Polski Rejestr Statków

RULES

PUBLICATION NO. 113//P

WIRE ROPE AND CHAIN SLINGS

2016

Publications P (Additional Rule Requirements) issued by Polski Rejestr Statków
complete or extend the Rules and are mandatory where applicable.

GDAŃSK

Publication No. 113/P – Wire Rope and Chain Slings – 2016, was approved by the PRS S.A. Board on 31 March 2016 and enters into force on 11 April 2016

PRS/OP, 03/2016

CONTENTS

1 APPLICATION

1.1 The requirements of this *Publication* apply to steel wire rope slings made from zinc coated wire, fibre (hemp, sisal, manila hemp) or chains. The Polish Standard PN-92/M-84720 presents details of manufacture. Steel wire ropes shall be of ordinary lay with fibre or steel core, of nominal wire strength 1570 or 1770 MPa.

1.2 The scope of application of this *Publication* is consistent with the scope of PRS *Rules* in which it is referred to.

1.3 The *Publication* contains requirements concerning structure of slings and their testing and surveys.

1.4 The *Publication* may be applied to slings used in offshore industry, in production bays, for transferring various machinery and manufacturing materials.

2 NORMATIVE REFERENCES

The wire rope slings shall comply with the below standards:

EN 13414-1:2003+A2:2008, Part 1: Slings for general lifting service, Polish standard PN-EN 13414-1+A2
EN 13414-2:2003+A2:2008, Part 2: Specification for information for use and maintenance to be provided by the manufacturer, Polish Standard PN-EN 13414-2+A2
EN 13414-3:2003+A2:2008, Part 3: Grommets and cable-laid slings, Polish Standard: PN-EN 13414-3+A1

Additionally, the below Polish standards apply:

PN-92/M-84720 – Zawiesia z lin stalowych i włókiennych. Ogólne wymagania i badania
PN-M-84736 – Zawiesia jednopętlowe z lin stalowych,
PN-M-84737 – Zawiesia dwupętlowe z lin stalowych,
PN-M-84735 – Zawiesia w obwodzie zamkniętym z lin stalowych;
PN-EN 818-4+A1:2008 – Łańcuch o ogniwach krótkich do podnoszenia ładunków – Bezpieczeństwo – Część 4: Zawiesia łańcuchowe – Klasa 8

3 DEFINITIONS

Steel wire rope sling for general lifting service – an assembly of components which includes one or more free end legs or an endless sling which is intended for a variety of lifting operations and not designed for one specific lifting application.

Terminal fittings – a link, link assembly, hook or other device permanently fitted at the upper or lower end of a sling and intended to connect the sling to the load or the lifting machine.

Master link – a link forming the upper terminal of a sling by means of which the sling is attached to the hook of a crane or other lifting (see Fig. 1).

Intermediate master link – a link used to connect one or two legs of a sling to a master link (see Figure 1). Intermediate links can be assembled with a master link to form a permanent master link assembly.

Wire rope grommet – an endless wire rope sling, made from one continuous length of strand, formed to make a body wrapped around a strand core. Strand terminals of one end of the rope are spliced into the strands of the other end, making an eye.

Cable –laid grommet – an endless wire rope sling made from cable-laid rope. Strand terminals at one wire rope end are spliced into the strands of the other end, making an eye.

Cable-laid wire rope sling – a sling made from wire rope constructed from six unit ropes laid as outer over one core unit rope with a terminal at each end, usually in the form of a spliced eye. (Fig. 2).

W o r k i n g   l o a d   l i m i t   (W L L) – maximum mass which a sling is authorized to sustain in general service, expressed in tons of mass.

C o m p e t e n t   p e r s o n – a person with suitable qualifications, training, and sufficient knowledge, experience, skill and necessary instructions, for the performance of required examinations and inspections.

Inspection – a visual check on the condition of the wire rope sling to identify obvious damage or deterioration which may affect its fitness for use.

T h o r o u g h   e x a m i n a t i o n – a visual examination carried out by a competent person, and where necessary, supplemented by other means such as measurement and non-destructive testing, in order to detect damage or deterioration and to assess its importance in relation to the safety and continued safe use of the wire rope sling.

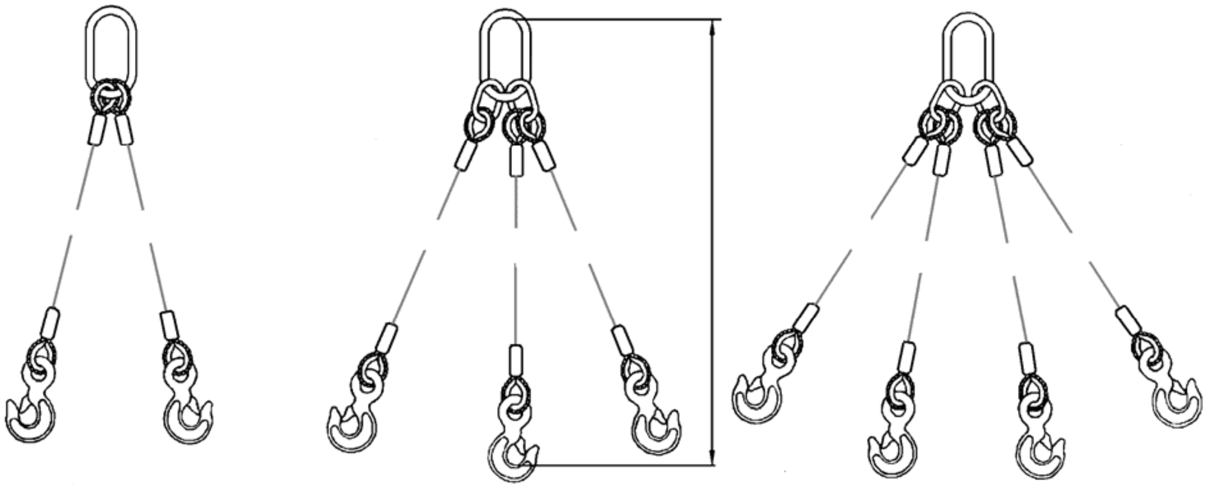

Fig. 1. Multi-leg slings

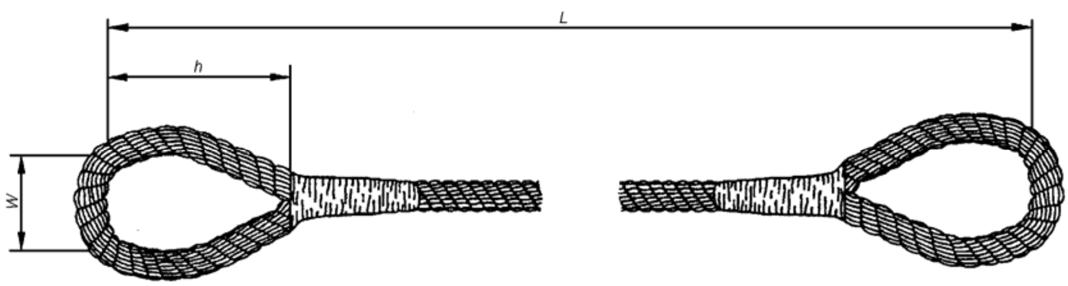

Fig. 2. Cable-laid wire rope sling

4 SLING EXAMPLES

Single-leg slings shall be one of the types shown in Fig. 3, with or without terminal fittings such as links or hooks (see Fig. 3). Where a single-leg sling is used for wrapping or supporting the load (Fig. 4), the sling shall always be fitted with a thimble.

Examples of single-leg slings			
Ferrule secured hard eye	Hand spliced soft eye	Ferrule secured soft eye with stirrup	Ferrule secured soft eye
 FK	 S	 FK	 F
Terminal fittings			
link at upper end	link at lower end	shackle at lower end	hook at lower end
 FKo	 FKo	 FKs	 FKh

Rys. 3. Examples of slings and their terminal fittings

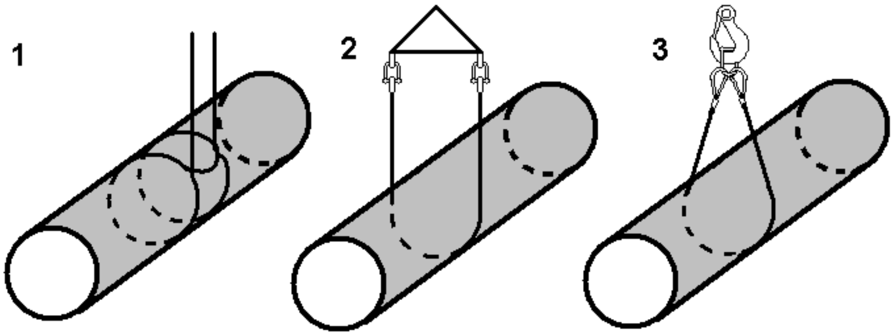

Fig. 4. Attaching load by supporting and wrapping

1 – load wrapping, 2,3 – load supporting

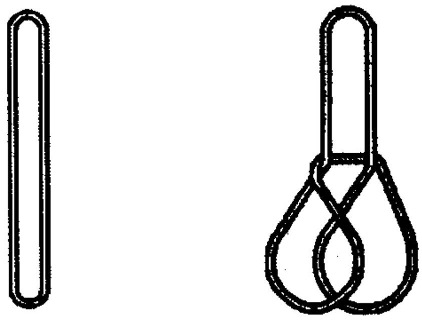

Fig. 5. Endless sling

5 REQUIREMENTS

5.1 General

The minimum length of plain rope between the inside ends of ferrules terminating a sling leg shall be 20 times the nominal rope diameter, while the minimum length of plain rope between the tails of splices shall be at least 15 times the nominal rope diameter. The peripheral length of a soft eye shall be at least four rope lay lengths. A stirrup can be fitted to protect the bearing surface of the soft eye. Hard eyes shall be fitted with thimbles.

5.2 Terminal fittings

Working load limit, WLL:

- of any master link shall be at least equal to that of the sling,
- of any intermediate link fitted to a three-leg or four-leg sling shall be at least equal to 1.6 times the WLL of one of the legs suspended from it,
- of the lower terminal fitting(s) shall be at least equal to that of the leg(s) to which it is/they are fitted.

5.3 WLL for single-leg sling

The working load limit, WLL, of a single-leg sling shall be calculated as follows:

$$\mathrm{WLL} = (K_T/Z_P)(F_{\min}/g),$$

where:

K_T is a factor which allows for the efficiency of the termination. For ferrule secured terminations K_T shall be 0.9 and for spliced terminations K_T shall be 0.8,

Z_P is the coefficient of utilization and for wire rope legs has the value = 5, while for chain legs has the value = 4,

F_{min} is the minimum breaking force of the rope,
$g = 9.81$ m/s^2 is the acceleration of gravity.

If the breaking force F_{min} is measured in kN, then F_{min}/g is measured in tons/9.81.

5.4 WLL for endless slings

The working load limit, WLL, for endless slings is determined from the below formula:

WLL = $(2/Z_P)(F_{min}/g)$ for the load supported, or
WLL = $(2\text{-}k_z/Z_P)(F_{min}/g)$ for the load wrapped (Fig. 4).

It has been assumed that the sling load is distributed symmetrically and the coefficient k_z taking into account the effect of rope bending on its strength is equal to:

0.8 – for steel wire rope slings,
0.7 – for fibre rope slings.

The working load limits for ropes, depending on the rope diameter, sling type (endless, multi-leg) and their legs angle to vertical are given in EN 13414-1 Standard. For multi-leg slings, each leg shall be of the same type.

The internal angle of home pocket loop shall be not more than 30º. The maximum transverse dimension of load shall be 0.3 x loop length.

5.5 WLL for multi-leg slings

$$\text{WLL} = (K_T K_L/Z_P)(F_{min}/g),$$

where K_L is a coefficient taking into account the number of sling legs and their angle to vertical. The coefficient values are as below:

for two-leg slings

$K_L = 1.4$ where the leg angle to vertical is less than 45°,
$K_L = 1.0$ where the leg angle to vertical is between 45° and 60°,

for three and four leg slings

$K_L = 2.1$ where the leg angle to vertical is less than 45°,
$K_L = 1.5$ where the leg angle to vertical is between 45° and 60°,

The leg angle to vertical may not be more than 60°.

6 DETERMINATION OF SLING STRENGTH

The working load limit, WLL, is determined depending on the breaking force of a leg F_{min}. Considering the adopted values of the coefficient of utilization Z_P (for wire ropes equal to 5 and for chains equal to 4), the formulae given in Chapter 5 specify approximate/estimated values of WLL.

In special cases, when the sling shall be selected for big and heavy loads of known mass, alternative methods of determination of sling strength may be applied.

6.1 Working load limit

The sling load W_L comprises static load S, increased by dynamic loads S_L. The sling load is equal to: $W_L = S + S_L$. Taking into account that $S_L = v_r\,(km)^{1/2}$, where v_r is the hook speed in relation to load at the sling tensioning [m/s], $k \equiv G/\Delta h$ is a vertical sling stiffness [N/m], equal to the suspended weight $G = mg$ [N] related to vertical elongation Δh [m] of the sling, and m [kg] is a mass of suspended load. Therefore:

$$W_L = S[1 + v_r(k/Gg)^{1/2})] \equiv \psi S$$

where $g = 9.81$ m/s^2 is the acceleration of gravity. The static load (leg tension) $S > G$ is greater than the suspended load, when the legs are open (the difference increases with opening of the angle). In such case it is recommended that legs angles to vertical should be equal and not less than 15°, In order to avoid problems with stability of suspended cargo. The expression in square bracket is a coefficient of dynamic overload, ψ. The coefficient ψ is greater than 1 and increases with the sling stiffness k. The dynamic load is equal to $S_L = (\psi - 1)S$. In the case of multi-leg slings, S means the tension (load to one leg, with unequal loads it is the greatest of them).

In shipbuilding applications, the sling load shall additionally consider forces from ship movements on waves which apparently increase the gravity force of suspended load. The forces shall be adopted according to short term assumption with 10^{-4} security, i.e. the amplitude of additional mass force at the highest permissible sea state, where loading operations may be conducted, shall not be exceeded more frequently than once for 10^4 oscillations.

The working load of a sling M_L (M_L is the mass, the weight of which causes the biggest tension of sling leg) shall be calculated according to the below formula:

$$M_L = W_l/g.$$

6.2 Working load limit (WLL)

The working load limit for slings is specified by the formula: $\mathrm{WLL} = 1.4M_L$ – it is greater than the working load M_L by 40%. WLL means a permitted mass the sling can be loaded with.

6.3 Leg strength

The sling shall carry the below test loads due to rest mass equal to:

a) 2.0 WLL, for a sling of WLL up to 20 t (tons of mass);
b) 1.0 WLL + 20 t, for a sling of WLL above 20 t and up to 40 t.;
c) 1.5WLL, for a sling of WLL above 40 t.

The test shall be attended by a competent person. The load shall be applied for at least 5 min. After the test, no damages to sling items shall occur, such as separation of eye splices, displacement of wire ropes in rope securing devices, fractures, deformations of permanent chain links, etc. Permanent elongation of ropes in relation to original length shall not exceed 2% for steel wire ropes, 10% for hemp ropes, and 14% for sisal and manila ropes.

6.4 Tension of legs in two-leg sling

Static tension of legs S, needed for the determination of the load of sling W_L, depends on the number of legs and their angles to vertical. Where, as in Fig. 6, the centre of gravity of the mass of suspended load lays in the vertical line passing the hook axis, the forces acting in ropes are determined by the below formulae:

$$S_1 = G\sin\alpha_2/\sin\gamma,$$
$$S_2 = G\sin\alpha_1/\sin\gamma.$$

where G is the lifted load, while α_1 and α_2 are the legs angles to vertical. The sum of angles $\alpha_1 + \alpha_2$ means the angle between the legs. This angle may not be greater than 120°. The angle between ropes is then $\gamma = \alpha_1 + \alpha_2$.

Note: When the angle $\alpha_2 \to 0$, tension $S_2 \to G$, and $S_1 \to 0$, what can be presented by the triangle of forces, therefore when the angle to vertical of one leg approaches zero, the load it carries increases and the load carried by the other leg lowers. When the ropes angle to vertical is equal, i.e. $\alpha_1 = \alpha_2 = \alpha$, , tensions of legs are also equal, $S = G\sin\alpha/\sin 2\alpha = G/2\cos\alpha$. When the leg angle $\alpha_1 \to 90°$, $S_1 \to G\,\mathrm{tg}\,\alpha_2$, and $S_2 \to G/\cos\alpha_2$, i.e. the triangle of forces is nearing the right-angled triangle, in which forces S_1 and G are its legs.

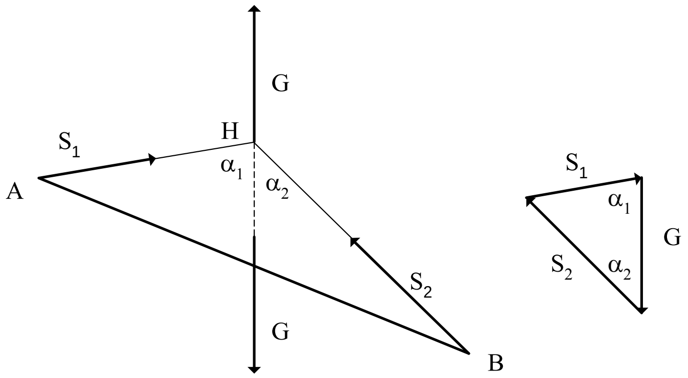

Fig. 6. Forces acting in a two-leg sling

6.5 Tension of legs in three-leg sling

Three- and four-leg slings make a pyramid, as in Fig. 7.

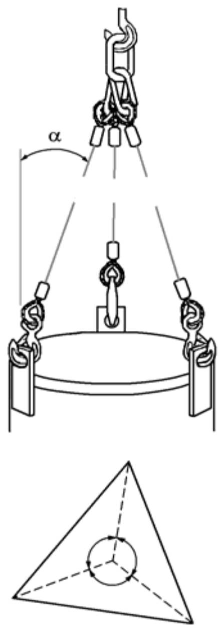

Fig. 7. Forces acting in a three-leg sling

The centre of gravity of the lifted mass is situated on the vertical line passing through the hook axis. The sum of the vertical projections of leg forces is equal to the gravity force of the lifted load G :

$$S_1 \cos \alpha_1 + S_2 \cos \alpha_2 + S_3 \cos \alpha_3 = G,$$

where:

S_1, S_2, S_3 are leg forces,

$S_2 = S_1(\sin \alpha_1 / \sin \alpha_2) \sin \beta_3 / \sin \gamma_1$,

$S_3 = S_1(\sin \alpha_1 / \sin \alpha_3) \sin \beta_2 / \sin \gamma_{1,}$

α_1, α_2, α_3 are leg angles to vertical.

Angles between leg projections γ_1 are sum of angles β_2 and β_3.

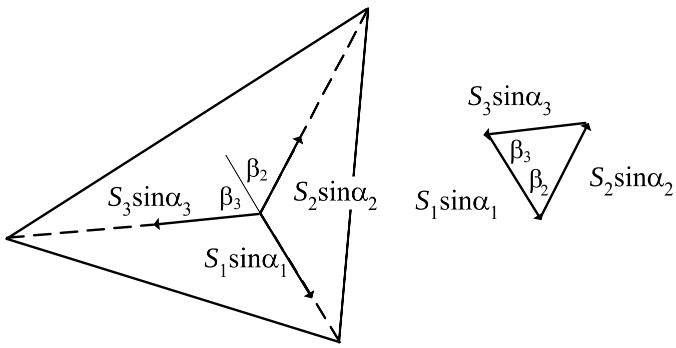

Fig. 8. Horizontal projection of sling forces

Note:

Calculation example

Horizontal projection (to pyramid base) of forces show forces $S_1\sin\alpha_1$, $S_2\sin\alpha_2$, $S_3\sin\alpha_3$ acting centrifugally along the projections of wire ropes (Fig.8). It appears from the law of sines applied to the triangle of forces that $S_1\sin\alpha_1/\sin(\beta_2 + \beta_3) = S_2\sin\alpha_2/\sin\beta_3 = S_3\sin\alpha_3/\sin\beta_2$, where β_2 and β_3 are deflections of projections of the ropes 2 and 3 from the projections of rope 1; each of them is lower than 90°. The sum of deflection angles $\beta_2 + \beta_3$ indicates an angle between projections of ropes 2 and 3. The angle is lower than 180°. When the angle between the projections of ropes is $\gamma_1 = \beta_2 + \beta_3$, the horizontal projections of rope forces will be expressed as one of them by formulae:

Substituting the values in the equilibrium equation gives the formula:

$$S_1[\cos\alpha_1 + (\sin\alpha_1/\mathrm{tg}\alpha_2)\sin\beta_3/\sin\gamma_1 + (\sin\alpha_1/\mathrm{tg}\alpha_3)\sin\beta_2/\sin\gamma_1] = G.$$

The formula determines the tension in the first leg:

$$S_1\cos\alpha_1[1 + (\mathrm{tg}\alpha_1/\sin\gamma_1)(\sin\beta_3/\mathrm{tg}\alpha_2 + \sin\beta_2/\mathrm{tg}\alpha_3)] = G.$$

Other forces are determined by similar formula, when the angles between forces and their division are known (Fig. 9). The angles are as below:

$$\gamma_2 = 180° - \gamma_1 + \beta_2 = 180° - \beta_3$$
$$\gamma_3 = 180° - \beta_2.$$

Forces in two other legs are calculated by similar formulae:

$$S_2\cos\alpha_2[1 + (\mathrm{tg}\alpha_2/\sin\beta_3)(\sin\beta_2/\mathrm{tg}\alpha_3 + \sin\gamma_1/\mathrm{tg}\alpha_1)] = G,$$
$$S_3\cos\alpha_3[1 + (\mathrm{tg}\alpha_3/\sin\beta_2)(\sin\gamma_1/\mathrm{tg}\alpha_1 + \sin\beta_3/\mathrm{tg}\alpha_2)] = G.$$

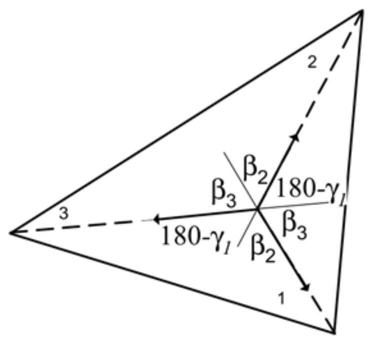

Fig. 9. Division of angles among forces

When the legs angle to vertical $\alpha_1 = \alpha_2 = \alpha_3 = \alpha$ is equal and the angle between legs projections to the level $\gamma_1 = \gamma_2 = \gamma_3 = 120°$ is equal, then the forces in legs $S_1 = S_2 = S_3 = S$ are also equal $S = G/3\cos\alpha$.

6.6 Tension of legs in four-leg sling

Calculations for a four-leg sling may be based upon a two-leg sling, when the hook corner fittings make a rectangle of length AB. The legs *AH* and *BH* are projections of legs attached to the corner fittings of transverse side of the rectangle (Fig. 10); a hook is situated in point *H*.

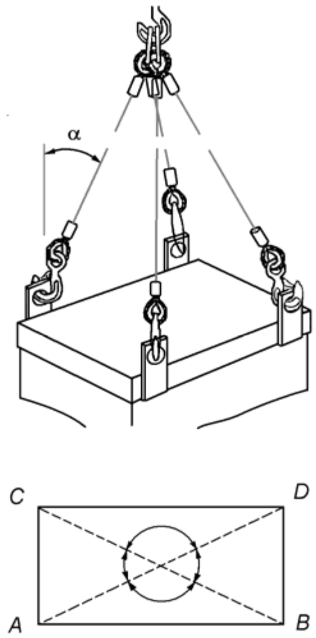

Fig. 10. Four-leg slings

Note:

The tension of legs in the four-leg sling is statically indeterminable. It can be determined only with an additional assumption. For example, when the leg angle to vertical is equal, i.e. when the lower corner fittings make a rectangle, the lengths of legs are the same and the centre of gravity is situated under the centre of the rectangle, as show in Fig. 10, it can be assumed that leg tensions are equal. In such case the tension of one leg is $S = G/4\cos\alpha$.

If for any reasons one of legs fails to operate, e.g. becomes longer than the others due to wear, then automatically the leg situated diagonally stops to operate and the whole load is sustained by the other diagonal pair of legs. It is consequent from the condition of the balance of horizontal projection of forces. For four-leg slings, there exist a risk that after one of legs stops to operate, the load sustained by the other operating pair of legs doubles.

If the centre of gravity of the load is not situated in the centre of rectangle length, the length of legs may not be equal. In such case, the calculation is reduced to the case of two-leg sling, as shows in Fig. 6, where two corner fittings from the transverse sides of the rectangle exist in each of points A and B and legs of equal length are attached in pairs thereto. In such case, the forces S_1 and S_2 can be considered as a resultant of equal leg tensions in the transverse sides of the rectangle.

7 MARKING AND EXAMINATIONS

7.1 Marking

Each sling shall be legibly and durably marked with the below information:
– the sling manufacturer's identifying mark;
– numbers and/or letters identifying the sling with the manufacturer’s quality certificate;
– WLL for one-leg sling or WLL for angle ranges 0°÷45° and 45°÷60°, for multi-leg slings,
– the sling nominal length, in meters,
– markings required by other regulations,
– number of PRS issued certificate, if required.

Marking of chain slings shall include the sling class and the number of legs.

Marking of webbing slings is placed on the label on the webbing. The marking shall include:
– WLL for use in a simple system,
– kind of webbing material,
– the class of fittings,
– nominal length,
– manufacturer’s identifying mark,
– identification code,
– European Standard No.,

– marking required by other regulations, including CE Mark,
– a symbol identifying the certificate of the sling examination by PRS, if required.

Marking of slings may be performed on:
– the master link,
– a ferrule,
– a ring attached to the leg close to the eye or loop,
– a durably attached plate (tag).

All marks shall be stamped so that the strength properties of links and ferrules are not impaired and the marking plates shall be made of anti-corrosion material. For the endless slings, the point of contact of the core (and of the splice) shall be marked, or the marking renewed.

7.2 Types of examination

Examination of a sling during manufacture covers:
– checking material certificates,
– external inspection,
– checking dimensional conformity with drawings,
– checking the strength, as in 6.3 .

For each sling, material certificates are checked and external inspection made. Dimensional and strength check is carried out on random samples of number equal to $0.37N^{0,64}$ rounded up, where N is the number of items in the batch.

Examination of the sling during in-service inspections comprises:
– external inspection.

A sling shall be withdrawn from service in the case of damage to such elements as:
– for wire ropes: permanent break-down, knots or flattening of the rope, corrosion, separating of lopp and eye splices, displacement of ropes in ferrules, fractures,
– for chains: excessive corrosion wear, excessive stretching, durable deformation of chain links, etc.

Durable elongation of wire ropes in relation to original length shall not exceed 2% for steel wire ropes, 10% for hemp ropes and 14% for sisal and manila ropes.

In no place the wear of chain and fittings, defined as reduction of mean diameter measured in two directions, shall exceed 10% of the original dimension.

7.3 Certificate

Foe each sling or batch of slings approved as conforming with requirements, the sling manufacturer shall supplied a certificate, including at least the below information:
– the name and address of the manufacturer,
– the name and address of the workshop performing examinations,
– the mark identifying the manufacturer,
– type of sling, including its material, structure, etc.,
– the number of batch,
– number of slings,
– nominal length of a sling, in m,
– the value of test loads,
– working load limit (WLL), in t,
– a signature of the person performing examinations.