INTERNATIONAL STANDARD

ISO 17558

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Steel wire ropes — Socketing procedures — Molten metal and resin socketing

Câbles en acier — Procédés de manchonnage — Manchonnage à l'aide de métal fondu et de résine

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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.

ISO 17558 was prepared by Technical Committee ISO/TC 105, *Steel wire ropes*.

This first edition of ISO 17558 cancels and replaces ISO 7595:1984 and ISO/TR 7596:1982, of which it constitutes a technical revision.

Introduction

This International Standard was developed in response to a worldwide demand for a specification combining the procedures for the socketing of steel wire ropes by molten metal and resin. With an increasing use of resin as a socketing medium, opportunity was taken to review and update the requirements formerly given by ISO/TR 7596.

Each socket design should be used only with the appropriate method or methods of socketing which have been proven as being satisfactory by prototype testing.

Sockets, if properly attached to the wire rope, should sustain the full breaking force of the rope. This is important because accidental release of a load due to failure of a rope termination could create a hazard.

Steel wire ropes — Socketing procedures — Molten metal and resin socketing

1 Scope

This International Standard specifies procedures for the molten metal and resin socketing of steel wire ropes. It also specifies a type testing method for assessing the performance of a socketing system.

The procedures described in this International Standard are for use with sockets having a strength exceeding that of the minimum breaking force of the rope to be socketed and made from a material that remains unchanged when the socketing media is hot metal.

Operating temperature limits for ropes socketed with lead-based alloys, zinc and zine-based alloys and resin are given for information in Annex E.

2 Normative references

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

ISO 75-2:2004, *Plastics — Determination of temperature of deflection under load — Part 2: Plastics and ebonite*

ISO 604, *Plastics — Determination of compressive properties*

ISO 3838, *Crude petroleum and liquid or solid petroleum products — Determination of density or relative density — Capillary-stoppered pyknometer and graduated bicapillary pyknometer methods*

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

ISO 17893, *Steel wire ropes — Definitions, designation and classification*

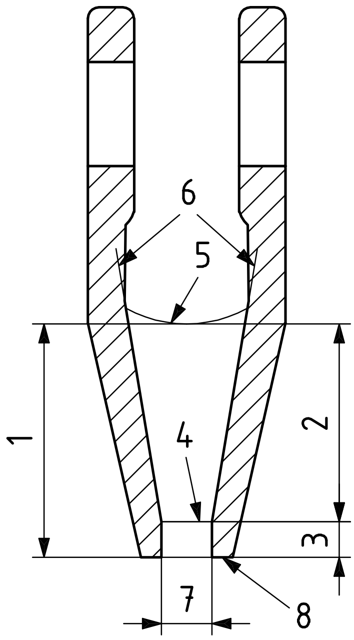
EN 59, *Glass reinforced plastics — Measurement of hardness by means of a Barcol impressor*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 17893 and the following apply.

3.1
socket
wire rope termination incorporating a socket basket

See Figure 1.



Key

1 overall basket length [tapered portion plus parallel portion(s), if applicable, plus radius at rope entry]
2 tapered portion of socket basket
3 parallel portion of socket basket and any radius at rope entry
4 small end of tapered portion of socket basket
5 large end of tapered portion of socket basket
6 included angle of tapered portion of socket basket
7 bore (smallest internal diameter at rope entry)
8 base of socket

NOTE The base of the socket is often called the “mouth” or “nose”.

Figure 1 — Nomenclature of typical parts of socket basket

3.1.1
socketing
procedure whereby a socket is attached to a wire rope by means of molten metal or resin

3.1.2
socketing system
method of attachment comprising instructions and materials for the socketing of wire ropes with molten metal or resin

3.1.3
socketing medium
molten metal or resin used for socketing

3.2
socket basket
tapered portion of a socket within which the wire rope brush is secured

3.3
serving
seizing
method or material that secures a wire rope to prevent it from unlaying

3.3.1
permanent serving
serving applied prior to socketing and remaining in place at least until the socketing operation has been completed

3.3.2
temporary serving
serving applied and subsequently removed at various stages of the socketing operation

3.4
gelling
change in condition of a resin from a liquid to a semi-solid, jelly-like composition

3.5
hooking
procedure whereby the end of a wire-forming part of a brush is bent to form a hook

3.6
socketer
person trained in socketing having the requisite knowledge and experience to ensure that the required operations and procedures are correctly carried out

3.7
qualified person
person who, by possession of a recognized degree in an applicable field or certificate of professional standing, or who, by extensive knowledge, training and experience, has successfully demonstrated the ability to solve or resolve problems relating to the subject matter and work

3.8
socketing system designer
person or organization that designs and is responsible for type testing of the socketing system

4 Preparation for socketing

4.1 Serving

4.1.1 Serving of wire rope

The wire rope shall be served taking into account the type of rope, the length of the socket basket, the length of the brush to be formed, any additional brush length for the hooking or protrusion of wires and the depth of any serving that may be included within the socket.

Additional servings or additional length of serving may be required for spiral rope.

Two types of serving shall be used as follows.

Temporary servings shall be used to hold the strands and wires in position during the cutting operation.

A permanent serving shall be used to hold the strands and wires in position during the socketing operation. The permanent serving shall be in position before cutting the rope. The position of the permanent serving shall permit the correct positioning of the brush in relation to the socket.

NOTE The permanent serving is attached to that part of the rope which remains partly within the bore or immediately adjacent to the base of the socket when the socketing has been completed.

4.1.2 Serving material

Serving shall be of wire or strand or, alternatively, a mechanical device, e.g. clamps.

When serving wire or strand is used for permanent serving it shall be tinned or galvanized soft wire or strand for galvanized rope, and bright, tinned or galvanized soft wire or strand for bright rope.

Copper and brass wires shall not be used for servings.

Materials used for permanent serving shall preserve the rope lay and shall not cause deleterious electrolytic reaction in service.

The serving material shall be capable of withstanding the temperature involved in the socketing procedure.

4.2 Cutting of rope

The wire rope shall be cut by abrasive wheel, percussive or shearing methods, paying particular attention not to disturb the position of the wires below the permanent serving.

Cutting methods that fuse the wire rope end shall not be used.

4.3 Preparation of the socket

Dirt, grease, scale or residues shall be removed from the inside of the socket basket.

NOTE This does not preclude the use of a releasing agent when socketing with resin.

4.4 Inserting rope into socket

One of two procedures shall be used to insert the rope into the socket.

In the first method, the rope shall be inserted into the socket prior to the preparation of the brush. In the second method, after the brush has been prepared in accordance with 4.6, it shall be closed and compacted to enable it to be inserted into the bore of the socket without damaging the rope.

4.5 Preparation of the brush

The temporary serving at the point of cut shall be removed and the strands fanned outwards to allow opening of the wires.

The rope including any steel core shall be unlaid into its constituent wires to form an open brush. See Figure 2.

Wires should not be bent to an excessive angle at the permanent serving, since this can cause premature failure. The opening angle of the brush should not exceed 45° from the vertical, see Figure 2. Special care should be taken with locked-coil rope due to the sensitivity of the lock coil wire section.

When socketing fibre core ropes or ropes with non-metallic components, the core or those non-metallic components shall be removed from the brush.

When socketing fibre core ropes using molten metal, the exposed end of the fibre core should be protected from the heat created by the molten metal so that the fibre core material does not ignite, melt or otherwise burn, smoke or smoulder; alternatively, with preformed round-strand ropes, a longer piece of the fibre core may be removed and replaced by a suitable wire rope. In this case, the permanent serving should be removed, the rope unlaid over a longer distance, the fibre core cut and the rope inserted, the rope strands closed again and the permanent serving re-applied at its original position. The replacement core should then be completely unlaid to form an open brush.

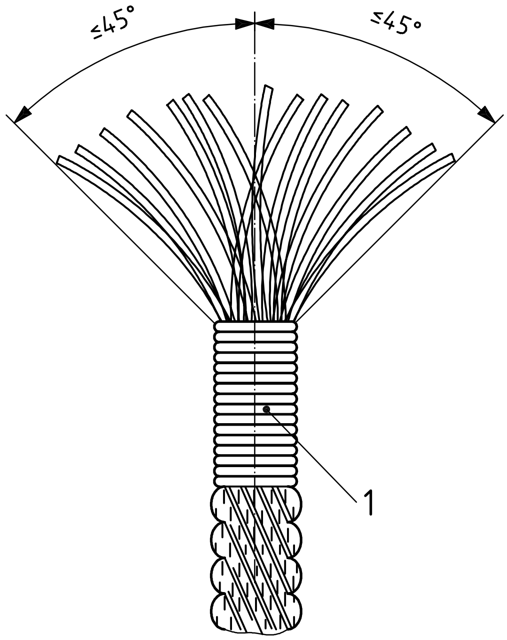
The following diameters, d_R, for the replacement core are recommended:

— ropes with 6 strands, $d_R = 0{,}35d_m$ to $0{,}40d_m$;

— ropes with 8 strands, $d_R = 0{,}47d_m$ to $0{,}52d_m$;

where d_m is the measured diameter of the rope.

After dealing with the core, the individual wires from the strands shall be unlaid (but not straightened) completely down to the permanent serving and a brush formed.



Key

1 permanent serving

Figure 2 — Brush opening angle

4.6 Cleaning and degreasing of brush

The brush shall be thoroughly cleaned and degreased.

The brush shall be dry and free from any visible residue.

Care shall be taken that the degreasing is confined to the brush.

The degreasing agent shall be worked well into the root of the brush.

The brush shall be held downwards to prevent the degreasing agent from being trapped in the root of the brush.

The time between cleaning and pouring should be as short as possible to minimize oxidation of the brush.

It is essential that when using solvents the solvent manufacturer's instructions are followed.

Some national regulations or specific methods of socketing require bright wires to be pre-treated when socketed with molten metal. In certain conditions, this might also be required to improve adhesion between the wires and the socketing metal when socketing with lead-based alloys. In these cases, the procedures given in Annex A are recommended.

4.7 Hooking

Wires shall be hooked when specified by the socket manufacturer, rope manufacturer or socketing system designer.

NOTE Hooking of wires of ropes of coarse constructions, e.g. 6 × 7, could be necessary.

The dimensions of the hooked portion shall be such that it does not impede the flow of the molten metal or resin during socketing, or reduce the brushed length of embedded wire in the socketing medium.

4.8 Positioning and alignment of the brush, rope and socket

The brush shall be reshaped into a form approximating the shape of the socket basket. The wires across the brush shall be evenly distributed. The brush shall be positioned in the socket basket either until the ends of the wires, or the bends in the hooked wires, are visible above the basket of the socket (protruding wire method) or with the wire ends or the bends in the hooked wires slightly below the top of the socket (non-protruding wire method), see Figure 3. In the non-protruding wire method, the distance between the end of the brush and the large end of the socket basket shall be no greater than 5 % of the length of the basket.

If the non-protruding wire method is used, the rope just below the base of the socket should be marked to indicate any movement of the rope during subsequent operations.

The axes of the rope and the socket shall be aligned and this alignment maintained during socketing.

The concentricity between the rope and the socket base should be optimized.

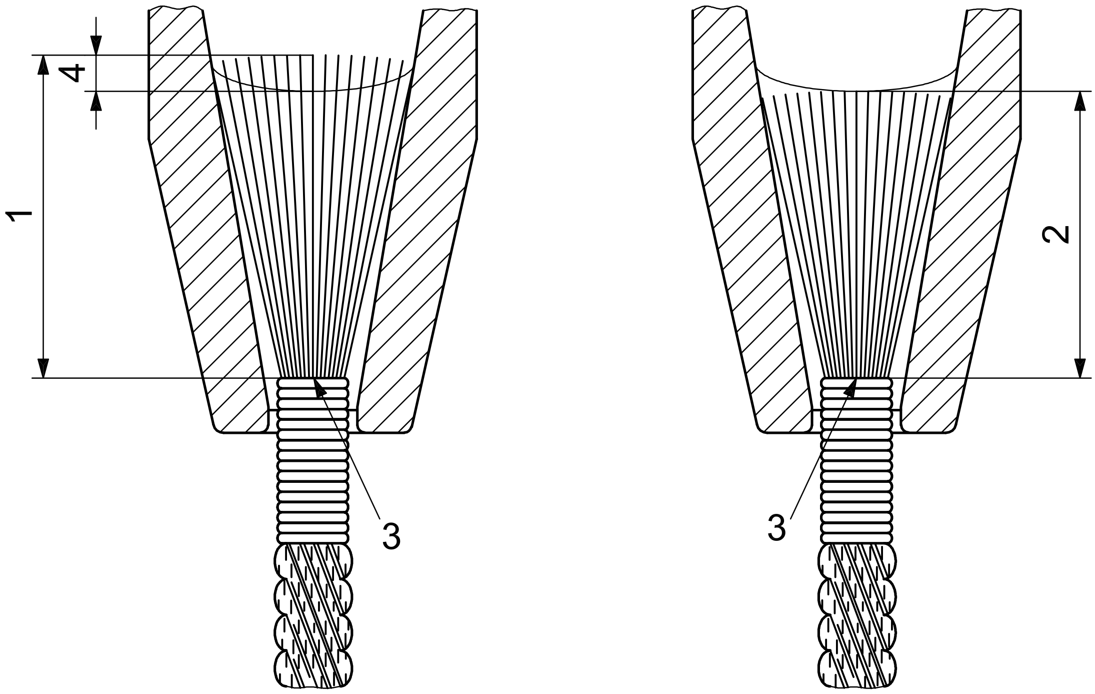
To avoid differential length movement of wires in the brush as a consequence of bending the rope too close to the socket, the rope should be maintained straight for a determined length immediately below the socket. This can be satisfied either by the rope being straight for a length of at least 30 rope diameters, after which the rope may be bent in a curve having a radius of at least 50 rope diameters; or being straight for a length of at least 20 rope diameters if securely clamped to a beam.

4.9 Sealing

The clearance between the rope and the bore of the socket shall be sealed with a material that prevents leakage of molten metal or resin.

If using sealing materials containing water, care should be taken to ensure that all moisture has been removed before starting to pour the molten metal.

Care should be taken to ensure that the sealing material is not pushed into the gap between the socket and rope at the bore. If this occurs, it will prevent penetration of the socketing medium through to the socket bore, which could lead to corrosion and premature failure.



a) Protruding wire method **b) Non-protruding wire method**

Key

1 length of brush — protruding wire method

2 length of brush — non-protruding wire method

3 root of brush

4 protruding wires

Figure 3 — Nomenclature of brush

5 Socketing

5.1 General information

The medium used for socketing shall be either

— molten metal conforming to Annex B, or

— resin conforming to Annex C, or

— other molten metal or resin materials that, when tested in accordance with Annex D, satisfy the requirements of Annex D.

Reclaimed socketing medium shall not be re-used.

5.2 Molten metal socketing

5.2.1 Pre-heating the socket

The socket shall be heated in accordance with a qualified person's instructions to ensure that the molten metal is able to fill the socket basket without solidifying prematurely.

Unless specified otherwise in these instructions, the socket temperature shall be at least 50 % of the melting temperature, in degrees Celsius (°C), of the socketing medium.

NOTE The relationship between socket pre-heat and metal pouring temperatures influences the attainment of satisfactory metal filling of the socket. The closer the pouring temperature of the metal to its melting point, the greater must be the pre-heat temperature of the socket.

The pre-heat temperature should be achieved gradually by applying heat evenly around the outer surface of the socket.

Care should be taken not to overheat any part of the socket, and to ensure that the flame does not come into contact with any part of the rope.

5.2.2 Melting the metal

Sufficient metal shall be melted to ensure complete filling of the basket. Melting temperatures and compositions of media shall be in accordance with Annex B.

The containers used for melting and pouring the socketing metal shall be of a material that does not adversely affect the molten metal.

Containers used for the melting of one family of metals shall not be used for the melting of any other family of metals.

Galvanized containers shall not be used with lead-based alloys.

Lead-based alloys should be kept molten for as short a time as possible to minimize oxidation and loss of antimony and tin.

5.2.3 Pouring

Immediately prior to pouring, the temperature of the molten metal shall be taken to ensure that it is within the limits given in Annex B.

Before pouring, any dross should be removed from the surface of the molten metal and the molten metal stirred to ensure even temperature distribution within the container.

The ladle, socket and brush shall be dry to avoid the explosive generation of steam.

The molten metal shall be poured slowly to allow the escape of gases until the socket basket is completely filled.

If more than one ladle is required to totally fill a socket basket, any subsequent pour(s) shall occur before solidification of the medium within the socket.

Shrinkage occurs in the metal at the top of the socket basket. When required, sufficient additional metal shall be poured (topping up) to fill the depression. This should be carried out as the existing metal solidifies and where necessary, the surface should be re-liquefied before topping up commences, e.g. by gentle heating of the poured metal at the top of the socket basket.

5.2.4 Cooling

The socketing metal shall be undisturbed during cooling so that it solidifies naturally.

5.3 Resin socketing

5.3.1 General

The resin manufacturer's instructions shall be adhered to. Resin system packages or kits shall not be used after the expiry date indicated on the container. Resin system packages or kits shall not be subdivided prior to mixing.

5.3.2 Pouring

The socket shall be filled from a single mix of resin until the socket basket is full. Leaks occurring during pouring and the topping-up operation shall be identified and stopped by proper sealing. If a leak is identified and stopped prior to gelling, the socket shall be topped up (refilled).

5.3.3 Curing

The resin mixture shall be allowed to harden after gelling.

The socket shall not be moved until the resin has hardened to the point that when a sharp instrument such as a screwdriver blade is drawn over the surface of the resin at the large end of the cone, only a shallow, light-coloured scratch mark is left on the surface.

NOTE It is quite normal, particularly in the case of small sockets, to have a thin, tacky layer on the surface of the resin after curing. The scratch test can be carried out through this layer.

The resin system manufacturer's instructions shall be followed prior to applying a load to the socketed assembly.

5.4 Final preparation

After socketing the sealing shall be removed. The permanent serving should be removed up to the base of the socket.

A corrosion protection compound or lubricant shall be applied to the rope in the vicinity of the base of the socket if the original rope lubricant has been removed in this area as a result of the socketing procedure.

6 Inspection

The socketed termination shall be visually inspected to confirm that

a) the gap between the rope (or rope serving) and the bore at the base of the socket is filled with the socketing medium,

b) the axis of the socket is coincident with the axis of the rope, and

c) the socket basket is filled to the top with the socketing medium.

7 Marking

The socketed termination manufacturer's trade mark, identification or symbol shall be legibly and durably marked at the larger end of the socket.

Marking shall be by stamping or by a label embedded in, or affixed to, the socketed medium.

The indentation from any stamping shall be such as not to impair the mechanical properties of the socketed portion of the termination.

Annex A
(informative)

Procedure for pre-treatment of bright rope for improved adhesion when socketing with lead-based alloys

A.1 General

Before pouring of the socketing medium, the wire brush of a wire rope may be pre-treated using this procedure.

The fluxing solution and its components are strong skin irritants. Care should be taken to ensure that they do not come into contact with bare skin.

A.2 Fluxing

Approximately two thirds of the length of a clean brush should be dipped into a zinc ammonium chloride solution for approximately 1 min.

A suitable zinc ammonium chloride solution has a composition as follows:

— zinc chloride (ZnCl) at a mass fraction of 26,00 %;

— ammonium chloride (NH_4Cl) at a mass fraction of 1,75 %;

— hydrochloric acid (HCl) at a mass fraction of 5,25 %;

— 30,00 % solution with water;

— water (H_2O) at a mass fraction of 67,00 %.

Its density at 20 °C should be 1,30 g/cm^3.

A.3 Coating

This process should be carried out slowly and carefully to avoid splashing hot metal.

Immediately following fluxing, and while the brush is still wet, approximately three-quarters of the brush length of the wire brush should be slowly immersed in tin solder (60 % Sn, 40 % Pb) at a bath temperature of (290 ± 10) °C.

After tinning, the wires should have a tight adherent metal coating for about two-thirds of the brush length. If this condition is not achieved, the fluxing and metallic-coating process should be repeated. Alternatively, a new brush may be formed if the length allows.

WARNING — Breathing lead fumes can seriously damage health.

Annex B
(normative)

Molten metal socketing media

B.1 Lead-based alloys

Lead-based alloys having an approximate melting point of 240 °C shall have a pouring temperature of (350 ± 10) °C. Their composition shall be in accordance with Table B.1.

Table B.1 — Composition of lead-based alloys

Composition mass fraction (%)						**Total impurities** [a] max. mass fraction (%)
Sn	Sb	Cd	Cu	As	Pb	
4,75 to 5,25	14,5 to 15,5	—	—	—	Remainder	0,2
7,0 to 8,0	9,0 to 10,0	—	—	—	Remainder	0,2
9,0 to 11,0	9,0 to 11,0	1,72 to 2,5	0,3 to 0,7	0,3 to 0,7	Remainder	0,2

[a] Maximum permitted impurity levels: 0,005 % Al; 0,005 % Zn; 0,05 % Cu (copper impurity level applies to the first two alloys only).

WARNING — Breathing lead fumes can seriously damage health.

Local regulations should be checked to determine whether such alloys are allowed to be used for socketing.

B.2 Zinc

Zinc shall have a minimum purity by mass of 99,9 % and an approximate melting point of 419 °C.

The pouring temperature shall not exceed 538 °C.

B.3 Zinc-based alloys

The melting point and pouring temperatures of zinc-based alloys shall be in accordance with those specified by the manufacturer of the alloy.

Annex C
(normative)

Resin socketing media

C.1 General

Resin systems shall be polyester-based and shall include an inorganic filler and a curing agent.

C.2 Physical properties

Resin systems shall have the following physical properties:

a) when tested in accordance with ISO 604, the resin system (cube size 40 mm) shall have a minimum ultimate compressive strength of 90 N/mm^2;

b) when tested in accordance with ISO 604, the resin system shall have a minimum ultimate shear strength of 15 N/mm^2;

c) when tested in accordance with ISO 75-2:2004, Method A, the resin system shall have a minimum heat distortion point of 110 °C;

d) when tested in accordance with ISO 604, the resin system shall have a minimum modulus of elasticity of 6 000 N/mm^2;

e) when tested in accordance with EN 59, the resin system shall have a minimum Barcol hardness of 36;

f) when tested in accordance with ISO 3838, the resin system shall have a specific gravity of between a minimum of 1,54 and a maximum of 1,96.

Annex D
(normative)

Type testing for performance assessment of socketing system

D.1 General

For each socketing system for which the socket is intended to be used, the socket system designer shall carry out tensile tests on socketed end terminations representing the most extreme and unfavourable combinations of rope construction, rope strength and socket basket dimensions.

NOTE Too short a basket length could, at worst, result in insufficient embedded length of wire and pull-out of the rope from the socket.

D.2 Test method

D.2.1 General

The test method shall be in accordance with D.2.2. The testing machine shall conform to ISO 7500-1.

The minimum free test length, excluding terminations, shall be in accordance with Table D.1.

Table D.1 — Test lengths

Dimensions in millimetres

Nominal rope diameter d	**Minimum test length**	
	Stranded rope	Spiral rope
$d \leqslant 6$	300	500
$6 < d \leqslant 20$	600	1 000
$20 < d \leqslant 60$	$30d$	$50d$
$d > 60$	3 000	3 000

The selected test piece shall have its ends secured to ensure that the rope does not visibly unravel.

D.2.2 Test method

The test piece in the machine shall be mounted and secured to ensure that all the wires in the rope are subjected to the force during the test. If sockets or cones are used, the method of socketing shall be as specified in this International Standard.

After 80 % of the minimum breaking force, F_{min}, has been applied, the force shall be increased at a rate of not more than 0,5 % of the minimum breaking force per second.

The measured breaking force value, F_m, shall be deemed to have been reached when no further increase in the applied force is possible and the rope is broken.

The test may be terminated without breaking the rope when the minimum breaking force, F_{min}, value is achieved or exceeded.

The test may be discounted in cases where the rope fracture occurs within a distance of six rope diameters from the base of the grip or the termination and the minimum breaking force has not been achieved.

D.3 Acceptance criteria

The rope shall be deemed to have satisfied the breaking force requirement when the measured force, F_m, reaches or exceeds the guaranteed value.

If any of the tensile tests fail to meet the minimum breaking force, a further two socketed end terminations shall be tested. These tests shall use the same

a) rope size, construction and minimum breaking force,

b) size, design and material of socket,

c) socketing medium, and

d) same method of socketing.

If these tests are satisfactory, the method of socketing and the socketing medium shall be deemed suitable for the socket and ropes under test.

If one or both the terminations fail the retesting, the method of socketing and socketing media shall be deemed unsuitable for the socket and ropes under test.

D.4 Test report

The test report shall include the following:

a) the test number;

b) a reference to the test method used;

c) the rope designation, minimum breaking force of the rope and socketing media for which the socket is suitable;

d) the test results.

Annex E
(informative)

Operating temperature limits

Unless stated otherwise by the socketing system designer or socket manufacturer, the following operating temperature limits apply to ropes socketed with media covered by this International Standard.

a) Lead-based alloys

— – 45 °C to + 80 °C

b) Zinc- and zinc-based alloys

— stranded rope with fibre core: – 40 °C to + 80 °C

— stranded rope with steel core: – 40 °C to + 120 °C

— spiral rope: – 40 °C to + 120 °C

c) Resin

— stranded rope with fibre cores: – 50 °C to + 80 °C

— stranded rope with steel cores: – 50 °C to + 110 °C

— spiral rope: – 50 °C to + 110 °C

For temperatures outside the limits given, discussion should be undertaken with the manufacturer or system designer, in particular in order to consider loading conditions.

Bibliography

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

[2] ISO 3108, *Steel wire ropes for general purposes — Determination of actual breaking load*

[3] ISO 3189-1, *Sockets for wire ropes for general purposes — Part 1: General characteristics and conditions of acceptance*

[4] ISO 4381, *Plain bearings — Lead and tin casting alloys for multilayer plain bearings*

[5] ISO 10425, *Steel wire ropes for the petroleum and natural gas industries — Minimum requirements and terms of acceptance*

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