INTERNATIONAL STANDARD

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Petroleum and natural gas industries — Drilling and production equipment — Hoisting equipment

Industries du pétrole et du gaz naturel — Équipements de forage et de production — Équipement de levage

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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.ch
Web www.iso.ch

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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 3.

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 International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 13535 was prepared by Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum and natural gas industries*, Subcommittee SC 4, *Drilling and production equipment*.

Annexes A and B form a normative part of this International Standard. Annex C is for information only.

Introduction

This International Standard is based upon API Spec 8C [2], 3rd edition, December 1997.

Users of this International Standard should be aware that further or differing requirements may be needed for individual applications. This International Standard is not intended to inhibit a vendor from offering, or the purchaser from accepting, alternative equipment or engineering solutions for the individual application. This may be particularly applicable where there is innovative or developing technology. Where an alternative is offered, the vendor should identify any variations from this International Standard and provide details.

Petroleum and natural gas industries — Drilling and production equipment — Hoisting equipment

1 Scope

This International Standard provides requirements for the design, manufacture and testing of hoisting equipment suitable for use in drilling and production operations.

This International Standard is applicable to the following drilling and production hoisting equipment:

a) hoisting sheaves;

b) travelling blocks and hook blocks;

c) block-to-hook adapters;

d) connectors and link adapters;

e) drilling hooks;

f) tubing hooks and sucker-rod hooks;

g) elevator links;

h) casing elevators, tubing elevators, drill-pipe elevators and drill-collar elevators;

i) sucker-rod elevators;

j) rotary swivel-bail adapters;

k) rotary swivels;

l) power swivels;

m) power subs;

n) spiders, if capable of being used as elevators;

o) wire-line anchors;

p) drill-string motion compensators;

q) kelly spinners, if capable of being used as hoisting equipment;

r) pressure vessels and piping mounted onto hoisting equipment;

s) safety clamps, if capable of being used as hoisting equipment;

t) guide dollies (annex B).

This International Standard establishes requirements for two product specification levels (PSLs). These two PSL designations define different levels of technical requirements. All the requirements of clause 4 through clause 11 are applicable to PSL 1 unless specifically identified as PSL 2. PSL 2 includes all the requirements of PSL 1 plus the additional practices as stated herein.

Supplementary requirements apply only when specified. Annex A gives a number of standardized supplementary requirements.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 10422, *Petroleum and natural gas industries – Threading, gauging and thread inspection of casing ,tubing and line pipe threads – Specifications*.

ISO 11960, *Petroleum and natural gas industries – Steel pipes for use as casing or tubing for wells*.

API[1] RP 9B, *Application, Care, and Use of Wire Rope for Oil Field Service*.

API Spec 7, *Rotary Drill Stem Elements*.

ASME[2] B31.3, *Chemical Plant and Petroleum Refinery Piping*.

ASME V BPVC Section 5, 1998, *Non-destructive Examination*.

ASME VIII, DIV 1, *Rules for Construction of Pressure Vessels*.

ASME IX, *Welding and Brazing specification*.

ASTM[3] A 370, *Standard Test Methods and Definitions for Mechanical Testing of Steel Products*.

ASTM A 388, *Standard Practice for Ultrasonic Examination of Heavy Steel Forgings*.

ASTM A 488, *Standard Practice for Steel Castings, Welding, Qualifications of Procedures and Personnel*.

ASTM A 770, *Standard Specification for Through-Thickness Tension Testing of Steel Plates for Special Applications*.

ASTM E 4, *Load Verification of Testing Machines*.

ASTM E 125, *Standard Reference Photographs for Magnetic Particle Indications on Ferrous Castings*.

ASTM E 165, *Standard Test Method for Liquid Penetrant Examination*.

ASTM E 186, *Standard Reference Radiographs for Heavy-Walled (2 to 4 1/2-in. (51 to 114-mm)) Steel Castings*.

ASTM E 280, *Standard Reference Radiographs for Heavy-Walled (4 1/2 to 12-in. (114 to 305-mm)) Steel Castings*.

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1) American Petroleum Institute; 1220 L St N.W.; Washington DC, 20005; USA.

2) American Society of Mechanical Engineers; 345 East 47th Street; New York, NY 10017; USA.

3) American Society for Testing and Materials; 100 Barr Harbor Drive; West Conshohocken, PA 19428; USA.

ASTM E 428, *Standard Practice for Fabrication and Control of Steel Reference Blocks Used in Ultrasonic Inspection*.

ASTM E 446, *Standard Reference Radiographs for Steel Castings Up to 2 in. (51 mm) in Thickness*.

ASTM E 709, *Standard Guide for Magnetic Particle Examination*.

ASNT-TC-IA[4], *Recommended practice for personnel qualification and certification in non-destructive testing*.

AWS D1.1, *Structural welding code*.

AWS QC1, *Standard for AWS Certification of Welding Inspectors*.

EN 287 (all parts), *Approval testing of welders – Fusion welding*.

EN 288 (all parts), *Specification and qualification of welding procedures for metallic materials*.

MSS[5] SP-55, *Quality standard for steel castings for valves, flanges and fittings and other piping components – Visual method for evaluation of surface irregularities.*

3 Terms, definitions and abbreviated terms

For the purposes of this International Standard, the following terms, definitions and abbreviated terms apply.

3.1 Terms and definitions

3.1.1
bearing-load rating
calculated maximum load for bearings subjected to the primary load

3.1.2
design load
sum of static and dynamic loads that would induce the maximum allowable stress in an item

3.1.3
design safety factor
factor to account for a certain safety margin between the maximum allowable stress and the specified minimum yield strength of a material

3.1.4
design verification test
test performed to validate the integrity of the design calculations used

3.1.5
dynamic load
load applied to the equipment due to acceleration effects

3.1.6
equivalent-round
standard for comparing various shaped sections to round bars, used for determining the response to hardening characteristics when heat-treating low-alloy and martensitic corrosion-resistant steels

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4) American Society for Nondestructive Testing; 4153 Arlingate Plaza; Box 28518; Columbus, OH 43228; USA.

5) Manufacturers' Standardization Society of the Valve and Fittings Industry; 127 Park Street NE; Vienna, VA 22180; USA.

3.1.7
linear indication
indication revealed by NDE, having a length of at least three times the width

3.1.8
load rating
maximum operating load, both static and dynamic, to be applied to the equipment

NOTE The load rating is numerically equivalent to the design load.

3.1.9
maximum allowable stress
specified minimum yield strength divided by the design safety factor

3.1.10
primary load
axial load which equipment is subjected to in operations

3.1.11
primary-load-carrying component
component of the equipment through which the primary load is carried

3.1.12
product specification level
degree of controls applied on materials and processes for the primary-load-carrying components of the equipment

NOTE The two product specification levels are identified by the code PSL 1 or PSL 2.

3.1.13
proof load test
production load test performed to validate the load rating of a unit

3.1.14
repair
removal of defects from, and refurbishment of, a component or assembly by welding, during the manufacture of new equipment

NOTE The term "repair", as referred to in this International Standard, applies only to the repair of defects in materials during the manufacture of new equipment.

3.1.15
rounded indication
indication revealed by NDE, with a circular shape or with an elliptical shape having a length of less than three times the width

3.1.16
safe working load
the design load minus the dynamic load

3.1.17
size class
designation by which dimensionally-interchangeable equipment of the same maximum load rating is identified

3.1.18
special process
operation which may change or affect the mechanical properties, including toughness, of the materials used in the equipment

3.1.19
test unit
prototype unit upon which a design verification test is conducted

3.2 Abbreviated terms

ER equivalent-round

HAZ heat-affected zone

PSL product specification level

NDE non-destructive examination

PLC principal loading condition

PWHT post-weld heat-treatment

4 Design

4.1 General

Hoisting equipment shall be designed, manufactured and tested so that it is in every respect fit for its intended purpose. The equipment shall safely transfer the load for which it is intended. The equipment shall be designed for simple and safe operation. Guide dollies shall be designed in accordance with annex B.

4.2 Design conditions

The following design conditions shall apply:

a) the operator of the equipment shall be responsible for determination of the safe working load for any hoisting operation;

b) the minimum design and operating temperature shall be – 20 °C, unless supplementary requirement SR 2 has been applied (see A.3).

CAUTION — The equipment should not be used at the full load rating at temperatures below –20 °C unless appropriate materials with the required toughness properties at lower design temperatures have been used (see A.3).

4.3 Strength analysis

4.3.1 General

The equipment design analysis shall address excessive yielding, fatigue and buckling as possible modes of failure.

The strength analysis shall be generally based on the elastic theory. An ultimate strength (plastic) analysis may, however, be used where appropriate. Finite-element mesh analysis, in conjunction with analytical methods, may be used.

All forces that may govern the design shall be taken into account. For each cross-section to be considered, the most unfavourable combination, position and direction of forces shall be used.

4.3.2 Simplified assumptions

Simplified assumptions regarding stress distribution and stress concentration may be used, provided that the assumptions are made in accordance with generally accepted practice or based on sufficiently comprehensive experience or tests.

4.3.3 Empirical relationships

Empirical relationships may be used in lieu of analysis, provided such relationships are supported by documented strain gauge test results that verify the stresses within the component. Equipment or components which, by their design, do not permit the attachment of strain gauges to verify the design shall be qualified by testing in accordance with 5.5.

4.3.4 Equivalent stress

The strength analysis shall be based on elastic theory. The nominal equivalent stress, according to the Von Mises-Hencky theory, caused by the design load shall not exceed the maximum allowable stress AS_{max} as calculated by equation (1).

$$AS_{\text{max}} = \frac{YS_{\text{min}}}{SF_{\text{D}}} \tag{1}$$

where

YS_{min} is the specified minimum yield strength;

SF_{D} is the design safety factor.

4.3.5 Ultimate strength (plastic) analysis

An ultimate strength (plastic) analysis may be performed under any one of the following conditions:

a) for contact areas;

b) for areas of highly localized stress concentrations caused by part geometry, and other areas of high stress gradients where the average stress in the section is less than or equal to the maximum allowable stress as defined in 4.3.4.

In such areas, the elastic analysis shall govern for all values of stress below the average stress.

In the case of plastic analysis, the equivalent stress as defined in 4.3.4 shall not exceed the maximum allowable stress AS_{max} as calculated by equation (2).

$$AS_{\text{max}} = \frac{TS_{\text{min}}}{SF_{\text{D}}} \tag{2}$$

where

TS_{min} is the specified minimum ultimate tensile strength;

SF_{D} is the design safety factor.

4.3.6 Stability analysis

The stability analysis shall be carried out according to generally accepted theories of buckling.

4.3.7 Fatigue analysis

The fatigue analysis shall be based on a period of time of not less than 20 years, unless otherwise agreed.

The fatigue analysis shall be carried out according to generally accepted theories. A method that may be used is defined in reference [3].

4.4 Size class

The size class shall represent the dimensional interchangeability and the load rating of equipment.

4.5 Contact surface radii

Figure 7, Figure 8, Figure 9 and Table 6 show radii of hoisting-tool contact surfaces. These contact radii are applicable to hoisting tools used in drilling (including tubing hooks), but all other work-over tools are excluded.

4.6 Rating

All hoisting equipment furnished under this International Standard shall be rated as specified herein.

Such ratings shall consist of a load rating for all equipment and a bearing-load rating for all equipment containing bearings within the primary load path.

The bearing-load rating is intended primarily to achieve consistency of ratings, but is also intended to provide a reasonable service life for bearings when used at loads within the equipment-load rating.

The load rating shall be based on the design safety factor as specified in 4.7, the specified minimum yield strength of the material used in the primary-load-carrying components and the stress distribution as determined by design calculations and/or data developed in a design verification load test as specified in 5.5.

The load rating shall be marked on the equipment (refer to clause 10).

4.7 Design safety factor

The design safety factor shall be established from Table 1 as follows.

Table 1 — Design safety factor

Load rating R kN (ton)	**Design safety factor** SF_D
1 334 kN (150 short tons) and less	3,00
1 334 kN (150 short tons) to 4 448 kN (500 short tons) inclusive	$3{,}00 - [0{,}75 \times (R - 1\,334)/3\,114]$ [a]
Over 4 448 kN (500 short tons)	2,25

[a] In this formula, the value of R shall be in kilonewtons.

The design safety factor is intended as a design criterion and shall not under any circumstances be construed as allowing loads on the equipment in excess of the load rating.

4.8 Shear strength

For purposes of design calculations involving shear, the ratio of yield strength in shear to yield strength in tension shall be 0,58.

4.9 Specific equipment

Refer to clause 9 for all additional equipment-specific design requirements.

4.10 Design documentation

Documentation of the design shall include methods, assumptions, calculations and design requirements. Design requirements shall include, but not be limited to, those criteria for size, test and operating pressures, material, environmental and specification requirements, and pertinent requirements upon which the design is to be based.

The requirements shall also apply to design change documentation.

5 Design verification test

5.1 General

To assure the integrity of equipment design, design verification testing shall be performed as specified below.

Design verification testing of equipment shall be carried out and/or certified by a department or organization independent of the design function.

Equipment which, by virtue of its simple geometric form, permits accurate stress analysis through calculation only shall be exempted from design verification testing.

5.2 Sampling of test units

To qualify design calculations applied to a family of units with an identical design concept but of varying sizes and ratings, the following sampling options apply:

— a minimum of three units of the design shall be subjected to design verification testing. The test units shall be selected from the lower end, middle and upper end of the size/rating range;

— alternatively, the required number of test units shall be established on the basis that each test unit also qualifies one size or rating above and below that of the selected test unit.

NOTE The second option generally applies to limited product size/rating ranges.

5.3 Test procedures

5.3.1 Functional test

Load the test unit to the design load. After this load has been released, check the unit to verify that the functions of the equipment and its components have not been impaired by this loading.

5.3.2 Design verification test

Apply strain gauges to the test unit at all places where high stresses are anticipated, provided that the configuration of the units permits such techniques. Tools such as finite-element analysis, models, brittle lacquer, etc. should be used to confirm the proper location of the strain gauges. Three element strain gauges should be applied in critical areas to permit determination of the shear stresses and to eliminate the need for exact orientation of the strain gauges.

The design verification test load to be applied to the test unit shall be determined as follows:

Design verification test load = 0,8 $\times R \cdot SF_D$, but not less than $2R$ (3)

where

R is the load rating in kilonewtons;

SF_D is the design safety factor as defined in 3.1.3 and 4.7.

Load the unit to the design verification test load. This test load should be applied carefully, reading the strain gauge values and observing the yield. The test unit should be loaded as many times as necessary to obtain adequate data.

The stress values computed from the strain gauge readings shall not exceed the values obtained from design calculations (based on the design verification test load) by more than the uncertainty of the testing apparatus specified in 5.6. Failure to meet this requirement or premature failure of any test unit shall be cause for a complete reassessment of the design followed by additional testing of an identical number of test units as originally required, including a test unit of the same size and rating as the one that failed.

Upon completion of the design verification test, disassemble the unit and check the dimensions of each part for evidence of yielding.

Individual parts of a unit may be tested separately if the holding fixtures simulate the load conditions applicable to the part in the assembled unit.

5.4 Determination of load rating

Determine the load rating from the results of the design verification test and/or the design and stress-distribution calculations required by clause 4. The stresses at that rating shall not exceed the values allowed in 4.3. Localized yielding is permitted at areas of contact. In a test unit that has been design-verification tested, the critical permanent deformation determined by strain gauges or other suitable means shall not exceed 0,2 %, except in contact areas. If the stresses exceed the allowable values, redesign the affected part or parts to obtain the desired rating. Stress-distribution calculations may be used to establish the load rating of equipment only if the results of the analysis are shown to be within acceptable engineering allowances as verified by the design verification test prescribed by clause 5.

5.5 Alternative design verification test procedure and rating

Destructive testing of the test unit may be used, provided an accurate yield and tensile strength of the material used in the equipment has been determined. This may be accomplished by using tensile-test specimens of the actual material in the part destructively tested and determining the yield-to-ultimate strength ratio. The ratio is then used to rate the equipment by the following equation:

$$R = L_b \cdot \frac{YS_m}{TS_a \cdot SF_D} \quad (4)$$

where

SF_D is the design safety factor (see 4.7);

YS_m is the minimum specified yield strength;

TS_a is the actual ultimate tensile strength;

L_b is the breaking load;

R is the load rating.

Since this method of design qualification is not derived from stress calculations, qualification shall be limited to the specific model, size and rating tested.

5.6 Design verification test apparatus

Calibrate the loading apparatus used to simulate the working load on the test unit in accordance with ASTM E 4 so as to ensure that the prescribed test load is obtained. For loads exceeding 3 558 kN (400 short tons), verify the load-testing apparatus with calibration devices traceable to a Class A calibration device and having an uncertainty of less than 2,5 %.

Test fixtures shall load the test unit (or part) in essentially the same manner as in actual service and with essentially the same areas of contact on the load-bearing surface. All equipment used to load the test unit (or part) shall be verified as to its capability to perform the test.

5.7 Design changes

When any change in design or manufacturing method changes the load rating, a supportive design verification test in conformance with clause 5 shall be carried out. The manufacturer shall evaluate all changes in design or manufacturing methods to determine whether the load rating is affected. This evaluation shall be documented.

5.8 Records

All design verification records and supporting data shall be subject to the same controls as specified for design documentation in 11.2.

6 Materials requirements

6.1 General

All materials shall be suitable for the intended service.

The remainder of clause 6 describes the various material qualification, property and processing requirements for primary-load-carrying components and pressure-containing components unless otherwise specified.

6.2 Written specifications

Materials shall be produced to a written material specification which shall, as a minimum, define the following parameters and limitations:

— mechanical property requirements;

— material qualification;

— processing requirements, including permitted melting, working and heat treatment;

— chemical composition and tolerances;

— repair-welding requirements.

The description of the working practice shall include the forging reduction-ratio.

6.3 Mechanical properties

Materials shall meet the property requirements specified in the manufacturer's material specification.

The impact toughness shall be determined from the average of three tests, using full-size test pieces if the size of the component permits. If it is necessary for sub-size impact test pieces to be used, the acceptance criteria for impact values shall be those stated below but multiplied by the appropriate adjustment factor listed in Table 3. Sub-size test pieces of width less than 5 mm shall not be used.

For materials of a specified minimum yield strength of at least 310 MPa (45 ksi), the average impact toughness shall be at least 42 J (31 ft-lb) at – 20 °C, with no individual value less than 32 J (24 ft-lb).

For materials with a minimum specified minimum yield strength of less than 310 MPa (45 ksi), the average impact toughness shall be 27 J (20 ft-lb) at – 20 °C with no individual value less than 20 J (15 ft-lb).

For design temperatures below – 20 °C (e.g. arctic service), supplementary impact toughness requirements shall apply, see annex A, SR2.

Where the design requires through-thickness properties, materials shall be tested for reduction of area in the through-thickness direction in accordance with ASTM A 770. The minimum reduction shall be 25 %.

PSL 2 components shall be fabricated from materials meeting the applicable requirements for ductility specified in Table 2.

Table 2 — Elongation requirements (PSL-2)

Yield strength		**Elongation, minimum** %	
MPa	(ksi)	$L_o = 4d$ [a]	$L_o = 5d$ [a]
Less than 310	(45)	23	20
310 to 517	(45 to 75)	20	18
Over 517 to 758	(Over 75 to 110)	17	15
Over 758	(Over 110)	14	12

[a] Where L_0 is the gauge length and d is the diameter.

Table 3 — Adjustment factors for sub-size impact specimens

Specimen dimensions mm	**Adjustment factor**
10,0 × 7,5	0,833
10,0 × 5,00	0,667

6.4 Material qualification

Perform the mechanical tests on qualification test-coupons representing the heat and heat-treatment lot used in the manufacture of the component. Tests shall be performed in accordance with ASTM A 370, or equivalent standards, using material in the final heat-treated condition. For the purposes of material qualification testing, PWHT is not considered heat-treatment, provided that the PWHT temperature is below that which changes the heat-treatment condition of the base material.

Determine the size of the qualification test-coupon for a part using the equivalent-round method. Figure 1 and Figure 2 illustrate the basic models for determining the equivalent-round of simple solid and hollow parts. Any of the shapes shown may be used for the qualification test-coupon. Figure 4 describes the steps for determining the governing equivalent-round for more complex sections. Determine the equivalent-round of a part using the actual dimensions of the part in the "as-heat-treated" condition. The equivalent-round of the qualification test-coupon shall be equal to or greater than the equivalent-round dimensions of the part it qualifies, except that the equivalent-round is not required to exceed 125 mm (5 in). Figure 3 and Figure 5 illustrate the procedure for determining the required dimensions of an ASTM A 370 keel block.

Qualification test-coupons shall either be integral with the components they represent, or be separate from the components, or be taken from sacrificed production part(s). In all cases, test-coupons shall be from the same heat as the components they qualify, shall be subjected to the same working operations and shall be heat-treated together with the components.

Test specimens shall be removed from integral or separate qualification test-coupons so that their longitudinal centreline axis is entirely within the centre core 1/4-thickness envelope for a solid test-coupon or within 3 mm (1/8 in) of the mid-thickness of the thickest section of a hollow test-coupon. The gauge length on a tensile specimen or the notch of an impact specimen shall be at least 1/4 thickness from the ends of the test-coupon.

Test specimens taken from sacrificed production parts shall be removed from the centre core 1/4-thickness envelope location of the thickest section of the part.

6.5 Manufacture

The manufacturing processes shall ensure repeatability in producing components that meet all the requirements of this International Standard.

All wrought materials shall be manufactured using processes which produce a wrought structure throughout the component.

All heat-treatment operations shall be performed utilizing equipment qualified in accordance with the requirements specified by the manufacturer or processor. The loading of the material within heat-treatment furnaces shall be such that the presence of any one part does not adversely affect the heat-treatment response of any other part within the heat-treatment lot. The temperature and time requirements for heat-treatment cycles shall be determined in accordance with the manufacturer's or processor's written specification. Actual heat-treatment temperatures and times shall be recorded, and heat-treatment records shall be traceable to relevant components.

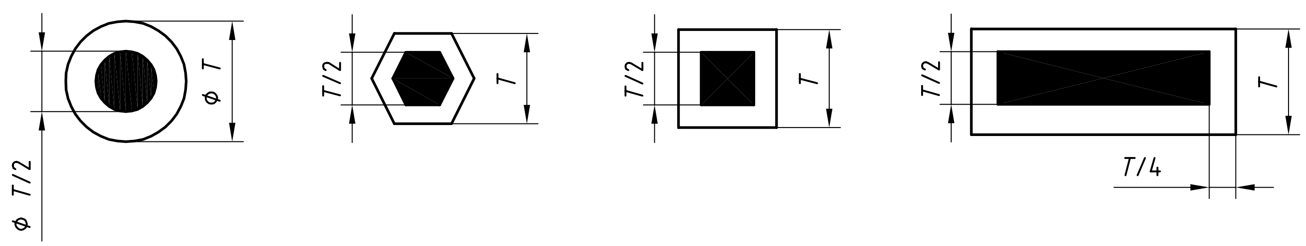
NOTE Annex C may be consulted for guidance on the qualification of heat-treatment equipment.

For PSL 2, the manufacturer shall specify the melting, refining, casting, and working practices for all components. The specified practices shall be recorded in the required written material specification.

6.6 Chemical composition

The material composition of each heat shall be analysed for all elements specified in the manufacturer's written material specification.

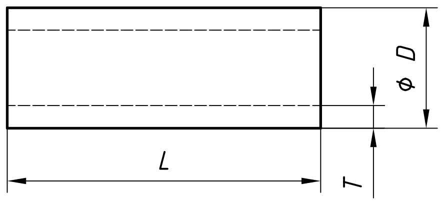
For PSL 2, the maximum mass fraction of sulfur and phosphorus shall each be 0,025, expressed as a percentage.



ER = T	ER = 1,1 T	ER = 1,25 T	ER = 1,5 T
a) Round	**b) Hexagon**	**c) Square**	**d) Rectangle or plate**

NOTE If L is less than T, consider section as a plate of thickness L.

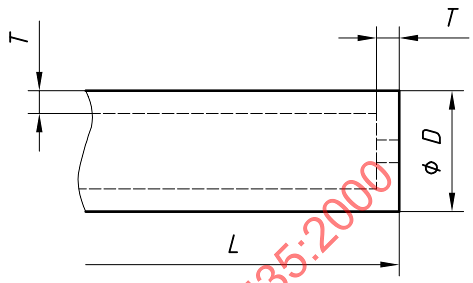
Figure 1 — Equivalent-round models — Solids of length L



ER = 2 T

NOTE If L is less than D, consider as a plate of thickness T.
If L is less than T, consider as a plate of thickness L.

a) Open at both ends

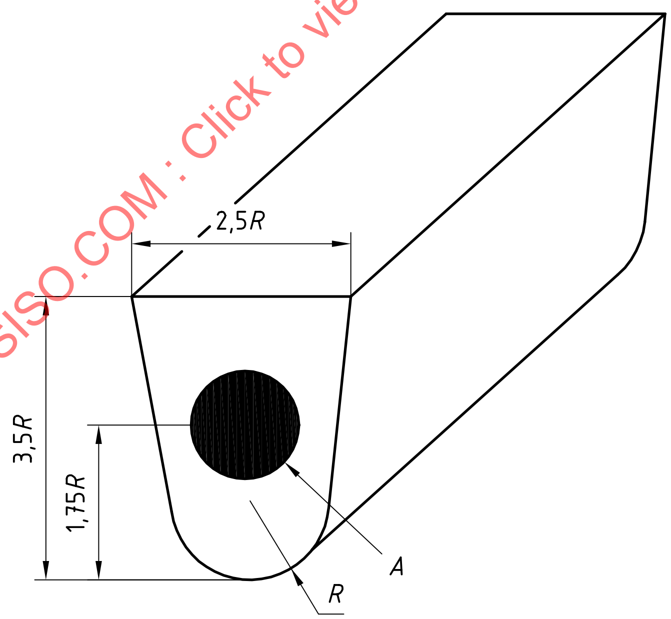


ER = 2,5 T if D is less than or equal to 63,5 mm (2,5 in).
ER = 3,5 T if D is greater than 63,5 mm (2,5 in).

NOTE Use maximum thickness, T, in the calculation.

b) Restricted or closed at one or both ends

Figure 2 — Equivalent-round models — Tube (any section)

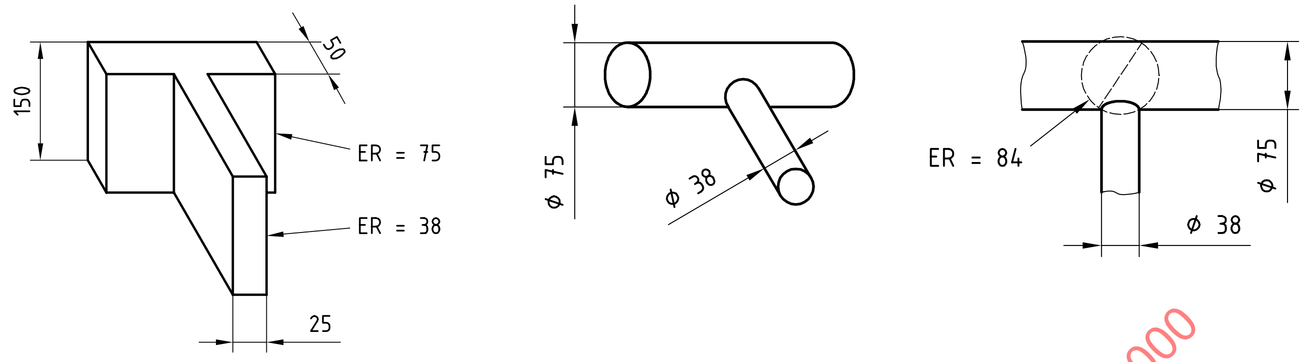


ER = 2,3 R

NOTE Shaded area A indicates 1/4-T envelope for test specimen removal.

Figure 3 — Equivalent-round models — Keel block configuration

Dimensions in millimetres



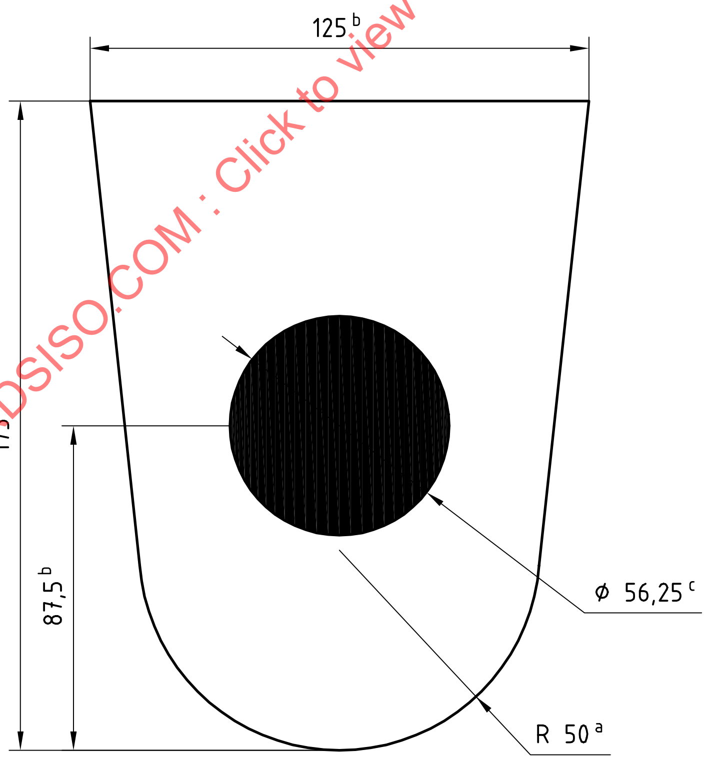
a) Reduce to simple sections **b) ER values** **c) ER intersectional value**

NOTE The following steps should be used in determining the governing equivalent-round (ER), for complex sections:

- Reduce the component to simple sections a).
- Convert each simple section to an equivalent-round b).
- Calculate the diagonal through the circle that would circumscribe the intersection of the ER values c).
- Use the maximum ER value, whether for a single section or an intersection as the ER of the complex section.

Figure 4 — Equivalent-round models — Complex shapes

Dimensions in millimetres



To develop a keel block for ER = 115 mm, see footnotes below:

a Noting from Figure 3 that ER = 2,3 R, then R = ER/2,3 = 50 mm.

b Construct keel block as illustrated in Figure 3 using multiples of R.

c Diameter D.

Figure 5 — Example of development of keel block dimensions

7 Welding requirements

7.1 General

The remainder of this clause describes requirements for the fabrication and repair welding, where permitted, of primary-load-carrying components and pressure-containing components, including attachment welds.

7.2 Welding qualifications

All welding undertaken on components shall be performed using welding procedures qualified in accordance with:

— PSL 1: ASME B31.3, ASME IX, AWS D1.1, EN 288 and/or ASTM A 488 or equivalent standards;

— PSL 2: ASME IX or equivalent standards.

This welding shall only be carried out by welders or welding operators who are qualified in accordance with the aforementioned standards or EN 287.

Welding procedures for base materials not listed in the above standards shall be qualified individually or as a group based on weldability, tensile properties or composition. If the parent metal is insufficiently ductile to meet the bend test requirements of ASME IX, the bend test (for PSL 1 or PSL 2) shall be conducted in the following manner:

A bend bar comprised of parent metal, heat-treated to the ductility and strength requirements of the applicable specification, shall be bent to failure. The side-bend specimen shall then be capable of being bent to within 5° of the angle thus determined.

7.3 Written documentation

Welding shall be performed in accordance with welding procedure specifications written and qualified in accordance with the applicable standard. The welding procedure specifications shall describe all the essential, non-essential and supplementary-essential (when required) variables as listed in the applicable standard.

The procedure qualification record shall record all essential and supplementary-essential (when required) variables of the welding procedure used for the qualification tests. Both the welding procedure specifications and the procedure qualification record shall be maintained as records in accordance with clause 11.

7.4 Control of consumables

Welding consumables shall conform to the consumable-manufacturer's specifications. The manufacturer shall have a written procedure for storage and control of welding consumables.

Materials of low-hydrogen type shall be stored and used as recommended by the welding consumable manufacturer to retain their original low-hydrogen properties.

7.5 Weld properties

The mechanical properties of the weld, as determined by the welding procedure qualification test, shall at least meet the minimum specified mechanical properties required by the design. If impact testing is required for the base material, it shall also be a welding procedure qualification requirement. Results of testing in the weld and HAZ shall meet the minimum requirements of the base material. For attachment welds, the HAZ of materials requiring impact testing, but not necessarily the weld, shall meet the above requirements.

All weld testing shall be performed with the test weldment in the applicable post-weld heat-treated condition.

For welded components with weld thicknesses greater than 25,4 mm (1 in) that are not post-weld heat-treated, a lowering of the impact test temperature should be considered by the manufacturer.

7.6 Post-weld heat-treatment

Post-weld heat-treatment of components shall be in accordance with the applicable qualified welding procedure specification.

7.7 Fabrication welds

In addition to the requirements specified in 7.2 to 7.6, weld-joint types and sizes shall meet the manufacturer's design requirements and shall be documented in the manufacturer's welding procedure specification.

7.8 Repair welds

7.8.1 Access

There shall be adequate access to evaluate, remove and inspect the non-conforming condition causing the need for the repair.

7.8.2 Fusion

The welding procedure specification and the available access for repair shall be such as to ensure complete fusion of the weld with the base material.

7.8.3 Forgings and castings

All repair-welding shall be performed in accordance with the manufacturer's welding procedure specifications. Welding procedure specifications shall be documented and shall be supplied at the purchaser's request.

Prior to any repair the manufacturer shall document the following criteria for permitted repairs:

— defect type;

— defect size limits;

— definition of major/minor repairs.

All excavations, prior to repair, and the subsequent weld repair shall meet the quality control requirements specified in clause 8.

For PSL 2, for major weld repairs as defined in 8.4.9.3 the manufacturer shall also produce a dimensional sketch of the area to be repaired and the repair sequence. Documentation of repairs shall be maintained in accordance with requirements of clause 11.

7.8.4 Tubulars

Repair welding on wrought tubular goods is not allowed.

7.8.5 Heat-treatment

The welding procedure specification used for qualifying a repair shall reflect the actual sequence of weld repair and heat-treatment performed on the repaired item.

8 Quality control

8.1 General

This clause specifies the quality control requirements for equipment and material. All quality control work shall be controlled by the manufacturer's documented instructions, which shall include appropriate methodology and quantitative and qualitative acceptance criteria.

Instructions for NDE activities shall be sufficiently detailed regarding the requirements of this International Standard. All NDE instructions shall be approved by an ASNT TC-1A level III examiner or an examiner qualified to an equivalent standard.

The acceptance status of all equipment, parts and materials shall be indicated either on the equipment, parts or materials or in the records traceable to the equipment, parts or materials.

8.2 Quality control personnel qualifications

NDE personnel shall be qualified and/or certified in accordance with ASNT TC-1A or an equivalent standard.

Personnel performing visual inspection of welding operations and completed welds shall be qualified in accordance with:

— AWS QC1 or equivalent standard;

or

— the manufacturer's documented training programme (if equivalent to the above).

All personnel performing other quality control activities directly affecting material and product quality shall be qualified in accordance with the manufacturer's documented procedures.

8.3 Measuring and test equipment

Equipment used to inspect, test or examine material or other equipment shall be identified, controlled, calibrated and adjusted at specified intervals in accordance with documented manufacturer instructions, and consistent with a recognized industry standard (e.g., MIL STD 120 [4] or ISO 10012-1 [1]), to maintain the required level of accuracy.

8.4 Quality control for specific equipment and components

8.4.1 General

The quality control requirements shall apply to all primary-load-carrying components and/or pressure-containing equipment and components unless specified otherwise.

8.4.2 Chemical analysis

Methods and acceptance criteria shall be in accordance with 6.6.

8.4.3 Tensile testing

Methods and acceptance criteria shall be in accordance with 6.3 and 6.4.

8.4.4 Impact testing

Methods and acceptance criteria shall be in accordance with 6.3 and 6.4.

8.4.5 Traceability

Components shall be traceable by heat, and heat-treatment lot, identification.

Identification shall be maintained on materials and components through all stages of manufacturing and on the finished components or assembly. Manufacturer's documented traceability requirements shall include provisions for maintenance and replacement of identification marks and identification control records. Fasteners and pipe fittings shall be exempt from the traceability requirements provided they are marked in accordance with a recognized industry standard.

8.4.6 Visual examination

Components shall be visually examined. Visual examination of castings shall be in accordance with MSS SP-55. Examination of wrought material shall be in accordance with the manufacturer's documented procedures.

8.4.7 Surface NDE

8.4.7.1 General

All accessible surfaces of each finished component shall be inspected in accordance with 8.4.7 after final heat-treatment and final machining operations.

If the equipment is subjected to a load test, the qualifying NDE shall be carried out after the load test. For materials susceptible to delayed cracking, as identified by the manufacturer, NDE shall be done no earlier than 24 h after the load test. The equipment shall be disassembled for this inspection. Any surface coating shall be removed prior to the examination.

8.4.7.2 Method

Ferromagnetic materials shall be examined by the magnetic particle method in accordance with ASME V, 1998, Sub-section A, Article 7, and Sub-section B, Article 25 or ASTM E 709. Machined surfaces shall be examined by the wet fluorescent method, other surfaces shall be examined by a wet method or dry method.

Non-ferromagnetic materials shall be examined by the liquid penetrant method in accordance with ASME V, 1998, Sub-section A, Article 6, and Sub-section B, Article 24 or ASTM E 165.

If the use of prods cannot be avoided, all prod burn-marks shall be removed by grinding and the affected areas shall be re-examined by the liquid penetrant method.

8.4.7.3 Evaluation of indications

Only those indications with major dimensions greater than 2 mm (1/16 in) and associated with a surface rupture shall be considered relevant indications. Inherent indications not associated with a surface rupture (i.e., magnetic permeability variations, non-metallic stringers, etc.) shall be considered non-relevant. If magnetic particle indications greater than 2 mm (1/16 in) are believed to be non-relevant, they shall either be examined by the liquid penetrant method to confirm they are non-relevant or they shall be removed and re-inspected to confirm they are non-relevant.

Relevant indications shall be evaluated in accordance with the acceptance criteria specified in 8.4.7.4.

8.4.7.4 Acceptance criteria

8.4.7.4.1 Castings

ASTM E 125 shall be applied as a reference standard for the evaluation of magnetic particle indications on castings. The acceptance criteria shall be as specified in Table 4 for PSL 1 and Table 5 for PSL 2.

Table 4 — PSL 1 — Maximum allowable degrees for discontinuities

Type	Maximum allowable degree		
	Discontinuity descriptions	**Critical areas**	**Non-critical areas**
I	Hot tears, cracks	None	Degree 1
II	Shrinkage	Degree 2	Degree 2
III	Inclusions	Degree 2	Degree 2
IV	Internal chills, chaplets	Degree 1	Degree 1
V	Porosity	Degree 1	Degree 2

Table 5 — PSL 2 — Maximum allowable degrees for discontinuities

Type	Maximum allowable degree		
	Discontinuity descriptions	**Critical areas**	**Non-critical areas**
I	Hot tears, cracks	None	None
II	Shrinkage	None	Degree 1
III	Inclusions	Degree 1	Degree 2
IV	Internal chills, chaplets	None	Degree 1
V	Porosity	Degree 1	Degree 2

The manufacturer shall establish and maintain critical area drawings, identifying high-stress areas, which shall be used in conjunction with this clause. For purposes of this clause, critical areas shall be all areas where the stress in the component exceeds the value of:

$$\text{High stress} \geqslant \frac{YS_{\text{min}}}{1{,}33\ SF_{\text{D}}} \quad (5)$$

where

YS_{min} is the specified minimum yield strength;

SF_{D} is the design safety factor.

If critical areas are not identified on critical area drawings then all surface areas of the component shall be considered critical.

Areas of components in which the stress is compressive, and/or where the stress level is less than the result of equation (6), shall be exempt from the acceptance criteria defined in Table 4 and Table 5.

$$\text{Low stress} \leqslant \frac{0{,}1\ YS_{\text{min}}}{SF_{\text{D}}} \quad (6)$$

where

YS_{min} is the specified minimum yield strength;

SF_{D} is the design safety factor.

8.4.7.4.2 Wrought materials

The following acceptance criteria shall apply for surface NDE of wrought materials:

- no relevant indications with a major dimension equal to or greater than 5 mm (3/16 in);
- no more than ten relevant indications in any continuous 40 cm^2 (6 in^2) area;
- no more than three relevant indications in a line separated by less than 2 mm (1/16 in) edge-to-edge;
- no relevant indications in pressure-sealing areas, in the root area of rotary threads or in the stress-relief features of threaded joints.

8.4.8 Volumetric NDE of castings

8.4.8.1 Method

Radiographic examination of castings shall be in accordance with ASME V, 1998, Sub-section A, Article 3, and Sub-section B, Article 22 with the restriction that fluorescent intensifying screens shall not be used.

Ultrasonic examination shall be in accordance with ASME V, 1998, Sub-section A, Article 5, and Sub-section B, Article 23. The component(s) shall be examined by the straight beam method in accordance with SA-609 of Article 23 and shall be supplemented by angle beam examination as in T-510, T-520, T541.4.1, T-541.4.2 and T-542.4.3 of Article 5 in areas where a back reflection cannot be maintained during the straight beam examination, or where the angle between the two surfaces of the component is more than 15°.

8.4.8.2 Sampling

Primary-load-carrying castings shall be examined by volumetric NDE on the following sampling basis as a minimum:

- all areas of initial or prototype castings shall be examined by ultrasonic or radiographic methods until the results of such examination indicate that a satisfactory production technique has been established;
- thereafter, one casting out of each production lot or, for production lots of less than ten castings, one out of every ten production castings, shall be volumetrically examined in all critical areas as identified on critical area drawings. If any casting shows any indications outside the acceptance criteria defined in 8.4.8.3, two more castings from that production lot shall be examined by the same method. If the two additional castings are acceptable, the remainder of the batch may be accepted and the initial non-conforming casting shall be repaired or scrapped.

8.4.8.3 Acceptance criteria

Areas of components in which the stress is compressive and/or where the stress level is less than the value of low stress (as calculated in 8.4.7.4) shall be exempt from volumetric examination.

a) Radiography

The acceptance criteria for radiographic examination are based on the standard reference radiographs of ASTM E 446, ASTM E 186, or ASTM E 280 depending on the wall thickness being examined.

In all cases, cracks, hot tears and inserts (defect types D, E and F, respectively) are not permitted.

The remaining indication types shown in the reference radiographs shall meet Severity Level 2 in all critical areas and Severity Level 3 in non-critical areas. Critical areas shall be as defined in 8.4.7.4. If critical areas are not identified on critical area drawings then all areas of the component shall be considered critical.

b) Ultrasonic examination

The acceptance criteria for both straight beam and angle beam ultrasonic examination of castings are based on SA-609 in ASME V, 1998, Sub-section B, Article 23. The acceptance criteria shall be as follows:

1) PSL 1: Quality Level 3;

2) PSL 2:

   i) Quality Level 1 for casting thicknesses up to 50 mm (2 in);

   ii) Quality Level 2 for casting thicknesses from 50 mm (2 in) to 100 mm (4 in);

   iii) Quality Level 3 for casting thicknesses over 100 mm (4 in);

   Regardless of casting thickness, Quality Level 1 shall apply within 50 mm (2 in) of the casting surface.

   Discontinuities indicated as having a change in depth of 25 mm (1 in) or half the thickness, whichever is the lesser, are not permitted.

8.4.9 NDE of welds

8.4.9.1 General

If examination is required, essential welding variables and equipment shall be monitored during welding. The entire accessible weld, plus at least 13 mm (1/2 in) of surrounding base metal, shall be examined in accordance with the methods and acceptance criteria of 8.4.9.

The NDE required under 8.4.9 shall be carried out after final heat-treatment.

8.4.9.2 Fabrication welding

8.4.9.2.1 Visual examination

All fabrication welds shall be visually examined in accordance with ASME V, 1998, Sub-section A, Article 9. Undercuts shall not reduce the thickness in the affected area to below the design thickness, and shall be ground to blend smoothly with the surrounding material.

Surface porosity or exposed slag are not permitted on, or within 3 mm (1/8 in) of, sealing surfaces.

8.4.9.2.2 Surface NDE

All primary-load-carrying and pressure-containing welds and attachment welds to main load bearing and pressure-containing components shall be examined as specified in 8.4.7.2.

The following acceptance criteria shall apply:

— no relevant, linear indications (see 3.1.7);

— no rounded indications (see 3.1.15) with a major dimension greater than 4 mm (1/8 in), for welds whose depth is 17 mm (5/8 in) or less;

— no rounded indications with a major dimension greater than 5 mm (3/16 in) for welds whose depth is greater than 17 mm (5/8 in);

— no more than three relevant indications in a line separated by less than 2 mm (1/16 in) edge to edge.

8.4.9.2.3 Volumetric NDE

Primary-load-carrying welds and pressure-containing welds shall be examined by either ultrasonic or radiographic methods in accordance with ASME V, 1998, Sub-section A, Article 5 and Article 2 respectively.

For PSL 1, this applies to full penetration welds only.

For PSL 2, this applies to all welds.

Acceptance criteria shall be in accordance with the requirements of ASME VIII Div. 1, UW-51 and Appendix 12, as appropriate.

8.4.9.3 Repair welds

8.4.9.3.1 Weld excavations

Magnetic particle examination shall be performed on all excavations for weld repairs, with the method and acceptance criteria as specified in 8.4.7.

8.4.9.3.2 Repair welds in castings

All repair welds in castings shall be examined in accordance with 8.4.7.2. Acceptance criteria shall be identical to those for fabrication welds (see 8.4.9.2).

For PSL 2, if the depth of repair exceeds 25 % of the original wall thickness, or 25,4 mm whichever is less, the repair shall be classed as major and shall also be examined by either radiography or ultrasonic methods. The methods and acceptance criteria shall be as defined for critical areas in 8.4.9.2.

8.4.9.3.3 Repair of welds

NDE of the repairs of weld defects shall be identical to that of the original weld (see 8.4.9.2).

8.5 Dimensional verification

Verification of dimensions shall be carried out on a sample basis as defined and documented by the manufacturer.

All main load-bearing and pressure-sealing threads shall be gauged to the requirements of the relevant thread specification(s).

For PSL 2, the verification of external interface dimensions shall be carried out on each component and/or assembly as relevant.

8.6 Proof load test

8.6.1 Extent

Each production unit of the following equipment shall be given a proof load test in accordance with 8.6.2:

a) elevators;

b) elevator links;

c) spiders (if capable of being used as elevators);

d) safety clamps (if capable of being used as hoisting equipment).

Equipment not listed above shall be given a proof load test if supplementary requirement SR-1 (see annex A) is specified in the order.

8.6.2 Procedure

The equipment shall be mounted in a test fixture capable of loading the equipment in essentially the same manner as in actual service and with essentially the same areas of contact on the load-bearing surfaces.

A test load equal to 1,5 × the load rating shall be applied and held for a period of not less than 5 min.

Following the load test, the design functions of the equipment shall be checked, as applicable. Proper functioning of the equipment shall not be impaired by the load test.

Assembled equipment shall be subsequently stripped down to a level that will permit full surface NDE of all primary-load-carrying components (excluding bearings).

All critical areas of the primary-load-carrying components shall be subjected to magnetic particle examination in accordance with 8.4.7.

8.7 Hydrostatic testing

8.7.1 General

If hydrostatic testing of equipment is required, as indicated in clause 9, the requirements of 8.7 shall apply.

8.7.2 Hydrostatic testing

The hydrostatic test shall be carried out in the following four steps:

a) primary pressure-holding period;

b) reduction of the pressure to zero;

c) thorough drying of external surfaces of the equipment;

d) secondary pressure-holding period.

The timing of the secondary holding period shall not start until the test pressure has stabilized and the equipment and pressure-monitoring devices have been isolated from the pressure source.

Specific hydrotesting requirements are included under the relevant equipment headings of clause 9.

8.7.3 Calibrated pressure gauges

Calibrated pressure gauges and recording equipment shall be used during testing. Recorder graphs shall be signed, dated and made traceable to the equipment being tested.

8.8 Functional testing

Specific functional testing requirements are included under the relevant equipment headings of clause 9.

9 Equipment

9.1 General

All the requirements of clause 4 through clause 8 apply to the primary-load-carrying components unless specifically noted otherwise in this clause. It is the equipment designer's responsibility to determine the primary load path through the equipment and to define the primary-load-carrying components.

9.2 Hoisting sheaves

9.2.1 Materials for sheaves

Sheaves are exempt from impact testing.

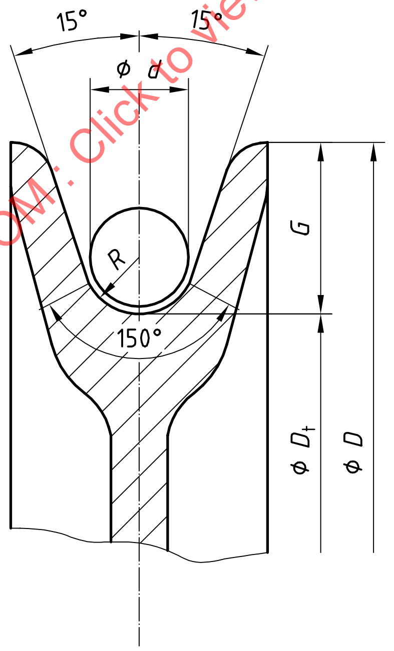
9.2.2 Sheave NDE

Surface-hardened areas of sheave grooves shall be exempt from the requirements of 8.4.7. NDE of the groove area may be performed prior to surface hardening the groove.

Sheave webs manufactured from rolled steel plate less than 50 mm (2 in) thickness and having a specified minimum yield strength less than 310 MPa (45 ksi) shall be exempt from surface NDE.

9.2.3 Sheave diameter

The sheave diameter shall be the overall diameter (D) shown in Figure 6. Sheave diameters shall, whenever practicable, be determined in accordance with API RP 9B.



Key
D_t = Tread diameter
G = Total groove depth

Figure 6 — Sheave grooves

9.2.4 Drilling and casing line sheaves

Grooves for drilling and casing line sheaves shall be made for the selected rope size. The bottom of the groove shall have a radius, R, [see equations (7) and (8) below] subtending an arc of 150°. The sides of the groove shall be tangent to the ends of the bottom arc. Total groove depth shall be a minimum of 1,33 d and a maximum of 1,75 d, where d is the nominal rope diameter shown in Figure 6.

9.2.5 Sand-line sheaves

Grooves for sand-line sheaves shall be made for the selected rope size. The bottom of the groove shall have a radius of between R_{min} and R_{max} [see equations (7) and (8)] subtending an arc of 150°. The sides of the groove shall be tangent to the ends of the bottom arc. Total groove depth shall be a minimum of 1,75 d and a maximum of 3 d, where d is the nominal rope diameter shown in Figure 6.

NOTE API RP 9B gives details of sheave-groove gauging practice and data for worn sheaves.

$$R_{min} = R_{rope} \times 1{,}06 \quad (7)$$

$$R_{max} = R_{rope} \times 1{,}10 \quad (8)$$

where

R_{min} is the minimum new groove radius;

R_{max} is the maximum new groove radius;

R_{rope} is the nominal rope radius.

9.2.6 Marking

Sheaves shall be marked with the manufacturer's name or mark, the sheave groove size and the sheave outside diameter. These markings shall be cast or stamped on the side of the outer rim of the sheave.

EXAMPLE A 914 mm (36 in) sheave with a 28,6 mm (1-1/8 in) groove manufactured by the AB Company is marked as follows:

AB CO 28,6 ISO 13535 914

9.3 Travelling blocks

9.3.1 Sheaves

Travelling block sheaves shall comply with the applicable requirements of 9.2.

9.3.2 Sheave bearing rating

The bearing rating of travelling blocks shall be determined by the formula:

$$W_B = \frac{N \cdot W_R}{357} \quad (9)$$

where

W_B is the calculated block bearing rating, expressed in kilonewtons (kN);

N is the number of sheaves in the block;

W_R is the individual sheave bearing rating at 100 r/min for 3 000 h minimum life for 90 % of bearings, expressed in newtons (N).

For anti-friction bearing design and manufacturing requirements, see 9.15.

9.3.3 Travelling blocks

Contact-surface radii shall comply with the dimensions in Table 6 and Figure 7.

9.3.4 Hook blocks

Contact-surface radii shall comply with the dimensions in Table 6 and Figures 7, 8 and 9. The method of connection between the travelling block component and the hook component shall be at the discretion of the manufacturer.

9.3.5 Travelling-block hood-eye

The travelling-block hood-eye is a lifting eye located at the top of the travelling block and is used for lifting and hanging-off the weight of the travelling block and the attachments underneath. The load rating of the hood-eye shall be established with a minimum safety factor of 2,25. The load rating of the hood-eye shall be marked near the top handling member of the travelling block.

When verifying that the hood-eye can be used safely to lift or hang-off the travelling assembly, the mass of the travelling block shall be added to the mass of the attachments beneath.

9.3.6 Travelling block marking.

Marking shall be in accordance with clause 10.

9.4 Block-to-hook adapters

Block-to-hook adapters shall have the same load rating as the hook.

9.5 Connectors, link-adapters and drill-pipe elevator-adapters

The drill-pipe elevator-adapter shall be made to seat on a tapered or square-shouldered drill-pipe elevator and shall have its elevator link ears designed to comply with the contact radii in Table 6 and Figure 9.

The contact radii of link adapters shall comply with the dimensions in Table 6 and Figure 9.

9.6 Drilling hooks

Contact surface radii of drilling hooks shall comply with the dimensions in Table 6 and Figure 7 through Figure 9.

9.7 Elevator links

Elevator links shall comply with the dimensions in Table 6 and Figure 9.

Elevator links shall be designed and manufactured in pairs. Links up to and including 4,25 m (14 ft) in length (as measured between the contact surfaces) shall match within 4 mm (1/8 in). Links over 4,25 m (14 ft) in length shall match within 7 mm (1/4 in).

9.8 Elevators

9.8.1 Dimensions

Drill-pipe elevators for use with taper-shoulder tool joints and square-shoulder tool joints shall have bore dimensions as specified in Table 7.

Casing elevators and tubing elevators shall be suitable for use with casing and tubing manufactured in accordance with ISO 11960 and shall have bore dimensions as specified in Tables 8 and 9 respectively (see Figure 10).

NOTE The allowable tolerance on the outside diameter immediately behind the tubing upset may cause problems with slip-type elevators.

9.8.2 Drill-pipe elevator marking

In addition to the markings specified in 10.2, drill-pipe elevators shall be marked designating drill-pipe size and style from Table 7.

9.8.3 Slip-type elevators and slip-type spiders

Design verification testing of slip-type elevators and slip-type spiders shall be carried out with the slips/inserts in place. Production-load testing may be carried out without the slips/inserts installed, using a tapered mandrel designed to simulate the actual loading conditions.

The slips' activating mechanism shall be functionally tested on each production unit, demonstrating full compliance with design requirements.

Inserts are exempt from mechanical testing and traceability requirements.

Slips are exempt from impact testing.

Table 6 — Hoisting tool contact-surface radii

Load rating		Travelling block and hook bail radius [a] mm				Hook and swivel bail radius [b] mm			
kN	Short tons	A_1 max.	A_2 min.	B_1 min.	B_2 max.	E_1 min.	E_2 max.	F_1 max.	F_2 min.
222 to 356	25 to 40	69,85	69,85	82,55	76,20	50,80	38,10	76,20	76,20
357 to 578	41 to 65	69,85	69,85	82,55	76,20	50,80	44,45	88,90	88,90
579 to 890	66 to 100	69,85	69,85	82,55	76,20	57,15	50,80	101,60	101,60
891 to 1 334	101 to 150	69,85	69,85	82,55	76,20	63,50	57,15	114,30	114,30
1 335 to 2 224	151 to 250	101,60	101,60	82,55	76,20	69,85	63,50	114,30	114,30
2 225 to 3 113	251 to 350	101,60	101,60	82,55	76,20	76,20	69,85	114,30	114,30
3 114 to 4 450	351 to 500	101,60	101,60	88,90	82,55	88,90	82,55	114,30	114,30
4 451 to 5 782	501 to 650	101,60	101,60	88,90	82,55	88,90	82,55	114,30	114,30
5 783 to 6672	651 to 750	152,40	152,40	88,90	82,55	107,95	101,60	114,30	114,30
6 673 to 8 896	751 to 1 000	152,40	152,40	158,75	152,40	133,35	127,00	127,00	127,00

Load rating		Elevator link upper eye and hook link ear radius [c] mm				Elevator link lower eye and elevator link ear radius [c] mm			
kN	Short tons	C_1 max.	C_2 min.	D_1 min.	D_2 max.	G_1 max.	G_2 min.	H_1 min.	H_2 max.
222 to 356	25 to 40	38,10	38,10	31,75	22,23		25,40		50,80
357 to 578	41 to 65	63,50	63,50	31,75	22,23		25,40		50,80
579 to 890	66 to 100	63,50	63,50	38,10	28,58		25,40		50,80
891 to 1 334	101 to 150	63,50	63,50	38,10	28,58	23,82	38,10	50,80	50,80
1 335 to 2224	151 to 250	101,60	101,60	44,45	34,93	30,94	47,63	69,85	69,85
2 225 to 3 113	251 to 350	101,60	101,60	44,45	34,93	37,31	47,63	69,85	69,85
3 114 to 4 450	351 to 500	101,60	120,65	57,15	47,63	47,63	50,80	82,55	82,55
4 451 to 5 782	501 to 650	101,60	120,65	57,15	47,63	57,15	60,32	127,00	127,00
5 783 to 6 672	651 to 750	101,60	127,00	63,50	63,50	57,15	60,32	127,00	127,00
6 673 to 8 896	751 to 1 000	114,30	127,00	76,20	69,85	69,85	73,03	158,75	158,75

a See Figure 7.

b See Figure 8.

c See Figure 9.

Table 7 — Drill-pipe elevator bores and markings

Tool- joint designation reference	Drill pipe size and style (all weights and grades)	Tool joints								Elevator marking
		Taper shoulder				Square shoulder				
		Neck diameter D_{TE} max.[a]		Elevator bore		Neck diameter D_{SE} max.[b]		Elevator bore		
		mm	in	mm	in	mm	in	mm	in	
NC 26 (2-3/8 IF)	2-3/8 EU	65,09	2-9/16	67,47	2-21/32		c		c	2-3/8 EU
NC 31 (2-7/8 IF)	2-7/8 EU	80,96	3-3/16	83,34	3-9/32	80,96	3-3/16	87,73	3-3/8	2-7/8 EU
NC 38 (3-1/2 IF)	3-1/2 EU	98,43	3-7/8	100,81	3-31/32	98,43	3-7/8	103,19	4-1/16	3-1/2 EU
NC 40 (4FH)	3-1/2 EU	98,43	3-7/8	100,81	3-31/32	98,43	3-7/8	103,19	4-1/16	
NC 40 (4 FH)	4 IU	106,36	4-3/16	101,86	4-9/32	104,78	4-1/8	109,54	4-5/16	4 IU
NC 46 (4 IF)	4 EU	114,30	4-1/2	121,44	4-25/32	114,30	4-1/2	122,24	4-13/16	4 EU, or 4-1/2 IU, or 4-1/2 IEU
NC 46 (4 IF)	4-1/2 IU	119,06	4-11/16	121,44	4-25/32	117,48	4-5/8	122,24	4-13/16	
NC 46 (4 IF)	4-1/2 IEU	119,06	4-11/16	121,44	4-25/32	117,48	4-5/8	122,24	4-13/16	
4-1/2 FH	4-1/2 IU	119,06	4-11/16	121,44	4-25/32	117,48	4-5/8	122,24	4-13/16	
4-1/2 FH	4-1/2 IEU	119,06	4-11/16	121,44	4-25/32	117,48	4-5/8	122,24	4-13/16	
NC 50 (4-1/2 IF)	4-1/2 EU	127,00	5	133,35	5-1/4	127,00	5	134,94	5-5/16	4-1/2 EU, or 5 IEU
NC 50 (4-1/2 IF)	5 IEU	130,18	5-1/8	133,35	5-1/4	130,18	5-1/8	134,94	5-5/16	
5-1/2 FH	5 IEU	130,18	5-1/8	133,35	5-1/4	130,18	5-1/8	134,94	5-5/16	
5-1/2 FH	5-1/2 IEU	144,46	5-11/16	147,64	5-13/16	144,46	5-11/16	149,23	5-7/8	5-1/2 IEU
6-5/8 FH	6-5/8 IEU	176,21	6-15/16	178,66	7-1/32	c	c	c	c	6-5/8 IEU

Tolerances: Bore: $^{+0,8}_{0}$ mm ($^{+1/32}_{0}$ in) Taper: $^{+2^\circ}_{0^\circ}$

NOTE Elevators with the same bores are the same elevators.

[a] Dimension D_{TE} from API Spec 7.

[b] Dimension D_{SE} from API Spec 7.

[c] Not manufactured.

9.9 Rotary swivels

9.9.1 Swivel bearing-load rating

The bearing-load rating of swivels shall be determined by the formula:

$$W_S = \frac{W_R}{800} \quad (10)$$

where

W_S is the calculated main bearing thrust rating at 100 r/min, expressed in kilonewtons (kN);

W_R is the main bearing thrust rating at 100 r/min for 3 000 h minimum life for 90 % of bearings, expressed in newtons (N).

For anti-friction bearing design and manufacturing requirements, see 9.15.

9.9.2 Rotary swivel prototype pressure testing

The assembled test unit shall be statically pressure-tested.

The test pressure shall be twice the working pressure for working pressures up to and including 34,5 MPa (5 000 psi). For working pressures above 34,5 MPa (5 000 psi), the test pressure shall be at least 1,5 times the working pressure, but not less than 69 MPa (10 000 psi). The test pressure shall be held for two cycles of 3 min each in accordance with the pressure/time sequence specified in 9.9.3.

9.9.3 Production pressure-testing

The cast components of the rotary-swivel hydraulic circuit shall be pressure-tested in production. The production test-pressure shall be shown on the cast member.

The hydrostatic pressure-test shall consist of the following four steps:

a) primary pressure-holding period;

b) reduction of the pressure to zero;

c) thorough drying of all external surfaces of the components;

d) secondary pressure-holding period.

The test pressure shall be equal to the rated working pressure. The pressure-holding periods shall be not less than 3 min, the timing of which shall not start until the test pressure has been reached and the equipment and pressure-monitoring device have been isolated from the pressure source. During this period, no detectable pressure drop or leakage shall be allowed.

Table 8 — Casing-elevator bores

Casing	Elevator		Bores	
Nominal casing size	Top bore diameter T_B		Bottom bore diameter [a] B_B	
	mm	(in)	mm	(in)
4 ½	116,69	(4,594)	116,69	(4,594)
4 ¾	123,04	(4,844)	123,04	(4,844)
5	130,18	(5,125)	130,18	(5,125)
5 ½	142,88	(5,625)	142,88	(5,625)
5 ¾	149,23	(5,875)	149,23	(5,875)
6	155,58	(6,125)	155,58	(6,125)
6 5/8	171,45	(6,750)	171,45	(6,750)
7	180,98	(7,125)	180,98	(7,125)
7 5/8	197,64	(7,781)	197,64	(7,781)
7 ¾	200,81	(7,906)	200,81	(7,906)
8 5/8	223,04	(8,781)	223.04	(8,781)
9	232,56	(9,156)	232,56	(9,156)
9 5/8	248,44	(9,781)	248,44	(9,781)
9 7/8	254,79	(10,031)	254,79	(10,031)
10 ¾	277,83	(10,938)	277,83	(10,938)
11 ¾	303,23	(11,938)	303,23	(11,938)
12 7/8	331,80	(13,063)	331,80	(13,063)
13 3/8	344,50	(13,563)	344,50	(13,563)
13 5/8	350,85	(13,813)	350,85	(13,813)
14	360,76	(14,203)	360,76	(14,203)
16	411,96	(16,219)	411,96	(16,219)
18	463,55	(18,250)	463,55	(18,250)
18 5/8	479,43	(18,875)	479,43	(18,875)
20	515,14	(20,281)	515,14	(20,281)
21 ½	553,24	(21,781)	553,24	(21,781)
22	565,94	(22,281)	565,94	(22,281)
24	617,55	(24,313)	617,55	(24,313)
24 ½	630,25	(24,813)	630,25	(24,813)
26	669,14	(26,344)	669,14	(26,344)
27	694,54	(27,344)	694,54	(27,344)
28	720,32	(28,359)	720,32	(28,359)
30	771,53	(30,375)	771,53	(30,375)

Table 8 — Casing-elevator bores (*continued*)

Casing	Elevator		Bores	
Nominal casing size	Top bore diameter T_B		Bottom bore diameter [a] B_B	
	mm	(in)	mm	(in)
32	822,73	(32,391)	822,73	(32,391)
36	925,53	(36,438)	925,53	(36,438)

Tolerances:

$T_B \leqslant 254$ mm ± 0,40 mm — $B_B \leqslant 254\ ^{+0,80}_{-0,40}$ mm

($T_B \leqslant 10$ in ± 1/64 in) — ($B_B \leqslant 10\ ^{+1/32}_{-1/64}$ in)

254 mm $< T_B \leqslant 508\ ^{+0,80}_{-0,40}$ mm — 254 mm $\leqslant B_B \leqslant 508\ ^{+1,60}_{-0,40}$ mm

(10 in $< T_B \leqslant 20\ ^{+1/32}_{-1/64}$ in) — (10 in $< B_B \leqslant 20\ ^{+1/16}_{-1/64}$ in)

$T_B > 508\ ^{+1,60}_{-0,80}$ mm — $B_B > 508\ ^{+1,60}_{-0,80}$ mm

($T_B > 20\ ^{+1/16}_{-1/32}$ in) — ($B_B > 20\ ^{+1/16}_{-1/32}$ in)

NOTE 1 Refer to Figure 7 for the relationship of T_b and B_b.

NOTE 2 Longitudinal, circumferential or spiral welds should be ground flush in the area of slip or elevator contact.

NOTE 3 Bore sizes take in account a casing tolerance of +1 %/ –0,5 % on the casing outside diameter. If the casing diameter including the circumferential weld is within the standard tolerance, these bores can be used. If the bottom bore may interfere with circumferential, longitudinal, or spiral welds, consideration should be given to grinding flush in the area of possible slip contact or elevator contact.

[a] Bottom bore B_B is optional; some elevator designs do not have a bottom bore.

Table 9 — Tubing elevator bores

Tubing	Non-upset tubing						External-upset tubing							
Nominal size	Collar diameter		Top bore T_B		Bottom bore B_B		Collar diameter		Upset diameter		Top bore T_B		Bottom bore[a] B_B	
	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in
1,050	33,35	1,313	28,58	1,125	28,58	1,125	42,16	1,660	33,40	1,315	36,12	1,422	36,12	1,422
1,315	42,16	1,660	35,31	1,390	35,31	1,390	48,26	1,900	37,31	1,469	40,08	1,578	40,08	1,578
1,660	52,17	2,054	44,04	1,734	44,04	1,734	55,88	2,200	46,02	1,812	48,82	1,922	48,82	1,922
1,900	55,88	2,200	50,39	1,984	50,39	1,984	63,50	2,500	53,19	2,094	55,96	2,203	55,96	2,203
2 3/8	73,03	2,875	62,31	2,453	62,31	2,453	77,80	3,063	65,89	2,594	68,66	2,703	68,66	2,703
2 7/8	88,90	3,500	75,01	2,953	75,01	2,953	93,17	3,668	78,59	3,094	81,36	3,203	81,36	3,203
3 1/2	107,95	4,250	90,88	3,578	90,88	3,578	114,30	4,500	95,25	3,750	98,02	3,859	98,02	3,859
4	120,65	4,750	103,58	4,078	103,58	4,078	127,00	5,000	107,95	4,250	110,72	4,359	110,72	4,359
4 1/2	132,08	5,200	116,66	4,593	116,66	4,593	141,30	5,563	120,65	4,750	123,42	4,859	123,42	4,859

CAUTION — Do not use external-upset tubing elevators on non-upset tubing.

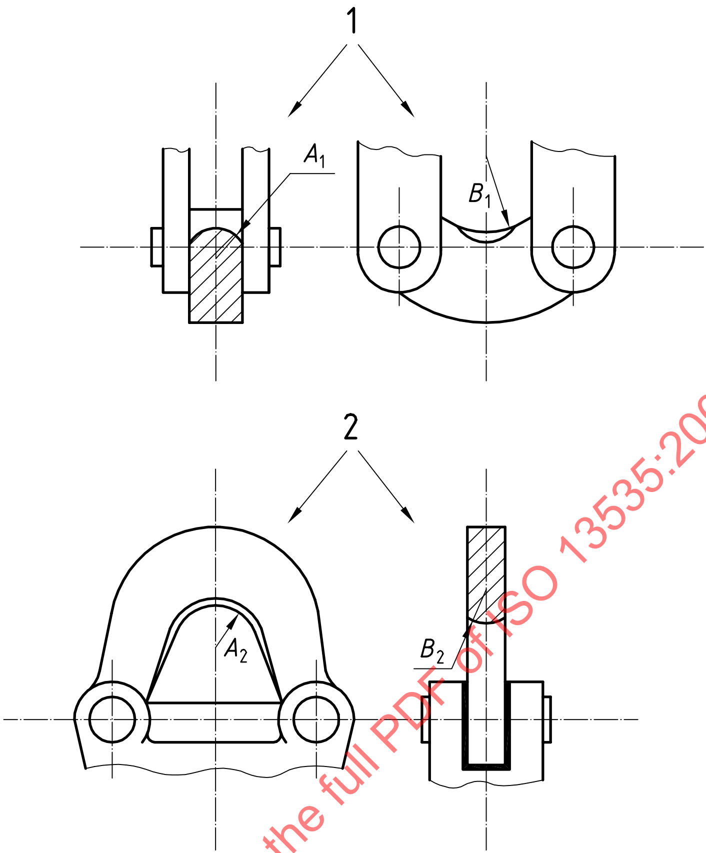
Tolerances:

Top bore (T_B): ± 0,40 mm (± 1/64 in)

Bottom bore (B_B): $^{+0,80}_{-0,40}$ mm ($^{+1/32}_{-1/64}$ in)

NOTE Refer to Figure 7 for the relationship of T_B and B_B.

[a] Bottom bore, B_B, is optional, some elevator designs do not have a bottom bore.

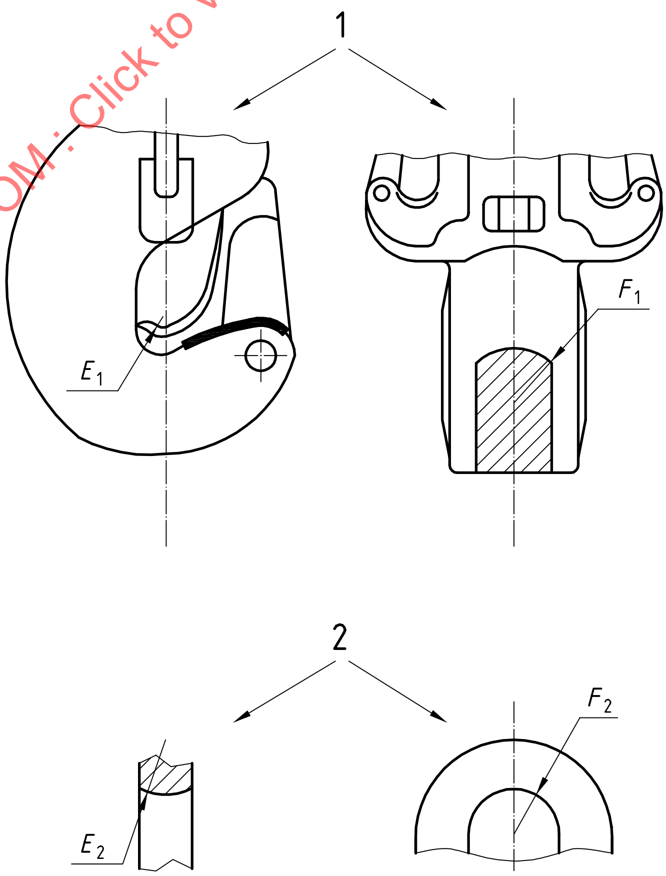


Key

1 Travelling block becket

2 Hook bail

Figure 7 — Travelling block and hook bail

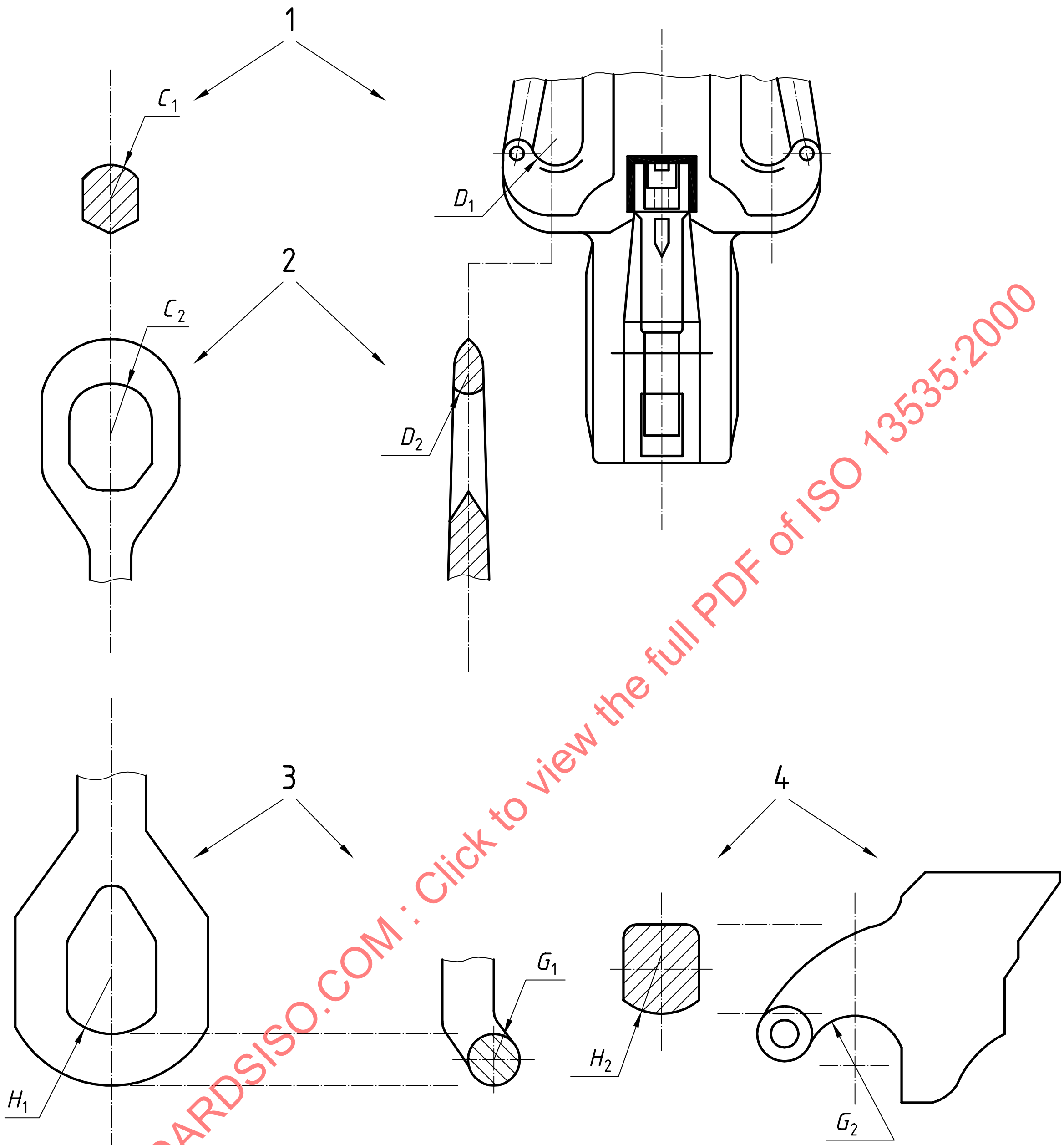


Key

1 Hook

2 Swivel bail

Figure 8 — Hook and swivel bail contact-surface radii



Key

1 Hook link ear
2 Elevator link upper eye
3 Elevator link lower eye
4 Elevator link ear

Figure 9 — Elevator link eye and hook link ear contact-surface radii

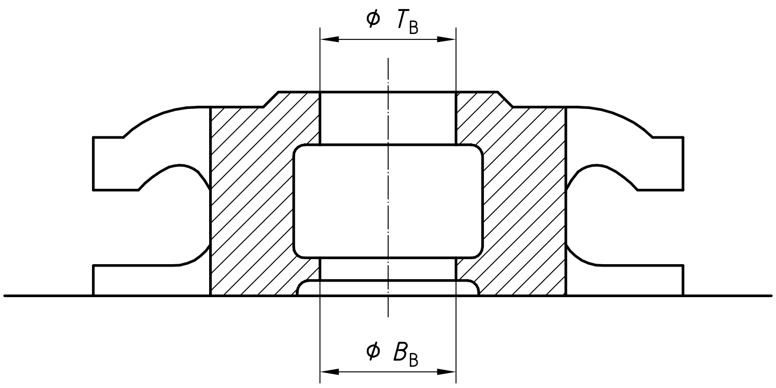
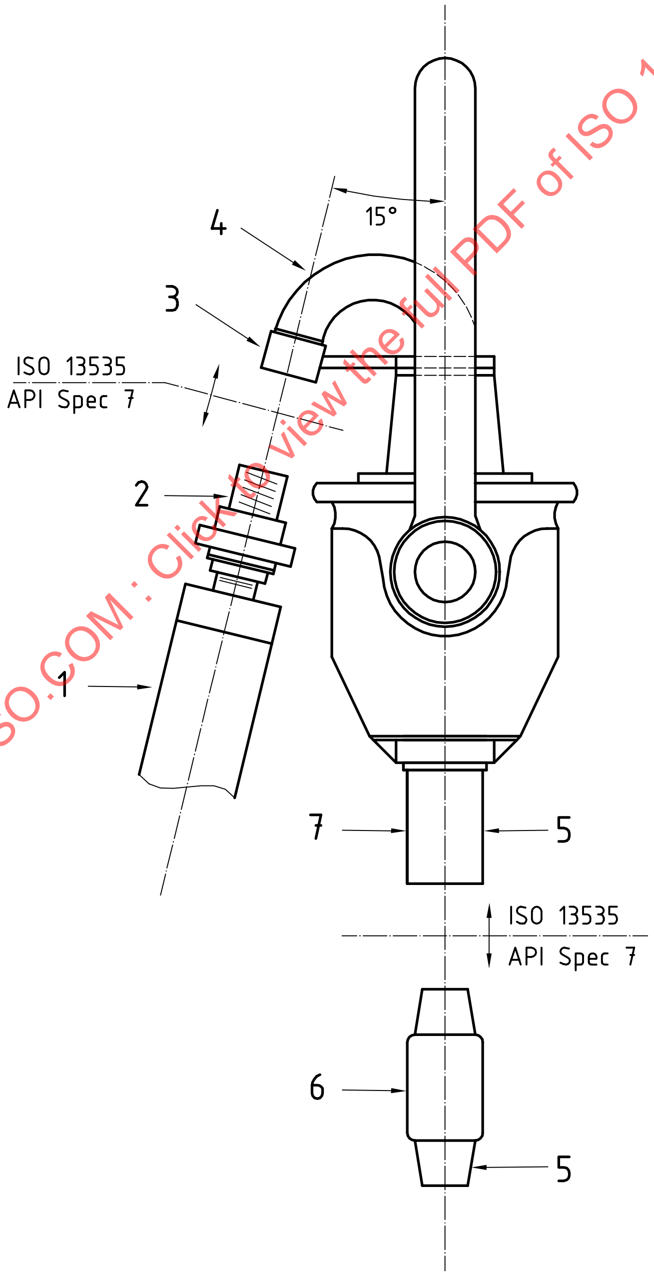


Figure 10 — Casing and tubing elevator bores



Key

1 Rotary drilling hose
2 External pipe thread [a]
3 Internal pipe thread [a]
4 Gooseneck
5 API standard rotary connection LH
6 Swivel sub
7 Swivel stem

a Other connections may be used, see 9.9.4.1.

Figure 11 — Rotary swivel connections

9.9.4 Swivel gooseneck connection

9.9.4.1 Dimensions

The angle between the gooseneck centreline and the vertical shall be 15°. The connection size and type shall be agreed by the purchaser and manufacturer and specified on the purchase order (see Figure 11).

9.9.4.2 Threads

If gooseneck connections are threaded, the threads shall comply with ISO 10422.

Nominal size threads shall be marked with the size and type of thread.

See clause 10 for further marking requirements.

9.9.5 Rotary swivel-sub connection

The connection shall comply with the applicable requirements, including gauging and marking, as specified in API Spec 7.

9.9.6 Rotary-hose safety-chain attachment

Gooseneck connections shall be provided with a suitable lug, containing a 28,6 mm (1 1/8 in) diameter hole to accommodate the clevis of a chain having a breaking strength of no less than 71,1 kN (16 000 lb). The location of the lug is at the choice of the manufacturer. The lug shall have a breaking strength of no less than 71,1 kN (16 000 lb).

9.9.7 Swivel washpipes

Swivel washpipes shall be exempt from the impact requirements of clause 6 and the NDE requirement of clause 8.

9.10 Power swivels

A power swivel is a device which moves with the travelling block and is designed to provide rotary power to the top of the drill string for drilling operations. It replaces the rotary swivel and includes a rotary seal and bearing for supporting the drill-string weight.

The bearing-load rating shall be calculated using equation (10) in 9.9.1.

Pressure testing shall be in accordance with 9.9.2 and 9.9.3.

Power-swivel gooseneck and sub connections, and rotary-hose safety-chain attachments shall be in accordance with 9.9.5 and 9.9.6.

9.11 Power subs

9.11.1 General

A power sub is a device which moves with the travelling block and is designed to provide rotary power to the top of the drill string for drilling operations. It attaches to the bottom of the rotary swivel, but does not include a rotary seal or bearing for supporting the drill-string weight.

9.11.2 Power sub gooseneck extension

Power sub gooseneck extensions shall meet the thread and marking requirements of 9.9.4. If a gooseneck extension is used which causes the rotary-hose safety-chain attachment on the rotary swivel to be in an inconvenient location, an additional attachment lug shall be provided. This attachment lug shall meet the requirement of 9.9.6.

9.11.3 Power sub connections

Both the upper and lower power sub connections shall meet the requirements of 9.9.5.

9.12 Wireline anchors

Wireline anchors shall be classed by the rated line pull, in kilonewtons (kN).

The load rating of wireline anchors shall be determined as outlined in 4.6 except that the design safety factor shall be determined as given in Table 10.

Table 10 — Load rating of wireline anchors

Load rating R	Design safety factor SF_D
178 kN (20 short tons) $\leqslant R$	3,00
178 kN (20 short tons) $< R \leqslant$ 445 kN (50 short tons)	3,00 – 0,75 (R – 178)/267 [a]
$R >$ 445 kN (50 short tons)	2,25

[a] In this formula the value of R shall be in kilonewtons.

9.13 Drill-string motion compensators

Drill-string motion compensators, either travelling or top-mounted, shall comply with clause 9. Travelling drill-string motion compensators' contact-surface radii shall comply with the dimensions given in Table 6 and Figure 7.

9.14 Pressure vessels and piping

Pressure vessels and piping forming part of the equipment shall be manufactured in accordance with a recognized code or standard.

9.15 Anti-friction bearings

Anti-friction bearings used as primary-load-path components shall be designed and manufactured in accordance with a recognized bearing industry code or standard. Anti-friction bearings shall be exempt from the requirements of clause 4 through clause 8.

9.16 Safety clamps when capable of being used as hoisting equipment

9.16.1 Inserts

Inserts shall be exempt from mechanical testing and traceability requirements.

9.16.2 Clamp make-up torque

Manufacturers shall state the minimum and maximum make-up torque for the clamp to achieve the load rating.