EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

WHITE DRAFT
prEN 10138-3

April 2005

ICS

English version

Prestressing steels - Part 3: Strand

Armatures de précontrainte - Partie 3 : Torons

Spannstähle - Teil 3: Litze

This draft European Standard is submitted to ECISS/COCOR before submission to CEN members for second formal vote. It has been drawn up by the Technical Committee ECISS/TC 19.

If this draft becomes a European Standard, CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

This draft European Standard was established by CEN in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Management Centre has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

Warning : This document is not a European Standard. It is distributed for review and comments. It is subject to change without notice and shall not be referred to as a European Standard.

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Management Centre: rue de Stassart, 36 B-1050 Brussels

Ref. No. prEN 10138-3:2005: E

Contents

Page

Foreword

This document (prEN 10138-3:2005) has been prepared by Technical Committee ECISS/TC 19 “Concrete reinforcing and prestressing steels - Properties, dimensions, tolerances and specific tests”, the secretariat of which is held by DIN.

This document is currently submitted to the 2nd COCOR Vote.

This European Standard consists of the following parts, under the general title *Prestressing steels*:

— *Part 1: General requirements*

— *Part 2: Wire*

— *Part 3: Strand*

— *Part 4: Bar*

1 Scope

This Part of EN 10138 gives specific requirements for technical classes of high tensile steel wire strand, which has been given a stress relieving heat treatment.

It is applicable to products with at least two wires, which may be indented or compacted, i.e.:

a) 2-wire strand;

b) 3-wire strand;

c) indented 3-wire strand;

d) 7-wire strand;

e) indented 7-wire strand;

f) 7-wire compacted strand.

NOTE General requirements are given in prEN 10138-1.

2 Normative references

The following referenced documents are indispensable for the application 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.

EN 10016-1, *Non-alloy steel rod for drawing and/or cold rolling — Part 1: General requirements*.

EN 10016-2, *Non alloy steel rod for drawing and/or cold rolling — Part 2: Specific requirements for general purposes rod.*

EN 10016-4, *Non-alloy rod for drawing and/or cold rolling — Part 4: Specific requirements for rod for special applications.*

EN 10027-1, *Designation system for steels — Part 1: Steel names, principal symbols.*

EN 10027-2, *Designation system for steels — Part 2: Steel numbers*

prEN 10138-1, *Prestressing steels — Part 1: General requirements.*

CR 10260, *Designation system for steel — Additional symbols.*

EN ISO 15630-3, *Steel for the reinforcement and prestressing of concrete — Test methods — Part 3: Prestressing steels (ISO 15630-3:2002).*

3 Terms and definitions

For the purposes of this Part of EN 10138 the terms and definitions given in prEN 10138-1 apply.

4 Symbols and designations

Symbols used in this Part of EN 10138 and the corresponding designations are listed in Table 1.

Table 1 — Symbols and corresponding designations

Symbol	Unit	Designation
a	mm	Depth of the indentations
c	mm	Indentation spacing
l	mm	Length of the indentations
d	mm	Nominal diameter of the product
S_n	mm^2	Nominal cross-sectional area of the product
M	g/m	Mass per metre of the product
F_m	kN	Specified characteristic value of maximum force
$F_{m,\,max}$	kN	Specified maximum value of maximum force
$F_{p0,1}$	kN	Specified characteristic value of 0,1 % proof force
σ	-	Stress ratio i.e. Maximum force in the tensile test determined on a test piece divided by the actual 0,1 % proof force
A_{gt}	%	Specified minimum value of percentage total elongation at maximum force
L_o	mm	Original gauge length of the extensometer for the determination of A_{gt}
F_{ma}	kN	Actual maximum force, in the tensile test, determined on a test piece adjacent to the test piece submitted to special property test
F_{up}	kN	Upper force in the axial load fatigue test
F_r	kN	Force range in the axial load fatigue test
d_{sw}	mm	Nominal diameter of a constitutive wire of a strand

5 Designation

5.1 For the steel grades covered by this Part of EN 10138 the steel names shall be allocated in accordance with EN 10027-1 and CR 10260; the steel numbers shall be allocated in accordance with EN 10027-2.

5.2 The designation shall consist of:

a) the number of this Part of EN 10138;

b) the steel name consisting of:

1) the letter Y for prestressing steel;

2) the nominal tensile strength in MPa;

3) the letter S for strand;

4) the number 2, 3 or 7 to indicate the number of wires in the strand;

5) where appropriate, the letter G to indicate compacted strand;

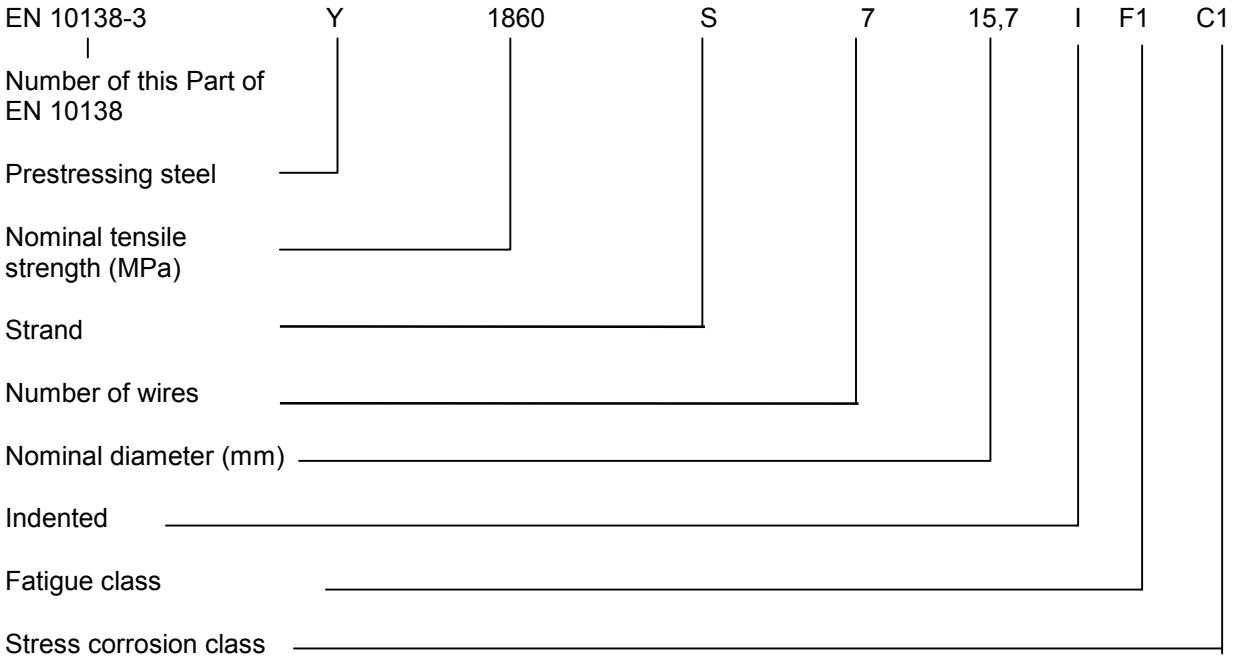
c) the nominal diameter of the strand in mm (see Table 3);

d) where necessary the letter I to indicate indented;

e) Fatigue class (F1 or F2);

f) Stress corrosion class (C1 or C2).

EXAMPLE



i.e. EN 10138-3-Y1860S7-15,7-I-F1-C1

NOTE The steel number can be used instead of the steel name i.e. EN 10138-3-1.1366-15,7-F1-C1

6 Manufacture

6.1 General

The strand shall be manufactured from wire produced from wire rod conforming to EN 10016-1 and EN 10016-2 or EN 10016-4 and from steel in accordance with prEN 10138-1.

6.2 Stranding process

6.2.1 2-wire strand

The strand shall consist of two wires of the same nominal diameter, spun together in helical form over a theoretical common axis with a lay length of 14 to 22 times the nominal strand diameter.

6.2.2 3-wire strand

The strand shall consist of three wires of the same nominal diameter, spun together in helical form over a theoretical common axis with a lay length of 14 to 22 times the nominal strand diameter.

6.2.3 7-wire strand

The strand shall include a straight central wire, called a core wire around which are spun six wires in one layer. The outer wires shall be tightly spun around the central wire with a lay length between 14 and 18 times the nominal strand diameter. The diameter of the central wire shall be at least 3,0 % greater than the diameter of the outer helical wires.

6.2.4 7-wire compacted strand

Seven wire strand which after stranding has been compacted by drawing or rolling before stress relief treatment. When stranding and compacting are carried out simultaneously, the straight central wire shall be at least the same diameter as the outer helical wires. The latter shall have a lay length of 14 to 18 times the nominal strand diameter.

6.3 Indented strand

Indentation of wires of 3-wire strand or the indented outer wires of 7-wire strand shall be completed before stranding.

NOTE 1 The centre wire of indented 7-wire strand is normally plain.

The dimensions of the indentation shall be in accordance with Table 2 and Figure 1. One line of indentations shall be at a contrary angle to the others.

NOTE 2 Other types of indentation may be presented but should be fully specified in a similar manner to Table 2 and Figure 1 by the producer and accepted by the purchaser.

Table 2 — Specified indentation

Dimensions in mm

Nominal strand diameter d	Nominal depth a	Depth tolerance	Length l	Pitch c
≤ 12	0,06	± 0,03	3,5 ± 0,5	5,5 ± 0,5
> 12	0,07	± 0,03	3,5 ± 0,5	5,5 ± 0,5

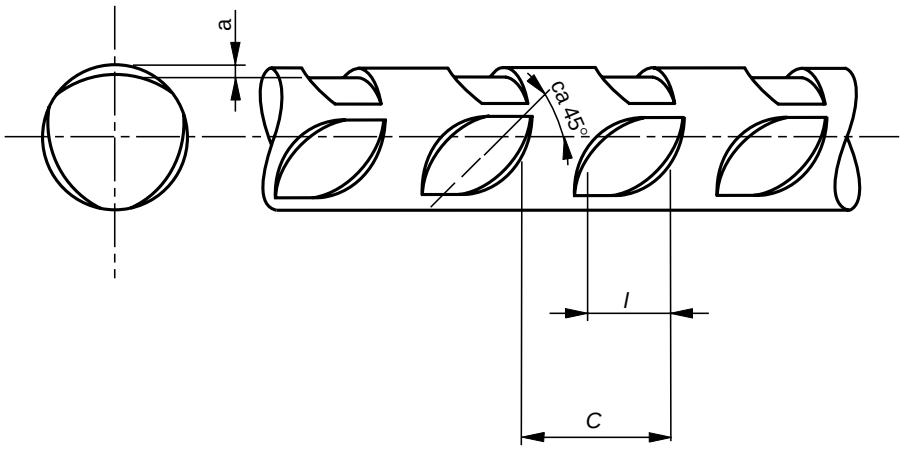


Figure 1 — Indentation

7 Requirements

7.1 General

Nominal and specified properties shall be in accordance with Tables 3, 4 and 5.

7.2 Behaviour during cutting

When the strand is cut with a disc cutter, the individual wires either shall not unravel or shall be capable of being repositioned without difficulty.

7.3 Straightness

Straightness shall be determined in accordance with EN ISO 15630-3. The maximum bow height from a base line 1 m in length, measured from the inside of the curve, shall be not greater than 25 mm for all wire diameters.

NOTE Alternative agreements on straightness including for cut lengths using the method in EN ISO 15630-3 may be agreed between producer and purchaser at the time of ordering.

Table 3 — Dimensions and properties of 2 and 3 wire strands

Steel designation		Nominal [a]				Specified			
Steel name	Steel number	Diameter d mm	Tensile strength R_m MPa	Cross-sectional area [b] S_n mm²	Mass per metre [b] M g/m	Permitted deviation on mass per metre %	Characteristic value of maximum force F_m kN	Maximum value of maximum force $F_{m,max}$ kN	Characteristic value of 0,1% proof force $F_{p0,1}$ [c] kN
Y1770S2	1.1345	5,6	1 770	9,70	75,8	± 2	17,2	19,8	14,8
		6,0		15,1	117,9		26,7	30,7	23,0
Y1770S3	1.1359	7,5	1 770	29,0	226,5	± 2	51,3	59,0	44,1
Y1860S2	1.1346	4,5	1 860	7,95	62,1	± 2	14,8	17,0	12,7
Y1860S3	1.1360	4,85	1 860	11,9	92,9	± 2	22,1	25,4	19,0
		6,5		21,2	165,6		39,4	45,3	33,9
		6,9		23,4	182,8		43,5	50,0	37,4
		7,5		29,0	226,5		53,9	62,0	46,4
		8,6		37,4	292,1		69,6	80,0	59,9
Y1920S3	1.1357	6,3	1 920	19,8	154,6	± 2	38,0	43,7	32,7
		6,5		21,2	165,6		40,7	46,8	35,0
Y1960S3	1.1361	4,8	1 960	12,0	93,7	± 2	23,5	27,0	20,9
		5,2		13,6	106,2		26,7	30,7	23,8
		6,5		21,2	165,5		41,6	47,8	37,0
		6,85		23,6	184,3		46,3	53,2	41,2
Y2060S3	1.1362	5,2	2 060	13,6	106,2	± 2	28,0	32,2	24,9
Y2160S3	1.1363	5,2	2 160	13,6	106,2	± 2	29,4	33,8	26,2

[a] The modulus of elasticity may be taken to be 195 GPa (kN/mm²).

[b] The nominal mass per metre is calculated from the cross-sectional area and a density of 7,81 kg/dm³.

c The specified characteristic value of the 0,1 % proof force is calculated from the specified characteristic value of the maximum force with a ratio of 0,86. For the grade Y1960S3, Y2060S3 and Y2160S3 the specified characteristic value of the 0,1 % proof force is calculated with a ratio of 0,89.

Table 4 — 7 wire strand - Dimensions and properties

Steel designation		Nominal [a]				Specified			
Steel name	Steel number	Diameter D mm	Tensile strength R_m MPa	Cross-sectional area [b] S_n mm^2	Mass per metre [b] M g/m	Permitted deviation on mass per metre %	Characteristic value of maximum force F_m kN	Maximum value of maximum force $F_{m,\,max}$ kN	Characteristic value of 0,1 % proof force [c] $F_{p0,1}$ kN
Y1670S7	1.1364	15,2	1 670	139	1 086	± 2	232	267	200
Y1700S7G	1.1370	18,0	1 700	223	1 742	± 2	379	436	326
Y1770S7	1.1365	6,9	1 770	29,0	226,5	± 2	51,3	59,0	44,1
		9,0		50,0	390,5		88,5	102	76,1
		9,3		52,0	406,1		92,0	106	79,1
		9,6		55,0	429,6		97,4	112	83,8
		11,0		70,0	546,7		124	143	107
		12,5		93,0	726,3		165	190	142
		12,9		100	781,0		177	204	152
		15,2		139	1 086		246	283	212
		15,3		140	1 093		248	285	213
		15,7		150	1 172		266	306	229
		18,0		200	1 562		354	407	304
Y1820S7G	1.1371	15,2	1 820	165	1 289	± 2	300	345	258
Y1860S7	1.1366	6,9	1 860	29,0	226,5	± 2	53,9	62,0	46,4
		7,0		30,0	234,3		55,8	64,2	48,0
		8,0		38,0	296,8		70,7	81,3	60,8
		9,0		50,0	390,5		93,0	107	80,0
		9,3		52,0	406,1		96,7	111	83,2
		9,6		55,0	429,6		102	117	87,7
		11,0		70,0	546,7		130	150	112
		11,3		75,0	585,8		140	161	120
		12,5		93,0	726,3		173	199	149
		12,9		100	781,0		186	214	160
		13,0		102	796,6		190	219	163

Table 4 — 7 wire strand - Dimensions and properties

Steel designation		Nominal [a]				Specified			
Steel name	Steel number	Diameter D mm	Tensile strength R_m MPa	Cross-sectional area [b] S_n mm^2	Mass per metre [b] M g/m	Permitted deviation on mass per metre %	Characteristic value of maximum force F_m kN	Maximum value of maximum force $F_{m,max}$ kN	Characteristic value of 0,1 % proof force [c] $F_{p0,1}$ kN
		15,2		139	1 086		259	298	223
		15,3		140	1 093		260	299	224
		15,7		150	1 172		279	321	240
Y1860S7G	1.1372	12,7	1 860	112	874,7	± 2	208	239	179
		15,2		165	1 289		307	353	264
Y1960S7	1.1367	9,0	1 960	50,0	390,5	±2	98,0	113	86,2
		9,3		52,0	406,1		102	117	89,8
Y2060S7	1.1368	6,4	2 060	25,0	195,3	± 2	51,5	59,2	45,3
		6,85		28,2	220,2		58,1	66,8	51,1
		7,0		30,0	234,3		61,8	71,1	54,4
		8,6		45,0	351,5		92,7	107	81,6
		11,3		75,0	585,8		155	178	136
Y2160S7	1.1369	6,85	2 160	28,2	220,2	± 2	60,9	70,0	53,6

[a] The modulus of elasticity may be taken to be 195 GPa (kN/mm^2).

[b] The nominal mass per metre is calculated from the nominal cross-sectional area and a density of 7,81 kg/dm^3.

[c] The specified characteristic value of the 0,1 % proof force is calculated from the specified characteristic value of the maximum force with a ratio of 0,86. For the grade Y1960S7, Y2060S7 and Y2160S7 the specified characteristic value of the 0,1 % proof force is calculated with a ratio of 0,88.

Table 5 — Additional requirements for prestressing strand

<table>
<tr><th colspan="4">Property</th><th colspan="3">Specification</th></tr>
<tr><td colspan="4">Minimum total percentage elongation at maximum force, $A_{gt,}$ with $L_o \geq 500$ mm</td><td colspan="3">3,5 %</td></tr>
<tr><td colspan="4">Reduction in area at break</td><td colspan="3">Ductile wire breaks visible to the unaided eye [a]</td></tr>
<tr><td>Maximum relaxation at 1 000 h [d]</td><td colspan="3">For initial force corresponding to
70 % F_{ma}
80 % F_{ma}</td><td colspan="3">
2,5 %
4,5 % [b]</td></tr>
<tr><td>Fatigue force range F_r with upper limit F_{up} according to 70 % actual maximum force (F_{ma}) Class F1</td><td colspan="3">- for plain strand
- for indented strand</td><td colspan="3">190 MPa x S_n for ≥ 2 x 10^6 cycles
170 MPa x S_n for ≥ 2 x 10^6 cycles</td></tr>
<tr><td>Fatigue force range F_r with upper limit F_{up} according to 80 % actual maximum force (F_{ma}) Class F2</td><td colspan="3">- for plain strand
- for indented strand</td><td colspan="3">200 MPa x S_n for ≥ 2 x 10^6 cycles
180 MPa x S_n for ≥ 2 x 10^6 cycles</td></tr>
<tr><td rowspan="5">Stress corrosion resistance [c]
80 % actual max. force (F_{ma})</td><td rowspan="5"></td><td rowspan="5"></td><td></td><td>Minimum (h)</td><td>Median (h)</td></tr>
<tr><td>Class C1 [c]</td><td>Test solution A</td><td>$d_{sw} \geq 3{,}2$ mm</td><td>2,0</td><td>5</td></tr>
<tr><td></td><td></td><td>$d_{sw} < 3{,}2$ mm</td><td>1,5</td><td>3</td></tr>
<tr><td rowspan="2">Class C2 [c]</td><td rowspan="2">Test solution A</td><td>$d_{sw} \geq 3{,}2$ mm</td><td>2,0</td><td>5</td></tr>
<tr><td>$d_{sw} < 3{,}2$ mm</td><td>1,5</td><td>3</td></tr>
<tr><td colspan="4">Maximum D-value of deflected tensile test applies to 7-wire strand with a nominal diameter ≥ 12,5 mm and compacted strand only</td><td colspan="3">28 % [b]</td></tr>
</table>

[a] Ruptures in "cup and cone" are prohibited. In case of dispute the percentage reduction of area shall be determined and the value shall be ≥ 25 % for plain wire and ≥ 20 % for indented wire.

[b] The requirement for 70% F_{ma} is mandatory. A requirement for a value of 80% F_{ma} may be agreed between purchaser and manufacturer for specific applications.

[c] Test solution A defined in EN ISO 15630-3. For strands of nominal diameter ≥ 12,5 mm when other regulatory requirements for stress corrosion exist the additional test solution B for initial type testing defined in EN ISO 15630-3 shall be used.

[d] For specific applications the requirement may be varied by agreement between producer and purchaser.

8 Evaluation of conformity

The requirements in prEN 10138-1 shall be met.

9 Test methods

The test methods shall be in accordance with EN ISO 15630-3.

10 Delivery conditions

10.1 Identification

The requirements in prEN 10138-1 shall be met.

10.2 Delivery documentation

The requirements in prEN 10138-1 shall be met.

NOTE Where documents refer to the steel heat for strands, the heat shall be that of the predominate heat in the constituent wires of the strands

10.3 Dimensions and mass of unit of product

The dimensions and mass of the unit of product shall be agreed at the time of ordering between the purchaser and the producer consistent with the restrictions in prEN 10138-1. The producer shall state the coil dimensions.

10.4 Packaging

The coils shall be correctly conditioned (restraining bands) so as not to be damaged (collapse) during transport. The coils shall be marked with the direction of unwinding. A particular conditioning (e.g. core for the coil, packing paper or paperboard, protection by a water-soluble oil film) may be agreed between the purchaser and the producer.