BS ISO 18264:2016

BSI Standards Publication

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

bsi.

National foreword

This British Standard is the UK implementation of ISO 18264:2016.

The UK participation in its preparation was entrusted to Technical Committee TCI/77, Ropes and cordage and fishing nets.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Published by BSI Standards Limited 2016

ISBN 978 0 580 95313 2

ICS 59.080.01

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 October 2016.

Amendments/corrigenda issued since publication

Date	Text affected

BS ISO 18264:2016

INTERNATIONAL STANDARD

ISO 18264

First edition
2016-10-15

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
ISO 18264:2016(E)

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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 on 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 the following URL: www.iso.org/iso/foreword.html.

The committee responsible for this document is ISO/TC 38, *Textiles*.

Introduction

This International Standard 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 International Standard specifies the requirements related to safety, including methods of rating and testing eye-and-eye and endless sling constructions used as single (1) leg, two (2) leg, three (3) leg or four (4) leg lifting configurations (with and without fittings).These sling constructions are made of 8-strand braided ropes (type L), 12-strand braided ropes (type T), covered rope constructions (type C) according to ISO 10325. Alternatively, other laid and braided rope constructions deviating from ISO 10325, but tested according to ISO 2307, may be used. This International Standard is applicable to rope constructions made of High Modulus Polyethylene [HMPE, also referred to as Ultra High Molecular Weight Polyethylene (UHMWPE)] fibre having a minimum reference number of 12 and a maximum reference number of 72, even though there is no direct link between rope reference numbers and the type of lifting operations, either general-purpose or special lifting operations.

Parts of the braided load bearing constructions in such slings, or the whole sling, can be enclosed in a protective cover/jacket/sleeve. The protective cover/jacket/sleeve is designed to be non-load bearing as it is intended only for protection and containment of the load bearing core.

The fibre rope slings covered by this International Standard 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, safety factors, also referred to as design factors, or work load limits specified.

Lifting operations not covered by this International Standard would include the lifting of persons, potentially dangerous materials such as molten metal and acids, glass sheets, fissile materials, nuclear reactors and special lifting operations.

This International Standard deals with the technical requirements to minimize the hazards listed in Clause 4 which can arise during the use of fibre rope slings when carried out in accordance with the instructions and specification given by the manufacturer, its authorized representative or qualified and/or competent person.

2 Normative references

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

ISO 1968, *Fibre ropes and cordage — Vocabulary*

ISO 2076, *Textiles — Man-made fibres — Generic names*

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 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 12480-1, *Cranes — Safe use — Part 1: General*

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

3 Terms and definitions

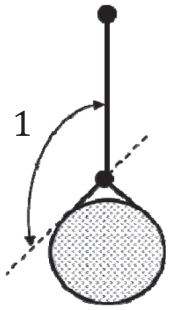
For the purposes of this document, the terms and definitions given in ISO 1968 and the following apply.

3.1
abnormal operating conditions
environmental conditions that are unfavourable, harmful or detrimental to or for the operation of sling assemblies, such as excessively high ambient temperature, exposure to chemicals, dust laden atmospheres and hazardous locations

3.2
abrasion
mechanical wearing of a surface resulting from frictional contact with other materials and objects

3.3
angle of choke
α_{CHOKE}
angle formed in a sling body as it passes through the choking eye or fittings

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

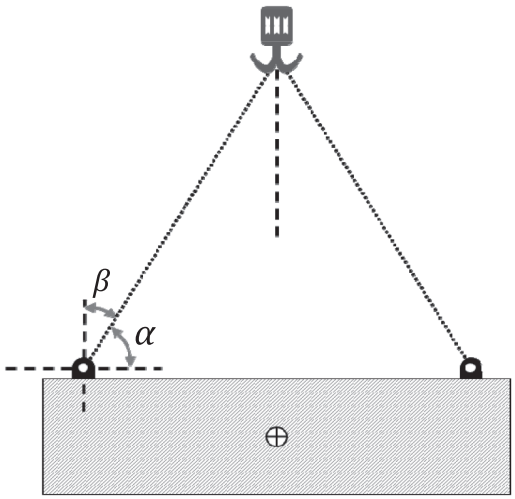


Key
1 α_{CHOKE}

Figure 1 — Example of angle of choke

3.4
angle of loading
horizontal angle
α
angle formed by the sling leg with the horizontal line

Note 1 to entry: See Figure 2.



Key

β vertical angle

α angle of loading

Figure 2 — Example of angle of loading

3.5
competent person
designated person, suitably trained and qualified by knowledge and practical experience, and with the necessary instructions to enable the required tests and examination to be carried out

3.6
design factor
DF
ratio of the maximum load and the rated load of the *sling construction* (3.26)

Note 1 to entry: Also referred to as safety factor (SF) as defined in ISO 1968.

Note 2 to entry: Fittings may have different design factors from that of the fibre rope to which they are connected.

Note 3 to entry: This term has the same meaning as the term ”working coefficient” or “safety factor” used in the EU Machinery Directive

3.7
effective work length
EWL
L_{EW}
actual finished length of the fibre rope sling construction, inclusive of fittings, from bearing point to bearing point

Note 1 to entry: See *nominal length* (3.20).

3.8
general-purpose lifting operation
operation also referred to as routine lifts or lifting operation and, as opposed to special lifting operation, can be identified and described as the one which[6]

— is covered by a *job risk assessment* (JRA) (3.14),

— may not require a new *lift plan* (LP) (3.16),

— is operation/lift for which a lift plan (LP) can be generic, but should still be reviewed prior to the operation,

— is known, repetitive operation/lift, familiar to the qualified and/or *competent person* (3.5) or lifting team,

— is repetitive lift which is covered by a previously prepared JRA and LP, however, this should be reviewed by a qualified and/or competent person,

— is where the identified lifting team is trained in the use of the specific lifting equipment/devices and familiar with its opportunities and limitations and competent to complete the entire operation,

— is where qualified and/or competent person or lifting team has performed their roles previously,

— is where all personnel involved is familiar with the written JRA and LP for the operation being conducted, and

— is where the LP is verified as the current issue before the operation

3.9
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.

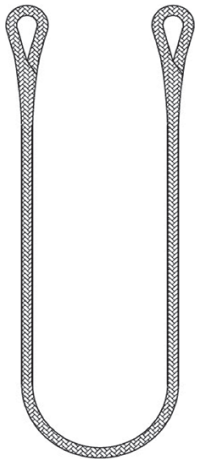


Figure 3 — Example of basket hitch

3.10
choker hitch
method rigging a sling in which the sling passed around the load, then through one loop eye, end fitting, or other device, with the other loop eye or end fitting attached to the lifting device

Note 1 to entry: This *hitch* (3.11) can be done with a sliding choker hook or similar device (see Figure 4).

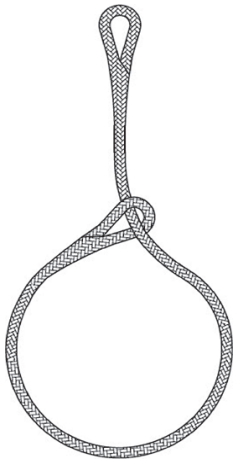


Figure 4 — Example of choker hitch

3.11
hitch
method of rigging (attaching) one or several slings temporarily to a load, or object, for the purpose of lifting

3.12
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* (3.11) 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

3.13
intermediate master link
link used to connect one or two legs of a sling to a *master link* (3.17)

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

3.14
job risk assessment
JRA
process where

— health and safety hazards are identified,

— the risks associated with the hazards are analyzed 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 may 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).

3.15
lifting configuration
special condition (lifting mode) to which a *sling assembly* (3.24) is subject when being attached simultaneously to a suspended load and to a 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* (3.4) under which they spread and in which the sling assembly is connected to the suspended load. As part of the rigging arrangement additional hardware, such as, e.g. (intermediate) master links, shackles and spreader bars, may be used.

3.16
lift plan
LP
documented plan of the proposed lifting operation covering aspects such as the following:

— characterization the load in terms of dimensions, weight and center 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 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

3.17
master link
link forming the upper terminal of a sling or *intermediate master link* (3.13) by means of which the sling is attached to the hook of a crane or other lifting machine

3.18
multi-leg sling
sling assembly (3.24) composed of multiple (two, three or four) and identical legs with the top ends gathered in a fitting that goes over the lifting hook

Note 1 to entry: Also called bridle sling.

EXAMPLE Examples are given in Figures 9 to 11.

3.19
nominal diameter
d_{ROPE}
specified diameter of the rope which is usually used as the reference number for a given product

3.20
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.

3.21
proof force
F_p
force applied as a test to a finished *sling construction* (3.26), as specified in *proof test* (3.22)

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

3.22
proof test
non-destructive force (or load) test made to a predefined *proof force* (3.21) (or load) of a *sling construction* (3.26)

3.23
rated force
F_R
maximum allowable tension of a *sling construction* (3.26)

Note 1 to entry: Also referred to as rated load.

Note 2 to entry: Expressed in kN.

3.24
sling assembly
one or more sling leg(s)/*sling constructions* (3.26) combined with rigging hardware (such as, e.g. links, shackles, thimbles) to be used as part of a rigging arrangement for the purpose of lifting a load

3.25
sling body
fibre rope used as load bearing part to create a *sling assembly* (3.24)

3.26
sling construction
eye-and-eye (see Figure 6) or endless construction (see Figure 7) of a fibre rope used to create a *sling assembly* (3.24)

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

3.27
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.

3.28
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.

3.29
special lifting operations
operations which do not meet all criteria for *general-purpose lifting operations* (3.8) and are lifting operations where[10]

— a *job risk assessment* (JRA) (3.14) is required to identify and mitigate the risks and a completed *lift plan* (LP) (3.16) is required, and

— a 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.

3.30
splice
loop, or eye, formed in the end of a rope or the 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

3.31
working load limit of the lifting configuration
WLL_{LC}
maximum allowable total suspended mass a *lifting configuration* (3.15) is authorized to sustain in *general-purpose lifting operations* (3.8)

Note 1 to entry: Expressed in t.

4 Hazards

The accident 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 and durability of lifting accessories, this International Standard specifies requirements for the design, manufacture, testing, use and maintenance to ensure the specified levels of performance are met.

Endurance/durability has not been identified as a risk when properly designed and manufactured fibre rope slings, comprising high tenacity HMPE fibre, having the specified levels of performance, given in this International Standard, 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 International Standard also gives the requirements for marking and the manufacturer's certificate.

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

Table 1 lists those hazards, as derived from ISO 12100:2010, in so far as they are dealt with in this International Standard that require action to reduce those hazards identified as being specific and significant for fibre rope slings made of HMPE fibre rope.

It is known that HMPE fibres are susceptible to creep, like most synthetic fibres, that under certain conditions can lead to creep rupture. Under constant loading HMPE fibres and ropes show an irreversible deformation (creep) behaviour that is strongly dependent upon load and temperature, as well as the type of HMPE fibre.[10] Different HMPE fibres display different creep behaviour under identical conditions.

Depending on the conditions the slings are intended to be used, the sling user shall consult the sling manufacturer in order to select the appropriate design.

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; derived from Table B.1	Examples of hazards		Hazard mitigation requirements in relevant (sub)clause(s) of this International Standard
	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, 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, …	Being run over, crushing, cutting, abrasion, puncture, tilting, overloading, falling, …	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, …	Melting, burn, falling, …	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, …	Cutting, abrasion, puncture, falling, …	4, 5, 9, 10, Annex B
Combination of hazards: All the above	Combination of origins mentioned above	Combination of consequences mentioned above	5, 6, 7, 8, 9, 10, Annexes A and B

a A single origin of a hazard can have several potential consequences.

b 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 International Standard for the use of sling assemblies are a High Modulus Polyethylene (HMPE) fibres as defined in ISO 2076.

The HMPE rope constructions covered by this International Standard 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.

5.2 Coatings

Finishes and coatings shall not impair the performance of the 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 may be applied during rope or sling production, or afterwards on the finished sling in a separate step.

NOTE 2 Coatings may be 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 may require different frictional properties and coating characteristics.

5.3 Cover (sleeves, jackets)

When fitted to sling leg(s), covers, partly or fully enclosing the fibre rope, shall provide appropriate protection against abrasion and cutting during storage, handling and use of the sling construction/assembly during the lifting operation.

The edges of 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 cover depends on performance requirements and potential risks (abrasion, cutting, puncture, exposure to chemicals, etc.) to be mitigated.

5.4 Mechanical components

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

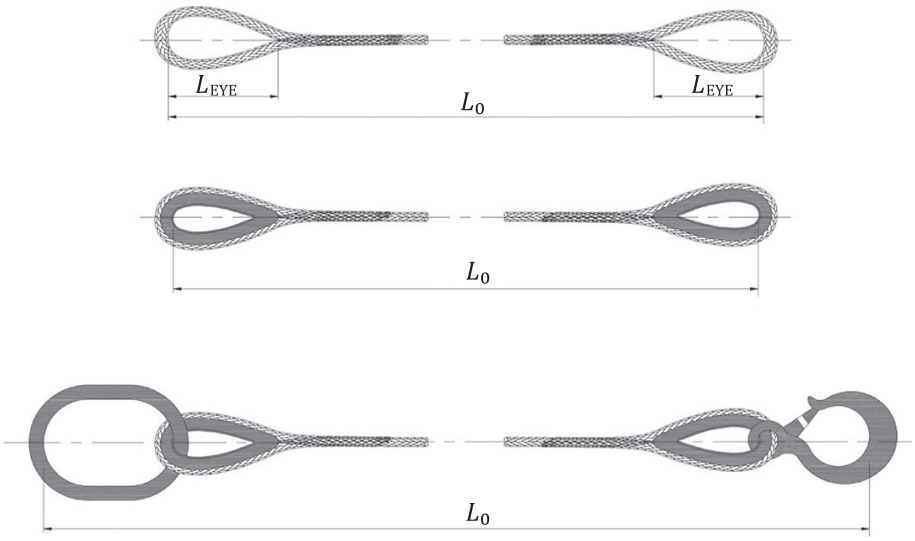
5.5 Other materials and components

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 International Standard.

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, spliced at each end. Figure 6 shows three typical examples of such construction.

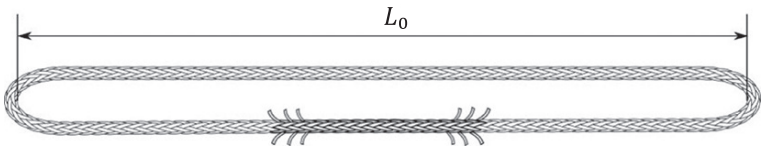


Key

L_0 nominal length of the sling

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.



Key

L_0 nominal length of the sling

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 International Standard.

Sling constructions, used in a multi-leg sling assembly, shall be constructed so that all corresponding components are identical in respect of rope construction, size, material and fittings/links.

6.2 Fabrication

6.2.1 Splicing

Splicing is the commonly used method of fabricating eye-and-eye or endless sling construction. All splices shall be made by a trained and competent splicer 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 preferably 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;

— 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 in this International Standard;

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

— if thimbles do not have ears to prevent rotation, they shall be lashed to the rope. Thimbles shall be used in the slings whenever required and installed in a manner that will prevent the thimble from rotating inside the eye or falling out of the eye.

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_{EYE}) 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 given below. Deviations shall be documented and verified in accordance with Clause 7.

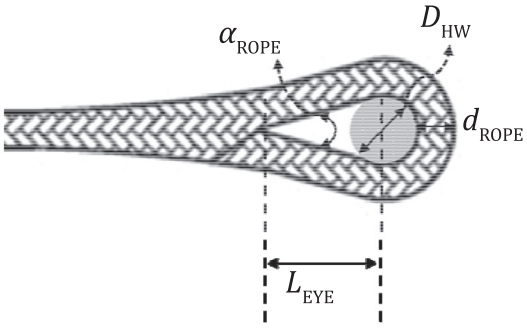


Figure 8 — Soft eye dimensions

Design rules:

— $D_{HW}/d_{ROPE} \geq 2$; besides, it shall never be <1.

— $L_{EYE}/D_{HW} \geq 3$, alternatively, $\alpha_{ROPE} \leq 20°$.

where

D_{HW} is the diameter of the hardware (pin, bollard, shackle, trunnion or fitting) being used during type testing and use;

d_{ROPE} is the fibre rope reference number;

L_{EYE} is the length of the eye;

α_{ROPE} is the angle between two legs of the eye.

6.2.2.2 Endless sling constructions

The recommended D_{HW}/d_{ROPE} for and endless construction is preferably equal to 3 and never less than 1. Deviations shall be documented and verified in accordance with Clause 7 in this International Standard.

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 link 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 and shackles, according to ISO 2415.

d) thimbles shall comply with ISO 2262 or other applicable national standard.

The diameter, width and roughness of the bearing surface of the fitting/link can (severely) affect the strength of the sling construction and assembly. Thus, thimble, or hard, eyes are recommended.

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.

6.3 Lifting configurations

For general-purpose lifting operations, eye-and-eye and endless sling constructions are used as

— single leg lifting configuration, or

— multi-leg lifting configuration

A two leg lifting configuration shall comprise two identical sling legs being connected to a master link or crane hook. Figure 9 shows a typical two leg lifting configuration.

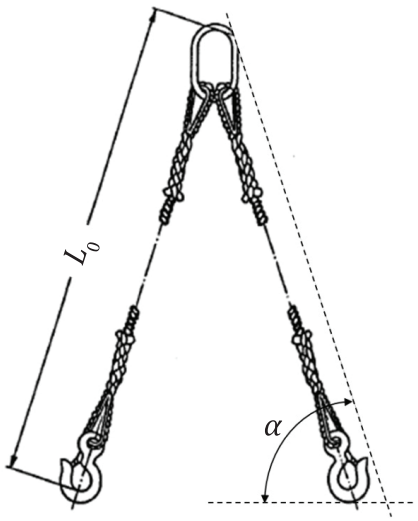


Figure 9 — Typical two (2) leg lifting configuration

Three-leg lifting configuration shall be produced as per Figure 10 in the same way, but two legs shall be attached to one intermediate link and one leg to the other.

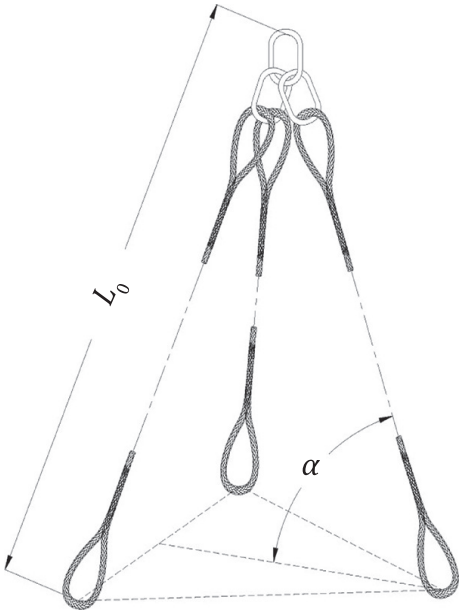


Figure 10 — Typical three (3) leg lifting configuration

A four leg lifting configuration shall comprise of four identical sling legs. Each pair of sling legs is connected to an intermediate link. The two intermediate links shall be attached to a master link or crane hook. Figure 11 shows a typical four-leg lifting configuration.

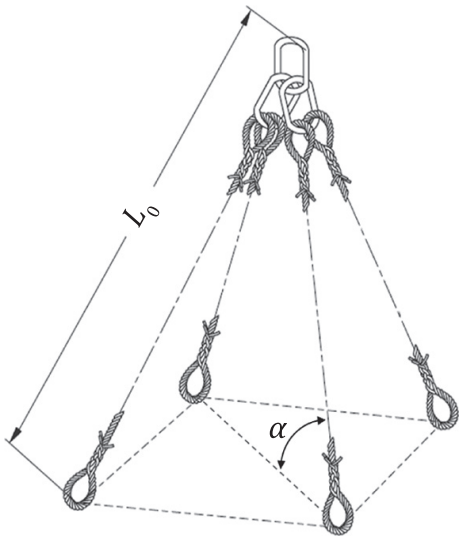


Figure 11 — Typical four (4) leg lifting configuration

NOTE In case the effective work length of the sling assemblies in a multi-leg configuration are not identical, the lifting operation is perceived as a special lifting operation.

6.4 Design factor

The design factor (DF) shall comply with the minimum 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	Min. DF	Reference
European Union	7	Machinery Directive 2006/42/EC[5]
United States	5	ASME B30.9 2010[9]
Japan	6	JIS B8818[7]
Other regions	Design factor shall comply with respective regional requirements	

6.5 Working load limit

6.5.1 Calculation of the working load limit of a lifting configuration (WLL_{LC})

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

a) the rope 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);

e) the diameter of curvature over which the sling is used (6.2.2).

The rated force (F_R) and the working load limit (WLL_{LC}) of a lifting configuration shall be calculated according to Formulae (1) and (2).

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

$$WLL_{LC} = (F_R / g) \cdot M \tag{2}$$

where

F_R is the rated force, expressed in kN;

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

WLL_{LC} 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)		Vertical angle (ß)	Sling leg	
			Eye-and-eye sling construction	Endless sling construction
Single-leg (vertical hitch or straight pull)		0°	1,0	1,0
Basket hitch		0°	2,0	2,0
Multiple-leg	Two-leg bridle (including angle of loading <90° in case of basket hitch) 	0° 30° 45° 60°	2,0 1,7 1,4 1,0	2,0 1,7 1,4 1,0
	Three- and four-leg bridle 	45°	1,4	1,4
Choker hitch		M shall be determined by the sling manufacturer or its authorized representative in accordance with Clause 7.		

Angles of loading (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.

Angle of choke (α_{CHOKE}; see Figure 1) shall preferably bigger than 120°.

NOTE Mode factors are based on identical WLL and L_{EW} of each sling construction in a multi-leg sling assembly;

The values as given in Table 3, excluding choker hitch as lifting configuration, are based on minimum D_{HW}/d_{ROPE} in accordance with 6.2.2.

The mode factors for lifting configuration 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 3 shall be determined by the sling manufacturer.

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 International Standard.

6.5.2 Calculation of the working load limit of a lifting configuration (WLL_{LC}) as a consequence of bending losses

6.5.2.1 Eye-and-eye construction utilized in vertical hitch or multi-leg assembly

When using an eye-and-eye construction in a vertical hitch (i.e. straight pull) or a multi-leg assembly (not meaning a basket hitch; see Figures 9 to 11), it is not necessary to account for bending loss in case the D_{HW}/d_{ROPE} is at least equal to one in accordance with 6.2.2.1.

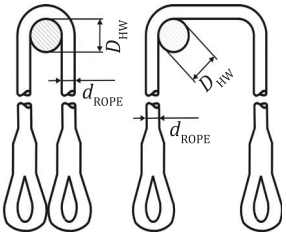
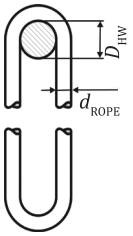
6.5.2.2 Eye-and-eye and endless construction utilized in basket hitch

When using an endless construction or an eye-and-eye construction in basket hitch configuration (e.g. bent over bow of a shackle or crane hook), the D_{HW}/d_{ROPE} shall be preferably equal to 3 and never less than 1. In case the D_{HW}/d_{ROPE} is less than 3, the sling construction shall be de-rated in accordance with Formulae 3 a) and 4 a) in Table 4.

6.5.2.3 Endless construction attached to fittings

When linking an endless construction to fittings (e.g. the bow of a shackle or crane hook), the D_{HW}/d_{ROPE} shall preferably be equal to 3 and never less than 1. In case the D_{HW}/d_{ROPE} is less than 3, the sling construction shall be de-rated in accordance with Formulae 3 b) and 4 b) in Table 4.

Table 4 — Formulae for de-rating of a sling construction

	Sling construction in basket hitch	**Endless construction attached to fitting/hardware**
De-rating of a sling construction in case $1 \leq D_{HW}/d_{ROPE} < 3$ (see also Table B.1)		
	$F_{R;\ DE\text{-}RATED;\ BASKET\ HITCH} = F_R * (1 - (0{,}5/\sqrt{(D_{HW}/d_{ROPE})}))$ Formula 3 a)	$F_{R;\ DE\text{-}RATED;\ LINKED\ TO\ FITTING} = F_R * (1 - (0{,}5/\sqrt{(D_{HW}/d_{ROPE})})) * 1{,}27$ Formula 3 b)
	$WLL_{LC;\ DE\text{-}RATED;\ BASKET\ HITCH} = (F_{R;\ DE\text{-}RATED;\ BASKET\ HITCH}/g) * M$ Formula 4 a)	$WLL_{LC;\ DE\text{-}RATED;\ LINKED\ TO\ FITTING} = (F_{R;\ DE\text{-}RATED;\ LINKED\ TO\ FITTING}/g) * M$ Formula 4 b)

where

$F_{R;}$ de-rated; basket hitch — is the rated force of a sling construction utilized in a basket hitch at $1 < D_{HW}/d_{ROPE} < 3$, expressed in kN;

$F_{R;}$ de-rated; linked to fitting — is the rated force of an endless construction linked to a fitting with $1 \leq D_{HW}/d_{ROPE} < 3$, expressed in kN;

F_R — is the rated force resulting from BS_{SC} determined according to Clause 7, expressed in kN;

D_{HW}/d_{ROPE}	is the ratio of diameter of applied hardware (e.g. shackle, lifting point or crane hook; D_{HW}) and the rope reference number (d_{ROPE});
WLL_{LC}; DE-RATED; BASKET HITCH	is the de-rated work load limit of the lifting configuration when utilized in a basket hitch at $1 \leq D_{HW}/d_{ROPE} < 3$, expressed in t;
WLL_{LC}; DE-RATED; LINKED TO FITTING	is the de-rated work load limit of an endless construction when linked to fittings with $1 \leq D_{HW}/d_{ROPE} < 3$, expressed in t;
g	is the the acceleration of gravity (9,81 m/s^2);
M	is the mode factor (see ISO 1968).

6.6 Effective work length

The effective work length of a sling construction shall not differ from the nominal length by more than 2,0 %, when axially loaded under rated force and measured with a steel tape or rule graduated in increments of 1 mm. 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 Smaller tolerances may be agreed 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 and effective work length, verification of the splice(s), 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.

In case sling constructions are being changed, such as design changes and source of material, attention needs to be paid to 7.5.

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 for verification of sling constructions

7.3.1 General

Type tests shall demonstrate the certified minimum breaking force (MBF) of sling constructions manufactured according to the requirements laid down in this International Standard for each manufacturer.

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 have to be type-tested separately.

Any change in the design, material type and specification, method of manufacture and/or in any dimension outside normal manufacturing tolerances that could lead to a modification of the mechanical properties, require that the type tests specified in this subclause shall be carried out on the modified sling construction.

All sling constructions to be type tested shall comply with all other requirements of this International Standard.

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.

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

As the results of type and manufacturing testing of sling assemblies, as described in 7.3 to 7.5, is also depending also D_{HW}/d_{ROPE} and other testing conditions, the sling manufacturer, or its authorized representative, shall make sure a consistent D_{HW}/d_{ROPE} and other testing conditions shall be applied. A change in D_{HW}/d_{ROPE} and other testing conditions during type and manufacturing testing of sling assemblies shall be combined with corresponding documentation.

7.3.2 Methodology

For the purposes of determination of the breaking force of sling constructions, either being an eye-and-eye or endless construction without mechanical component(s), ropes being used are grouped by rope reference numbers (d_{ROPE}; expressed in mm) as shown in Table 5.

Table 5 — Grouping of sling constructions for type testing by rope reference numbers (d_{ROPE})

Group	Min d_{ROPE} (mm)	Max d_{ROPE} (mm)
A	≥12	22
B	22	32
C	32	48
D	48	≤72

The type tests are to be carried out on the reference numbers marking the boundaries of groups A to D. The test results on the reference numbers 22, 32 and 48 may be taken for verification in both groups to which these reference numbers belong.

For ropes smaller than 22 mm, the smallest size available shall be tested. However, this reference number shall not be less than 12 mm. For sizes up to 72 mm, the type test shall be performed on the largest size intended. However, this reference number shall not exceed 72 mm.

7.3.3 Basic procedure for type testing/verification of MBF

Basic type testing shall be applied in case the sling construction, as characterized in accordance with 7.3.1, is an eye-and-eye or endless construction designed and manufactured with ropes in accordance with ISO 10325 and tested accordingly or in case

— sling constructions, as characterized in accordance with 7.3.1, comply with other local and/or International Standards, provided that this International Standard is consistent, i.e. the MBFs of the reference numbers in-between the boundaries of the groups in Table 5 are not higher than the values interpolated according to Formulae (5) to (12) in Table 6, or

— sling constructions, which have at least once passed the procedure in accordance with this subclause as well as 7.3.4 and which have to be re-tested due to reasons given in 7.3.1.

The compliance of the sling construction, as characterized in accordance with 7.3.1, with a pre-set MBF is to be verified by testing three samples from any reference number according to 7.3.2 and Table 5. The sling construction passes the test when all three specimens achieve higher breaking forces than the pre-set MBF.

The MBF certified for reference numbers in-between the reference numbers tested shall be interpolated as shown by Formulae (5) to (12) in Table 6.

Table 6 — Formulae (5) to (12) to calculate the minimum breaking force (MBF) within a group of rope reference numbers (d_{ROPE})

Group	Min d_{ROPE} (mm)	Max d_{ROPE} (mm)	Formula for MBF	Formula for scale factor
A	≥12	22	$MBF = MBF_{MIN} \cdot \left(\frac{d}{d_{MIN}} \right)^{SF_A}$ **Formula (5)**	$SF_A = \frac{\ln\left(\frac{MBF_{22}}{MBF_{MIN}} \right)}{\ln\left(\frac{d_{22}}{d_{MIN}} \right)}$ **Formula (6)**
B	22	32	$MBF = MBF_{22} \cdot \left(\frac{d}{d_{22}} \right)^{SF_B}$ **Formula (7)**	$SF_B = \frac{\ln\left(\frac{MBF_{32}}{MBF_{22}} \right)}{\ln\left(\frac{d_{32}}{d_{22}} \right)}$ **Formula (8)**
C	32	48	$MBF = MBF_{32} \cdot \left(\frac{d}{d_{32}} \right)^{SF_C}$ **Formula (9)**	$SF_C = \frac{\ln\left(\frac{MBF_{48}}{MBF_{32}} \right)}{\ln\left(\frac{d_{48}}{d_{32}} \right)}$ **Formula (10)**
D	48	≤72	$MBF = MBF_{48} \cdot \left(\frac{d}{d_{48}} \right)^{SF_D}$ **Formula (11)**	$SF_D = \frac{\ln\left(\frac{MBF_{MAX}}{MBF_{48}} \right)}{\ln\left(\frac{d_{MAX}}{d_{48}} \right)}$ **Formula (12)**

where

SF_A is the scale factor to be applied for rope diameters from group A; as scale factors for ropes from group B (SF_B), group C (SF_C) and group D (SF_D);

d is the reference number of rope belonging to sling construction of which the minimum breaking strength needs to be calculated, expressed in mm;

d_{32} is the reference number of rope equal to 32 mm used in the sling construction; as reference number of rope equal to 22 mm and 48 mm used in sling construction (resp. d_{22} and d_{48});

d_{MIN} is the minimum reference number of rope used in group A for a sling construction, expressed in mm (not less than 12 mm);

d_{MAX} is the maximum reference number of rope used in group D for a sling construction, expressed in mm (not greater that 72 mm);

MBF is the calculated minimum breaking force of the sling construction within a specific group, expressed in kN;

MBF_{32} is the minimum breaking force of the sling construction made from rope with reference number 32, expressed in kN; as MBF for sling constructions made with reference numbers 22 and 48 (MBF_{22} and MBF_{48});

MBF_{MIN} is the minimum breaking force of the sling construction made from rope with the minimum reference number in group A, expressed in kN;

MBF_{MAX} is the minimum breaking force of the sling construction made from rope with the maximum reference number in group D, expressed in kN.

7.3.4 Extended procedure for type testing/verification of MBF

In case a sling construction, referred to in 7.3.3, including

a) eye-and-eye construction designs deviating from the design used for testing in accordance with ISO 10325 or other standards, and

b) endless construction, the certified MBF of the sling construction shall be set as the mean MBF of five break test less two times the standard deviations as a result of these break tests.

The verification shall be executed in accordance with 7.3.2 and Table 5. The MBF certified for reference numbers in-between the reference numbers tested shall be interpolated as shown by Formulae (5) to (12) in Table 6 (see also 7.3.3).

7.3.5 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 (see Table 5) 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 or 7.3.4 and 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 either 7.3.3 or 7.3.4.

NOTE Local legislation is to be observed when type-testing slings constructions with fittings. Subjection to higher loads might 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 (L_{EW}; L_0 as in Figures 6, 7, 9, 10 and 11) of sling legs, either an eye-and-eye, endless or any other construction [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 (F_R) of the sling construction. The effective work length is measured with a steel tape or rule graduated in increments of 1 mm.

NOTE Deviations from this method may be agreed between parties.

When mechanical components are used for the determination of the L_{EW}, 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 force 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 (F_R);

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.

7.4.3.3 Proof test certificate

When a certificate of testing is required, the certificate, issued by the company performing the test, shall show the following:

a) test date;

b) description of the test method and testing conditions (such as D_{HW}/d_{ROPE}, testing speed and preloading procedure);

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

d) amount of applied load;

e) product rated capacity;

f) any indicated result.

7.4.4 Breaking force tests

The manufacturing testing shall be performed on each sling construction, including each type of HMPE fibre, rope, coating, splicing or finishing methodology and without mechanical component(s) that is being supplied.

The sling manufacturer shall select at least one sling assembly from the manufacturing batch for testing for every 500 units manufactured or every three years, whichever comes first.

The length of the sling for manufacturing test should be equal to the manufacturing batch. Testing of a shorter sling leg is only acceptable where the test machine facility is too short in length.

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.

If, during testing, any of these samples does not sustain a force equal to at least the certified minimum break strength, but sustains a load of not less than 90 % of this force, three further samples from the same batch shall be tested. If, during testing, the sample does not sustain a force equal to at least the certified minimum breaking strength, the whole batch shall be rejected and deemed not to comply with this International Standard.

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.

Besides the results of the test, also the test method and testing conditions (such as D_{HW}/d_{ROPE}, testing speed and preloading procedure) shall be recorded.

7.5 Type and manufacturing testing in case of modifications to sling constructions

In case of 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 and 7.4, for each type of sling construction.

The sling manufacturer shall select a rope size representative for the minimum and maximum of the relevant group (see Table 4 and 7.3.2) out of which two test pieces shall be manufactured by each splicer.

7.6 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 vertical angle (β) of 0° to 60° (0°, 30°, 45° and 60°);

b) minimum bending diameter for endless construction;

c) material of the rope, rope core and cover, if any, fibre material(s) of the load bearing core of the sling assembly, as well as fibre material(s) of the non-load bearing jacket of the sling assembly in case a jacketed sling assembly is supplied;

d) reference number of the rope;

e) grade of fittings;

f) effective work length;

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

h) identification code (see 6.7);

i) mandatory marking.

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 at the end of the splice;

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.

NOTE 1 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.

NOTE 2 If the label is lost, the sling assembly cannot be used or it can be replaced by a competent person.

8.2.2 Label colour

The label shall be easily detectable on the sling construction. So, 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) 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 slings, assemblies the angle to the vertical;

c) type, including eye, fitting and effective work length;

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 force of the sling assembly;

g) number of this International Standard;

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.

Annex A
(normative)

Instructions for selection, use, inspection and maintenance to be provided by the sling manufacturer or its authorized representative with the HMPE fibre rope slings

A.1 General

This Annex gives guidance to the manufacturer regarding information on use, inspection and maintenance which shall be provided with the fibre rope slings conforming to this International Standard or in accordance with the National Regulations.

NOTE Annex B is informative and provides some detailed information for use and maintenance which may be appropriate.

The manufacturer of fibre rope slings shall provide documented information, covering the subjects listed below, with each commercially indivisible batch of slings (see Clause 9). Annex B contains guidance to assist the manufacturer in the preparation of this information.

A.2 Limitations on the use of the fibre rope sling assemblies due to environmental conditions or hazardous applications (see B.1)

a) Selective material resistance to chemicals.

b) Restrictions due to temperature.

c) Susceptibility to cutting and abrasion.

d) Degradation due to ultra-violet radiation.

A.3 Documentation required before first use

Before putting a fibre rope sling assembly into first use, the sling manufacturer, or its authorized representative, shall provide the following (see B.2):

a) a manufacturer's certificate according to Clause 9;

b) a proof test certificate according to 7.4.3.3;

c) instructions and guidelines for storage, handling/use, inspection and discard of the sling assembly(ies) being put in service.

A.4 Inspection required before first use

Before each use/period of use, the user of the fibre rope sling assembly(ies) shall (see B.2 and B.3)

a) inspect the sling assembly(ies) in accordance with the instructions and guidelines as to be provided by the sling manufacturer or its authorized representative,

b) inspect the presence of a required and readable sling assembly label and legibility of marking, and

c) verify whether the present damage(s) to the sling assembly(ies) require discard hereof in accordance with the instructions and guidelines to be provided by the sling manufacturer or its authorized representative.

A.5 Periodic thorough examination and maintenance

a) Withdrawal criteria including missing/damaged label or illegible marking.

b) Records of examination.

Annex B
(informative)

Suggested content of information to be provided by the manufacturer or its authorized representative with the HMPE fibre rope sling assembly

B.1 Use of HMPE fibre rope sling assembly in adverse conditions and hazardous applications

The material from which HMPE fibre rope sling assembly constructions are manufactured are typically highly crystalline and does not contain any chemical functionalities, as aromatic rings, amide, hydroxyl or others, that are susceptible to interaction and/or reaction by chemical components. The result is that HMPE fibres are very resistant against these components. If exposure to chemicals is likely, the sling manufacturer, its authorized representative and/or the fibre supplier should be consulted.

Solutions of acids or alkalis which are harmless can become sufficiently concentrated by evaporation to cause damage. Contaminated sling assemblies should be taken out of service at once, soaked in cold water, dried naturally and referred to a competent person for examination. The competent person takes the decision if the sling assemblies can be used again.

Slings with grade 8 fittings and multi-leg sling assembly with grade 8 master links should not be used in acidic conditions. Contact with acids or acidic fumes causes hydrogen embrittlement to grade 8 materials.

It should be noted that the effects of chemicals may increase with rising temperature.

Sling assemblies are suitable for use and storage in a temperature range of -40 °C to +70 °C. These ranges vary in a chemical environment, in which case the manufacturer or supplier should be consulted. Limited indirect ambient heating, within these ranges, is acceptable for drying.

Sling assemblies may be susceptible to degradation if exposed to ultraviolet radiation/sunlight. With ultraviolet radiation/sunlight only penetrating to shallow depths, the retention strength of such slings is dependent upon sling body diameter, type of rope/sling construction and use of protective measures such as coatings or jackets. Consequently, non-covered ropes of small diameter are much more affected than large diameter ropes. It is therefore recommended to prevent exposure of sling assemblies to direct sunlight or sources of ultra-violet radiation

Mildew does not attack HMPE fibre ropes, although surface contamination may provide a nutrient which permits its growth. This will not affect the strength of HMPE fibre rope and may be removed by washing them in clear water in cleaning agents. Detergents can be used after consultation of the manufacturer or of the supplier.

B.2 Inspection of HMPE fibre rope sling assemblies in service

Before first use of the sling assembly, it should be ensured that

a) sling assembly corresponds precisely to that specified on the order,

b) manufacturer’s certificate is in hand,

c) identification and WLL marked on the sling assembly correspond with the information on the certificate and

d) instructions and guidelines for storage, handling/use, inspection and discard of the sling assembly are available.

Before each use, the sling assembly should be inspected for defects and to ensure that the identification and specification are correct. A sling assembly that is unidentified or defective should never be used, but should be referred to a competent person for examination. These examinations should extend to any fittings and lifting accessories used in association with the sling assembly. If any doubt exists as to the fitness for intended use, or if any of the required markings have been lost or become illegible, the sling assembly should be removed from service for examination by a competent person.

During the period of use, careful and frequent inspection of the sling assembly reflects prudent safety management required to protect personnel and property.

Guidelines are available that can provide enhanced sling assembly durability and important information for safer use.[4]

During inspection, the following defects or damages, but not limited to the ones mentioned, may affect the fitness for continued safe use of sling assemblies:

a) excessive tension/shock loading;

b) internal wear/abrasion;

c) external wear/abrasion;

d) cutting;

e) pulled strands and yarns;

f) improper splices;

g) damage caused by chemicals;

h) damage caused by heat;

i) damaged, cracked or deformed fittings;

j) irreversible elongation.

NOTE Under constant loading, HMPE fibres and ropes show an irreversible deformation (creep) behaviour that is strongly dependent upon load and temperature, as well as the type of HMPE fibre.[10]

Different HMPE fibres display different creep behaviour under identical conditions. Depending on the sling and conditions the slings are intended to be used, the sling user should consult the sling manufacturer, or its authorized representative and the fibre manufacturer in order to select the appropriate fibre and design of the sling assembly.

Change in length can be evaluated in accordance with 7.4.2.

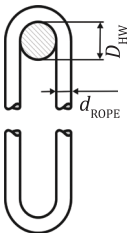
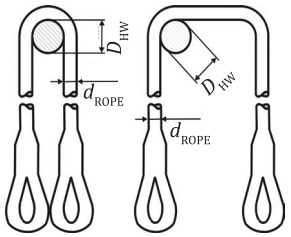
B.3 Correct selection and use of fibre rope sling assembly

In selecting and specifying a sling assemblies, consideration should be given to the required working load limit (WLL), taking into account the mode of use and the nature of the suspended load to be lifted. The size, shape, weight of the suspended load and position of the centre point of gravity, together with the intended method of use, working environment and nature of the suspended load all affect the correct selection.

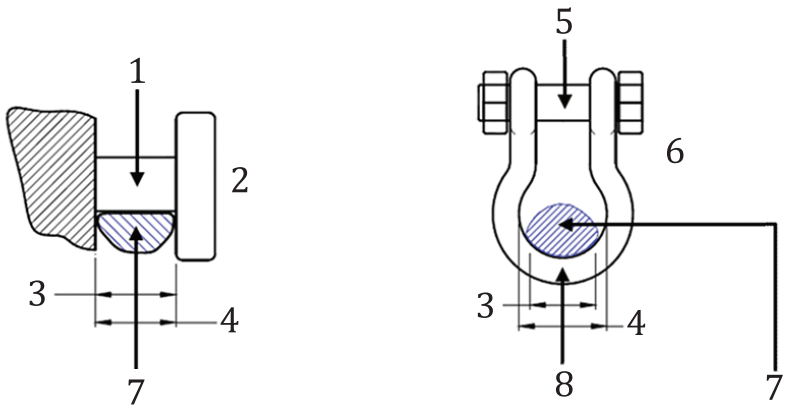
The selected sling assembly should be both strong enough, the correct length for the mode of use and not be affected adversely by the environment or the suspended load. If a multi-leg lifting configuration is used to lift a load, the lifting configuration should be chosen such that the sling forming each leg is not overloaded and that the suspended load remains balanced and stable.

The strength of a sling can be affected by the diameter and the actual inside width of the fittings/links to which they are attached. Careful attention must be paid to 6.2.2, 6.3, 6.4 and 6.5 for (de-)rating of the slings (see Table B.1 as reference).

Table B.1 — Reference for rating and de-rating of slings

	Sling construction in basket hitch	Endless construction attached to fitting/hardware
D_{HW}/d_{ROPE}		
3	70 %	90 %
2,5	70 %	85 %
2	65 %	80 %
1,5	60 %	75 %
1	50 %	65 %
NOTE % mentioned is % of the determined spliced break strength of the sling construction (see 6.5 and Clause 7).		

The natural flattening width (the actual width) of the rope shall be equal to, or smaller than, the effective inside width of the mechanical component. Examples are given in Figure B.1. The sling manufacturer's recommendation shall be followed when fittings are used with the sling.



Key

1 $D_{CAST\ HOOK/TRUNNION}$
2 trunnion
3 effective inside width
4 actual inside width
5 $D_{SHACKLE\ PIN}$
6 shackle
7 sling
8 $D_{SHACKLE\ BOW}$

Figure B.1 — Examples for effective and actual inside width

Consideration should also be given to ancillary fittings and lifting devices which should be compatible with the sling(s). The termination should be also considered, i.e. whether fittings, hard eyes or soft eyes are required.

The sling manufacturer, or its authorized representative, should provide instructions and recommendations for correct and safe use of the slings.

When using sling constructions with soft eyes, care should be taken to ensure that the eye is of sufficient size so that the lifting machine hook to which the eye is fitted or lifting accessory which may be placed in the eye, does not open the eye.

Make sure that the shackle is supporting the load correctly so the shackle can move freely along the axis of the shackle body centreline.

Avoid introduction of bending loads, unstable loads and do not apply overloads.

To avoid eccentric loading of the shackle and the sling assembly, attach the sling assembly preferably to the bow of the shackle.

When using the sling in a choker hitch, preferably use the sling and shackle such that the sling body passes through the bow of the shackle in the choking eye or fitting (see 3.3).

Avoid applications where due to movement (e.g. of the load or the sling) the sling can move and possibly be damaged.

Fibre rope slings should not be overloaded. The correct mode factor should be used. Rated loads for some modes of use may be given on the label.

In the case of multi-leg sling configuration, the angle of loading should be maintained above the minimum.

Good slinging practices should be followed. The slinging, lifting and lowering operations should be planned before commencing the lift.

HMPE fibre rope slings should be correctly positioned and attached to the suspended load in a safe manner. They should never be knotted or twisted.

Damage to labels should be prevented by keeping them away from the suspended load, the hook and the angle of choke.

In the case of multi-leg slings, the WLL values have been determined on the basis that the loading of the sling legs is symmetrical. This means that when a suspended load is lifted, the sling legs are symmetrically disposed in plan and subtended at the same angle of loading.

In the case of three leg lifting configuration, and if the legs are not symmetrically disposed in plan, the greatest tension is in the leg where the sum of the plan angles to the adjacent legs is greatest.

The same effect occurs in four leg lifting configuration, except that the rigidity of the suspended load should also be taken into account.

NOTE With a rigid suspended load, the majority of the weight may be taken by only three, or even two, of the legs, with the remaining legs only serving to balance the load.

Slings should be protected from (sharp) edges, friction, abrasion and penetration, whether from the suspended load, the lifting appliance or any other foreign object, by the use of protective sleeves, suitable packing and/or edge protector. Such protective measures should be carefully selected for its protective purpose.

Protective measures should always be supplied by the manufacturer or by the supplier along with the slings and positioning hereof should be inspected by a qualified and/or competent person.

The suspended load should be secured by the sling(s) in such a manner that it cannot topple or fall out of the sling(s) during the lift. The sling(s) should be arranged so that the point of lift is directly above

the centre of gravity of the suspended load and the suspended load is balanced and stable. Movement of the sling over the lifting point is possible if the centre of gravity of the suspended load is not below the lifting point.

When using basket hitch, the suspended load should be secure since there is no gripping action as the choke hitch and sling can roll through the lifting point. For slings used in pairs, the use of a spreader is recommended so that the sling legs hang as vertically as possible and to ensure that the suspended load is equally divided between the legs.

When a sling is used in choke hitch, it should be positioned so as to allow the natural (120°) angle to form and avoid heat being generated by friction. A sling should never be forced into position nor any attempt made to tighten the bite.

Care should be taken to ensure the safety of personnel during the lift. Persons in the danger area should be warned that the operation is to take place and, if necessary, evacuated from the immediate area. Hands and other parts of the body should be kept away from the sling to prevent injury as the slack is taken up.

Reference should also be made to ISO 12480-1 for planning and management of the lifting operation and adoption of safe systems of working.

A trial lift should be made. The slack should be taken up until the sling is taut. The suspended load should be raised slightly and a check made that it is secure and assumes the position intended. This is especially important with basket or other loose hitches where friction retains the suspended load.

If the suspended load tends to tilt, it should be lowered and attachments repositioned. The trial lift should be repeated until the stability of the suspended load is ensured.

Care should be taken when making the lift to ensure that the suspended load is controlled, e.g. to prevent accidental rotation or collision with other objects.

Snatch or shock loading should be avoided, as this will increase the forces acting on the sling.

A suspended load in the sling or the sling itself should not be dragged over the ground or rough surfaces.

The suspended load should be lowered in an equally controlled manner as when lifted.

Trapping the sling when lowering the suspended load should be avoided. The suspended load should not rest on the sling, if this could cause damage and pulling the sling from beneath the suspended load when the suspended load is resting on it should not be attempted.

On completion of the lifting operation, the sling should be returned to proper storage.

When not in use, slings should be stored in clean, dry and well ventilated conditions, at ambient temperature and on a rack, away from any heat sources, contact with chemicals, fumes, corrodible surfaces, direct sunlight or other sources of ultra-violet radiation.

Prior to placing in storage, slings should be inspected for any damage which may have occurred during use. The damaged slings should never be returned to storage.

Where lifting slings have come into contact with acids and/or alkalis, dilution with water or neutralization with suitable media is recommended prior to storage.

Depending on the material of the lifting sling and the chemicals referred to in B.1, it may be necessary in some cases to request additional recommendations from the sling manufacturer, or its authorized representative, on the cleaning procedure to be followed after the sling has been used in the presence of chemicals.

Slings which have become wet in use, or as a result of cleaning, should be hung up and allowed to dry naturally.

B.4 Inspection and repair

Examination periods should be determined by a competent person, taking into account the application, environment, frequency of use and similar matters, but in any event, slings should be visually examined at least annually by a competent representative to establish their fitness for intended use.

Visual examination should each time be performed by the end user.

Records of such examinations should be maintained.

Damaged slings should be withdrawn from service. Never attempt to carry out repairs to slings yourself. The sling manufacturer, or its authorized representative, shall provide instructions and recommendations in view of inspection and repair in order to contribute to correct and safe lifting operations.

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ICS 59.080.01
Price based on 35 pages

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