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Steel wire rope net panels and rolls — Definitions and specifications

National foreword

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**Steel wire rope net panels and rolls —
Definitions and specifications**

*Panneaux et rouleaux de filet en câble d'acier — Définitions et
spécifications*



Reference number
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Contents

Page

Foreword	iv
1 Scope	1
2 Normative references	1
3 Terms and definitions	1
4 Description of use and applications	2
5 Wire rope net panels	2
5.1 General.....	2
5.2 Double knot.....	4
5.3 Clips or staple knot.....	4
5.4 Without connection clips.....	4
6 Properties of wire used in knots	5
6.1 Mechanical properties.....	5
6.2 Coating properties.....	6
7 Wire rope properties	6
8 Rope net properties	6
8.1 Ageing and corrosion resistance.....	6
8.1.1 Zn class B.....	6
8.1.2 Zn class A.....	6
8.1.3 Zn95Al5 class B.....	6
8.1.4 Zn95Al5 class A.....	6
8.1.5 Advanced metallic coatings (as Zn90Al10) class B.....	6
8.1.6 Advanced metallic coatings (as Zn90Al10) class A.....	6
8.1.7 Additional organic coating.....	6
8.2 Maximum breaking load of knot.....	7
8.3 Maximum load of tear break of knot.....	7
8.4 Rope net tests (longitudinal tensile test with no lateral contraction and load bearing capacity test).....	8
9 Sampling and testing	8
10 Inspection and documentation	8
Annex A (informative) Possible metallic coating options	9
Annex B (informative) Load bearing capacity tests	11
Annex C (informative) Net tensile strength (longitudinal tensile test with no lateral contraction)	17
Bibliography	19

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.

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The committee responsible for this document is ISO/TC 17, *Steel*, Subcommittee SC 17, *Steel wire rod and wire products*.

Steel wire rope net panels and rolls — Definitions and specifications

1 Scope

This International Standard specifies the characteristics of steel wire rope net panels and rolls for retaining of unstable slopes controlling and preventing rockfalls and loose debris flow along roads, highways and railway, urban areas, mines and quarries, and for snow avalanche protection.

Steel wire rope net panels and rolls are produced from metallic-coated wire ropes.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 2408, *Steel wire ropes for general purposes — Minimum requirements*

ISO 7500-1, *Metallic materials — Calibration and verification of static uniaxial testing machines — Part 1: Tension/compression testing machines — Calibration and verification of the force-measuring system*

ISO 7989-1, *Steel wire and wire products — Non-ferrous metallic coatings on steel wire — Part 1: General principles*

ISO 7989-2:2007, *Steel wire and wire products — Non-ferrous metallic coatings on steel wire — Part 2: Zinc or zinc-alloy coating*

ISO 10474, *Steel and steel products — Inspection documents*

ISO 22034-1, *Steel wire and wire products — Part 1: General test methods*

EN 10204, *Metallic products — Types of inspection documents*

3 Terms and definitions

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

3.1

wire rope net panel

panel made from *wire rope* (3.2) or ropes arranged in a plain structure and connected at the points of overlapping by wire knots, by interlinking of the wire ropes or by metallic *clips* (3.5)

3.2

wire rope

standard steel wire ropes according to ISO 2408

3.3

wire rope net sizes

average value of the net dimensions

Note 1 to entry: Distance between two ropes in the same direction.

3.4

knot

point of connecting, overlapping or crossing of the net wire ropes

Note 1 to entry: A knot can be released using wires, *clips* (3.5) or by twisting the wrapping ropes.

3.5

clips

metallic shell-like elements with fastening tabs to be used for forming connections between adjacent ropes

3.6

knot without clips

knot (3.4) of panel in which the overlapping points of the wrapping ropes are connected by twisting the *wire ropes* (3.2)

3.7

nominal net size

distance between two junctions when measured along any single rope

3.8

dimensions of a panel

length and width expressed in metres

3.9

advanced metallic coating

metallic coating with a not specified composition having a superior corrosion resistance

4 Description of use and applications

The typical use for the considered products is retaining of unstable slopes, controlling and preventing rockfalls and loose debris flow along roads, highways and railway, urban areas, mines and quarries, and for snow avalanche protection.

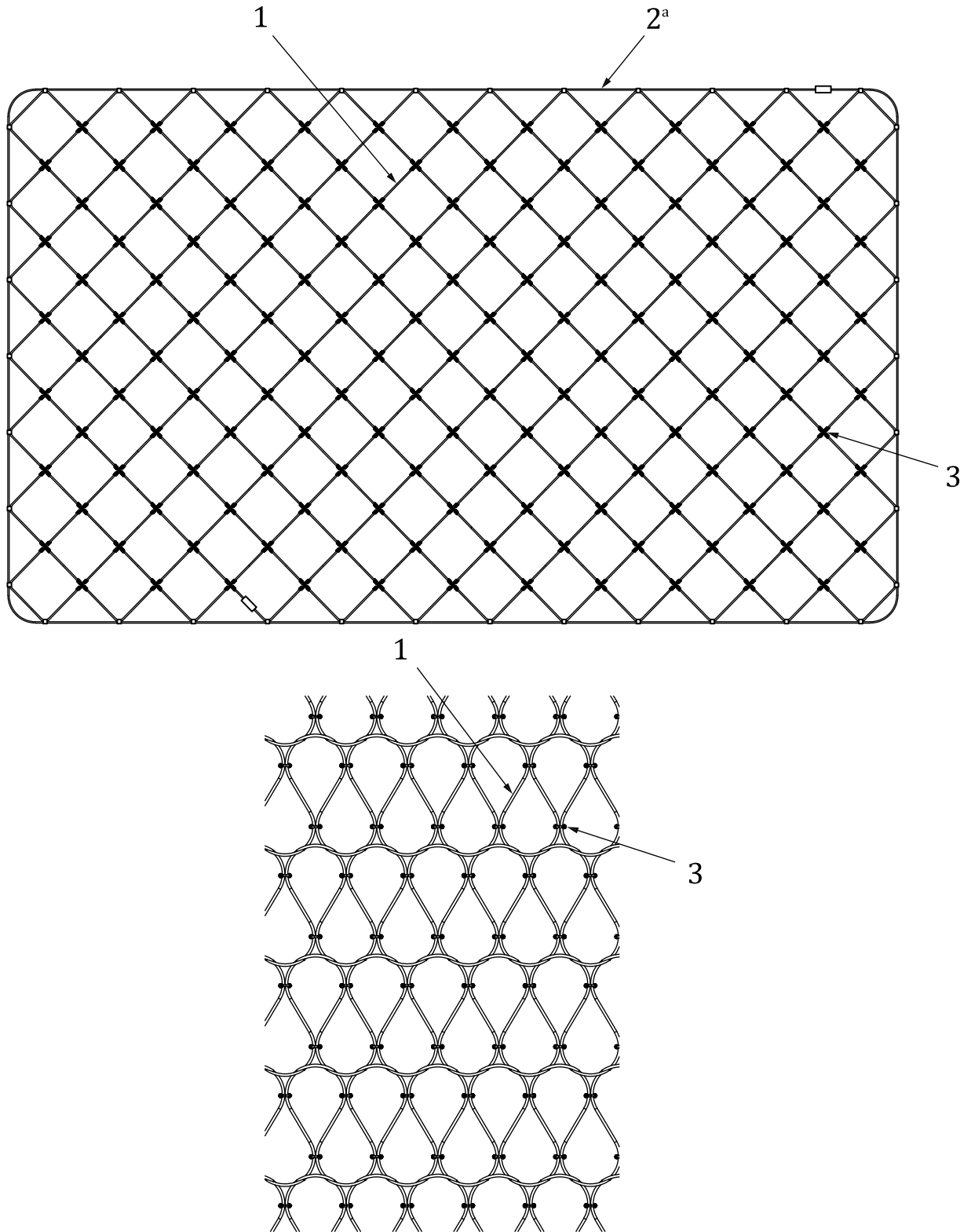
[Figure 1](#) shows some relevant examples of applications of wire rope net panels.

5 Wire rope net panels

5.1 General

Wire rope net panels are made of square nets or other shapes (e.g. triangular, jersey, rhomboidal, etc.) of nets manufactured with one or more than one rope as shown in [Figure 1](#).

Wire rope net can be manufactured both in panels and in rolls.



Key

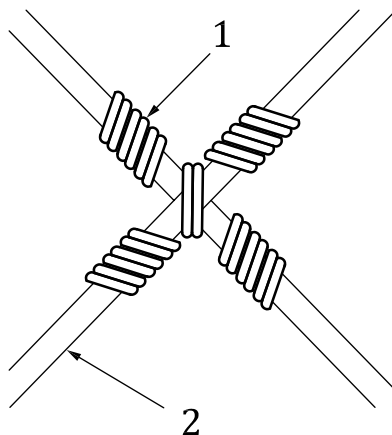
- 1 net rope
- 2 perimetral rope
- 3 knot
- a Optional.

Figure 1 — Examples of wire rope net panels and their components

The knot can be made in the different ways described in 5.2 to 5.4.

5.2 Double knot

This kind of knot (see Figure 2) is made by two bindings, each one obtained by looping a pair of steel 3,00 mm wires coated with a zinc-aluminium-5 % alloy. The two bindings tightly envelop the ropes crossing each other.



- Key**
- 1 steel wire
 - 2 net rope

Figure 2 — Example of double knot

The use of single knot may be agreed between the supplier and purchaser, provided that performance to punching tests of the panel meets the project requirement.

5.3 Clips or staple knot

In this kind of panel (see Figure 3), the overlapping points of the wrapping rope are connected using electro-plated clips, which are made of two half-shells pressure-closed.

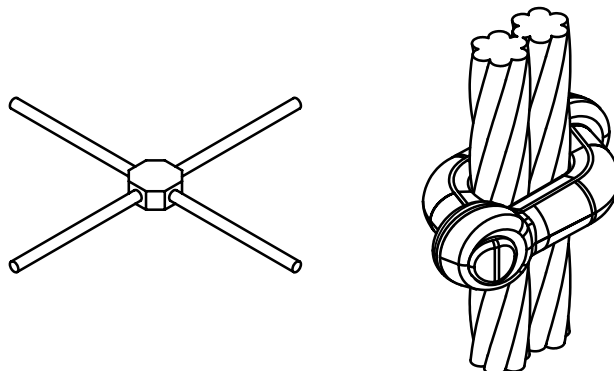


Figure 3 — Examples of clips knot and staple knot (patented)

5.4 Without connection clips

See Figure 4.

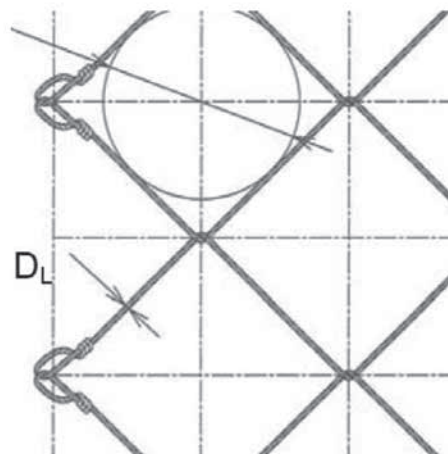


Figure 4 — Example of wire rope net where knot is formed without connection clips

The main properties of the wire ropes panels are specified in [Table 1](#).

Table 1 — Main properties of wire ropes panel

Items	Nominal net size ^a mm	Net wire ropes		Peripheral wire ropes (optional)	
		Diameter (mm) and type ^b	Minimum breaking load (kN)	Diameter (mm) and type ^b	Minimum breaking load (kN)
Wire rope net panel Double knot	250 × 250	8 mm 6 × 7 + WC	40,7	10 mm 6 × 19 + WC	63,0
	300 × 300	10 mm 6 × 19 + WC	63,0	12 mm 6 × 19 + WC	90,7
	400 × 400	12 mm 6 × 19 + WC	90,7	14 mm 6 × 19 + WC	124,0
				16 mm 6 × 19 + WC	161,0
Wire rope net panel Clips knot	200 × 200	8 mm 6 × 7 + WC	40,7	10 mm 6 × 19 + WC	63,0
	250 × 250			12 mm 6 × 19 + WC	90,7
	300 × 300			14 mm 6 × 19 + WC	124,0
		16 mm 6 × 19 + WC	161,0		
Wire rope net rolls without connection clips	250 × 250	8,6 mm (3 × 4) mm	61,4	12 mm 6 × 19 + WC	90,7
	275 × 275	6,6 mm (3 × 3) mm	36,7	16 mm 6 × 19 + WC	161,3

^a The tolerance on the net nominal size is ±10 % but can change in relation to the panel dimensions.

^b Rope type (see ISO 2408), rope grade 1 770 N/mm².

Other net sizes are possible, in accordance with project design requirements.

6 Properties of wire used in knots

6.1 Mechanical properties

The tensile strength of the wire used in knot shall be a minimum of 350 N/mm². The tensile strength of the wire used in knot shall be tested in accordance with ISO 22034-1.

6.2 Coating properties

The steel wire used in knot must be a nominal minimum diameter of 3,00 mm and coated with a zinc-aluminium alloy in accordance with the ISO 7989-1 and ISO 7989-2, class A. Method of assessment and acceptance criteria for zinc and zinc alloy coating weight are prescribed in ISO 7989-2:2007, Clause 5.

Lower wire diameters may be used provided that performance characteristics of the whole net panel can be demonstrated to be appropriate for the intended use.

The corrosion resistance of the connections (clips, staples, etc.) shall exceed the corrosion resistance of the ropes after the manufacturing.

7 Wire rope properties

Wire ropes used in wire rope net panels shall be in accordance with ISO 2408:2004, Table 1. Non-ferrous metallic coatings on steel wire shall be in accordance with ISO 7989-2, class A or class B.

8 Rope net properties

8.1 Ageing and corrosion resistance

8.1.1 Zn class B

When subjected to the neutral salt spray test according to the procedures in ISO 9227, after a period of 200 h of exposure, the net samples shall not show more than 5 % of DBR.

8.1.2 Zn class A

When subjected to the neutral salt spray test according to the procedures in ISO 9227, after a period of 500 h of exposure, the net samples shall not show more than 5 % of DBR.

8.1.3 Zn95Al5 class B

When subjected to the neutral salt spray test according to the procedures in ISO 9227, after a period of 500 h of exposure, the net samples shall not show more than 5 % of DBR.

8.1.4 Zn95Al5 class A

When subjected to the neutral salt spray test according to the procedures in ISO 9227, after a period of 1 000 h of exposure, the net samples shall not show more than 5 % of DBR.

8.1.5 Advanced metallic coatings (as Zn90Al10) class B

When subjected to the neutral salt spray test according to the procedures in ISO 9227, after a period of 1 000 h of exposure, the net samples shall not show more than 5 % of DBR.

8.1.6 Advanced metallic coatings (as Zn90Al10) class A

When subjected to the neutral salt spray test according to the procedures in ISO 9227, after a period of 2 000 h of exposure, the net samples shall not show more than 5 % of DBR.

8.1.7 Additional organic coating

Wire ropes used in wire rope net panel could be additionally organic coated. The polymeric coating material mechanical characteristics (tensile strength and elongation), after exposure to UV-rays, the

number of hours QUV-A (ISO 4892-3 exposure mode 1) shall not decrease by more than 25 % from the initial test results. These results cannot be compared to ISO 9227.

8.2 Maximum breaking load of knot

For wire knots (double or single) and clips knots, the value of the maximum breaking load shall be evaluated using the “test on knot” as reported below. See [Figure 5](#).

For the test, the element is mounted in a calibrated test traction rig. The test should allow the evaluation of the slipping force of the rope through the knot. Tests shall be performed on a minimum number of three samples.

The tensile test machine shall be of class 1 according to ISO 7500-1 (definition of class of testing machine).

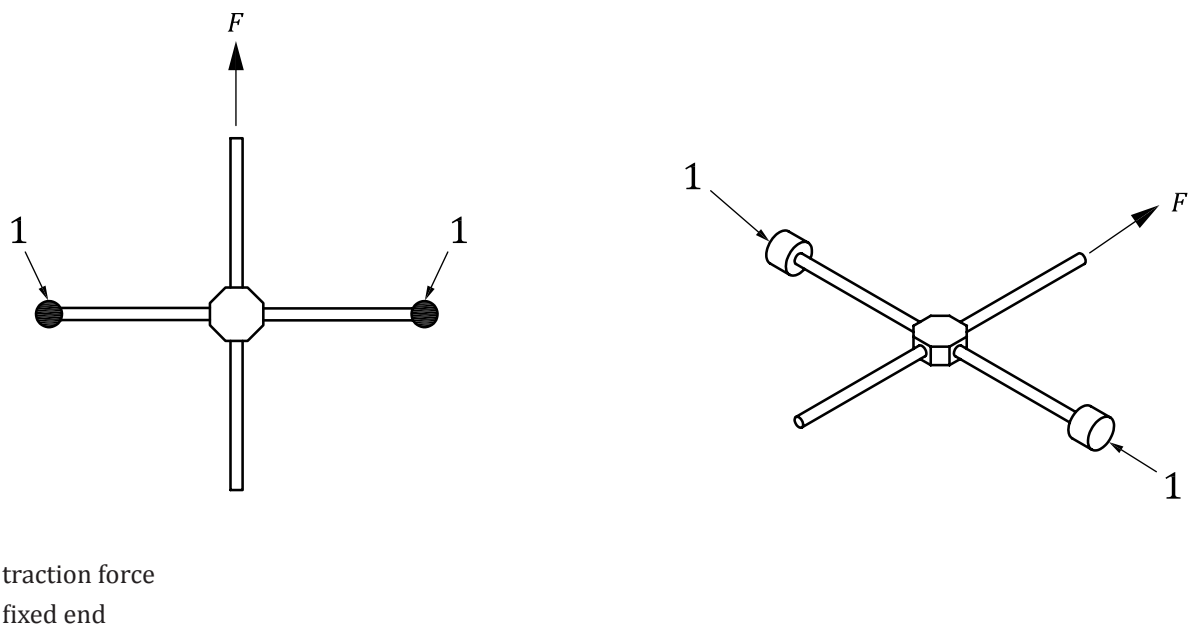


Figure 5 — Scheme for test on knot — Maximum slipping force

8.3 Maximum load of tear break of knot

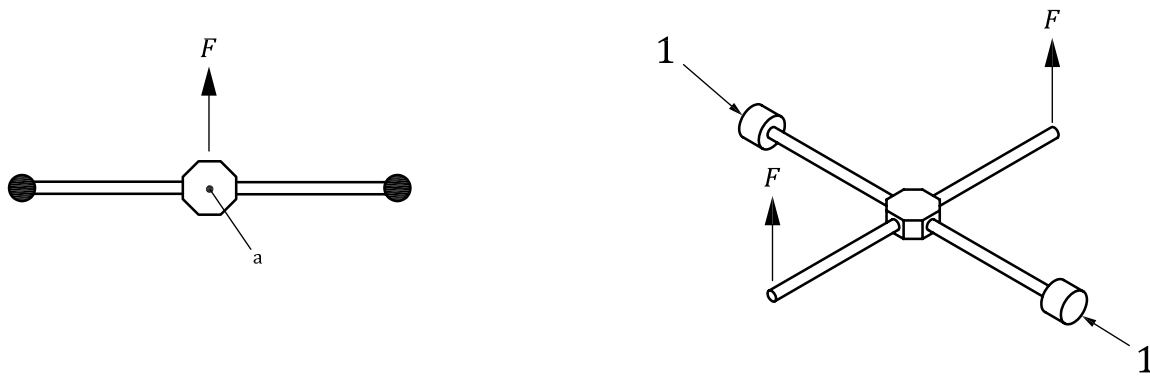
For wire knots (double or single) and clips knots, the value of the maximum load of tear break shall be evaluated using the “test on knot” as reported below.

The value of the maximum load of tear break shall be evaluated using the following test procedure (see [Figure 6](#)).

For the test with the element, mount the element in a calibrated test traction. The test should allow the evaluation of the breaking force of the knot defined as maximum load of tear break.

The testing machine shall be of class 1 according to ISO 7500-1.

Tests shall be performed on a minimum number of three samples.



Key

- F traction force
- 1 fixed end
- a Section of the wire ropes.

Figure 6 — Scheme for test on knot — Maximum load of tear break

8.4 Rope net tests (longitudinal tensile test with no lateral contraction and load bearing capacity test)

Tensile strength and load bearing capacity tests are described in [Annex B](#) and [Annex C](#).

Tensile strength and load bearing capacity tests are indications of product performance and quality. The use of the results for design purposes shall be based on an engineering judgement in accordance with the experience and the current practice and site conditions.

9 Sampling and testing

The manufacturer is responsible for the control of product quality.

10 Inspection and documentation

If agreed at the time of ordering, a certificate according to ISO 10474 or EN 10204 shall be supplied containing the following data:

- steel wire rope coating (type and class);
- knot coating (type and class);
- type of net;
- type of knot;
- maximum breaking load of knot and load of tear break of knot (if applicable);
- number of hours of exposure without showing not more than 5 % of DBR.

If requested, the following data shall also be supplied:

- steel wire rope net tensile strength;
- steel wire rope net load bearing capacity.

Annex A (informative)

Possible metallic coating options

The wire of the rope panel is protected with a metallic coating. Depending on the corrosivity of the environment in which the wire rope net is/will be installed (see ISO 9223), several options are possible, see [Table A.1](#).

Table A.1 — Description of the environment of the installation site, coating wire rope requirement

Site environment level (in accordance with ISO 9223:2012, Table 4)	Coating	Class (ISO 7989-2)	Estimated working life of the product (year)
Low aggressive: (C2) Dry conditions Temperate zone, atmospheric environment with low pollution, e.g. rural areas, small towns (over 100 m above sea level). Dry or cold zone, atmospheric environment with short time of wetness, e.g. deserts, sub-arctic areas.	Zinc	A B	25 10
	Zn95 %/Al5 % alloy	A B	50 25
	Advanced metallic coating	A B	120 50
Medium aggressive: (C3) Dry conditions Temperate zone, atmospheric environment with medium pollution or some effect of chlorides, e.g. urban areas, coastal areas with low deposition of chlorides, e.g. sub-tropical and tropical zone, atmosphere with low pollution	Zinc	A	10
	Zn95 %/Al5 % alloy	A B	25 10
	Advanced metallic coating	A B	50 25
High aggressive: (C4) Wet conditions Temperate zone, atmospheric environment with high pollution or substantial effect of chlorides, e.g. polluted urban areas, industrial areas, coastal areas, without spray of salt water, exposure to strong effect of de-icing salts, e.g. subtropical and tropical zone, atmosphere with medium pollution industrial areas, coastal areas, shelter positions at coastline.	Zn95 %/Al5 % alloy	A	10
	Advanced metallic coating	A B	25 10

NOTE Working life (product) — the period of time during which the performance of a product will be maintained at a level that enables a properly designed and executed works to fulfil the Essential Requirements (i.e. the essential characteristics of a product meet or exceed minimum acceptable values, without incurring major costs for repair or replacement). The working life of a product depends upon its inherent durability and normal installation and maintenance.

A clear distinction has to be made between the assumed economically reasonable working life for a product (also called: design working life), which underlies the assessment of durability in Technical Specifications, and the actual working life of a product in a works. The latter depends on many factors beyond the control of the producer, such as design, location of use (exposure), installation, use and maintenance.

The estimated working life can thus not be interpreted as being a guarantee given by the producer.

Technical Specification writers will have to take a view about the “normal” working life of the products that they deal with. The assumed working life of a product should take account of the assumed working life of the works, the ease and cost of repair or replacement of the product, maintenance requirements and exposure conditions.

Dark brown rust appearance on surface cannot be considered as the end of the working life.

The wire rope is closed by an aluminium ferrule: cylindric shape (DIN 3093), Al 5150 A, with resistance not less than 90 % of the rope breaking load.

When the edge/peripheral rope is requested, the cable is fixed to the wrapping rope using pressed aluminium C-ferrules: C open shape, Al 6060 T5.

For specific use, the wire rope net panels can also be produced with polymeric coated steel ropes.

Annex B (informative)

Load bearing capacity tests

B.1 Net load bearing capacity test procedures

The load bearing capacity of wire rope net panels should be evaluated according to the following test procedures.

The test consists in loading a sample of net perpendicularly to its plane by means of a hemispherical-shaped load sharing device (press). The press shall be located in the central point of the panel.

The hemisphere of the press is formed by a durable material such as concrete or steel.

The surface of the press shall be smooth, without any corners. Any attachment devices fitted on the surface of the press shall not interfere in any way with the test piece during the test.

The geometrical characteristics of the press are as follows (see [Figure B.1](#)):

- radius of curvature 1,200 mm;
- maximum diameter of the sample projected on a plane 1,000 mm;
- radius of curvature at the side 50 mm.

The test piece is loaded at the intersection of its diagonals (centre of test piece), moving the press with a speed not greater than 10 mm/s.

The test may be interrupted to allow the stroke of the thrust device to be restarted.

The sample tested is of rectangular shape, with a 3,0 m side (average value - tolerance ± 20 %). To allow installation of the system, the test applicant shall supply the sample to the laboratory with the dimensions planned for the test or larger, and the laboratory will then carry out the sampling. It shall be representative of the product in terms of materials and construction method.

The tests shall be performed in the laboratory at ambient temperature, and always in compliance with the standards which regulate the testing procedures for the various materials.

The punching test is carried out after fixing the test piece to a rigid frame and it is aimed at measuring the force-movement curve of the central point of the press measured perpendicularly to the plane of the test piece. The test shall allow failure of the specimen to be reached. The panel is considered to have failed when it is no longer able to support any increase to the applied force. The puncturing strength of a test piece is therefore defined as the maximum force imparted by the test piece during the test.

The test may also be performed without reaching failure of the panel. In this case, the limit strength which may be certified is equal to the maximum value of the force reached during the test.

The contrast frame is made from a rigid rectangular or square structure, the size of which fully holds the mesh test piece and the constraint devices (see [Figure B.2](#)). The distance between the rigid frame and the mesh test piece, i.e. the space holding the constraint devices, shall not be greater than 15 % of the average side length of the test piece.

The test piece shall be centred in the test frame; the width, a , of the constraining area shall be measured along the centreline of each side of the frame.

All the perimeter nets of the test piece are fixed to the frame by means of the constraining devices (e.g. shackles, connecting links, steel ropes or other methods agreed between the testing laboratory and the party requesting the test, and in line with the structural characteristics of the piece to be tested; however, the means of constraint shall not interfere with the structural behaviour of the test piece of a size suitable to obtain the planarity of the test piece before starting the test) by using either specific devices (e.g. screw tensioners) or frames with variable shapes.

Dimensions in millimetres

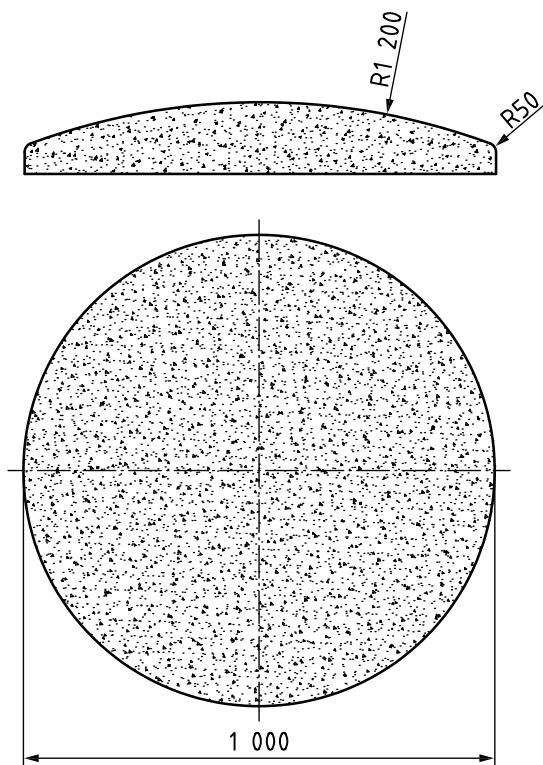
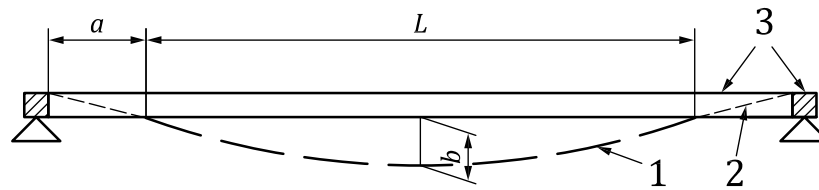


Figure B.1 — Geometrical characteristics of the press

The reference plane is defined by the four sides of the frame.

Before starting the test, the test piece shall be tensioned until it reaches a condition of “planarity”, which is considered to have been reached when the maximum sag at the centre is less than 20 % of the smallest side length of the test piece.



Key

- a constraining area $< 0,15 \times L$
- b $< 0,2 \times L$ [m]
- L $3,0 \pm 0,2 \times 3,0$ [m]
- 1 net test piece
- 2 tensioning devices
- 3 rigid frame

Figure B.2 — Section of the frame containing the net test piece and definition of the level conditions

B.2 Measurements and observations

The origin of the load-movement diagram is measured from the plane holding the panel constraining devices.

The following measurements shall be taken continuously during the test:

- force exercised by the press;
- movement of the press relative to the reference plane.

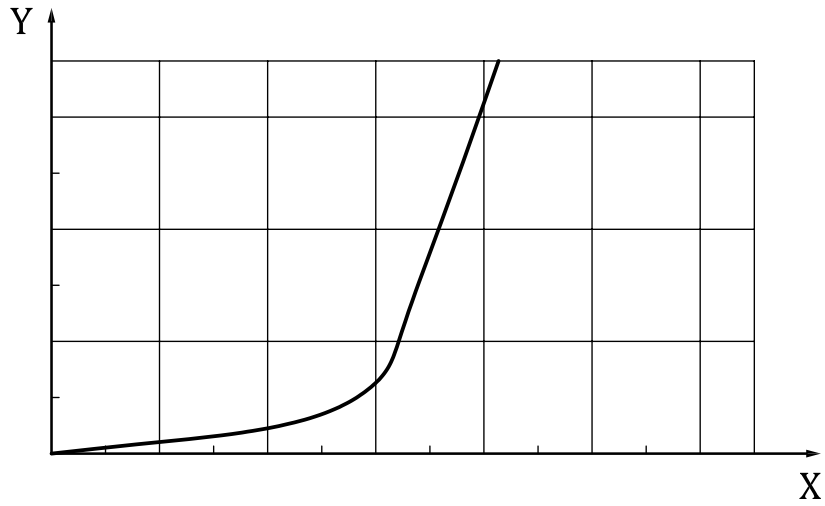
The force shall be measured by class 1 load cells, in accordance with ISO 376.

These measurements shall allow the curve characterized by the following parameters to be obtained:

- PBR maximum value of the force reached at failure of the test piece. If failure is not reached, this shall be declared;
- BR movement corresponding to actual failure load reached.

The load-movement curve measured at the centre of the press shall be provided for each product. An example of a graph is shown in [Figure B.3](#).

See also [Figure B.4](#).

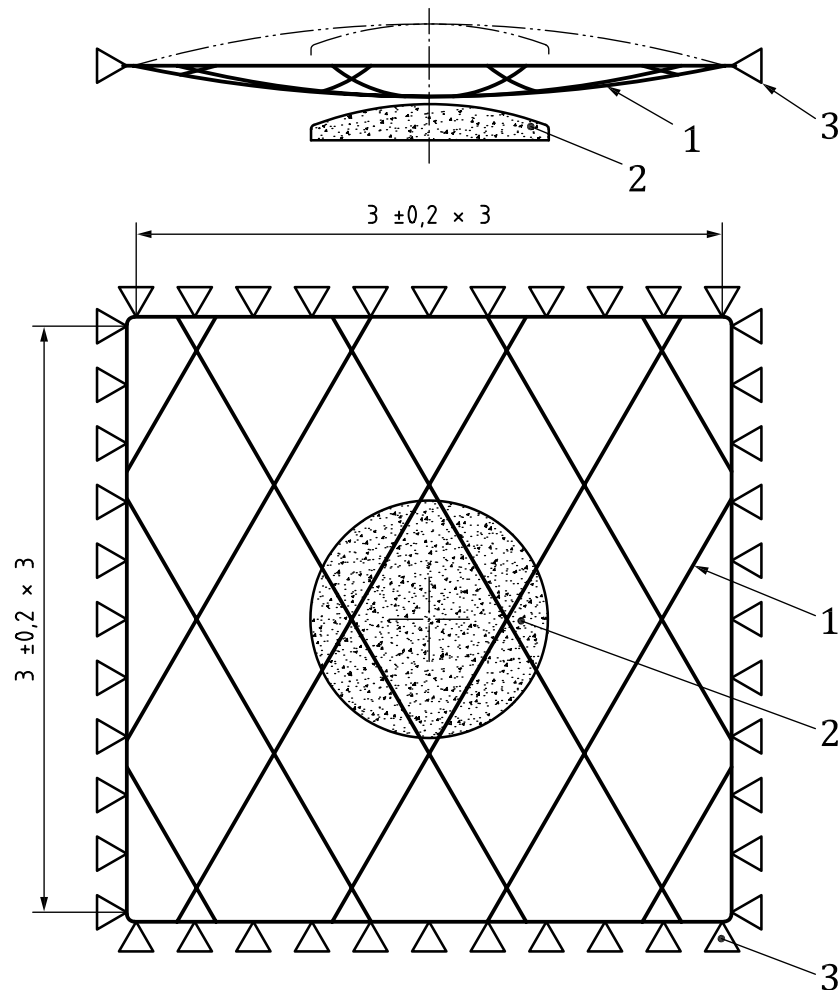


Key

X deformation at the centre, measured perpendicularly to the test piece

Y load

Figure B.3 — Example of load-movement curve



Key

- 1 net
- 2 press
- 3 perimeter constraining device

Figure B.4 — Example of set up for puncturing test

B.3 Test report

The test report must provide the following information, and give an accurate description of test piece (construction materials and relative strengths, construction characteristics, geometrical characteristics of mesh, technological details, etc.), supplied by the party requesting the test:

- a) nominal dimensions of test piece and actual dimensions under test conditions;
- b) description of instrumentation used and temperature during test;
- c) detailed description of the test piece constraining condition, complete with photographic documentation;
- d) maximum sag b reached at the start of the test in those cases in which it may be measured;
- e) average dimension a of the constraining area on the four sides;
- f) general description of the failure mode;

- g) actual failure load and relative stroke;
- h) load-movement diagram;
- i) photographic documentation of the test piece before and after the test.

Annex C (informative)

Net tensile strength (longitudinal tensile test with no lateral contraction)

C.1 Net tensile strength test procedures

The wire rope net tensile strength shall be determined according to the following test procedures.

The test determines the actual longitudinal tensile strength and transversal tensile strength, and the relative elongation of wire rope net panel.

For this purpose, a frame made of four steel beams, one of which is free to slide in the direction of the load (longitudinal direction) (see [Figure C.1](#)) shall be used.

The specimen shall have a width not less than 1 000 mm and a minimum area of 1,0 m². The specimen shall be fixed to the frame by means of lateral coupling devices, such as shackles or turnbuckles. The side coupling device shall be free to slide along the longitudinal beams.

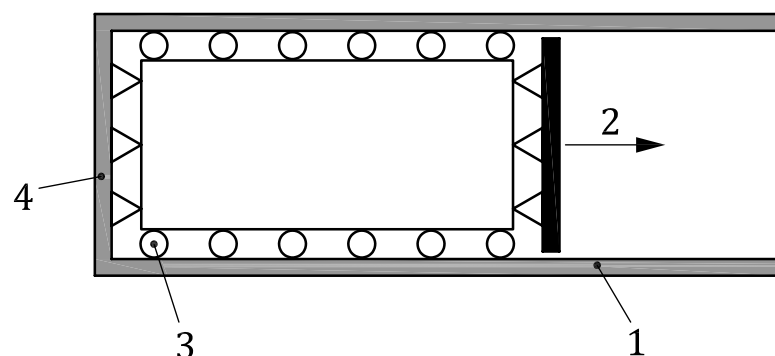
The test frame must be equipped with load cells in order to acquire the load applied and the overall side reaction (longitudinal and transversal reactions).

The net specimen is brought under conditions of flatness by means of coupling devices without altering the geometry of the net in unload conditions.

The rate of longitudinal elongation during the test shall be between 6 mm/min and 10 mm/min.

The test end when the specimen broken load or the maximum applicable load is reached.

The specimen broken load is reached when the specimen is no longer able to support any increase of the applied force. It is also allowed to perform the test without reaching the rupture of the test, in which case, the tensile strength corresponds to the maximum load reached during the test.



Key

- 1 fixed frame
- 2 movable beam
- 3 lateral constraint
- 4 longitudinal connection device

Figure C.1 — Example of frame configuration

C.2 Measurements and observations

The test must be recorded in a continuous way: the longitudinal load applied, the side reaction (transversal) and the displacement of the movable beam.

C.3 Test report

The test report must contain a full description of the specimen (the base materials and their strengths, construction details, geometric characteristics of the net, technological details, etc.) by the applicant for the test and report the following information for each direction of test:

- a) description of the failure modes;
- b) longitudinal strength vs. displacement of movable beam diagram and side reaction vs. displacement of movable beam diagram;
- c) breaking load, side reaction at breaking load, displacement of movable beam at breaking load;
- d) photographic documentation of the specimen before and after the test, in which shall be shown the connections to the frame.

Bibliography

- [1] ISO 376, *Metallic materials — Calibration of force-proving instruments used for the verification of uniaxial testing machines*
- [2] ISO 6988, *Metallic and other non organic coatings — Sulfur dioxide test with general condensation of moisture*
- [3] ISO 9223:2012, *Corrosion of metals and alloys — Corrosivity of atmospheres — Classification, determination and estimation*
- [4] ISO 9227, *Corrosion tests in artificial atmospheres — Salt spray tests*
- [5] ISO 22034-2, *Steel wire and wire products — Part 2: Tolerances on wire dimensions*
- [6] DIN 50018, *Testing in alternating condensation atmosphere containing sulphur dioxide*

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