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Stainless steel bars for the reinforcement of concrete

Barres en aciers inoxydables pour l'armature du béton

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Contents

Page

Foreword

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

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.

Stainless steel bars for the reinforcement of concrete

1 Scope

This document specifies technical requirements for hot rolled stainless steel plain bars and ribbed bars used as reinforcement in concrete.

It is applicable to steel delivered in the form of bars, coils and de-coiled products. It does not apply to ribbed bars produced from finished products

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 148-1, *Metallic materials — Charpy pendulum impact test — Part 1: Test method*

ISO 6935-1, *Steel for the reinforcement of concrete — Part 1: Plain bars*

ISO 6935-2, *Steel for the reinforcement of concrete — Part 2: Ribbed bars*

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

ISO 15510, *Stainless steels — Chemical composition*

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

EN 196-1, *Methods of testing cement — Part 1: Determination of strength*

EN 197-1, *Cement — Part 1: Composition, specifications and conformity criteria for common cements*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 6935-1, ISO 6935-2, ISO 15510 and the following apply.

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

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

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

3.1
stainless steel bars
stainless steel bars with at least 10,5 % (mass fraction) of chromium and max. 1,2 % (mass fraction) of carbon

4 Symbols

Symbol	Unit	Description
A	%	Percentage elongation after fracture
A_{gt}	%	Percentage total extension at maximum force
S_0	mm^2	Nominal cross-sectional area
d	mm	Nominal diameter of the bar
R_m	MPa[a]	Tensile strength
$R_{p0,2}$	MPa[a]	0,2 % proof strength, plastic extension
$R_{7,0}$	MPa[a]	7,0 % proof strength, plastic extension

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

5 Dimensions, mass per unit length and permissible deviations

Dimensions are given in Table 1, mass per unit length and permissible deviations are given in Table 2, Table 3 and Table 4. By agreement between the manufacturer and the purchaser, the following options shall be applied.

— Ribbed bars and plain bars for which the nominal diameters are other than those shown in Table 2 may be used. The permissible deviation of nominal diameters larger than 50 mm shall be ±4 %.

— The permissible deviation on mass per length of plain bars may be replaced by tolerances on diameters.

A list of options for agreement between the manufacturer and the purchaser is provided in Annex B.

Table 1 — Dimensions

Nominal bar diameter d mm		Nominal cross-sectional area[a] S_0 mm^2
Ribbed bars	Plain bars	
6	6	28,3
8	8	50,3
10	10	78,5
12	12	113
14	14	154
16	16	201
20	20	314
	22	380
25		491
28		616
32		804
40		1 257
50		1 964

[a] $S_0 = 0{,}785\,4 \times d^2$.

Table 2 — Mass per unit length and permissible deviations: Austenite

Nominal bar diameter[a] *d* mm		Mass per unit length[b] kg/m								Permissible deviation[c] %	
R	**P**	4301-304-00-I	4311-304-53-I	4401-316-00-I	4429-316-53-I	4404-316-03-I	4529-089-26-I	4315-304-51-I	4495-316-51-J	**R**	**P**
6	6	0,224		0,226			0,229	0,224	0,226	±8	±8
8	8	0,397		0,402			0,407	0,397	0,402	±8	±8
10	10	0,620		0,628			0,636	0,620	0,628	±6	±5
12	12	0,893		0,904			0,915	0,893	0,904	±6	±5
14	14	1,22		1,23			1,25	1,22	1,23	±5	±5
16	16	1,59		1,61			1,63	1,59	1,61	±5	±5
20	20	2,48		2,51			2,54	2,48	2,51	±5	±5
	22	3,00		3,04			3,08	3,00	3,04		±5
25		3,88		3,93			3,98	3,88	3,93	±4	
28		4,87		4,93			4,99	4,87	4,93	±4	
32		6,35		6,43			6,51	6,35	6,43	±4	
40		9,93		10,06			10,18	9,93	10,06	±4	
50		15,52		15,7			15,91	15,52	15,71	±4	

[a] "R" means ribbed bars and "P" means plain bars.

[b] Mass per unit length = Density × 10^{-3} × S_0.

[c] Permissible deviation refers to a single bar.

Table 3 — Mass per unit length and permissible deviations: Austenite-Ferrite

Nominal bar diameter[a] *d* mm		Mass per unit length[b] kg/m							Permissible deviation[c] %	
R	**P**	4482-320-01-X	4462-318-03-I	4362-323-04-I	4460-312-00-I	4410-327-50-E	4501-327-60-I	4062-322-02-U	**R**	**P**
6	6				0,221				±8	±8
8	8				0,392				±8	±8
10	10				0,612				±6	±5
12	12				0,881				±6	±5
14	14				1,20				±5	±5
16	16				1,57				±5	±5
20	20				2,45				±5	±5
	22				2,96					±5
25					3,83				±4	
28					4,80				±4	
32					6,27				±4	
40					9,80				±4	
50					15,32				±4	

[a] "R" means ribbed bars and "P" means plain bars.

[b] Mass per unit length = Density × 10^{-3} × S_0.

[c] Permissible deviation refers to a single bar.

Table 4 — Mass per unit length and permissible deviations: Ferrite and martensite

Nominal bar diameter[a] *d* mm		Mass per unit length[b] kg/m			Permissible deviation[c] %	
		Ferrite		Martensite		
R	**P**	4030-410-90-X	4003-410-77-I	4024-410-09-E	**R**	**P**
6	6		0,218		±8	±8
8	8		0,387		±8	±8
10	10		0,604		±6	±5
12	12		0,870		±6	±5
14	14		1,19		±5	±5
16	16		1,55		±5	±5
20	20		2,42		±5	±5
	22		2,93			±5
25			3,78		±4	
28			4,74		±4	
32			6,19		±4	
40			9,68		±4	
50			15,12		±4	

[a] "R" means ribbed bars and "P" means plain bars.

[b] Mass per unit length = Density × 10^{-3} × S_0.

[c] 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, 15 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 ISO 6935-2.

7 Chemical composition

The chemical composition of the steel, as determined by cast analysis, shall conform to Table 5, Table 6 and Table 7.

The elements not listed in Table 5, Table 6 and Table 7 shall not be intentionally added without agreement between manufacturer and purchaser. Precautionary measures shall be taken to avoid unintentional chemical elements which would impair mechanical properties.

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 5, Table 6 and Table 7 are given in Table 8.

Table 5 — Chemical composition based on cast analysis — Maximum values of mass fractions, in percentage: Austenite

ISO number[a]	C	Si	Mn	P	S	Cr	Mo	Ni[c]	N	Others[d]
4301-304-00-I	0,07	1,00	2,00	0,045	0,030[b]	17,5 to 19,5	-	8,0 to 10,5	0,10	-
4311-304-534	0,030	1,00	2,00	0,045	0,030	17,5 to 19,5	-	8,0 to 11,0	0,12 to 0,22	-
4401-316-00-I	0,08	1,00	2,00	0,045	0,030	16,0 to 18,0	2,00 to 3,0	10,0 to 13,0	0,10	-
4429-316-53-I	0,030	1,00	2,00	0,045	0,030	16,5 to 18,5	2,50 to 3,0	10,5 to 13,0	0,12 to 0,22	-
4404-316-03-I	0,030	1,00	2,00	0,045	0,030	16,5 to 18,5	2,00 to 3,0	10,0 to 13,0	0,10	-
4529-089-26-I	0,020	0,75	2,00	0,035	0,015	19,0 to 21,0	6,0 to 7,0	24,0 to 26,0	0,15 to 0,25	Cu: 0,50 to 1,50
4315-304-51-I	0,08	1,00	2,50	0,045	0,030	18,0 to 20,0	-	7,0 to 10,5	0,10 to 0,30	-
4495-316-51-J	0,08	1,00	2,00	0,045	0,030	16,0 to 18,0	2,00 to 3,0	10,0 to 14,0	0,10 to 0,22	-
4406-316-53-I	0,030	1,00	2,00	0,045	0,030	16,5 to 18,5	2,00 to 3,0	10,0 to12,5	0,12 to 0,22	
4571-316-35-I	0,08	1,00	2,00	0,045	0,030	16,5 to 18,5	2,00 to 2,50	10,5 to 13,5	-	Ti : 5xC to 0,70

[a] The ISO numbers and chemical compositions are referenced in ISO 15510.

[b] Particular ranges of sulphur mass fraction can provide improvement of particular properties. For machinability, a controlled sulphur mass fraction between 0,015 % to 0,030 % is recommended.

[c] For special purposes (e.g. hot workability), the maximum nickel mass fraction can be increased by the following amounts to minimize ferrite content:

— by 0,50 % for 4301-304-00-I;

— by 1,00 % for 4401-316-00-I and 4429-316-53-I;

— by 1,50 % for 4404-316-03-I.

[d] Nb can be added up to 0,15 %.

Table 6 — Chemical composition based on cast analysis — Maximum values of mass fractions, in percentage: Austenite-Ferrite

ISO number[a]	C	Si	Mn	P	S	Cr	Mo	Ni	N	Others
4482-320-01-X	0,030	1,00	4,0 to 6,0	0,035	0,030	19,5 to 21,5	0,10 to 0,60	1,50 to 3,50	0,05 to 0,20	Cu: 1,00
4462-318-03-I[b]	0,030	1,00	2,00	0,035	0,015	21,0 to 23,0	2,50 to 3,5	4,5 to 6,5	0,10 to 0,22	-
4362-323-04-I	0,030	1,00	2,00	0,035	0,015	22,0 to 24,5	0,10 to 0,60	3,5 to 5,5	0,05 to 0,20	Cu: 0,10 to 0,60
4460-312-00-I	0,050	1,00	2,00	0,035	0,030a	25,0 to 28,0	1,30 to 2,00	4,5 to 6,5	0,05 to 0,20	-
4410-327-50-E	0,030	1,00	2,00	0,035	0,015	24,0 to 26,0	3,0 to 4,5	6,0 to 8,0	0,24 to 0,35	-
4501-327-60-I	0,030	1,00	1,00	0,030	0,010	24,0 to 26,0	3,0 to 4,0	6,0 to 8,0	0,20 to 0,30	Cu: 0,50 to 1,00 W: 0,50 to 1,00
4062-322-02-U	0,030	1,00	2,00	0,040	0,010	21,5 to 24,0	0,45	1,00 to 2,80	0,18 to 0,26	-
4162-321-01-E	0,040	1,00	4,0 to 6,0	0,040	0,015	21,0to22,0	0,10to0,80	1,35to1,70	0,20to0,25	Cu: 0,10 to 0,80

[a] The ISO numbers and chemical compositions are referenced in ISO 15510.

[b] For special applications, the lower limits of N, Cr, and Mo can be limited to 0,14 %, 22,0 %, and 3,0 %.

Table 7 — Chemical composition based on cast analysis — Maximum values of mass fractions, in percentage: Ferrite and martensite

ISO number[a]	C	Si	Mn	P	S	Cr	Mo	Ni	N	Others
4030-410-90-X	0,030	1,00	1,00	0,040	0,030	11,00 to 13,50	-	-	-	-
4003-410-77-I	0,030	1,00	2,00	0,040	0,015	10,5 to12,5	-	0,30 to1,10	0,030	
4024-410-09-E	0,12 to 0,17	1,00	1,00	0,040	0,015	12,0 to 14,0	-	-	-	-

[a] The ISO numbers and chemical compositions are referenced in ISO 15510.

Table 8 — Permissible deviations of chemical compositions

Element	Specified limits, cast analysis % (mass fraction)		Permissible deviation[a] % (mass fraction)
C (Carbon)		≤0,010	+0,002
	>0,010	≤0,03	+0,005
	>0,030	≤0,17	±0,01
Si (Silicon)		≤1,00	+0,05
Mn (Manganese)		≤1,00	+0,03
	>1,00	≤2,50	+0,04
P (Phosphorus)		≤0,040	+0,005
	>0,040	≤0,045	+0,01
S (Sulphur)		≤0,030	+0,005
Cr (Chromium)	≥11,0	≤15,0	±0,10
	>15,0	≤20,00	±0,15
	>20,0	≤28,0	±0,20
Mo (Molybdenum)	>0,20	≤0,60	±0,03
	>0,60	≤2,00	±0,05
	>2,00	≤7,0	±0,10
Ni (Nickel)	≥3,5	≤5,0	±0,07
	>5,0	≤10,0	±0,10
	>10,0	≤20,0	±0,15
	>20,0	≤26,0	±0,20
N (Nitrogen)	≥0,05	≤0,19	±0,01
	>0,19	≤0,25	±0,02
	>0,25	≤0,35	±0,03
Cu (Copper)		≤0,50	±0,03
	>0,50	≤1,00	±0,05
W (Tungsten)		≤1,00	±0,03

[a] ± means that in one cast, the deviation can occur over the upper value or under the lower value of the specified range in Table 9, but not both at the same time.

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 in Table 9.

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 9 — Tensile properties

Ductility Class	Steel grade[a]	Specified characteristic value of 0,2 proof strength[b] $R_{p0,2}$ MPa[c]		Ductility properties		
				Specified characteristic value of $R_m/R_{p0,2}$[b]	Specified characteristic value of elongation[d] %	
		Minimum	Maximum		A[e]	A_{gt}
A	SB400AR	400	—	≥1,05	—	≥2,5
	SB450AR	450	—		—	
	SB500AR	500	—			
	SB550AR	550	—		—	
	SB600AR	600	—		—	
	SB700AR	700	—		—	
	SB750AR	750	—		—	
B	SB300BR SB300BP	300	—	≥1,08	≥16	≥5
	SB400BR	400	—		≥14	
	SB450BR	450	—		—	
	SB500BR	500	—		≥14	
	SB550BR	550	—		—	
	SB600BR	600	—		—	
	SB700BR	700	—		—	
	SB750BR	750	—		—	
C	SB400CR	400	—	≥ 1,15 and <1,35 [f]	—	≥7,5
	SB450CR	450	—		—	
	SB500CR	500	—		—	
	SB550CR	550	—		—	
	SB600CR	600	—		—	
	SB700CR	700	—		—	
	SB750CR	750	—		—	

a Reinforcement can be classified according to the specified characteristic values of yield strength. The first “SB” means "Stainless steel Bars for the reinforcement of concrete". The next 3 digits represent the specified characteristic value of yield strength. The sixth “A”, “B”, “C” and "D" means each ductility class. And last "R" and "P" mean Ribbed bar and Plain bar.

b The maximum actual proof strength $R_{p0,2}$, shall not exceed (1,3 x $R_{p0,2}$), where $R_{p0,2}$ is the characteristic value.

c If the total extension at maximum force (A_{gt}) is below the minimum value specified in Table 9, this shall not be the cause for non-conformity, provided the minimum percentage elongation after fracture is met as in Table 9.

d 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} shall be used.

e For steel bars with a nominal diameter equal to or higher 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 9 is limited to 4 %.

f In the case of austenitic and duplex stainless steels, because of their specific stress-strain constitutive relationship, the ratio is calculated by using the value of $R_{7,0}$ instead of R_m

1 MPa = 1 N/mm^2

Table 9 *(continued)*

Ductility Class	Steel grade[a]	Specified characteristic value of 0,2 proof strength[b] $R_{p0,2}$ MPa[c]		Ductility properties		
				Specified characteristic value of $R_m/R_{p0,2}$[b]	Specified characteristic value of elongation[d] %	
		Minimum	Maximum		A^e	A_{gt}
D	SB300DR	300	—	≥1,25	≥17	≥8
	SB300DP				≥19	
	SB400DR	400	1,25 × $R_{p0,2}$(min.)		≥17	
	SB420DP	420	540		≥16	
	SB500DR	500	1,25 × $R_{p0,2}$(min.)		≥13	

a Reinforcement can be classified according to the specified characteristic values of yield strength. The first “SB” means "Stainless steel Bars for the reinforcement of concrete". The next 3 digits represent the specified characteristic value of yield strength. The sixth “A”, “B”, “C” and "D" means each ductility class. And last "R" and "P" mean Ribbed bar and Plain bar.

b The maximum actual proof strength $R_{p0,2}$, shall not exceed (1,3 x $R_{p0,2}$), where $R_{p0,2}$ is the characteristic value.

c If the total extension at maximum force (A_{gt}) is below the minimum value specified in Table 9, this shall not be the cause for non-conformity, provided the minimum percentage elongation after fracture is met as in Table 9.

d 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} shall be used.

e For steel bars with a nominal diameter equal to or higher 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 9 is limited to 4 %.

f In the case of austenitic and duplex stainless steels, because of their specific stress-strain constitutive relationship, the ratio is calculated by using the value of $R_{7,0}$ instead of R_m

1 MPa = 1 N/mm^2

By agreement between the manufacturer and purchaser, the values shown in Table 9 may be used as specified minimum and/or maximum values instead of the specified characteristic values.

8.2 Bending properties

The bend test shall be performed in accordance with 9.2. 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 steel grades shall be performed in accordance with 9.3.

NOTE The rebend test is used to determine 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 Impact properties on austenitic-ferritic steels

If required by the purchaser and if the nominal diameter is 16 mm and above, the manufacturer shall provide the impact properties on Austenitic-Ferritic steels in accordance with 9.5.

The impact absorption energy value shall be as agreed between the purchaser and the manufacturer at the time of enquiry and order.

8.5 Magnetic permeability

If required by the purchaser, magnetic permeability shall be carried out in accordance with 9.6

8.6 Corrosion resistance properties

If required by the purchaser, the corrosion resistance test shall be carried out in accordance with 9.7.

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 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 10.

Table 10 — 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 ≤ 32	6d
32 < d ≤ 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.

9.3 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 11.

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 11 — 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 ≤ 25	8d
25 < d ≤ 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.

9.4 Chemical composition

Unless otherwise agreed when ordering, the choice of a suitable physical or chemical method of analysis to determine the product analysis is at the discretion of the manufacturer. In case of dispute about the analytical method, the chemical composition shall be determined by an appropriate referee method. The list of available International Standards on chemical analysis is given in ISO/TR 9769.

9.5 Impact property test

The V-notch impact test shall be carried out in accordance with ISO 148-1.

9.6 Magnetic permeability

The magnetic permeability test shall be carried out in accordance with Annex C

9.7 Corrosion resistance test

The corrosion resistance test shall be carried out in accordance with Annex B

10 Designation

Plain bars and 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 6435:2024;

c) ISO number (Chemical composition);

d) the steel grade;

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

EXAMPLE Reinforcing bars ISO NP6435 - 4462-318-03-I - SB500BR – 12

11 Marking

11.1 Marking on bars

All ribbed bars shall be identifiable by permanent marks that indicate:

a) the steel grade;

b) the name of the manufacturer.

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

Some examples of multinational marking systems are shown in ISO 6935-2:2019, Annex A.

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 6435:2024), the steel grade, the nominal diameter, the cast number or reference related to the test record and country of origin.

12 Testing and inspection

12.1 General

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

a) in accordance with requirements for the evaluation of conformity during production or 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 6, Table 7 and Table 8 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 Formula (1):

$$x_i > 0,95\, f_k \tag{1}$$

where f_k is the required characteristic value (*ReH* or elongation) according to Table ~~10~~9.

The mean value of the test unit shall satisfy Formula (2):

$$m > f_k + ks \tag{2}$$

where

k is the acceptability index according to Table 12;

s is the standard deviation of the test results.

Proven values of k, s for each product and manufacturer shall be used.

The mean value requirement of Formula (2) does not apply if all individual values lie above the required characteristic value.

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 12 — Acceptability index (k^a) 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	1 000	1,71
20	2,21	∞	1,64

[a] 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 (steel grade, bar size, production process) 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 5 test pieces (if appropriate, 20 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 (3) and (4):

$$m_{15} - 2{,}33 \times s_{15} \geq f_k \qquad (3)$$

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).

$$s_{15} = \sqrt{\frac{\sum (x_i - m_{15})^2}{14}} \qquad (4)$$

If the condition stated above is not fulfilled, the index is determined from the test results available, see Formula (5):

$$k' = \frac{m_{15} - f_k}{s_{15}} \qquad (5)$$

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 compliant with the requirements, if the condition stated in Formula (6) is fulfilled for all properties:

$$m_{60} - 1{,}93 \times s_{60} f_k \qquad (6)$$

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 conform with the requirements of this document. In this case, the test unit shall be considered compliant 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 conforms 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 conform 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 test shall be carried out for each nominal bar diameter.

b) Each individual test result shall meet the required values in Table 9 and the required bending properties in 8.2. 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:

- cast analysis;
- product analysis (if required);
- tensile test;
- bend test (and re-bend test if required);
- impact properties (if required);
- magnetic permeability (if required);
- corrosion resistance properties (if required).

Annex A
(informative)

Options for agreement between the manufacturer and purchaser

The provisions for which this document indicate that additional or deviating requirements can be agreed between the manufacturer and purchaser are listed below:

a) nominal diameter > 50 mm (Table 1, Table 2, Table 3, Table 4 and Clause 5);

b) delivery length and permissible deviations on delivery lengths (Clause 5);

c) product analysis, other alloy elements (Clause 7);

d) type of elongation (8.1);

e) specified minimum/maximum values (8.1 and 12.3.3);

f) mandrel diameters in bend tests (9.2 and Table 10);

g) mandrel diameters in rebend tests (9.3 and Table 11)

h) impact property (9.5)

i) magnetic permeability (9.6)

j) acceptance testing of specific delivery (12.3.1);

k) organization of delivery testing (12.3.2.1).

Annex B
(normative)

Corrosion resistant test

B.1 General

This annex provides reference indicating corrosion resistance of stainless steel. It defines a testing procedure for the evaluation of the corrosion behaviour of stainless steel bars embedded in mortar with mixed-in chlorides. The corrosion behaviour is evaluated on a set of 10 bars of a specific type of stainless steel embedded in a standardized mortar with a predefined amount of mixed-in chlorides (expressed as percentage by mass of cement, Cl test%).

B.2 Materials

B.2.1 Stainless steel bars

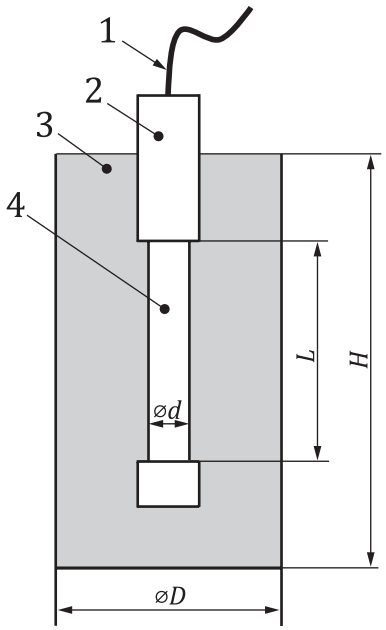
Tests shall be carried out on commercially produced stainless steel bars. Bars shall be tested in the as-received condition, unless otherwise specified. The surface conditions of the bars used for testing shall be documented. The nominal diameter of the bars shall be declared.

B.2.2 Mortar

A standard mortar shall be mixed with a Portland cement (type CEM I 52.5R in accordance with EN 197-1) and a water/cement ratio of 0,5. European CEN standard sand shall be used with a maximum size of 2 mm. Batches of mortar made of 1 350 g of sand, 450 g of Portland cement, 225 g of distilled water shall be mixed following the procedure described in EN 196-1. Chlorides will be added by dissolving sodium NaCl in the mixing water. The amount of salt (expressed as grams of salt) to be dissolved in the mixing water of each batch shall be calculated in order to achieve the amount of chloride ions requested of the test (Cl test% by mass of cement).

B.3 Specimens

Ten cylindrical mortar specimens of diameter D (in mm) and height H (in mm) shall be prepared (see Figure B.1).



Key

1 electrical connection
2 insulating coating
3 mortar
4 stainless steel bar
d diameter of the stainless steel bar
D diameter of the mortar specimen
H height of the mortar specimen
L exposed length of the stainless steel bar

Figure B.1 — Geometry of the specimens

In order to prevent leaching of chloride at the depth of the bars during the test, the diameter *D* shall be chosen in order to provide a concrete cover thickness of at least 25 mm, i.e. it will be: $D \geq d + 2\times25$ (mm). *H* shall be 100 ± 20 mm. A bar of stainless steel, 100 ± 20 mm long and with diameter *d*, shall be embedded along the axis of each specimen, as shown in Figure B.1.

An electrical contact shall be applied to one end of each bar (e.g. by using a rivet) and, then, both ends of each bar shall be properly masked in order to electrically insulate the cut surfaces and the electrical contact. Crevice corrosion underneath the coating shall be prevented (the use of a thin layer of styrene-butadiene rubber modified cement mortar in contact with the steel, coated with an insulating polymeric material after hardening or lacomite may be suitable methods).

The exposed length of the bars shall be at least 60 mm. The exposed surface shall be degreased with acetone before casting.

Cylindrical moulds (made of plastic or steel) shall be prepared, in a way that the steel bars may be fixed vertically in along their axis. The fixing system shall be such that the cover depth c is in the range of ±2 mm respect to the nominal value.

The mould shall be filled by the test mortar and this shall be compacted in order to prevent both segregation and an excessive amount of entrapped air. The use of a vibrating table or manual tamping with a rod are suitable methods.

After casting specimens shall be cured in the mould maintained at 23 ± 2 °C and R.H. >95 %. After 24 h, the specimens shall be demoulded and immersed for 6 days in a cell of a capacity of about 1 litre, filled with a saturated solution of Ca(OH)2 until the time for testing.