity assessment, to which the same specified requirements, specific rules and procedures apply

Note 1 to entry: Conformity assessment schemes may be operated at an international, national or sub-national level.

Note 2 to entry: Certification, i.e. third-party attestation related to products, processes, systems or persons, is applicable to all objects of conformity assessment except for conformity assessment bodies themselves, to which accreditation is applicable.

3.3
characteristic value
value having a prescribed probability of not being attained in a hypothetical unlimited test series

Note 1 to entry: Equivalent to "fractile", which is defined in ISO 3534-1:2006.

Note 2 to entry: A nominal value is used as the characteristic value in some circumstances.

[SOURCE: ISO 16020:2005, 2.4.10, modified —Note 2 to entry has been added.]

3.4
core
part of the cross section of a bar containing neither ribs nor indentations

[SOURCE: ISO 16020:2005, 2.2.5, modified — "wire" has been removed from the definition.]

3.5
ductility class
classification of the ductility properties of ribbed reinforcing bars 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

Note 1 to entry: See Table 6.

3.6
hot-rolled threaded reinforcing bar
type of bar with threaded geometry over its entire surface with two flat parts on the longitudinal side

Note 1 to entry: This type of bar with external threads is generally connected to other threaded bars with internally threaded couplers.

3.7
longitudinal rib
uniform continuous rib parallel to the axis of a bar

[SOURCE: ISO 16020:2005, 2.2.7.1, modified — "wire" has been removed from the definition.]

3.8
nominal cross-sectional area
S_0
cross-sectional area equivalent to the area of a circular plain bar of the same nominal diameter

[SOURCE: ISO 16020:2005, 2.2.15, modified — "wire" has been removed from the definition.]

3.9
product analysis
chemical analysis carried out on the product

[SOURCE: ISO 16020:2005, 2.4.4]

3.10
relative rib area
f_R
area of the projections of all transverse ribs within a defined length on a plane perpendicular to the longitudinal axis of the bar, divided by this length and the nominal circumference

[SOURCE: ISO 16020:2005, 2.2.11, modified — "wire" has been removed from the definition.]

3.11
rib height
a
distance from the highest point on the rib to the surface of the core measured perpendicular to the axis of a bar

Note 1 to entry: See Figure 2.

[SOURCE: ISO 16020:2005, 2.2.12, modified — "highest point" has replaced "one point", "perpendicular" has replaced "normal", "wire" has been removed from the definition and Note 1 to entry has been added.]

3.12
transverse rib spacing
c
distance between the centres of two consecutive *transverse ribs* (3.4) measured parallel to the axis of a bar

Note 1 to entry: See Figure 1.

[SOURCE: ISO 16020:2005, 2.2.10, modified — "wire" has been removed from the definition.]

3.13
part of the circumference without rib
Σ_{ei}
sum of the distances along the surface of the core between the ends of the *transverse ribs* (3.4) of adjacent rows measured as the projection on a plane perpendicular to the axis of a bar

[SOURCE: ISO 16020:2005, 2.2.13, modified — "or indentationless" has been removed from the term and "or indentations" and "wire" have been removed from the definition.]

3.14
transverse rib
rib at an angle, either perpendicular or oblique, to the longitudinal axis of the bar

[SOURCE: ISO 16020:2005, 2.2.7.2, modified]

3.15
transverse rib flank inclination
α
angle between the flank of a *transverse rib* (3.4) and the core surface of a bar measured perpendicular to the longitudinal axis of the *transverse rib* (3.4)

Note 1 to entry: See Figure 2.

[SOURCE: ISO 16020:2005, 2.2.9, modified — "wire" has been removed from the definition.]

3.16
transverse rib inclination
β
angle between the rib and the longitudinal axis of a bar

Note 1 to entry: See Figures 1, 3 and 4.

[SOURCE: ISO 16020:2005, 2.2.8, modified — "wire" has been removed from the definition.]

4   Symbols

For the purposes of this document, the symbols listed in Table 1 apply.

Table 1 — Symbols

Symbol	Unit	Description	Reference
a	mm	Rib height	3.11, Clause 6
A	%	Percentage elongation after fracture	8.1
A_{gt}	%	Percentage total extension at maximum force	8.1
S_0	mm^2	Nominal cross-sectional area	Clause 5, 9.1
b	mm	Top width of transverse rib at the mid-point	Clause 6
c	mm	Transverse rib spacing	3.12, Clause 6
d	mm	Nominal diameter of the bar	Clause 5, Clause 6, 9.3, 9.4, Clause 10, 11.1, 11.2,
Σ_{ei}	mm	Part of the circumference without rib	3.13, Clause 6
f_k	—	Required characteristic value	12.2, 12.3.2.3
f_R	—	Relative rib area	3.10, Clause 6
k, k'	—	Indices	12.3.2.3.1
m_n	—	Mean value of n individual values	12.3.2.3.1
n	—	Number of individual values	12.3.2.3.1
R_{eH}	MPa[a]	Upper yield strength	8.1
R_m	MPa[a]	Tensile strength	8.1
$R_{p0,2}$	MPa[a]	0,2 % proof strength, plastic extension	8.1
s_n	—	Standard deviation for n individual values	12.3.2.3.1
x_i	—	Individual value	12.3.2.3.1
α	degree	Transverse rib flank inclination	3.15, Clause 6
β	degree	Transverse rib inclination	3.16, Clause 6
T	mm	width of longitudinal flat part of hot-rolled threaded bar	Clause 6
[a] 1 MPa = 1 N/mm^2.			

5   Dimensions, mass per unit length and permissible deviations

Dimensions, mass per unit length and permissible deviations are given in Table 2. By agreement between the manufacturer and purchaser, ribbed bars for which the nominal diameters are other than those shown in Table 2 may be used. A list of options for agreement between the manufacturer and the purchaser is provided in Annex B.

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

Nominal bar diameter[a] d mm	Nominal cross-sectional area[b] S_0 mm^2	Mass per unit length	
		Requirement[c] kg/m	Permissible deviation[d] %
6	28,3	0,222	±8
8	50,3	0,395	±8
10	78,5	0,617	±6
12	113	0,888	±6
14	154	1,21	±5
16	201	1,58	±5
20	314	2,47	±5
25	491	3,85	±4
28	616	4,84	±4
32	804	6,31	±4
40	1 257	9,86	±4
50	1 964	15,42	±4

[a] Nominal diameters larger than 50 mm should be agreed between the manufacturer and purchaser. The permissible deviation on mass for such bars shall be ±4 %.

[b] $S_0 = 0,785\ 4 \times d^2$.

[c] Mass per unit length = $7,85 \times 10^{-3} \times S_0$.

[d] Permissible deviation refers to a single bar.

The delivery length is subject to agreement between the manufacturer and purchaser.

NOTE   Common delivery lengths of straight bars are 6 m, 9 m, 12 m and 18 m.

Unless otherwise agreed, the permissible deviation on delivery lengths from the rolling mill shall be $^{+100}_{0}$ mm.

6   Requirements for ribs

Ribbed bars shall have transverse ribs. Longitudinal ribs may be present or not.

There shall be at least two rows of transverse ribs equally distributed around the perimeter of the bar. The transverse ribs within each row shall be distributed uniformly over the entire length of the bar, except in the area of marking.

Ribs shall conform to the requirements given in Table 3.

Table 3 — Requirements for transverse ribs

	Nominal bar diameter d mm	Ribs of uniform height	Crescent-shaped ribs
Rib height, a Minimum	All	$0,03d$	$0,03d$
Transverse rib spacing, c Range	$6 \leq d < 10$ $d \geq 10$	$0,5d \leq c \leq 0,7d$ $0,5d \leq c \leq 0,7d$	$0,5d \leq c \leq 1,0d$ $0,5d \leq c \leq 0,8d$

Table 3 *(continued)*

	Nominal bar diameter *d* mm	Ribs of uniform height	Crescent-shaped ribs
Transverse rib inclination, β	All	$35° \leq \beta \leq 90°$	$35° \leq \beta \leq 75°$
Transverse rib flank inclination, α	All	$\alpha \geq 40°$	$\alpha \geq 40°$
Part of the circumference without rib, Σ_{ei} Maximum	All	—	$0{,}25d\pi$
Top width of transverse rib at the mid-point, *b* Maximum	$6 \leq d < 20$ $d \geq 20$	$0{,}4d$ $0{,}2d$	$0{,}2d$

Requirements for rib parameters may be specified by the relative rib area, or by agreement between the manufacturer and purchaser. Measurement of rib parameters shall be performed in accordance with ISO 15630-1.

Dimensions defining the rib geometry in Table 3 are shown in Figures 1 to 5.

When longitudinal ribs are present, their height shall not exceed $0{,}15d$.

For transverse rib spacing of hot-rolled threaded bars, a minimum limit less than $0{,}5d$ may be agreed at the time of enquiry and order, but the minimum limit shall not be less than $0{,}35d$.
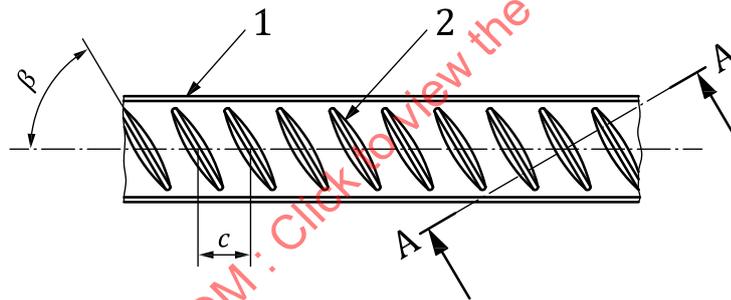
Key

1 longitudinal rib

2 transverse rib

Figure 1 — Ribbed bar — Definitions of geometry
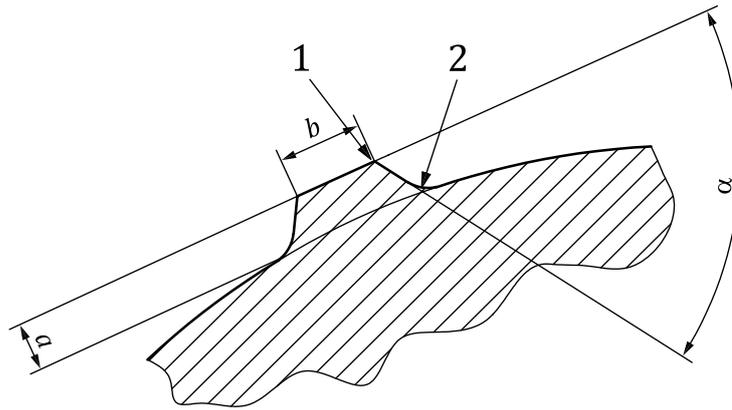
Key

1   rib
2   rounded transition

Figure 2 — Rib flank inclination, α, rib height, a, and top width of transverse rib at the mid-point, b — Section A-A from Figure 1
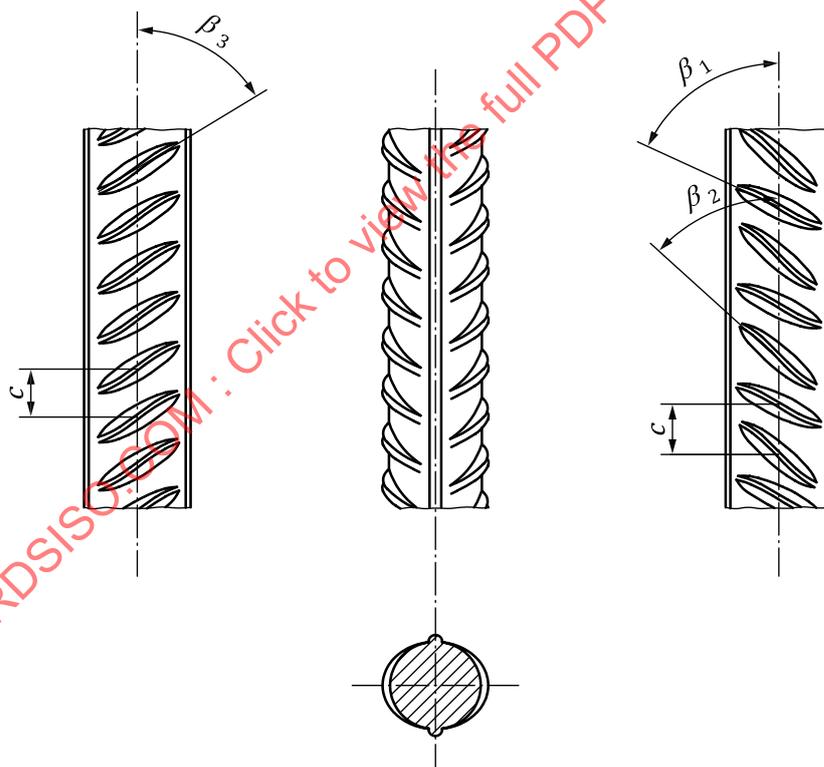
Figure 3 — Example of bar with varying rib inclinations to the longitudinal axis
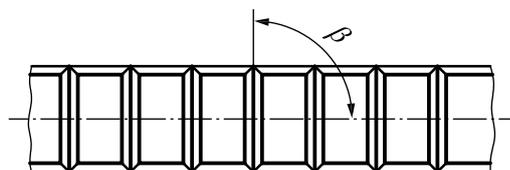
Figure 4 — Example of bar with transverse ribs of uniform height (β = 90°)
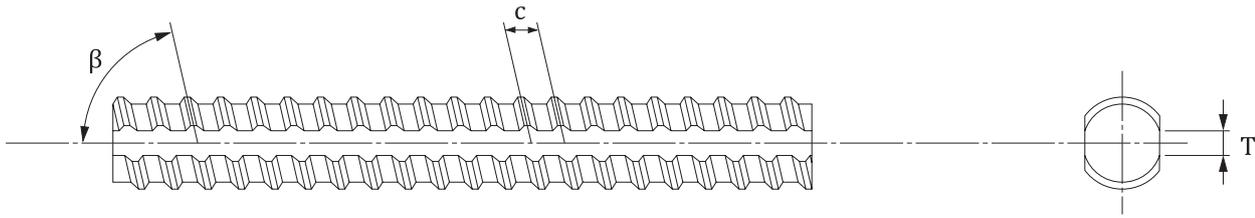
$$*\max T = \frac{3,124 \times d \times 0,25}{2}, \min T = 0$$

Figure 5 — Example of hot-rolled bar with threaded geometry and longitudinal flat part

7 Chemical composition

The chemical composition of the steel, as determined by cast analysis, shall conform to Table 4.

Calculate the carbon equivalent, CEV, according to Formula (1):

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

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

In cases where product analysis is required, it shall be agreed at the time of enquiry and order. The permissible deviation of the product analysis relative to the cast analysis as specified in Table 4 is given in Table 5.

Table 4 — Chemical composition based on cast analysis — Maximum values of mass fractions, in percentage

Steel grade[a, e]	C[b]	Si	Mn	P	S	N[c]	CEV[b, d]
B300A-R							
B300B-R							
B300C-R							
B400A-R							
B400B-R	—	—	—	0,060	0,060	—	—
B400C-R							
B500A-R							
B500B-R							
B500C-R							
B600A-R							
B600B-R	—	—	—	0,060	0,060	—	—
B600C-R							
B700A-R							
B700B-R	—	—	—	0,060	0,060	—	—
B700C-R							
B400AWR							
B400BWR							
B400CWR							
B500AWR	0,22	0,60	1,60	0,050	0,050	0,012	0,50
B500BWR							
B500CWR							
B450AWR	0,22	—	—	0,050	0,050	0,012	0,50
B450CWR							
B300D-R	—	—	—	0,050	0,050	—	—
B300DWR	0,27	0,55	1,50	0,040	0,040	0,012	0,49
B350DWR	0,27	0,55	1,60	0,040	0,040	0,012	0,51
B400D-R	0,29	0,55	1,60	0,040	0,040	—	0,55

[a] The first "B" stands for steel for reinforcing concrete. The next 3 digits represent the specified characteristic value of minimum upper yield strength. The fifth symbol stands for ductility class. The sixth symbol relates to welding; "-" means not intended for welding and "W" means intended for welding. The last "R" stands for ribbed bar.

[b] For B400AWR, B400BWR, B400CWR, B500AWR, B500BWR and B500CWR with nominal diameters larger than 32 mm, the maximum carbon content (C) is 0,25 % and the maximum carbon equivalent (CEV) is 0,55 %.

[c] The maximum mass fraction of nitrogen may be 0,017%, if sufficient quantities of nitrogen-binding elements such as B, Ti, Cr, Mo, V are intentionally added.

[d] Other carbon equivalent (CEV) formulae and values may be used by agreement between the manufacturer and purchaser.

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

[f] For B600D-R with nominal diameters larger than 32 mm. the maximum carbon content (c) is 0,40 % and the maximum carbon equivalent (CEV) is 0,70 %.

[g] If bars are manufactured purely by micro-alloying without quenching:

For B600D-R, the maximum C, Si and Mn shall be 0,45 %, 1,00 % and 2,00 % respectively.

The maximum carbon equivalent (CEV) shall be 0,58 % for B300DWR, 0,60 % for B350DWR, 0,65 % for B400D-R and B400DWR, 0,66 % for B420DWR, 0,70 % for B500D-R and B500DWR, and 0,80 % for B600D-R.

Table 4 *(continued)*

Steel grade[a, e]	C[b]	Si	Mn	P	S	N[c]	CEV[b, d]
B400DWR	0,29	0,55	1,80	0,040	0,040	0,012	0,56
B420DWR[d]	0,30	0,55	1,50	0,040	0,040	0,012	0,56
B500D-R	0,32	0,55	1,80	0,040	0,040	—	0,60
B500DWR	0,32	0,55	1,80	0,040	0,040	0,012	0,61
B600D-R	0,37	0,55	1,80	0,040	0,040	—	0,67
B700D-R	0,50	2,00	2,00	0,040	0,040	—	0,85

[a]   The first "B" stands for steel for reinforcing concrete. The next 3 digits represent the specified characteristic value of minimum upper yield strength. The fifth symbol stands for ductility class. The sixth symbol relates to welding; "-" means not intended for welding and "W" means intended for welding. The last "R" stands for ribbed bar.

[b]   For B400AWR, B400BWR, B400CWR, B500AWR, B500BWR and B500CWR with nominal diameters larger than 32 mm, the maximum carbon content (C) is 0,25 % and the maximum carbon equivalent (CEV) is 0,55 %.

[c]   The maximum mass fraction of nitrogen may be 0,017%, if sufficient quantities of nitrogen-binding elements such as B, Ti, Cr, Mo, V are intentionally added.

[d]   Other carbon equivalent (CEV) formulae and values may be used by agreement between the manufacturer and purchaser.

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

[f]   For B600D-R with nominal diameters larger than 32 mm. the maximum carbon content (c) is 0,40 % and the maximum carbon equivalent (CEV) is 0,70 %.

[g]   If bars are manufactured purely by micro-alloying without quenching:

For B600D-R, the maximum C, Si and Mn shall be 0,45 %, 1,00 % and 2,00 % respectively.

The maximum carbon equivalent (CEV) shall be 0,58 % for B300DWR, 0,60 % for B350DWR, 0,65 % for B400D-R and B400DWR, 0,66 % for B420DWR, 0,70 % for B500D-R and B500DWR, and 0,80 % for B600D-R.

Table 5 — Permissible deviation in product analysis in percentage by mass [a]

Elements	Specified maximum value in cast analysis in Table 4 %	Permissible deviation in product analysis from the specified limits of the cast analysis in Table 4 %
C	≤0,25	+0,02
	>0,25	+0,03
Si	≤0,60	+0,05
	>0,60	+0,07
Mn	≤1,65	+0,06
	>1,65	+0,08
P	≤0,05	+0,008
	>0,05	+0,010
S	≤0,05	+0,008
	>0,05	+0,010
N	≤0,012	+0,002

[a]   In cases of product analysis, the maximum value of carbon equivalent (CEV) shall be as given in Table 4 with a tolerance of 0,05.

8   Mechanical properties

8.1   Tensile properties

The tensile test shall be performed in accordance with 9.1.

The bars shall conform to the requirements for specified characteristic tensile properties specified in Table 6.

In the context of this document, the characteristic value is (unless otherwise indicated) the lower or upper limit of the statistical tolerance interval at which there is a 90 % probability ($1 - t = 0,90$) 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.

Table 6 — Tensile properties

Ductility Class	Steel grade	Specified characteristic value of upper yield strength R_{eH} MPa [c]		Ductility properties		
				Specified characteristic value of R_m/R_{eH}	Specified characteristic value of elongation[a] %	
		Minimum	Maximum	Minimum	A Minimum	A_{gt} Minimum
A	B300A-R	300	—	1,02	16	2
	B400A-R B400AWR	400	—		14	
	B500A-R B500AWR	500	—		14	
	B600A-R	600	—		10	
	B700A-R	700	—		8	
	B450AWR	450	1,25 × R_{eH}(min.)	1,05	—	2,5
B	300B-R	300	—	1,08	16	5
	B400B-R B400BWR	400	—		14	
	B500B-R B500BWR	500	—		14	
	B600B-R	600	—		10	
	B700B-R	700	—		8	
C	B300C-R	300	—	1,15	16	7
	B400C-R B400CWR	400	—		14	
	B500C-R B500CWR	500	—		14	
	B600C-R	600	—		10	
	B700C-R	700	—		8	
	B450CWR	450	1,25 × R_{eH}(min.)		—	7,5

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

[b] For bars with nominal diameter equal to or greater than 32 mm in ductility class D, the minimum specified characteristic value for A may be decreased by 2 % for each 3 mm increase in diameter. However, the maximum diminution from the minimum specified characteristic value stated in Table 6 is limited to 4 %.

[c] 1 MPa = 1 N/mm^2.

Table 6 *(continued)*

Ductility Class	Steel grade	Specified characteristic value of upper yield strength R_{eH} MPa [c]		Ductility properties		
				Specified characteristic value of R_m/R_{eH}	Specified characteristic value of elongation[a] %	
		Minimum	Maximum	Minimum	A Minimum	A_{gt} Minimum
D	B300D-R	300	—	1,25	17 [b]	8
	B300DWR	300	$1,3 \times R_{eH}$(min.)		17 [b]	
	B350DWR	350	$1,3 \times R_{eH}$(min.)		17 [b]	
	B400D-R	400	$1,3 \times R_{eH}$(min.)		16 [b]	
	B400DWR	400	$1,3 \times R_{eH}$(min.)		16 [b]	
	B420DWR	420	$1,3 \times R_{eH}$(min.)		16 [b]	
	B500D-R	500	$1,25 \times R_{eH}$(min.)		13 [b]	
	B500DWR	500	$1,3 \times R_{eH}$(min.)		13 [b]	
	B600D-R	600	$1,2 \times R_{eH}$(min.)		10 [b]	
	B700D-R	700	$1,2 \times R_{eH}$(min.)		10 [b]	

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

[b] For bars with nominal diameter equal to or greater than 32 mm in ductility class D, the minimum specified characteristic value for A may be decreased by 2 % for each 3 mm increase in diameter. However, the maximum diminution from the minimum specified characteristic value stated in Table 6 is limited to 4 %.

[c] 1 MPa = 1 N/mm².

By agreement between the manufacturer and purchaser, the values shown in Table 6 may be used as specified minimum and/or maximum values.

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

8.2 Bending properties

The bend test shall be performed in accordance with 9.3. After testing, the bars shall show neither rupture nor cracks visible to a person of normal or corrected vision.

8.3 Rebending properties after ageing

If required by the purchaser, the rebend test of bars of any of the 15 steel grades of B400A-R, B400B-R, B400C-R, B400AWR, B400BWR, B400CWR, B400DWR, B420DWR, B500A-R, B500B-R, B500C-R, B500AWR, B500BWR, B500CWR and B500DWR shall be performed in accordance with 9.4.

NOTE   The rebend test is used to verify the ageing properties of the bent bars.

After testing, the bars shall show neither rupture nor cracks visible to a person of normal or corrected vision.

8.4 Fatigue properties

If required by the purchaser, the manufacturer shall demonstrate the fatigue properties of the product based on axial-force-controlled fatigue testing in the fluctuating tension range in accordance with 9.5.

The specified number(s) of stress cycles, stress range(s) $2\sigma_a$ and maximum stress(es) σ_{max} shall be as agreed between the purchaser and manufacturer at the time of enquiry and order.

9 Testing

9.1 Tensile test

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

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

9.2 Conditions of testing

The conditions of testing are given in Table 7.

Table 7 — Conditions of testing

Manufacturing and delivery conditions of the product	Conditions of testing (test pieces)
Produced in straight lengths by hot rolling	As delivered[a] or aged[b]
Produced in straight lengths by cold working	Aged[b]
Produced and delivered as coil	Straightened and aged

[a]   Aged in the case of dispute.

[b]   Aged means: heating of the test piece to 100 °C, maintaining at this temperature ± 10 °C for a period of $1\ \mathrm{h}\ ^{+15}_{0}$ min and then cooling in still air to room temperature. The method of heating is left to the discretion of the manufacturer.

9.3 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 8.

Table 8 — Mandrel diameter to be used for the bend test

Dimensions in millimetres

Nominal bar diameter d	Mandrel diameter (max.)[a, b]
≤16	$3d$
$16 < d \le 32$	$6d$
$32 < d \le 50$	$7d$

[a]   For nominal diameters larger than 50 mm, the mandrel diameter in bend tests shall be agreed between the manufacturer and purchaser.

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

9.4 Rebend test

The rebend test shall be carried out in accordance with ISO 15630-1. The test piece shall be bent over a mandrel of the diameter specified in Table 9.

The angle of bend before heating (ageing) shall be at least 90°, and the angle of rebend shall be at least 20°. Both angles shall be measured before unloading.

If required, for the ageing after bending, the conditions of ageing shall be defined (temperature and time).

Table 9 — Mandrel diameter to be used for the rebend test

Dimensions in millimetres

Nominal bar diameter d	Mandrel diameter (max.)[a, b]
≤16	5d
$16 < d \leq 25$	8d
$25 < d \leq 50$	10d
[a] For nominal diameters larger than 50 mm, the mandrel diameter in rebend tests shall be agreed between the manufacturer and purchaser.	
[b] By agreement between the manufacturer and purchaser, larger mandrel diameters may be used.	

9.5 Fatigue test

The fatigue test shall be carried out according to ISO 15630-1.

9.6 Chemical composition

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.

10 Designation

Ribbed bars according to this document shall be designated in the following order:

a) reinforcing bars;

b) a reference to this document, i.e. ISO 6935-2;

c) the nominal diameter, in millimetres, according to Table 2;

d) the steel grade.

EXAMPLE   Reinforcing bars ISO 6935-2 – 12 B500CWR

11 Marking

11.1 Marking on bars

All bars should be identifiable by permanent marks that indicate:

a) the steel grade;

b) the name of the manufacturer.

If required, it is also permitted to mark the nominal bar diameter and the country of origin.

Some examples of multinational marking systems are shown in Annex A.

For hot-rolled threaded reinforcing bars, the marks shall be positioned on the bar where they do not interfere with subsequent threaded connection.

11.2 Identification of bundles

Each bundle of bars shall have a durable label affixed to it stating the name of the manufacturer, a reference to this document (i.e. ISO 6935-2), the steel grade, the nominal diameter, the cast number or reference related to the test record and country of origin.

12 Evaluation of conformity

12.1 General

Certification and inspection of steel bars for the reinforcement of concrete can be performed:

a) in accordance with a certification following a conformity assessment scheme, see 12.2; or

b) according to testing of a specific delivery, see 12.3.

12.2 Evaluation of conformity during production

This clause specifies requirements for the evaluation of conformity during production.

NOTE   ISO 10144 specifies scheme requirements for the certification for the continuous production of steel bars for the reinforcement of concrete in order to verify the conformity with requirements specified in product standards, such as ISO 6935-1 and this document.

For each of the characteristics specified in this document except chemical composition, one test piece shall be taken per 40 t for all nominal diameters, with at least three test pieces per cast and nominal diameter.

The chemical composition (cast analysis) listed in Table 4 shall also be determined for all casts. The contents of the elements specified in this document shall be determined in this analysis.

Each individual value x_i shall satisfy the Formula (2):

$$x_i \geqq 0{,}95 f_k \tag{2}$$

where f_k is the required characteristic value (R_{eH} or elongation) according to Table 6.

The mean value of the test unit shall satisfy the Formula (3):

$$m \geqq f_k + ks \tag{3}$$

where

k is the acceptability index according to Table 10;

s is the standard deviation of the test results.

Proven values of ks for each product and manufacturer shall be used.

The mean value requirement of Formula (3) does not apply if all individual values lie above the required characteristic value.

All casts shall comply with the requirements for chemical composition including carbon equivalent (CEV). All other requirements shall be met for each individual test piece.

Where test results are unsatisfactory according to this clause, the manufacturer shall immediately take the necessary precautions. Casts that do not conform to the requirements shall be set aside.

Table 10 — Acceptability index (k^*) as a function of the number (n) of the test results

n	k	n	k
5	3,40	30	2,08
6	3,09	40	2,01
7	2,89	50	1,97
8	2,75	60	1,93
9	2,65	70	1,90
10	2,57	80	1,89
11	2,50	90	1,87
12	2,45	100	1,86
13	2,40	150	1,82
14	2,36	200	1,79
15	2,33	250	1,78
16	2,30	300	1,77
17	2,27	400	1,75
18	2,25	500	1,74
19	2,23	1000	1,71
20	2,21	∞	1,64
* See 12.3.2.3.1 for k.			

12.3 Acceptance testing of a specific delivery

12.3.1 General

Provisions regarding the nature, extent and evaluation of acceptance testing on deliveries of reinforcing bars not subject to certification following a conformity assessment scheme are given in 12.3.2 and 12.3.3.

Acceptance testing of a specific delivery shall be performed according to 12.3.2.

By agreement between the manufacturer and purchaser, 12.3.3 may be used.

12.3.2 Evaluation of characteristic values

12.3.2.1 Organization

The tests shall be organized and carried out in accordance with the agreement between the purchaser and manufacturer, taking into consideration the national rules of the receiving country.

12.3.2.2 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 bars 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 12.3.2.3.1) from various bars for testing all other properties specified in this document.

12.3.2.3 Evaluation of the results

12.3.2.3.1 Inspection by variables

For properties that 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, see Formulae (4) and (5):

$$m_{15} - 2{,}33 \times s_{15} \geq f_k \tag{4}$$

where

   f_k is the required 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 % ($1 - t$ = 0,90).

$$s_{15} = \sqrt{\frac{\sum x_i - m_{15}^2}{14}} \tag{5}$$

If the condition stated above is not fulfilled, the index, see Formula (6):

$$k' = \frac{m_{15} - f_k}{s_{15}} \tag{6}$$

is determined from the test results available. Where $k' \geq 2$, testing can be continued. In this case, 45 additional 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 in Formula (7) is fulfilled for all properties:

$$m_{60} - 1{,}93 \times s_{60} \geq f_k \tag{7}$$

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 % ($1 - t$ = 0,90).

12.3.2.3.2 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 this document. 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 additional 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.

12.3.2.3.3 Chemical composition

Both test pieces shall comply with the requirements in this document.

12.3.3 Evaluation of specified minimum/maximum values

Tests shall be carried out in accordance with the following.

a) Bars of the same cast shall constitute one group. For every 50 t or fraction thereof, one tensile test and one bend/rebend test shall be carried out for each nominal bar diameter.

b) Each individual test result shall meet the required values in Table 6 and the required bending/rebending properties in 8.2 and 8.3. One cast analysis shall be carried out for every cast to verify chemical composition (see Clause 7). Samples shall be taken in accordance with ISO 14284.

c) If any test result does not meet the requirements, retests may be carried out in accordance with ISO 404.

d) The manufacturer shall submit a test report stating that the bars of the delivery satisfy the chemical and mechanical properties defined in Clauses 7 and 8, and a confirmation that the other requirements of this document are fulfilled.

12.3.4 Test report

The test report shall at least contain the following information:

a) designation of the reinforcing bars in accordance with this document;

b) marking on the reinforcing bars;

c) date of testing;

d) mass of the test unit;

e) test results.

Annex A
(informative)

Five examples of marking systems for ribbed bars

A.1 General

This annex lists examples of marking systems for ribbed bars as these are specified on regional level and for hot-rolled threaded reinforcing bars. This annex is presented for information only. To comply with the regional standards, the latest version of the relevant regional standard needs to be addressed in full.

A.2 References

References [5], [6], [7], [8], [9], [10], [11], [12] and [13] provide relevant information.

## A.3 Example No. 1: System according to EN 10080:2005

A.3.1   Each reinforcing bar shall bear on one rib row a mark identifying the works. This mark shall be repeated at an interval of not more than 1,5 m.

A.3.2   The mark shall consist of the following:

a)   a symbol denoting the beginning of the mark;

b)   a numerical system identifying the manufacturer, consisting of a country-of-origin number and a works number.

A.3.3   The numerical system identifying the country of origin and the works shall use one of the following methods:

a)   a number of normal ribs or indentations between widened ribs or indentations (for example, see Figure A.1);

b)   a number of normal ribs or indentations between missing ribs or indentations;

c)   numbers on the surface of the bar;

d)   rolled or indented marks with a number of normal ribs or indentations in between them.
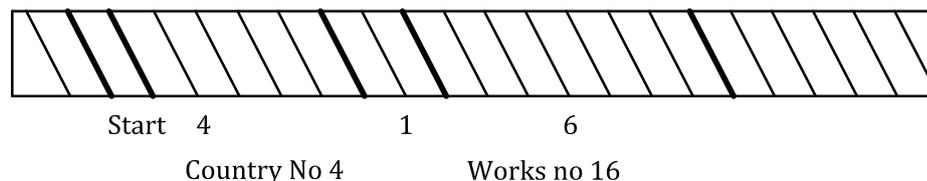
Figure A.1 — Example of manufacturer's identification mark (using widened ribs)

A.3.4   The symbol indicating the start of the mark shall be one of the following:

a)   where the marking method uses widened ribs or indentations, the symbol identifying the start of the mark shall consist of two consecutive widened ribs or indentations (for example, see Figure A.1);

b)   where the marking method uses missing ribs or indentations, the symbol identifying the start of the mark shall consist of two consecutive missing ribs or indentations;

c)   where numbers are rolled onto the surface of the bar, the symbol indicating the start of the mark shall be an X or O;

d)   where marks are rolled or indented onto the surface, the start of the mark shall consist of two marks between one pair of normal ribs or indentations.

A.3.5   The country of origin shall be indicated by a number between 1 and 9, according to Table A.1 (for example, see Figure A.1).

A.3.6   The works number shall consist of a one- or two-digit number between 1 and 99, except for multiples of 10 (for example, see Figure A.1).

Table A.1 — Marking of country of origin

Country	Number of normal oblique ribs between two thickened oblique ribs
Austria, Czech Republic, Germany, Poland, Slovakia	1
Belgium, Netherlands, Luxemburg, Switzerland	2
France, Hungary	3
Italy, Malta, Slovenia	4
UK, Ireland, Iceland	5
Denmark, Estonia, Finland, Latvia, Lithuania, Norway, Sweden	6
Portugal, Spain	7
Cyprus, Greece	8
Other countries	9

A.4   Example No. 2: System according to ASTM A615/A615M-16 and ASTM A706/A706M-16

A.4.1   When loaded for mill shipment, bars shall be properly separated and tagged with the manufacturer's cast or test identification number.

A.4.2   Each manufacturer shall identify the symbols of the manufacturer's own marking system.

A.4.3   All bars shall be identified by a distinguishing set of marks legibly rolled onto the surface of one side of the bar to denote, in the order given in a) to d), the following items (for example, see Figure A.2).

a)   Point of origin

Letter or symbol established as the manufacturer's mill designation.

b)   Size designation

Arabic number corresponding to bar designation number (nominal diameter).