INTERNATIONAL STANDARD

ISO 13535

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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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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:

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

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;