

September 1985

REINFORCEMENTS FOR CONCRETE - WELDED WIRE LATTICE
AND COMPONENTS

F : Armatures pour béton armé - Treillis soudés et éléments
constitutifs.

D : Stahlbetonbewehrung - Geschweisste Drahtmatten und
Bestandteile

French Standard certified by Decision of the Director
General of l'AFNOR (French Standards Institution) on
20 August 1985 to take effect from 20 September 1985.

Supersedes Standards NF A 35-020, NF A 35-021 and
NF A 35-022 of April 1980.

Correspondence There are no international standards dealing with this
subject.

Analysis This standard lays down the geometric characteristics,
mechanical and engineering properties together with the
conditions for testing welded wire lattice and its
components (plain wires or deformed wires).

Descriptors International Technical Thesaurus : reinforcement : structures,
welded wire lattice, geometric characteristics, mechanical
properties, acceptance testing, tests, designation, marking.

Modifications

The main modifications relate to:

- The presentation of the properties relating to welded wire lattice and its components in a single document, instead of three documents;
- The introduction of half-diameters;
- The maintaining of a single grade corresponding to a minimum value of $R_{p0,2} = 500 \text{ N/mm}^2$;
- The deletion of continuous ribbed sections in the deformed wires.

Corrections

 CONTENTS

	Page
1. SCOPE	3
2. FIELD OF APPLICATION	3
3. REFERENCES	4
4. CHARACTERISTICS AND PROPERTIES OF WELDED WIRE LATTICE	4
4.1 General	4
4.2 Geometric characteristics	4
4.3 Mechanical properties	6
4.4 Engineering properties	6
5. CONFORMITY WITH THE STANDARD	7
5.1 General	7
5.2 Delivery of products from which the test pieces are taken	7
6. SAMPLING AND PROOF OF ACCEPTANCE TESTING	8
6.1 Formation of batches	8
6.2 Acceptance unit	8
7. TEST METHODS	8
7.1 Tensile test	8

	Page
7.2 Bend test	9
7.3 Shear strength test	9
7.4 Test cancellation	9
7.5 Interpretation of results	9
8. DESIGNATION AND MARKING	10
8.1 Designation	10
8.2 Marking	12
APPENDIX A - Plain wires for manufacturing welded wire lattice	12
APPENDIX B - Deformed wires for manufacturing welded wire lattice	17

1. SCOPE

The purpose of this standard is to lay down the geometric characteristics, mechanical and engineering properties together with the conditions for testing welded wire lattice for reinforced concrete.

The purpose of the Appendices A and B, which form an integral part of the standard, is to lay down the geometric characteristics, mechanical and engineering properties, together with the shape parameters of the components of the welded wire lattice (1).

2. FIELD OF APPLICATION

This standard relates to prefabricated reinforcement which is in the form of flat lattices made up of plain or deformed wires or bars, of diameters between 3 and 16 mm inclusive, which are joined rigidly together into rectangular meshes.

The components are:

Either the reinforcement defined by Standard NF A 35-016, subject to

- (1) *The components of the welded wire lattice are usually obtained by cold working (cold drawing or rolling) of rod. Other forming processes can be used provided that the requirements of this standard are satisfied.*

compliance with the mechanical properties and the weldability defined in Appendices A and B of this standard;

Or reinforcement specific to the welded wire lattice defined in Appendices A and B.

The components are joined by resistance welding of each cross-over point, carried out in the factory on automatic machines.

The components in the same direction shall be of the same type (plain or deformed).

3. REFERENCES

- NF A 03-151 Iron and steel products - Tensile test on steel.
- NF A 03-157 Bend test on steel.
- NF A 03-705 Iron and steel products - Tensile test on wires.
- NF A 35-016 Reinforcement - Deformed bars and rod for reinforced concrete.
- NF A 35-018 Reinforcement - Suitability for welding.
- NF A 35-023 Reinforcement - Shear strength testing of cruciform welded joints.
- NF A 35-052 Carbon steel rod for welded wire lattice - Grades.

4. CHARACTERISTICS AND PROPERTIES OF WELDED WIRE LATTICE

4.1 General

The welded wire lattice can be in the form of sheets or rolls.

4.2 Geometric characteristics

The geometric characteristics of a welded wire lattice are: (see paragraph 8.1, Figure 1):

Length L and width l ;

Diameters D and d of the constituent plain or deformed wires;

Mesh dimensions E and e , in both directions;

The difference in diameter between two joined components;
Tolerances on the dimensions.

4.2.1 Mesh dimensions

The mesh dimensions, measured by the pitch between the axes of the components, are preferably selected from among the following nominal values, expressed in millimetres:

75 100 125 150 200 250 300

The pitch between parallel components can be constant or varying in an irregular fashion from one place in the lattice to another.

The value of 75 mm between axes of parallel components may only be permissible if the nominal diameter of these components does not exceed 12 mm.

When the components are arranged in bundles or two on the same side of the transverse bar (1), the mesh dimensions are measured between centres of gravity of the bundles. The value of 75 mm is then only permissible for components of nominal diameter not exceeding 8 mm.

4.2.2 Difference in diameter between joined components

The difference in diameter between components joined by welding to form a welded wire lattice shall not be more than the values given in the following table:

Maximum difference in diameter between joined components (mm)	Diameter of the largest component (mm)				
	3 to 5,5	6 to 7	7,5 to 9	9,5 to 12	14 and 16
	1,5	2	3	4	6

4.2.3 Tolerances

The tolerances relate to the following dimensions:

- (1) *Provision shall be made for a gap of 2 mm for welded wire lattice manufactured using plain wires.*

- Distance between two components: $\pm 5\%$;
- Distance between two components separated by ten meshes: $\pm 1\%$;
- Length of the components: $\pm 0,5\%$;
- Length and width of a lattice: $\pm 1\%$.

The squareness tolerance is such that the difference in length of the two diagonals of the sheet do not exceed 2% of their average length. The distance joins the two end cross-over points of the wires in the sheet.

4.3 Mechanical properties

The guaranteed mechanical properties (R_m , $R_{p0,2}$, A) are those of the components (see Appendices A and B).

These properties are measured on component parts which incorporate a transverse welded component in their middle. The test methods to be used are those described in the relevant standards relating to the components.

In all cases, the specified minimum value of the yield stress is 500 MPa.

4.4 Engineering properties

In addition to the engineering properties specific to the component parts, consideration must be given to the following:

- The suitability of component parts for ensuring mechanical bonds, denoted by the shear strength of the welded joints;

- The suitability of the lattice to ensure the mechanical bonds between it and the surrounding concrete;

- The ease of bending the welded component parts.

4.4.1 Shear strength of welded joints

The force for breaking the joint shall be at least equal to a third of the product of the nominal cross-sectional area of the largest diameter component by the guaranteed yield stress for this diameter.

4.4.2 Suitability of the lattice for ensuring mechanical bonds between it and the surrounding concrete

For welded wire lattice made up of plain components, the cracking coefficient is taken as 1.

For welded wire lattice made up of deformed components, the cracking coefficient is taken as 1,6 for diameters not less than 6 mm, to 1,3 for diameters below 6 mm. The embedding factor is taken as 1,5.

4.4.3 Ease of bending

The ease of bending is considered satisfactory if no breaking, splitting or cracking appears at the weld, during the bend test.

5. CONFORMITY WITH THE STANDARD

5.1 General

A batch of welded wire lattices is considered to comply with this standard:

If it comes from a producer who is subject to certification (1); in this case, products are tested by the producer under the conditions defined by the certification. They are usually only subjected by the user to an identification check and by visual examination;

Or if it is subject to acceptance tests usually carried out in the factory before despatch (2) in accordance with the rules defined in paragraph 6.

5.2 Delivery of products from which the test pieces have been taken

The sheets used for manufacturing inspection can be accepted on the basis of:

Either two short sheets for 5 t,

-
- (1) *At the date of publication of this standard, this is an approval certificate from the "Interdepartmental Committee for Certification and Testing of Reinforcements for reinforced concrete".*
- (2) *If it was not possible for the products to be acceptance tested before despatch, testing in accordance with the procedure defined in this standard shall be carried out by an authorized agency before use.*

Or one cut-out sheet per tonne, where the number of cross-pieces taken from this sheet may not be more than 4.

These sheets will have a special label affixed to draw the user's attention to their abnormal nature:

Short sheet,

Sheet to be reinforced at the cut-outs.

6. SAMPLING AND PROOF OF ACCEPTANCE TESTING

6.1 Formation of batches (see paragraph 5.1)

Acceptance tests are carried out on each batch corresponding to the same series of operations on the same welding machine carried out in the same workstation for a maximum period of 9 h. The batch is formed of welded wire lattice for which the components are of the same type in each direction.

6.2 Acceptance unit

The welded wire lattice is presented one batch at a time in the as-delivered condition.

For each acceptance unit (batch), 12 series of tests are carried out on cruciform welded joints, each series comprising:

- 1 tensile test;
- 1 bend test through 135°;
- 1 shear strength test.

7. TEST METHODS

7.1 Tensile test

The test is carried out in accordance with Standard NF A 03-705 for the wires, and with Standard NF A 03-151 for the bars and rods, the test piece having a welded transverse component in its middle.

This test can be carried out in the artificially aged condition (heating at

250°C for 30 min or at 100°C for 4 h and cooling in air).

7.2 Bend test

The bend is made on the largest component, positioning the weld junction on the face under tension, level with the bend radius. The diameter of the former, depending on the diameter of the wire, is given in the following table:

Wire diameter (mm)	Former diameter (mm)
$d \leq 12$	6 d
$12 < d \leq 16$	8 d

The test is stopped when the included angle reaches 135°.

7.3 Shear strength test

A shear strength test is carried out on the welded joint in accordance with Standard NF A 35-023.

7.4 Test invalidation

Any procedural error results in the invalidation of the test.

A procedural error must be taken as meaning incorrect mounting in the testing machine, incorrect operation of the latter or any other similar error.

7.5 Interpretation of results

No result shall be less than the limit; in addition, for $R_{p0,2}$ and R_m , the value of $m_{12} - 2,74 S_{12}$ shall not be less than the specified value,

$$\text{with } m_{12} = \sum_{i=1}^{12} \frac{x_i}{2}$$

$$\text{and } S_{12} = \sqrt{\frac{\sum (x_i - m_{12})^2}{11}}$$

The batch is considered as not complying if these conditions are not satisfied.

8. DESIGNATION AND MARKING

8.1 Designation

Barring special details (1), the welded wire lattice for which the nominal diameter and pitch of wires are constant in the same direction are defined by listing in succession:

The indication of the plain or deformed characteristic in the form of L (plain) or HA (deformed),

The nominal diameters, D and d, expressed in millimetres,

The mesh dimensions, E and e, expressed in millimetres,

The total length L and the total width l, expressed in millimetres,

The lengths, in millimetres, of the overhangs AV (front), AR (rear), ad (right-hand), ag (left-hand), at each of the ends.

(1) *For example, these details can correspond to the trade descriptions of standard products.*

	Direction 1	Direction 2
Diameter.....	D	d
Pitch	E	e
Length	L	l
Overhang	AV	ad
Overhang	AR	ag

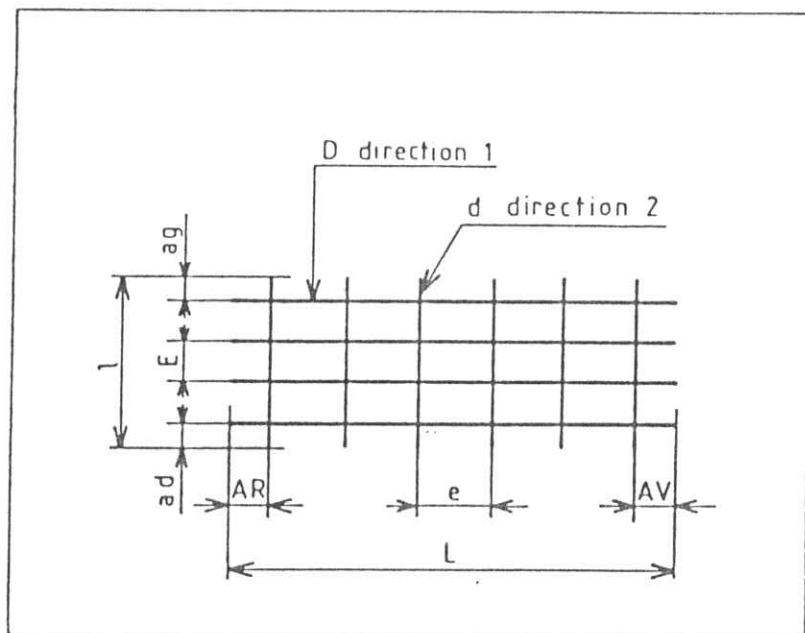


Figure 1 - Designation and allocation of symbols for the geometric characteristics of welded wire lattice

This list is drawn up for the component parts in each direction usually starting with the longest components (1).

A dimensioned drawing is always desirable in order to avoid any ambiguity; it is necessary when:

The dimensions of the overhangs result in a complete absence of symmetry,
The nominal diameters of the wires and/or their pitch are not constant in the same direction.

(1) In some special cases, the largest diameter may happen to be associated with the shortest wire.

8.2 Marking

Waterproof manufacturer labels shall be affixed to the lattices and clearly indicate the name of the production plant and the designation of the welded wire lattice on the basis of one label per roll or at least one label per bundle of sheets securely bound together.

APPENDIX A

PLAIN WIRES FOR MANUFACTURING WELDED WIRE LATTICE

(The contents of this Appendix form an integral part of Standard NF A 35-022)

CONTENTS

	Page
A.1 Scope and field of application	12
A.2 Characteristics and properties of plain wires	13
A.2.1 Geometric characteristics	13
A.2.2 Guaranteed mechanical properties	13
A.2.3 Guaranteed engineering properties	14
A.3 Test conditions	14
A.3.1 Tensile test	14
A.3.2 Bend test	15
A.3.3 Rebend test	15
A.3.4 Weldability	15
A.3.5 Other tests	15

A.1 Scope and Field of Application

The purpose of this appendix is to lay down the mechanical properties and geometric characteristics of plain wires, used for manufacturing welded wire

lattice, obtained by cold drawing and/or rolling of rods with reduction in cross-sectional area.

The characteristics and properties that the grades of rod for manufacturing welded wire lattice from plain wires shall satisfy are defined by Standard NF A 35-052.

A.2 Characteristics and Properties of Plain Wires

A.2.1 Geometric Characteristics

A.2.1.1 Nominal diameters

The range of nominal diameters of plain wires, expressed in millimetres, is as follows:

3 3,5 4 4,5 5 5,5 6 6,5 7 7,5 8 8,5 9 9,5
10 10,5 11 11,5 12

A.2.1.2 Tolerances

The tolerances on the nominal diameters are:

$\pm 0,10$ mm for $d \leq 6$ mm

$\pm 0,15$ mm for $d > 6$ mm.

A.2.2 Guaranteed Mechanical Properties

For plain wires, the guaranteed minimum values of the mechanical properties are as follows:

Grade	$R_{p0,2}$ (N/mm ²) (1)	R_m (N/mm ²) (1)	A % measured over $L_0 = 5d$
TLE 500	500	550	8
(1) 1 N/mm ² = 1 MPa. 32.4 TPa 35 TPa			

A.2.3 Guaranteed Engineering Properties

A.2.3.1 The engineering properties to be taken into consideration are:

The absence of defects detrimental to use;

The suitability for cold bending denoted by the minimum diameters of the formers for the bend tests and for the rebend tests;

The absence of embrittlement, denoted by the minimum diameter of the former for the rebend tests;

The suitability for cruciform resistance welding.

A.2.3.2 The maximum diameters of bending former for the 180° bend test and for the rebend test are 3,5 d and 6 d respectively.

A.3 Test Conditions

Except for concessions specified hereinafter, the tests are carried out in accordance with the French Standards in force.

A.3.1 Tensile Test

The mechanical properties are measured in accordance with the procedure defined by NF A 03-705.

A.3.1.1 *Definition of the guaranteed yield stress*

The guaranteed yield stress is the 0,2% yield stress.

A.3.1.2 The yield stress and strength values are calculated referring the loads obtained to the nominal cross-sectional area and not to the actual cross-sectional area of the wire.

A.3.1.3 For measuring the elongation, as an exception, the test piece used has a length between gauge marks given by the equation:

$$L_0 = 5 d$$

where d is the nominal diameter.

The test piece is formed by a length of untreated wire.

A.3.1.4 For diameters not exceeding 6 mm, the elongation at break is not measured in routine testing.

A.3.2 Bend Test

The test is carried out at an angle of 180° on a test piece formed by a length of untreated wire, in accordance with Standard NF A 03-157.

A.3.3 Rebend Test

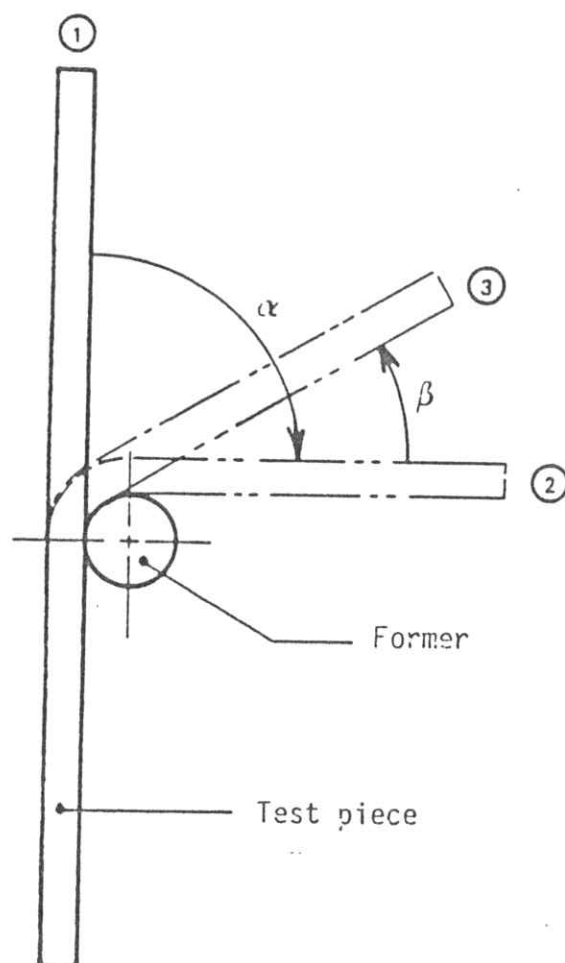
The test is carried out on a test piece formed by a length of untreated wire; the wire is first bent through an angle of 90° , then, after immersion for half an hour in boiling water (100°C), and cooling in air, it is bent back through an angle of 30° (see Figure 2).

A.3.4 Weldability

The plain wires shall satisfy the conditions of suitability for cruciform resistance welding, in accordance with Standard NF A 35-018.

A.3.5 Other Tests

If consideration is given to tests other than those in this standard, they shall be covered by special agreements between the parties.



- ① Test piece before bending
- ② Test piece bent through an angle $\alpha = 90^\circ$
- ③ Test piece bent back through an angle $\beta = 30^\circ$

Figure 2 - Explanatory diagram of the rebend test

APPENDIX B

DEFORMED WIRES FOR MANUFACTURING WELDED WIRE LATTICE

(The contents of this Appendix form an integral part
of Standard NF A 35-022)

CONTENTS

	Page
B.1 Scope and field of application	17
B.2 Definitions	18
B.3 Characteristics and properties of deformed wires	18
B.3.1 Geometric characteristics	18
B.3.2 Guaranteed mechanical properties	19
B.3.3 Engineering properties	19
B.4 Shape parameters	20
B.4.1 Indented sections	20
B.4.2 Ribbed sections	21
B.5 Measurement of shape parameters	22

B.1 Scope and Field of Application

The purpose of this appendix is to lay down the geometric characteristics, mechanical and engineering properties of deformed wires, used for manufacturing welded wire lattice, obtained by cold drawing and/or cold rolling of rods with a reduction in cross-sectional area.

The characteristics and properties that the grades of rod for manufacturing welded wire lattice formed by deformed wires shall satisfy are defined by Standard NF A 35-052.

B.2 Definitions

Wires for which the shape parameters satisfy the requirements (see paragraph B.4) are considered deformed.

For wires not satisfying these requirements, the bond strength is verified by comparative tests making it possible to ensure that the bond coefficients are at least equal to those of the wires defined by this standard (see paragraph 4.4.2).

B.3 Characteristics and Properties of Deformed Wires

B.3.1 Geometric Characteristics

The geometric characteristics are the nominal diameter, the nominal cross-sectional area and the nominal perimeter.

The nominal diameter of a deformed wire is that of a plain cylinder of the same linear mass.

The nominal cross-sectional area of a deformed wire is equal to the area of the circle of diameter equal to the nominal diameter.

The nominal perimeter of a deformed wire is equal to the perimeter of the circle of diameter equal to the nominal diameter.

B.3.1.1 *Nominal diameters*

The nominal diameters, in millimetres, of deformed wires are as follows:

4	4,4	5	5,5	6	6,5	7	7,5	8	8,5	9	9,5	10	10,5
				11	11,5	12	14	16					

B.3.1.2 *Shape parameters*

These parameters (height, pitch, length, tilting of indentations or projections) are defined in paragraph B.4.

B.3.1.3 Tolerances on mass per metre run (1)

The deformed wires are subject to a tolerance on the mass per metre run: the mass per metre run of the wire taken from any cross-section shall not deviate from the mass calculated from the nominal diameter by more than:

$\pm 5\%$ for $4 \leq d \leq 8$ mm

$\pm 4\%$ for $8,5 \leq d \leq 16$ mm.

B.3.2 Guaranteed Mechanical Properties

The minimum guaranteed values of the mechanical properties for the deformed wires are as follows:

Grade	$R_{p0.2}$ (N/mm ²) (1)	R_m (N/mm ²) (1)	A % measured over $L_0 = 5d$
Fe TE 500	500	550	8
(1) $1 \text{ N/mm}^2 = 1 \text{ MPa}$.			

B.3.3 Engineering Properties

B.3.3.1 Defects

The deformed wires shall not have defects detrimental to their use.

B.3.3.2 Rebend test

The steel shall withstand bending following by rebending round a former diameter given by the following table:

Table - Former diameter with respect to wire diameter

Grade	Rebend test	
	Wire diameter (mm)	Former diameter (mm)
Fe TE 500	$d \leq 12$	6d
	$12 < d \leq 16$	8d

(1) This is obtained by allocating a density of $7,85 \text{ kg/dm}^3$ to the steel.

The wire is first bent through an angle of 90° , then after immersion for half an hour in boiling water (100°C) and cooling in air, it is bent back through an angle of 30° (see Figure 2).

B.3.3.3 Weldability

The deformed wires shall satisfy the conditions of suitability for cruciform resistance welding defined in Standard NF A 35-018.

B.4 Shape Parameters

B.4.1 Indented Wires (see Figure 3)

These profiles contain at least 3 series of indentations.

The parameters defining the shape are:

The depth "a" of the indentations,

The width "b" of the bossing between two successive indentations of the same series,

The spacing "c" of the indentations,

The angle " β " of the indentations with respect to the longitudinal axis of the bar.

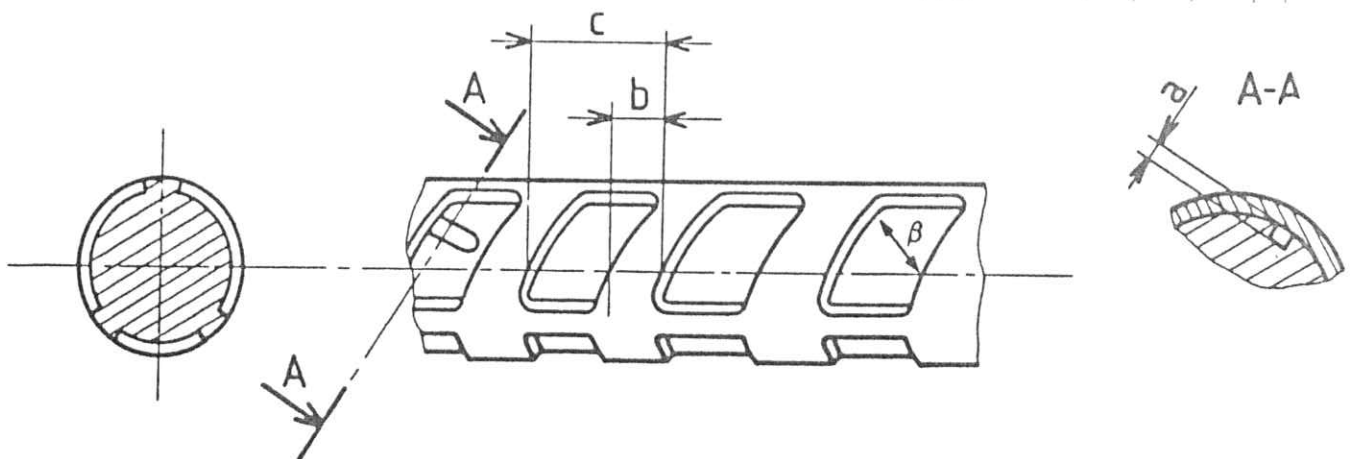


Figure 3 - Example of indented wire

The indentations shall cover approximately 80% of the periphery of the wire, calculated from the nominal diameter. The angle " β " shall be at least 45° .

The values of "b" and "c" are related by the condition $b \leq c$.

d (mm)	a min. (mm)	b min. (mm)	c max. (mm)
4	0,20	1	7
4,5	0,20	1	7
5	0,20	1	7
5,5	0,20	1	7
6	0,30	1	11
6,5	0,30	1	11
7	0,30	1	11
7,5	0,30	1	11
8	0,30	1	11
8,5	0,33	1	11
9	0,33	1	11
9,5	0,33	1	11
10	0,33	2	11
10,5	0,35	2	11
11	0,35	2	11
11,5	0,35	2	11
12	0,35	2	11
14	0,45	3	11
16	0,45	3	11

B.4.2 Ribbed Wires (see Figure 4)

The wires have a cylindrical body containing three areas without ribs alternating with three convex areas incorporating ribs.

The parameters defining the shape are:

The height "a" of the ribs,

The spacing "c" of the ribs,

The angle " β " of the ribs with respect to the axis of the bar.

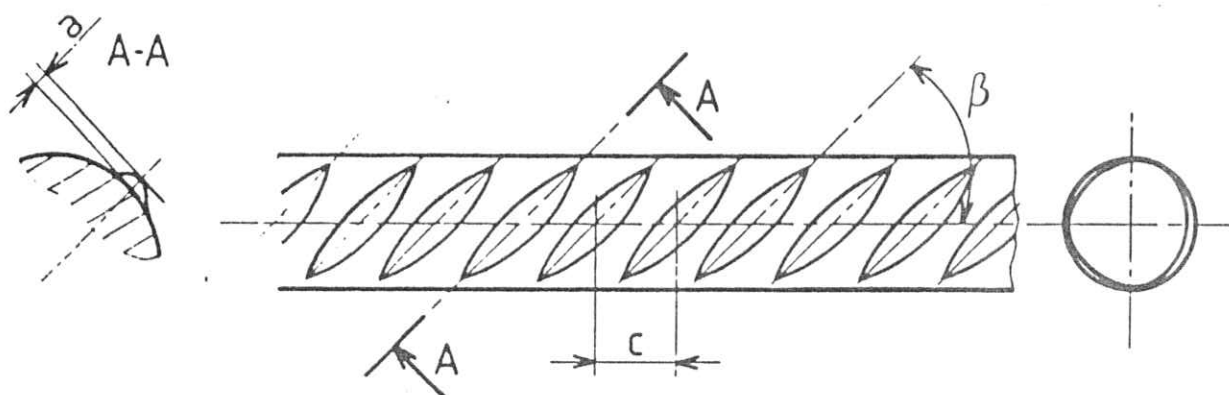


Figure 4 - Example of ribbed wire

The ribs shall extend over approximately 80% of the wire calculated from the nominal diameter.

The angle of the ribs with respect to the longitudinal axis of the bar shall be between 35° and 75° inclusive.

Nominal diameter	Height of ribs	Rib spacing		
d (mm)	a (mm)	c (mm)		
	min.	average	min.	max.
4	0,26	4	3,2	4,8
4,5	0,28	4,2	3,4	5,0
5	0,32	4,5	3,8	5,4
5,5	0,35	4,8	4,0	5,6
6	0,39	5,1	4,1	6,1
6,5	0,42	5,4	4,4	6,4
7	0,45	5,6	4,6	6,6
7,5	0,48	5,8	4,8	6,8
8	0,52	6,0	5,0	7,0
8,5	0,54	6,2	5,2	7,2
9	0,58	6,3	5,3	7,3
9,5	0,61	6,4	5,4	7,4
10	0,65	6,5	5,5	7,5
10,5	0,68	6,8	5,8	7,8
11	0,71	6,9	5,9	7,9
11,5	0,74	7,0	6,0	8,0
12	0,78	7,2	6,1	8,3
14	0,91	8,4	7,1	9,7
16	1,04	9,6	8,2	11,0

B.5 Measurement of Shape Parameters

B.5.1 Measurement of Height "a"

The depth of the indentations or the height of the ribs "a" shall be measured at the place where it is maximum.

B.5.2 Measurement of the Spacing "c"

The average spacing "c" of the indentations or of the ribs is obtained by taking a tenth of the length of a section with a straight generating line containing eleven indentations or ribs.

For sections with continuous helical ribs, the spacing "c" of the discontinuous embossings is obtained by taking the distance between two equivalent points of two separate embossings in the pitch of the continuous ribs and by dividing this distance by the number of spacings counted by following a helix parallel to the continuous ribs.