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ISO 18264

Second edition
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Textile slings — Lifting slings for general purpose lifting operations made from fibre ropes — High modulus polyethylene (HMPE)

Élingues textiles — Élingues de levage pour opérations de levage pour usage général en cordages en fibres — Polyéthylène à haut module (HMPE)

Reference number
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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 38, *Textiles.*

This second edition cancels and replaces the first edition (ISO 18264:2016), which has been technically revised.

The main changes are as follows:

— the Scope has been made more concise;

— the Normative references have been updated; some references have been moved to the Bibliography;

— the Terms and definitions have been updated;

— the formulae in Table 4 have been corrected;

— figures and designations have been changed in accordance with ISO/IEC Directives Part 2:2021;

— subclauses 7.3.2 and 7.3.3 have been rewritten and simplified. References are given to ISO 2377and ISO 9554 instead of repeating the texts in those standards.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

This document has been prepared to be a standard providing one means of complying with the essential safety requirements.

Textile slings — Lifting slings for general purpose lifting operations made from fibre ropes — High modulus polyethylene (HMPE)

1 Scope

This document specifies the requirements related to safety, including methods of rating and testing sling constructions made from fibre ropes. It is applicable to ropes made of high modulus polyethylene (HMPE) fibre having a minimum reference number of 12 and a maximum reference number of 72.

The fibre rope slings covered by this document are intended for general-purpose lifting operations only, i.e. when used for lifting objects, materials or goods which require no deviations from the requirements, design factors, or work load limits specified.

This document does not cover slings used for the lifting of persons, potentially dangerous materials such as molten metal and acids, glass sheets, fissile materials, nuclear reactors and special (non-routine and engineered) lifting operations. This document can be used as a reference for lifting slings made with HMPE fibres to be used in special lifting operations.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 1968, *Fibre ropes and cordage — Vocabulary*

ISO 2262, *General purpose thimbles for use with steel wire ropes — Specification*

ISO 2307, *Fibre ropes — Determination of certain physical and mechanical properties*

ISO 2415, *Forged shackles for general lifting purposes — Dee shackles and bow shackles*

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 7597, *Forged steel lifting hooks with latch, grade 8*

ISO 8539, *Forged steel lifting components for use with Grade 8 chain*

ISO 9554:2019, *Fibre ropes — General specifications*

ISO 10325, *Fibre ropes — High modulus polyethylene — 8-strand braided ropes, 12-strand braided ropes and covered ropes*

ISO 12100:2010, *Safety of machinery — General principles for design — Risk assessment and risk reduction*

ISO 16798, *Links of Grade 8 for use with slings*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 1968 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
abrasion
mechanical wearing of a surface resulting from frictional contact with other materials and objects

3.2
angle of choke
α_{CH}
angle formed in a sling body as it passes through the choking eye or fittings

Note 1 to entry: See 3.9, Figure 1 and Figure 4.

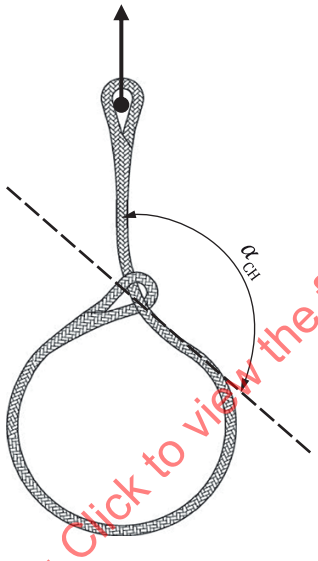
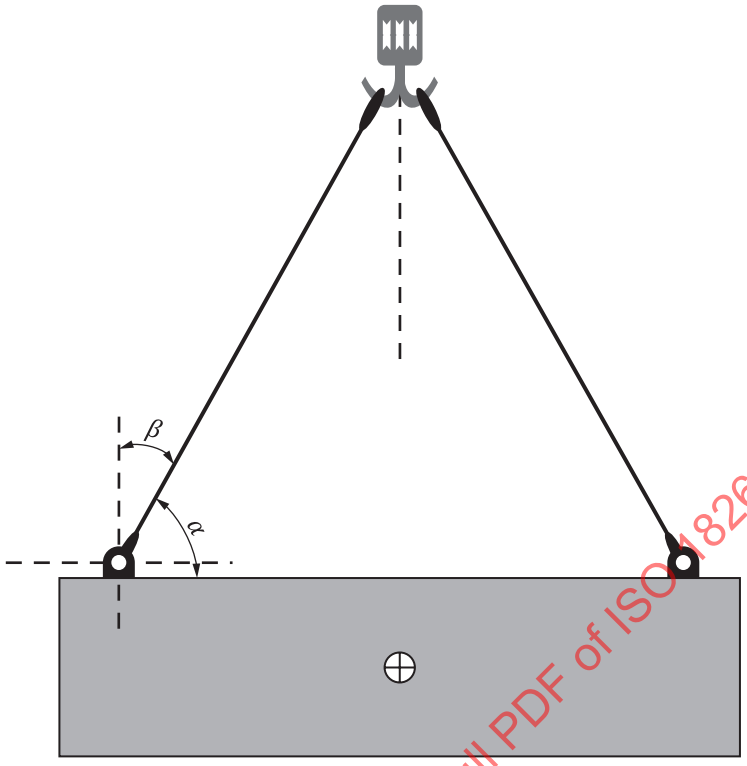


Figure 1 — Example of angle of choke

3.3
angle of loading
α
horizontal angle

Note 1 to entry: β vertical angle. See Figure 2.



Key

β vertical angle

α horizontal angle

Figure 2 — Example of angle of loading

3.4
competent person
designated person, suitably trained and qualified by knowledge and practical experience, and with the necessary instructions to enable the required tests and operations as well as examinations to be carried out

3.5
design factor
factor by which the nominal breaking strength of *sling construction* (3.25) is divided to determine its working load limit in straight pull

Note 1 to entry: Also referred to as safety factor (SF).

Note 2 to entry: This term has the same meaning as the term "working coefficient" used in the EU Machinery Directive.

Note 3 to entry: Fittings may have different design factors from that of the fibre ropes to which they are connected.

3.6
effective work length
EWL
actual finished length of the fibre rope sling construction, inclusive fittings, from bearing point to bearing point while being loaded to a reference load to be determined and documented by the manufacturer

Note 1 to entry: See *nominal length* (3.19) as well as Figure 6 and Figure 7.

3.7
general-purpose lifting operation
operation identified and described as the one which[8] is a repetitive lift covered by a previously prepared JRA and LP, carried out by lifting team trained in the use of specific lifting operation/device and competent to complete the entire operation

Note 1 to entry: Also referred to as routine lifts or lifting operation, and is the opposite of special (non-routine or engineered) lifting operation.

3.8
basket hitch
method of rigging a sling in which the sling is passed around the load and both loop eyes and end fittings are attached to the lifting device

Note 1 to entry: See Figure 3.

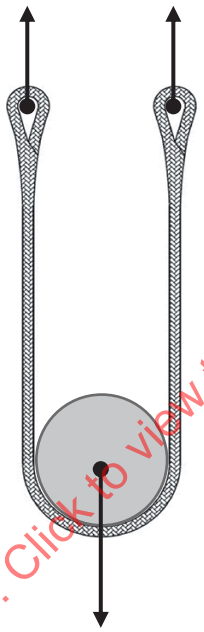


Figure 3 — Example of basket hitch

3.9
choker hitch
method of rigging a sling in which the sling is passed around the load, then through one loop eye, end fitting, or other piece of hardware, with the other loop eye or end fitting attached to the lifting device

Note 1 to entry: This *hitch* (3.10) can be done with a sliding choker hook or similar device (see Figure 4).

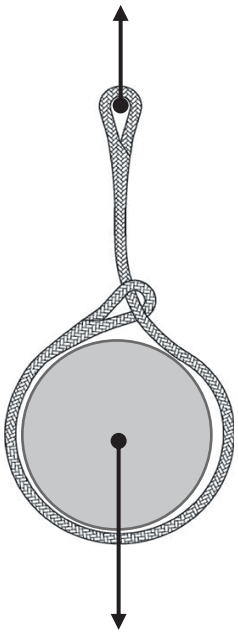


Figure 4 — Example of choker hitch

3.10
hitch
method of rigging (attaching) one or several slings temporarily to a load, or object, for the purpose of lifting

3.11
vertical hitch
method of rigging a sling in which the load is attached to the loop eye or end fitting at one end of the sling and the loop eye or end fitting at the other end is attached to the lifting device

Note 1 to entry: Any *hitch* (3.10) less than 5° from the vertical (β in Figure 2) may be considered a vertical hitch (see Figure 5).

Figure 5 — Example of vertical hitch

3.12
intermediate master link
link used to connect one or two legs of a sling to a *master link* (3.16)

Note 1 to entry: Intermediate links can be assembled with a master link to form a permanent master link.

3.13
job risk assessment
JRA
process where

— health and safety hazards are identified,

— risks associated with the hazards are analysed and evaluated, and

— appropriate ways to eliminate or control these hazards are determined

Note 1 to entry: In practical terms, a risk assessment is a thorough look at your workplace to identify those things, situations, processes, etc. that can cause harm, particularly to people. After identification is made, the user of the slings evaluates how likely and severe the risk is, and then decides what measures should be in place to effectively prevent or control the harm from happening. The result of this process is documented by the user of the slings in the form of a job risk assessment (JRA).

3.14
lifting configuration
arrangement characterized by the number of sling legs in the lifting assembly, the *angle of loading* (3.3) under which they spread and in which the sling assembly is connecting the suspended load and the lifting mechanism

Note 1 to entry: The lifting configuration is characterized by the number of sling legs in the lifting assembly, the angle of loading under which they spread and in which the sling assembly is connected to the suspended load. As part of the arrangement additional hardware, such as e.g. (intermediate) master links, shackles and spreader bars may be used".

3.15
lift plan
LP
documented plan of the proposed lifting operation

Note 1 to entry: Lift plan covers aspects such as the following:

— characterization of the load in terms of dimensions, weight and centre of gravity;

— characterization of the task in terms of lifting, rotation, speeds and travel directions;

— evaluation of the hazards to determine consequences resulting from collision, upset or dropping of the suspended load;

— determination of how to rig the load using good rigging practices and ensuring the use of proper rigging techniques during the lift;

— ensuring that the attachment points and suspended load can withstand the forces created by the rigging gear attachment;

— selecting equipment and rigging based on the type, category of lift and minimum capacity of lifting equipment (hoist, crane, slings, lifting fixture, etc.) and on the identified load, task and hazards;

— ensuring that sling angles are considered when determining forces on rigging equipment and the suspended load.

3.16
master link
link forming the upper terminal of a sling or *intermediate master link* (3.12) by means of which the sling is attached to the hook of a crane or other lifting device

3.17
multi-leg sling
sling assembly (3.23) composed of multiple (two, three or four) legs with the top ends gathered in a master link that goes over the lifting hook

Note 1 to entry: Also called bridle sling.

Note 2 to entry: Examples are given in Figures 9 to 11.

Note 3 to entry: Sling legs in one assembly may not necessarily have an equal EWL and/or R_F. In the case where EWL and/or R_F are not identical, such deviations need to be covered by the LP.

3.18
nominal diameter
d
specified diameter of the rope which is usually used as the reference number for a given product

3.19
nominal length
L_0
specified length of the sling leg, inclusive of fittings, from bearing point to bearing point

Note 1 to entry: See Figures 6 and 7.

3.20
proof force
F_p
force applied as a test to a finished *sling construction* (3.25), as specified in *proof test* (3.21)

Note 1 to entry: Also referred to as "proof load"

3.21
proof test
non-destructive force (or load) test made to a predefined *proof force* (3.20) (or load) of a *sling construction* (3.25)

3.22
rated force
R_F
maximum allowable force of a *sling construction* (3.25)

Note 1 to entry: Also referred to as rated load and expressed in kN.

3.23
sling assembly
one or more sling leg(s)/*sling constructions* (3.25) combined with rigging hardware (such as links, shackles, thimbles) to be used as part of a rigging arrangement for the purpose of lifting a load

3.24
sling body
fibre rope used as load bearing part to create a *sling assembly* (3.23)

3.25
sling construction
eye-and-eye (see Figure 6) or endless construction (see Figure 7) of a fibre rope used to create a *sling assembly* (3.23)

Note 1 to entry: Also referred to as sling leg.

3.26
sling manufacturer
person or company assembling or fabricating sling components into their final form

Note 1 to entry: The rope and sling manufacturer are not necessarily identical entities.

3.27
soft eye
eye made by forming the end of the fibre rope into a loop and by splicing the free end to the standing part

3.28
special lifting operations
lifting operations where [12]

— *job risk assessment (JRA)* (3.13) is required to identify and mitigate the risks and a completed *lift plan (LP)* (3.15) is required, and

— new specific lift plan (LP) is required based on a risk assessment

Note 1 to entry: Also referred to as non-routine lifts or engineered lifting operations.

3.29
splice

3.29.1
spliced eye
loop, or eye, formed in the end of a rope

3.29.2
cut splice
connection of two ends to create an endless connection by tucking the ends of the strands back into the main body of the fibre rope in a prescribed manner

3.30
working load limit of the lifting configuration
WLL
maximum allowable total suspended mass a *lifting configuration* (3.14) is authorized to sustain in *general-purpose lifting operations* (3.7)

4 Hazards

The accidental release of a suspended load or release of a suspended load due to failure of a component puts at risk, either directly or indirectly, the safety or health of those persons within the danger zone. In order to provide the necessary strength, durability and reliability of lifting accessories, this document specifies requirements for the design, manufacture, testing, use and maintenance of the slings to ensure the specified levels of performance are met.

Endurance/durability has not been identified as a risk when properly designed manufactured and tested fibre rope slings, comprising high tenacity HMPE fibre, having the specified levels of performance, given in this document, are properly used and inspected for general-purpose lifting operations.

Since failure can be caused by overloading or incorrect selection of the working load limit (WLL) and specification of lifting accessory, this document also gives the requirements for marking and the manufacturer's certificate.

Aspects of selection and safe and reliable use associated with good practice are given in Annex A and Annex B.

Table 1 lists those hazards, in accordance with ISO 12100, identified as being specific and significant for fibre rope slings made of HMPE.

Under constant or repeated loading, HMPE fibres and ropes may show irreversible deformation also referred to as creep, dependent upon load, time under load, temperature, as well as the type of HMPE fibre[12]. Different HMPE fibres exhibit different creep behaviour under identical conditions.

Depending on the conditions in which the slings are intended to be used, the sling user shall consult the sling manufacturer in order to select slings fit for the intended purpose and service.

Fit for the intended purpose implies assuring the right slings are made and put together properly prior to delivery. This is a supplier responsibility. In the case where the slings are used for the right thing, used the right way and kept in the right condition, the slings are fit for the intended service. This is a sling user responsibility.

Table 1 — Type or group of hazards and associated hazard mitigation requirements

Type or group of hazards and relevant subclause(s) of ISO 12100:2010, Table B.1	Examples of hazards		Hazard mitigation requirements in relevant (sub)clause(s) of this document
	a) Origin	b) Potential consequences	
Mechanical hazards: 6.1, 6.2.1, 6.2.2.1, 6.2.2.2, 6.2.3 a) and b), 6.2.6, 6.3.1, 6.3.2, 6.3.3, 6.3.4.3, 6.3.5.5, 6.4.1, 6.4.2, 6.4.3, 6.4.4, and 6.4.5	Human error/ behaviour, education and training, documentation, planning, cutting parts, falling objects, instability, rough surfaces, sharp edges, shock loading, incorrect or missing sling marking, handling, etc.	Being run over, crushing, cutting, internal and external wear, puncture, tilting, overloading, falling, etc.	Clauses 5, 6, 7, 8, 9, 10, Annexes A and B.
Thermal hazards: 6.1, 6.2.2.2, 6.2.3, 6.2.6, 6.3.2.1, 6.3.4.5, 6.4.5.1 a), b), d) and e)	Human error/ behaviour, education and training, documentation, planning, radiation of heat sources, vibration, etc.	Melting, burns, falling, etc.	Annex B
Hazards associated with the environment in which the machine is used: 6.1, 6.2.6, 6.3.2.1, 6.4.5.1 a) and b)	Human error/ behaviour, education and training, documentation, planning, dust, pollution, chemical components, temperature, handling, etc.	Cutting, internal and external wear, puncture, falling, etc.	Clauses 4, 5, 9, 10, Annex B
Combination of hazards: All the above	Combination of origins mentioned above	Combination of consequences mentioned above	Clauses 5, 6, 7, 8, 9, 10, Annexes A and B
NOTE 1 A single origin of a hazard can have several potential consequences. NOTE 2 For each type of hazard or group of hazards, some potential consequences can be related to several origins of hazard.			

5 Sling materials and components

5.1 Fibre ropes

Fibre rope materials covered by this document for the use of sling assemblies are high modulus polyethylene (HMPE) fibres as defined in ISO 2076.

The HMPE rope constructions covered by this document are the following:

— 8-strand braided ropes (type L), 12-strand braided ropes (type T) and covered rope constructions (type C) manufactured and tested in accordance with ISO 2307 and ISO 10325;

— laid and braided rope constructions deviating from ISO 10325, manufactured, and tested in accordance with ISO 2307 and ISO 9554;

— constructions designed and manufactured according to with ISO 10325 and ISO 9554 and tested according to ISO 2307; or

— other local and/or International Standards provided that this document is consistent.

5.2 Coatings

Finishes and coatings shall not impair the performance of a sling construction.

NOTE 1 A fibre finish is typically applied to the base fibre after creation of the individual filaments, but before winding of the roving or during twisting or assembly. A coating can be applied during rope or sling production, or afterwards on the finished sling in a separate step.

NOTE 2 Coatings are typically applied to improve performance in the following four principal areas:

— structural improvement such as, but not limited to, strength (variability), shape stiffness, environmental protection (e.g. chemicals) and cover slippage;

— splice optimization (such as friction);

— abrasion/fatigue (such as, but not limited to, tension and bending fatigue);

— functional additives (such as, but not limited to, colour, UV resistance, flame retardance and adhesion promotion).

NOTE 3 Different parts of the sling construction can require different frictional properties and coating characteristics.

5.3 Cover (sleeves, jackets)

Covers, partly or fully enclosing the fibre rope, shall provide appropriate protection against abrasion, cutting, tearing, and penetration during storage, handling and use of the sling construction/assembly during the lifting operation.

The edges of a cover shall be finished in such a way that they can neither unravel nor impair the performance of the load bearing core of the sling.

NOTE The type of fibre material(s) used in a cover depends on the performance requirements and potential hazards (abrasion, cutting, puncture, exposure to chemicals, etc.) to be mitigated.

5.4 Mechanical components

Mechanical components, such as thimbles, shackles, trunnions, fittings and (master) links, used as parts of a fibre rope sling construction shall be selected such that they are compatible with the fibre rope sling construction, they meet the requirements and they do not impair the performance of the sling construction (see 6.2.3).

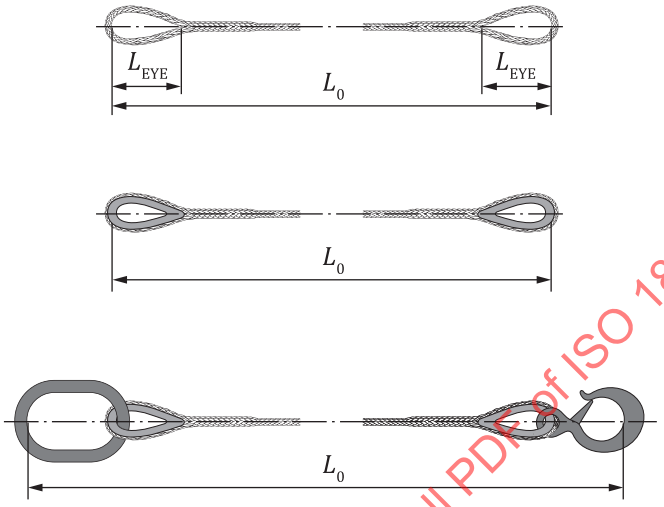
5.5 Other materials and components

Materials and components other than those listed in 5.4 may be employed. When such materials are employed, the sling manufacturer, its authorized representative or a qualified and/or competent person shall provide supportive data to minimize hazards and prove that these sling assemblies comply with all other requirements of this document.

6 Sling constructions, fabrication and lifting configurations

6.1 Sling constructions

An eye-and-eye construction shall be formed from a single piece of fibre rope and shall have eyes, with or without thimbles and fittings and or covers, spliced at each end. Figure 6 shows three typical examples of such construction.

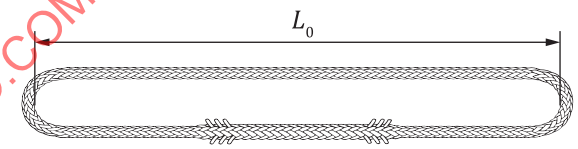


Key

L_0 effective work length of the sling construction

Figure 6 — Sling construction — Typical eye-and-eye constructions

An endless construction shall preferably be formed from a single piece of fibre rope and shall have the ends joined together by a splice. Figure 7 shows a typical example of an endless construction, also referred to as a "grommet".



Key

L_0 effective work length of the sling construction

Figure 7 — Sling construction — Typical endless construction

The fabrication of the sling construction, including deviations from the manufacturing methods, shall be verified and documented by the sling manufacturer in accordance with this document.

6.2 Fabrication

6.2.1 Splicing

Splicing is the commonly used method of fabricating sling construction. All splices shall be made by a trained and competent person and in accordance with the documented splicing instructions provided by the sling manufacturer, its authorized representative, or a competent person. Samples of these splices shall have been previously created in accordance with the application requirements and successfully verified by the testing in accordance with Clause 7.

In addition, the following shall be observed:

— in a typical eye-and-eye construction, no other splices than the splices required to create an eye shall be permitted;

— endless sling construction shall have only a single splice;

— where the protruding parts of the strands in a splice are contained, e.g. by binding, gluing, tapering, etc., to improve the appearance of the finished splice, such finishing shall not affect the performance of the splice and the sling construction;

— eye-and-eye sling constructions shall have a minimum undisturbed length of the rope of 10 times the rope reference number between the end of the splices; deviations shall be verified and documented in accordance with Clause 7;

— knots, clips or clamps shall not be used to fabricate slings;

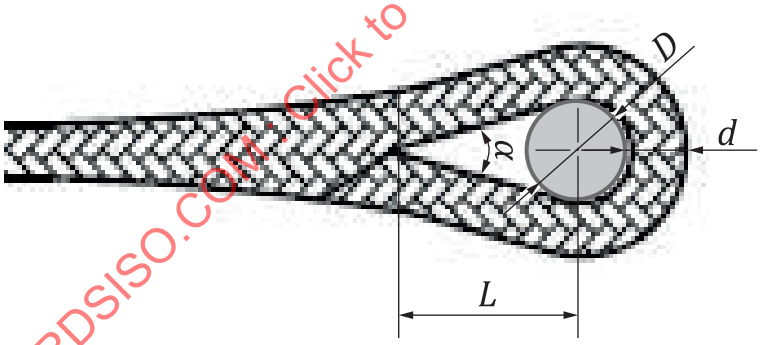
— if thimbles are required and do not have ears to prevent rotation, they shall be tied up to the rope.

NOTE Splice methodology for any sling construction is to be defined and documented by the sling manufacturer.

6.2.2 Considerations for connecting hardware and fittings

6.2.2.1 Eye-and-eye sling constructions

As a design rule, the minimum internal length (L) of a soft eye for an eye-and-eye sling construction, measured with a steel tape or rule graduated in increments of 1 mm, is in this subclause. Deviations shall be documented and verified in accordance with Clause 7.



Key

D diameter of the hardware (pin, bollard, shackle, trunnion or fitting) being used during type testing and use [a]

d fibre rope reference number

L length of the eye

α angle between two legs of the eye

NOTE If the hardware has a non-circular cross-section, D is the diameter of the point of highest curvature as illustrated by the red arrows in Figure 9.

Figure 8 — Soft eye dimensions

Design rules:

— D/d should be ≥ 2, and shall never be < 1.

— α shall be ≤ 20°.

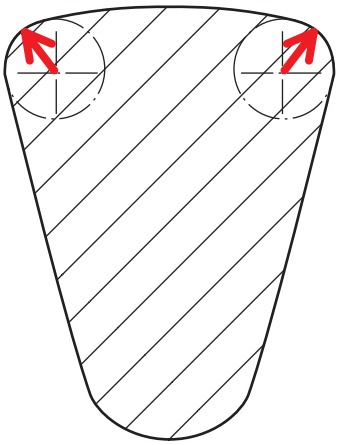


Figure 9 — Illustration of a non-circular cross-section

6.2.2.2 Endless sling constructions

The recommended D/d for an endless construction is preferably equal to 8 and never less than 1. Deviations shall be documented and verified in accordance with Clause 7.

6.2.3 Other requirements for mechanical components

Mechanical components used as parts of a sling construction and/or sling assembly shall be selected to meet the following requirements:

a) suitability of mechanical or socketed fittings shall be verified by a competent person;

b) the material shall be compatible with the mechanical and environmental requirements imposed on and by the sling construction and/or sling assembly. Master links shall be in accordance with ISO 16798. Other rigging hardware, when employed, shall be forged and shall meet the general requirements in accordance with ISO 8539.

c) eye hooks shall be in accordance with ISO 7597.

d) shackles shall be in accordance with ISO 2415.

e) thimbles shall be in accordance with ISO 2262.

The diameter, width and roughness of the bearing surface of the fitting/link can (severely) affect the strength of the sling construction and assembly. The use of thimbles is to be considered.

The natural flattening width, also referred to as the actual inside width, of the rope shall be equal to, or preferably less than, the effective inside width of the mechanical component. This is illustrated in Figure B.1.

6.3 Lifting configurations

For general purpose lifting operations, sling constructions are used as

— single leg lifting configuration, or

— multi-leg (2, 3 or 4 legs) lifting configuration.

A two-leg lifting configuration typically comprises two identical sling legs being connected to a master link, shackle, trunnion or crane hook. Figure 10 shows a typical two leg lifting configuration.

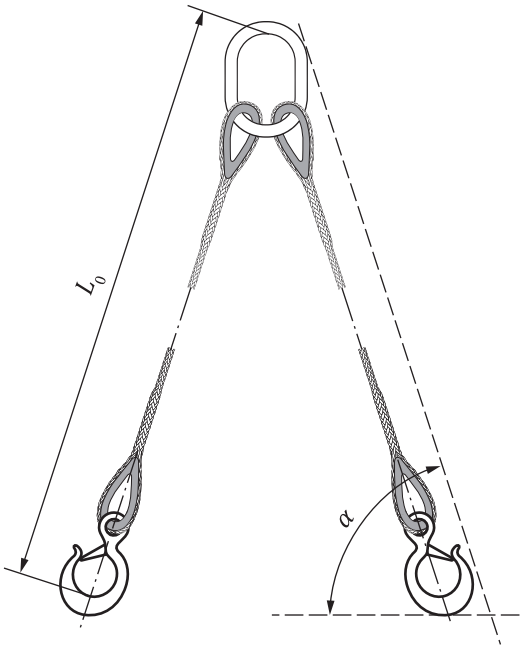


Figure 10 — Two (2)-leg lifting configuration

A three-leg lifting configuration is typically produced as per Figure 11 in the same way, but two legs shall be attached to one intermediate link and the remainder leg to the other intermediate link.

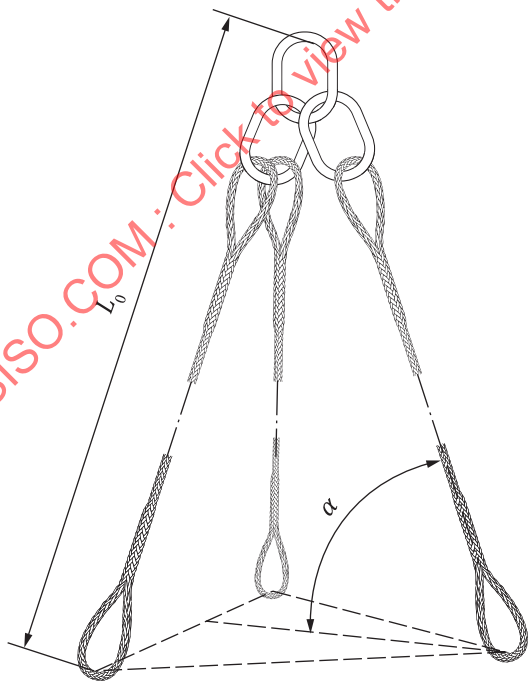


Figure 11 — Three (3)-leg lifting configuration

A four-leg lifting configuration shall comprise of four sling legs. Each pair of sling legs shall be connected to an intermediate link. The two intermediate links shall be attached to a master link or crane hook. Figure 12 shows a typical four-leg lifting configuration.

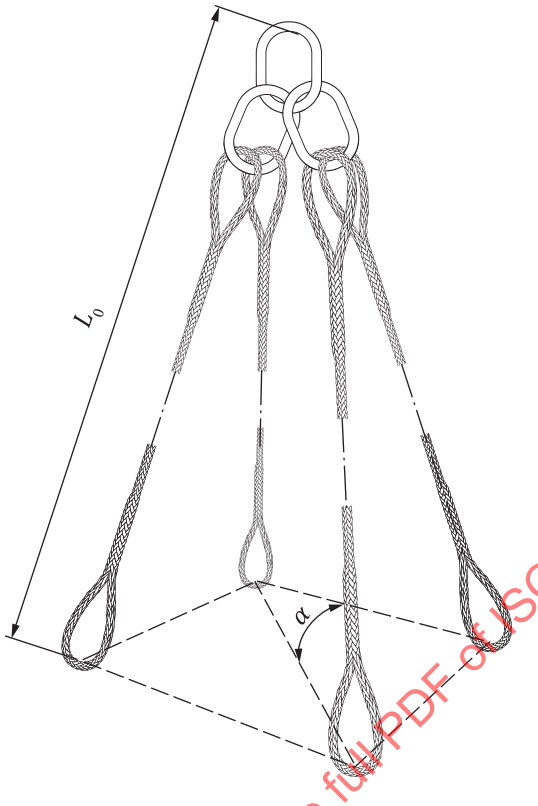


Figure 12 — Four (4)-leg lifting configuration

In the case where the effective work length and/or rated force of the sling legs in each of the a multi-leg configurations, as mentioned in Figures 10 to 12 are not identical, the lifting operation is perceived as a special lifting operation and verification of the effective work length and rated force of each sling leg shall be executed by the sling manufacturer or a competent person.

6.4 Design factor

The design factor (DF) for slings used in general-purpose lifting operations complies with the requirements for the region in which the sling constructions are put in use as shown in Table 2.

Table 2 — Regional design factors (DF) of fibre rope sling constructions

Region	DF	Reference
European Union	7	Machinery Directive 2006/42/EG[7]
United States	5	ASME B30.9[10]
Brazil	5	ABNT NBR 16957
Japan	6	JIS B8818[9]
Other regions	According to respective regional requirements	
NOTE 1 The DF's in this table are only applicable for slings used in general-purpose lifting operations; for engineered lifting operations deviations can apply. NOTE 2 The DF's in this table are only meant to be informative as design factors can be subject to change.		

6.5 Working load limit (WLL)

6.5.1 Calculation of the working load limit (WLL) of a lifting configuration

The working load limit of a sling construction depends on the following factors:

a) the rope, or sling, strength (depending on linear density and construction parameters);

b) the design factor (see 6.4);

c) the type of hitch (see Table 3);

d) the angle of loading (see Figure 2); and

e) the diameter of curvature over which the sling is tested or used (6.2.2.1).

The rated force (R_F) and the working load limit (WLL) of a lifting configuration shall be calculated according to Formulae (1) and (2).

$$R_F = BS_{SC}/\mathrm{DF} \tag{1}$$

$$\mathrm{WLL} = (R_F/g) \cdot M \tag{2}$$

where

R_F is the rated force of a sling construction, (see Figure 6), expressed in kN;

BS_{SC} is the spliced break strength of a sling construction, expressed in kN;

WLL is the work load limit of the lifting configuration, expressed in t;

g is the acceleration of gravity (9,81 m/s^2);

M is the mode factor (see ISO 1968).

Table 3 — Mode factors (=M) for eye-and-eye and endless sling constructions

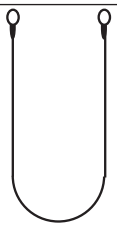
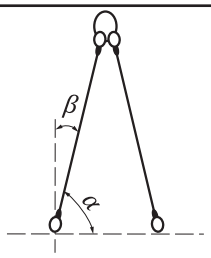
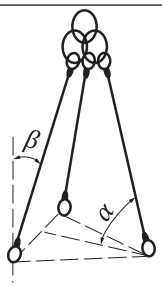
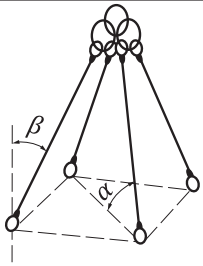
Configuration of sling leg(s)		Angle β [°]	Sling leg	
			Eye-and-eye sling construction	Endless sling construction
Single-leg (vertical hitch)		0–5	1,0	1,0
Basket hitch (incl. $\beta < 5°$)		0–5	2,0	2,0

Table 3 *(continued)*

Configuration of sling leg(s)		Angle	Sling leg	
		β [°]	Eye-and-eye sling construction	Endless sling construction
Two-leg bridle (incl. $\alpha < 90°$ in the case of a basket hitch)		0–45	1,4	1,4
Three-leg bridle		0–45	2,1	2,1
Four-leg bridle		0–45	2,1	2,1

Horizontal angles (α; see Figure 2) less than 30° shall not be used except when recommended by the sling manufacturer, its authorized representative or a qualified and/or competent person.

NOTE 1 Mode factors (M) are based on identical WLL and EWL of each sling leg in a multi-leg sling assembly.

NOTE 2 The values as given in Table 2, excluding choker hitch as lifting configuration, are based on minimum D/d in accordance with 6.2.2.

The mode factors for lifting configurations made up by sling assemblies of endless sling constructions shall be based on symmetrical positioning of the splice in accordance with Clause 7.

Mode factors for configurations deviating from the configurations mentioned in Table 2 shall be determined by the sling manufacturer or a qualified and/or competent person. Other configurations not covered by this subclause shall be rated in accordance with the recommendation by the sling manufacturer or a qualified and/or competent person and shall conform to all other provisions in this document.

6.5.2 Calculation of the working load limit (WLL) of a lifting configuration as a consequence of bending losses

6.5.2.1 Eye-and-eye construction

When utilizing an eye-and-eye construction in a vertical hitch (i.e. straight pull) or a multi-leg assembly), both mentioned in Figure 5, Figures 10 to 12 and Table 3, it is not necessary to account for bending loss in the case where the D/d of the applied hardware in the lifting configuration is at least equal to one (1) in accordance with 6.2.2.1.

In the case where this construction is utilized in a basket hitch (e.g. bent over bow of a shackle or crane hook), the *D*/*d* shall be at least equal to 8 to avoid derating. In the case where the *D*/*d* is less than 8, the sling construction shall be derated in accordance with Formula (4) (see Table 4). The *D*/*d* is not related to this ratio for the fittings/hardware to which the eyes of this construction are attached.

Derating shall be based on type tests as described in 7.3.

6.5.2.2 Endless construction

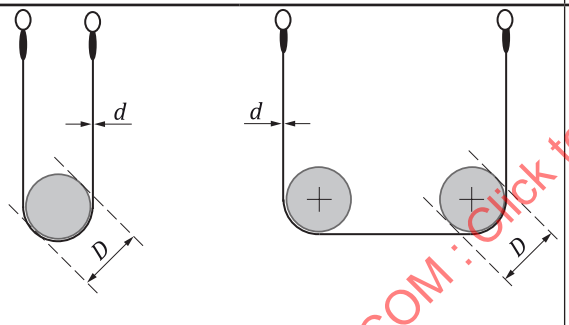
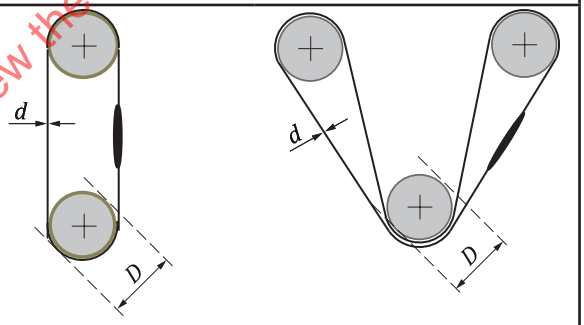
When linking an endless construction to fittings/hardware (e.g. the bow of a shackle or crane hook), the *D*/*d* shall be at least equal to 8 to avoid derating. In the case where the *D*/*d* is less than 8, the endless construction shall be de-rated. Consult the sling manufacturer for de-ratings, or de-rate the endless construction in accordance with Formulae (3) and (4) (see Table 4).

In the case where this endless construction is utilized in a basket hitch, the D/d shall be at least equal to 8 to avoid derating. In the case where the *D*/*d* is less than 8, the endless construction shall be derated in accordance with Formula in Table 4.

In the case where the basket lifting configuration comprises more than one type and size of fitting/hardware, the smallest *D*/*d* is to be used in view of de-rating.

De-rating shall be based on type tests as described in 7.3.

Table 4 — Formulae for de-rating a sling construction where *D*/*d* < 8

Eye-and-eye construction in basket hitch	Endless construction in vertical and basket hitch
	
	If R_F; ENDLESS CONSTRUCTION is determined at $D_T/d > D_U/d$ R_F; DERATED; LINKED TO FITTING = R_F; ENDLESS CONSTRUCTION $(1 - (0{,}5/\sqrt{(D_U/d)})$ See Formula (3) If R_F; ENDLESS CONSTRUCTION is determined at $D_T/d < D_U/d$ NO DERATING
WLL; DERATED; BASKET HITCH = (R_F; EYE-AND-EYE CONSTRUCTION $(1 - (0{,}5/\sqrt{(D_U/d)})\ /g) \cdot M$ See Formula (4)	WLL; DERATED; LINKED TO FITTING = (R_F; DE-RATED; LINKED TO FITTING/g) · M $(1 - (0{,}5/\sqrt{}\ (D_U/d))\ /g) \cdot M$ See Formula (4)

$$(1 - 0,\ 5/\sqrt{}\ (D_U/d)) \tag{3}$$

$$(1 - (0{,}5/\sqrt{}\ (D_U/d))\ /g) \cdot M \tag{4}$$

where

R_F; EYE-AND-EYE CONSTRUCTION	is the rated force of an eye-and-eye construction utilized in a vertical hitch(single-leg) hitch at $D/d \geq 1$, expressed in kN;
R_F; ENDLESS CONSTRUCTION	is the rated force of an endless construction utilized in a vertical hitch (single-leg) hitch based on spliced break strength with a specific D_T/d, expressed in kN;
R_F; derated; linked to fitting	is the rated force of an endless construction linked to a fitting with $D/d < 8$, expressed in kN; R_F is the rated force resulting from BS_{SC} determined according to 7, expressed in kN;
WLL; DE-RATED; BASKET HITCH	is the de-rated work load limit of the lifting configuration when utilized in a basket hitch at $D/d < 8$, expressed in t;
WLL; DE-RATED; LINKED TO FITTING	is the de-rated work load limit of an endless construction when linked to fittings with $D/d < 8$ expressed in t;
D_T/d	is the ratio of diameter of applied hardware (pin; D_T) and the rope reference number (d) during determination of the splice break strength;
D_U/d	is the ratio of diameter of applied hardware (e.g. shackle, lifting point or crane hook; D_U) in the lifting configuration and the rope reference number (d);
g	is the acceleration of gravity (9,81 m/s^2);
M	is the mode factor (see Table 3).

NOTE 1 Verify the surface condition and design of the fittings/hardware for the lifting configurations as depicted in Table 4. This review can reveal the need for local protection.

NOTE 2 The position of the splice in an endless construction can affect the rated load of an endless construction. Contact the manufacturer of the sling regarding optimal splice positioning and derating.

NOTE 3 For de-rating calculations always use the smallest D/d in the lifting configuration. If the hardware as a non-circular cross-section, D is the diameter of the point of highest curvature as illustrated by the red arrows in Figure 9.

6.5.2.3 Eye-and-eye and endless construction in a choker hitch

Angle of choke (α_{CH}; see Figure 1) in a choker hitch shall be bigger than 120°. Depending on this angle as well as the configuration of the choke (for example if the choke is on clear rope or on a splice), de-rating of the sling shall be recommended by the sling manufacturer or a qualified and/or competent person. The sling shall conform to all other provisions in this document.

6.6 Effective work length

The effective work length (L_0) of a sling construction (see Figure 6 and 7) shall not differ from the nominal length by more than 2,0 %, when axially loaded under rated force (R_F) and measured with a steel tape or rule graduated in increments of 1 mm, or other suitable and documented method like laser measurements. The length of each leg of a multi-leg lifting configuration, so called 'matched pairs', shall not differ from the lengths of the other legs by more than 1,5 %.

NOTE Different tolerances can be agreed upon between parties.

6.7 Traceability code

The traceability code, which is to be included in the sling identification (see 7.1), shall enable at least the following basic elements of the manufacturing record to be traced:

a) identification of rope, including nominal size;

b) identification of manufacturer's control;

c) identification and grade of fittings.

7 Sling verification

7.1 General

For the purpose of verification of the quality of an HMPE fibre rope sling construction, attention needs to be paid to the determination of the breaking force, effective work length, verification of the splice(s), and proof loading. These aspects are described in this subclause and only represent minimum requirements as far as tensile testing is concerned. The sling manufacturer may decide any additional testing or be requested upon and shall provide corresponding documentation.

All load testing and examination shall be carried out using a tensile test machine conforming to the requirements of class 1 of ISO 7500-1 and, where applicable, a steel tape or rule graduated in increments of 1 mm. All load testing and examination of the effective work length, as described in 7.3 to 7.5, shall be performed in accordance with ISO 2307.

If sling constructions are modified, such as but not limited to design modifications and source of material, attention needs to be paid to 7.3 and 7.4. During load testing, considerable energy is stored in the rope under tension. If the sample breaks, this energy will be suddenly released. Suitable precautions should therefore be taken to protect the safety of persons in the danger zone.

7.2 Qualification of personnel

All testing and examination shall be carried out by a competent person.

7.3 Type test of sling constructions

7.3.1 General

For each manufacturer, type tests shall demonstrate the specified minimum breaking strength (MBS) of sling constructions, manufactured according to the requirements laid down in this document.

A sling construction is characterized by its specific design, material type and specification, rope reference number, method of manufacturing (including coating, splicing, finishing) and the fittings attached to it.

Sling constructions that differ in one of these features shall be type-tested separately. Any change in the design, material type and specification, method of manufacture, any dimension outside normal manufacturing tolerances, D/d and other testing conditions that can lead to a modification of the mechanical properties, require that the type tests specified in this subclause shall be carried out on the (substantially) modified sling construction. Changes in a sling construction include changes in design, material type, material source, material specification, method of manufacture, any dimension outside normal manufacturing tolerances, and D/d.

All load testing and examination shall be carried out using a tensile test machine conforming to the requirements of class 1 of ISO 7500-1.

When verifying an endless construction, the splice shall be positioned mid length between the two attachment points. Positioning of the splice on the hardware is possible as long as it is well documented.

The type test shall be valid for a maximum of five years.

7.3.2 Methodology for testing of MBS

For the purposes of determination of the breaking strength of sling constructions, the methodology as described in ISO 9554:2019, Annex D shall be applied for either a single diameter (ISO 9554:2019, D1.1) or sling designs for a range of diameters (ISO 9554:2019, D1.2). Determination of the breaking strength of a single diameter requires a minimum of three samples. Sample size for a range of diameters is defined in ISO 9554:2019, D1.2.

The samples shall be mounted, straight and without twist, between the bollards of the test machine and subjected to a breaking strength in accordance with ISO 2307. Besides the results of the test, also the methodology, test method and testing conditions (such as D/d, testing speed and preloading procedure) of the bollards may differ from the actual hardware dimensions during sling use. This shall be considered in view of the rated force of the sling applied and eventual de-rating required (see 6.5.1).

A D/d equal to 8 is recommended as base line for endless sling constructions.

7.3.3 Type test to verify the interaction of a sling construction with fittings

A representative sling construction, of the type intended for use with fittings, shall be made with test fittings representing the smallest profile of engagement of the range of fittings that will be used in production.

The nominal sizes shall be selected according to 7.3.2 for each type of HMPE fibre, rope design, manufacturing methodology, splicing, finishing methodology and kind of fitting. For any nominal size chosen, two test pieces shall be created in accordance with 7.3.3 and proof tested in accordance with 7.4.3.

The fittings shall not get damaged in any way when the sling construction is subjected to a force at least equal to two times the rated force (R_F) of the sling construction as described in 7.4.3. The test results shall be interpreted in accordance with 7.3.3.

NOTE ISO standards are voluntary in nature. Local legislation is mandatory and will always take precedence over ISO standards. Subjection to higher loads can be required, e.g. four times the WLL of the constructions. In that case, this subclause applies analogously.

7.4 Manufacturing tests

7.4.1 Visual examination

Each completed sling or sling assembly shall be visually examined. If any non-compliance with the safety requirements or if any defect is found, the sling shall be rejected.

7.4.2 Determination of the effective work length of sling legs

For the purpose of the determination of the effective work length (EWL; L_0 as in Figures 6, 7, 9, 10 and 11) of sling legs, [with/without mechanical component(s)], a test piece shall be mounted, straight and without twist, between the bollards of the test machine and shall be subjected to a load equivalent to the rated force (R_F) of the sling construction. The effective work length is measured with a steel tape or rule graduated in increments of 1 mm, or other suitable and documented method like laser measurements.

NOTE Deviations from this method can be agreed upon between parties.

When mechanical components are used for the determination of the EWL, these components shall not be damaged when the sling construction is subjected to a load equivalent to the WLL of the sling construction.

7.4.3 Proof testing requirements

7.4.3.1 Proof load test

Unless specified by the purchaser, sling constructions are not required to be proof tested prior to their initial use if all components of the sling are new. All sling constructions incorporating previously used fittings at the time of manufacture shall be proof tested by the manufacturer or a qualified person.

7.4.3.2 Proof testing procedures

When sling constructions are proof tested, the testing shall be conducted using a pin diameter sized in accordance with 6.2.2 and shall be tested in accordance with the following:

a) each sling construction shall be proof loaded to a minimum of two times its rated force (R_F);

b) the proof load for fittings attached to single legs shall be a minimum of two times the single-leg vertical hitch rated load;

c) master links for two-leg bridle slings shall be proof loaded to a minimum of four times the single-leg vertical hitch rated load;

d) master links for three-leg bridle slings shall be proof loaded to a minimum of six times the single-leg vertical hitch rated load;

e) master links for four-leg bridle slings shall be proof loaded to a minimum of eight times the single-leg vertical hitch rated load.

In case of three-leg or four-leg bridle, proof testing of each of the links is to be assured through the hardware suppliers.

7.4.3.3 Proof test verification statement

When a verification statement of testing is required, the verification statement, issued by the company performing the test or an independent third party, shall show the following:

a) test data;

b) description of the test method and testing conditions [such as standard(s) applied, D/d, testing speed, preloading procedure and applied load];

c) product stock and serial number (if applicable);

d) product rated capacity;

e) any indicated result.

7.4.4 Breaking force tests

Unless specified by the purchaser, the break force testing of sling constructions are not required prior to their initial use if all components of the sling are new, and type testing completed in accordance with 7.3.

The sample shall be mounted, straight and without twist, between the bollards of the test machine and subjected to a force not less than the certified minimum breaking strength in accordance with ISO 2307, approved at the type test. If the sample sustains this force, it shall have passed the test.

The dimensions of the bollards may differ from the actual hardware dimensions during sling use. This shall be considered in the manufacturer's certificate (see Clause 9) in view of the rated force of the sling applied and eventual de-rating required (see 6.5.1)

If, during testing, any of these samples does not sustain a force equal to at least the specified sling strength, three further samples from the same batch shall be tested. If, during testing, any of these further samples does not sustain a force equal to at least the specified minimum breaking strength, the whole batch shall be rejected and deemed not to conform with this document. The results of the test, i.e. whether or not the sample was accepted or rejected, shall be recorded for the purposes of the manufacturer's record and eventually a verification statement like issued after proof testing. Besides the results of the test, also the methodology, test method and testing conditions (such as D/d, testing speed and preloading procedure) shall be recorded.

When there have been changes in source of material (type of HMPE fibre, type of coating), rope design, splicing methodology, manufacturing methodology or test conditions, the sling manufacturer shall perform and document the type tests, described in 7.3.

7.5 Visual examination

Each completed sling assembly shall be visually examined. If any non-compliance with the safety requirements or if any defect is found, the sling or sling assembly shall be rejected.

8 Sling marking

8.1 General

The marking of the sling shall include the following:

a) working load limit in straight lift in the case of single leg slings, or multi-leg slings having a horizontal angle(s) (α) of 0° to 45° (0°, 30° and 45°);

b) minimum bending diameter for endless construction;

c) material of the rope, rope core and cover;

d) reference number of the rope;

e) grade of fittings;

f) effective work length (L_0);

g) the manufacturer's name, symbol, trade mark or other unambiguous identification and, where applicable, his authorized representative;

h) identification code (see 6.7).

The marking shall be in a type size of not less than 1,5 mm in height.

8.2 Labelling

8.2.1 Information

The information specified in 8.1 shall be marked on a label attached to the sling as follows:

a) on single legs with soft eyes, in one eye adjoining the splice or on the standing part of rope within the splice area;

b) on single legs with thimbles, on the standing part of the rope at the end of the splice;

c) on multi-leg slings, on a durable label (e.g. a round tag) attached to the master link or one of the legs of the sling as in a) or b);

d) on endless slings, at the end of the splice.

If the label is lost, the sling assembly cannot be used or it shall be replaced by the sling manufacturer.

NOTE One suitable method for applying the marking is to inscribe the details onto a plastic sleeve threaded on the rope and shrunk to it, with a clear plastic sleeve shrunk over the market sleeve to protect it from soiling.

8.2.2 Label colour

The label shall be easily detectable on the sling construction. A signal colour, like red, yellow or orange, is recommended to be used.

9 Manufacturer's certificate

After all testing and examination, as specified in Clause 7, the manufacturer or its authorized representative, shall issue to the purchaser a certificate for each batch of slings delivered which shall include at least the following information:

a) the manufacturer's name, address, symbol or mark, and where applicable, the name address of the authorized representative;

b) WLL of the sling-leg, and for multi-leg sling assemblies, the angle to the horizontal;

c) type, including eye, fitting and EWL (L_0);

d) nominal diameter and linear density of the rope, rope material, core and cover and type of construction;

e) grade of fittings;

f) minimum breaking strength of the sling assembly and related D/d use during testing;

g) number of this document;

h) identification code;

i) identity of the person authorized to sign the certificate on behalf of the manufacturer and the date of signature or electronically generated certificates;

j) the design factors for mechanical components being used (e.g. hook, link, shackle).

NOTE Items b) to g) inclusive form the designation of the sling or of the sling assembly.

10 Instructions for selection, use, inspection and maintenance

Instructions for selection, use, inspection and maintenance shall accompany each sling or each delivery of slings supplied with a single order and shall conform to Annex A.