DEAS 412-2:2022

ICS 91.080.40

DRAFT EAST AFRICAN STANDARD

Steel for the reinforcement of concrete — Part 2: Ribbed bars

EAST AFRICAN COMMUNITY

Fourth Edition 2022

Copyright notice

Contents

Page

Foreword

Development of the East African Standards has been necessitated by the need for harmonizing requirements governing quality of products and services in the East African Community. It is envisaged that through harmonized standardization, trade barriers that are encountered when goods and services are exchanged within the Community will be removed.

The Community has established an East African Standards Committee (EASC) mandated to develop and issue East African Standards (EAS). The Committee is composed of representatives of the National Standards Bodies in Partner States, together with the representatives from the public and private sector organizations in the community.

East African Standards are developed through Technical Committees that are representative of key stakeholders including government, academia, consumer groups, private sector and other interested parties. Draft East African Standards are circulated to stakeholders through the National Standards Bodies in the Partner States. The comments received are discussed and incorporated before finalization of standards, in accordance with the Principles and procedures for development of East African Standards.

East African Standards are subject to review, to keep pace with technological advances. Users of the East African Standards are therefore expected to ensure that they always have the latest versions of the standards they are implementing.

The committee responsible for this document is Technical Committee EASC/TC 035, *Steel and Steel Products*.

Attention is drawn to the possibility that some of the elements of this document may be subject of patent rights. EAC shall not be held responsible for identifying any or all such patent rights.

This third edition cancels and replaces the second edition (EAS 412-2:2013), which has been technically revised.

EAS 412 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 2: Ribbed bars

1 Scope

This East African Standard specifies technical requirements for ribbed bars to be used as reinforcement in concrete.

This part of EAS 412 covers:

a) ribbed bars supplied in straight lengths; and

b) eleven steel grades not intended for welding which are, B500A- R, B500B-R, B500C-R, B600A-R, B600B-R, B600C-R, B600D-R, B700A-R, B700B-R, B700C-R and B700D-R,

and six steel grades intended for welding which are, B500AWR, B500BWR, B500CWR, B500DWR, B550DWR and B600DWR.

NOTE The steel grades are designated with steel names allocated in accordance with ISO/TS 4949. The first “B” stands for steel for reinforcing concrete. The next 3 digits represent the specified characteristic value of upper yield strength. The fifth symbol stands for ductility class (see 3.5). The sixth symbol relates to welding; “-” means not intended for welding and “W” means intended for welding. The last “R” stands for ribbed bar.

This standard does not apply to ribbed bars produced from finished products, such as plates and railway rails.

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

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

ISO 10144, *Steels for the reinforcement and prestressing of concrete — Certification scheme for steel bars and wires*

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, wire rod 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 http://www.iso.org/obp

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

3.2
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

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

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

3.5
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 (see Table 6)

3.6
longitudinal rib
uniform continuous rib parallel to the axis of the bar

3.7
nominal cross-sectional area
cross-sectional area equivalent to the area of a circular plain bar of the nominal diameter

3.8
product analysis
chemical analysis carried out on the product

3.9

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

3.10
rib height, *a*
distance from one point on the rib to the surface of the core, to be measured normal to the axis of the bar (see Figure 2)

3.11
rib spacing, *c*
distance between the centres of two consecutive transverse ribs measured parallel to the axis of the bar (see Figure 1)

3.12
ribless perimeter, Σf_i
sum of the distances along the surface of the core between the end of the transverse ribs of adjacent rows measured as the projection on a plane perpendicular to the axis of the bar

3.13
transverse rib
rib at an angle, either perpendicular or oblique, to the longitudinal axis of the bar

3.14
transverse-rib flank inclination*α*
angle between the flank of a transverse rib and the core surface of a bar measured perpendicular to the longitudinal axis of the transverse rib (see Figure 2)

3.15
transverse-rib inclination, *β*
angle between the rib and the longitudinal axis of the bar (see figures 1, 3 and 4)

4 Symbols and/or abbreviated terms

The symbols used in this part of EAS 412 are listed in Table 1.

Table 1 — Symbols

Symbol	Unit	Description
a	mm	Rib height
A	%	Percentage elongation after fracture
*A*gt	%	Percentage total extension at maximum force
*S*0	mm2	Nominal cross-sectional area
b	mm	Top width of transverse rib at the mid-point
c	mm	Transverse rib spacing
d	mm	Nominal diameter of the bar
Σ*e*i	mm	Part of the circumference without rib
*f*k	—	Required characteristic value
*f*R	—	Relative rib area
k, k'	—	Indices
mn	—	Mean value of *n* individual values
n	—	Number of individual values
*R*eH	MPa[a]	Upper yield strength
*R*m	MPa[a]	Tensile strength
*R*p0,2	MPa[a]	0,2 % proof strength, plastic extension
sn	—	Standard deviation for *n* individual values
xi	—	Individual value
α	degree	Transverse rib flank inclination
β	degree	Transverse rib inclination
T	mm	width of longitudinal flat part of hot-rolled threaded bar
[a] 1 MPa = 1 N/mm^2.		

5 Requirements for dimensions, mass per unit length and permissible deviations

The delivery length of bars shall be 6 m or 12 m permissible deviation on delivery length from rolling mill shall be $^{+100}_{0}$ mm. However, manufacturer and purchaser may agree on special ordered lengths upon notification to the regulator.

Dimensions, mass per unit length and permissible deviations shall be as given in Table 2.

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

Nominal bar diameter[a] d mm	Nominal cross-sectional area[b] A_n mm^2	Mass per unit length	
		Requirement[c] kg/m	Permissible deviation[d] %
6	28.3	0.222	± 6
8	50.3	0.395	± 6
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
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 Diameters larger han 50 mm shld be agreed beten the purchaser and manufacturer. The permsible deviaton n suc bars shall be ± 4 %.

b $A_n = 0.785\ 4 \times a^2$

c Mass per unit length = $7.85 \times 10^{-3} \times A_n$

d Permissible deviation refers to a single bar

6 Requirements for ribs

Ribbed bars shall have transverse ribs. 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.

Longitudinal ribs may or may not be present.

Ribs shall conform to the requirements in Table 3.

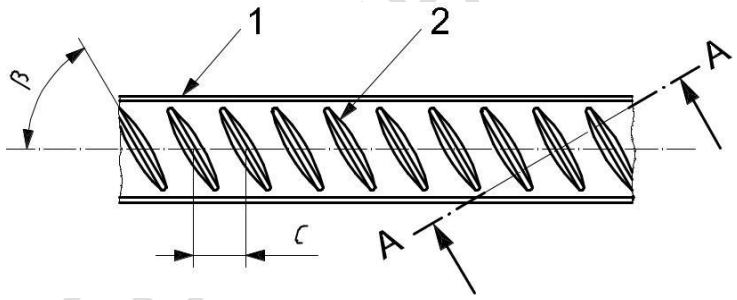
Table 3 — Requirements for ribs

	Nominal diameter d mm	**Ribs of uniform height**	**Crescent-shaped ribs**
Rib height, a, min.	All	0.05d	0.065d
Rib spacing, c	6 ≤ d< 10	0.5d ≤c ≤ 0,7d	0,5d ≤ c ≤ 1,0d
Range	d >10	0,5d ≤ c ≤ 0,7d	0,5d ≤ c ≤ 0,8d
Transverse-rib inclination, β	All	35° ≤ β ≤ 90°	35° ≤ β ≤ 75°
Transverse-rib flank inclination, α	All	α ≥45°	α ≥45°
Ribless perimeter, $\Sigma f_{i,\ max}$	All		0.25$d\pi$

Requirements for rib parameters may be specified by the relative rib area, 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 4.

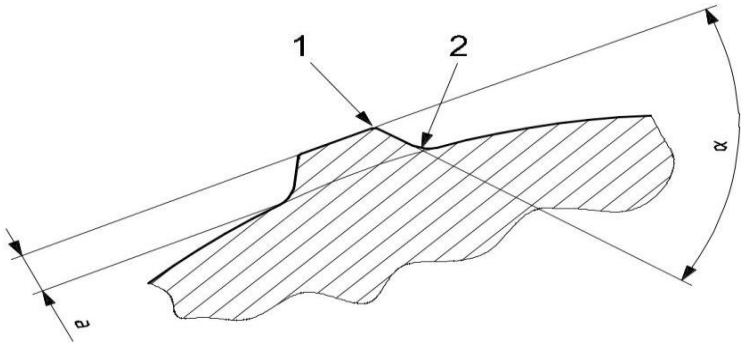
When longitudinal ribs are present, their height shall not exceed 0.15d.



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, and rib height, a — Section A-A from Figure 1

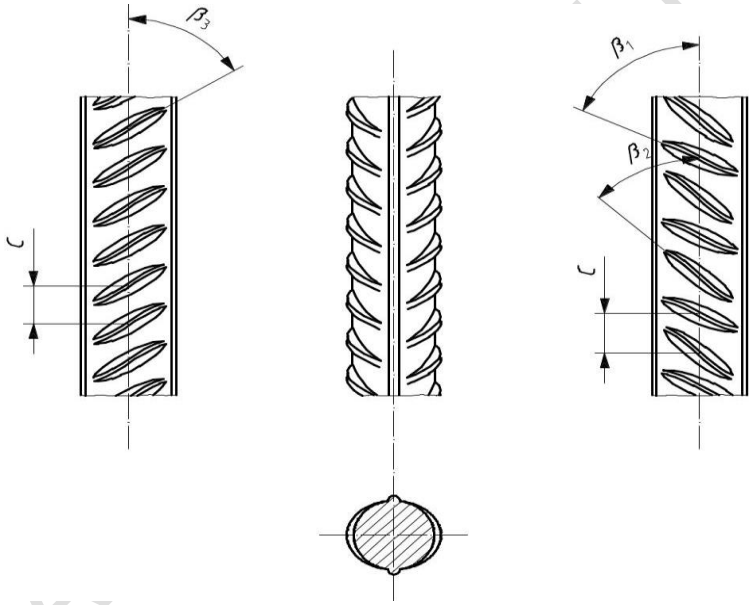


Figure 3 — Example of bar with varying rib inclinations to the longitudinal axis

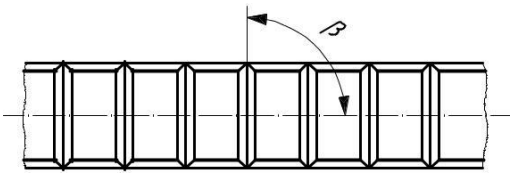


Figure 4 — Example of bar with transverse ribs of uniform height (β= 90°)

7 Chemical composition

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

The carbon equivalent value, CEV, is calculated as follows:

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

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

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]
B500A-R B500B-R B500C-R	—	—	—	0,060	0,060	—	—
B600A-R B600B-R B600C-R	—	—	—	0,060	0,060	—	—
B700A-R B700B-R B700C-R	—	—	—	0,060	0,060	—	—
B500AWR B500BWR B500CWR	0,22	0,60	1,60	0,050	0,050	0,012	0,50
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.

The permissible deviation of the product analysis relative to the cast analysis as specified in Table 4 are given in Table 5.

Table 5 — 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 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 material shall conform to the requirements for tensile properties specified in Table 6 when tested in accordance with 9.1.

In the context of this standard, 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.

Table 6 — Tensile properties

Ductility class	Steel grade	Specified characteristic value of upper yield strength R_{eH} N/mm^2		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	B500A-R B500AWR	500	-	1.02	14	2
	B600A-R	600	-		10	
	B700A-R	700	-		8	
B	B500B-R B500BWR	500	-	1.08	14	5
	B600B-R	600	-		10	
	B700B-R	700	-		8	
C	B500C-R B500CWR	500	-	1.15	14	7
	B600C-R	600	-		10	
	B700C-R	700	-		8	
D	B500D-R	500	1.25 × R_{eH}(min.)	1.25	13 [b]	8
	B500DWR		1.3 x R_{eH}(min.)		13 [b]	
	B600D-R	600	1.2 x R_{eH}(min.)		10 [b]	
	B700DWR	700	1.2 x R_{eH}(min.)		10 [b]	

[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.

[b] In the case of the bars with diameter 32 mm or more 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

If required by the purchaser, the bend test shall be performed in accordance with 9.2. After testing in accordance with 8.2, the bar shall show neither rupture nor cracks visible to a person of normal or corrected vision.

8.3 Rebending properties after aging

The rebend 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.

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

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 9.4.

The specified number(s) of stress cycles, stress range(s) 2σa and maximum stress(es) σmax 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 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.

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 7.

Table 7 — Mandrel diameter to be used for the bend test

Dimensions in millimetres

Nominal bar diameter *d*	**Mandrel diameter**(max.)[a, b]
≤16	3*d*
16 < *d* ≤ 32	6*d*
32 < *d* ≤ 50	7*d*
[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 8.

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.

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

Dimensions in millimetres

bar diameter *d*	**Mandrel diameter**(max.)[a, b]
≤16	5*d*
16 < *d* ≤ 25	8*d*
25 < *d* ≤ 50	10*d*
[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 Fatigue test

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

9.5 Chemical analysis

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 reference method specified in one of the International Standards listed in ISO/TR 9769.

10 Designation

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

a) a reference to this standard;

b) nominal diameter, in millimetres, according to Table 2; and

c) steel grade.

EXAMPLE

Reinforcing steel EAS 412-2 – 12 B500CWR

11 Marking

11.1.1 Each bar shall be legibly and indelibly marked with the following:

a) manufacturers name or logo;

b) steel grade; and

c) nominal diameter at interval of at most 1.5 m.

11.1.2 Each bundle shall be marked with the following:

a) manufacturers name or logo;

b) steel grade;

c) country of origin;

d) nominal diameter; and

e) batch/cast number at the time of dispatch from the manufacture premises.

12 Evaluation of conformity

12.1 General

Certification and inspection of reinforcement shall be performed in accordance with a certification scheme monitored by an external body, or according to acceptance testing of a specific delivery.

12.2 Certification scheme

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

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 steel not subject to a certification 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 according to an 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 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); and

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 standard.

12.3.2.3 Evaluation of the results

12.3.2.3.1 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); and

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:

$$m_{15} - 2.33 \times s_{15} \geq f_k$$

where

f_k is the specified characteristic value; and

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).

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

If the condition stated above is not fulfilled, the index

$$k' = \frac{m_{15} - f_k}{s_{15}} \quad (4)$$

is determined from the test results available. Where $k' \geq 2$, 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:

$$m_{60} - 1.93 \times s_{60} > f_k \quad (5)$$

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).

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 standard. In this case, the test unit shall be considered to comply with the requirements.

The tests may be continued when at most two 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 two 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 standard.

12.3.3 Evaluation of specified minimum/maximum values

Tests shall be carried out according to the following:

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

b) Each individual test result shall meet the required values in Table 6, and the required bending properties in 8.2 and 8.3.

c) One cast analysis shall be carried out for every cast to verify chemical composition (Clause 7). Samples shall be taken in accordance with ISO 14284.

d) If any test result does not meet the requirements, retests may be carried out, according to ISO 404.

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

12.3.4 Test report

The test report shall contain but not limited to the following information:

a) designation of the reinforcing steel in accordance with this standard;

b) marking on the reinforcing steel;

c) date of testing;

d) mass of the test unit; and

e) test results.

Bibliography

[1] EAS 412-2: 2019, *Steel for the reinforcement of concrete —Part 2: Ribbed bars.*

[2] IS 1786: 2008, *High strength deformed bars and wires for concrete reinforcement - Specification*

[3] ISO 6935-2: 2019, *Steel for the reinforcement of concrete — Part 2: Ribbed bars*.

