

Drilling and Production Hoisting Equipment (PSL 1 and PSL 2)

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Drilling and Production Hoisting Equipment (PSL 1 and PSL 2)

1 Scope

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

This 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 for traveling equipment (e.g. hooks, blocks, etc.).

This Standard establishes requirements for two product specification levels (PSLs). These two PSL designations define different levels of technical requirements. All the requirements of Section 4 through Section 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 referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

API Specification 5B, *Threading, Gauging, and Thread Inspection of Casing, Tubing, and Line Pipe Threads*

API Specification 5CT, *Specification for Casing and Tubing*

API Specification 7-1, *Specification for Rotary Drill Stem Elements*

API Specification 7-2, *Specification for Threading and Gauging of Rotary Shouldered Thread Connections*

API Recommended Practice 9B, *Application, Care, and Use of Wire Rope for Oil Field Service*

ASME B31.3 ¹, *Chemical Plant and Petroleum Refinery Piping*

ASME Boiler and Pressure Vessel Code, 2010, Section V, *Nondestructive Examination*; Section VIII, DIV 1, *Rules for Construction of Pressure Vessels*; Section IX, *Welding and Brazing Qualifications*

ASTM A 370 ², *Standard Test Methods and Definitions for Mechanical Testing of Steel Products*

ASTM A388, *Standard Practice for Ultrasonic Examination of Heavy Steel Forgings*

ASTM A488, *Standard Practice for Steel Castings, Welding, Qualifications of Procedures and Personnel*

ASTM A770, *Standard Specification for Through-Thickness Tension Testing of Steel Plates for Special Applications*

ASTM E4, *Load Verification of Testing Machines*

ASTM E125, *Standard Reference Photographs for Magnetic Particle Indications on Ferrous Castings*

ASTM E165, *Standard Test Method for Liquid Penetrant Examination*

ASTM E186, *Standard Reference Radiographs for Heavy-Walled (2 to 4 1/2-in. (51 to 114-mm)) Steel Castings*

ASTM E280, *Standard Reference Radiographs for Heavy-Walled (4 1/2 to 12-in. (114 to 305-mm)) Steel Castings*

ASTM E428, *Standard Practice for Fabrication and Control of Steel Reference Blocks Used in Ultrasonic Inspection*

ASTM E446, *Standard Reference Radiographs for Steel Castings Up to 2 in. (51 mm) in Thickness*

ASTM E709, *Standard Guide for Magnetic Particle Examination*

ASNT, SNT-TC-1A ³, *Recommended practice for personnel qualification and certification in nondestructive testing*

¹ ASME International, 3 Park Avenue, New York, New York 10016-5990, www.asme.org.

² ASTM International, 100 Barr Harbor Drive, West Conshohocken, Pennsylvania 19428, www.astm.org.

³ American Society for Nondestructive Testing, 1711 Arlingate Lane, P.O. Box 28518, Columbus, Ohio 43228, www.asnt.org.

AWS D1.1 ⁴, *Structural Welding Code*

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

EN 287-1 ⁵, *Qualification test of welders – Fusion welding – Steels*

[reference deleted]

ISO 15614-1 ⁶, *Specification and qualification of welding procedures for metallic materials—Welding procedure test—Part 1: Arc and gas welding of steels and arc welding of nickel and nickel alloys*

MSS SP-55 ⁷, *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 Abbreviations

3.1 Terms and Definitions

For the purposes of this document, the following terms and definitions apply.

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.

⁴ American Welding Society, 550 NW LeJeune Road, Miami, Florida 33126, www.aws.org.

⁵ European Committee for Standardization, Avenue Marnix 17, B-1000, Brussels, Belgium, www.cen.eu.

⁶ International Organization for Standardization, 1, ch. de la Voie-Creuse, Case postale 56, CH-1211, Geneva 20, Switzerland, www.iso.org.

⁷ Manufacturers Standardization Society of the Valve and Fittings Industry, Inc., 127 Park Street, NE, Vienna, Virginia 22180-4602, www.mss-hq.com.

3.1.7**identical design concept**

Property of a family of units whereby all units of the family have similar geometry in the primary load carrying areas.

3.1.8**linear indication**

An indication revealed by NDE, having a length of at least three times the width.

3.1.9**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.

3.1.10**maximum allowable stress**

The specified minimum yield strength divided by the design safety factor.

3.1.11**primary load**

Axial load that equipment is subjected to in operations.

3.1.12**primary load-carrying component**

Component of the equipment through which the primary load is carried.

3.1.13**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.

3.1.14**proof load test**

Production load test performed to validate the load rating of a unit.

3.1.15**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 standard, applies only to the repair of defects in materials during the manufacture of new equipment.

3.1.16**rounded indication**

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

3.1.17**safe working load**

The design load minus the dynamic load.

3.1.18**size class**

Designation by which dimensionally-interchangeable equipment of the same maximum load rating is identified.

3.1.19**size range**

Range of tubular diameters covered by an assembly.

3.1.20**special process**

An operation that can change or affect the mechanical properties, including toughness, of the materials used in the equipment.

3.1.21**test unit**

Prototype unit upon which a design verification test is conducted.

3.2 Abbreviations

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

ER	equivalent round
HAZ	heat affected zone
PSL	product specification level
NDE	nondestructive 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.

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 design and minimum operating temperature shall be $-20\text{ }^{\circ}\text{C}$ ($-4\text{ }^{\circ}\text{F}$), 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 $-20\text{ }^{\circ}\text{C}$ ($-4\text{ }^{\circ}\text{F}$) 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

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

4.3.1.2 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.

4.3.1.3 All forces that may govern the design shall be taken into account. For each cross section to be considered, the most unfavorable 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).

$$AS_{\max} = \frac{YS_{\min}}{SF_D} \quad (1)$$

where

$YS_{\min}$ is the specified minimum yield strength;

SF_D is the design safety factor.

4.3.5 Ultimate Strength (Plastic) Analysis

4.3.5.1 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.

4.3.5.2 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).

$$AS_{\max} = \frac{TS_{\min}}{SF_D} \quad (2)$$

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 [2].

4.3.8 Rotary-shouldered Connections

4.3.8.1 Design Verification

API rotary-shouldered connections are exempt from design verification testing as described in 5.3.2.

4.3.8.2 Rotary-shouldered Connections subjected only to Drill Stem Loads

Rotary-shouldered connections subjected only to drill stem loads shall be designed in accordance with API 7-1 and API 7-2.

4.3.8.3 Rotary-shouldered Connections subjected to Hoisting Loads other than Drill Stem Loads

API rotary-shouldered connections (RSC) subjected to hoisting loads other than drill stem loads (e.g. riser or casing running) shall be rated in accordance with this section. The manufacturer shall provide a recommended range of make-up torque (MUT), over which the RSC tensile load rating shall apply.

For any API rotary-shouldered connection, the rating shall be calculated as follows (see Figure 1 for locations of tensile areas):

Tensile load rating (for pin) in SI units, kN = $(YS_{\min}) (A_p) / (SF_D \times 1000)$

Tensile load rating (for box) in SI units, kN = $(YS_{\min}) (A_{bt}) / (SF_D \times 1000)$

or

Tensile load rating (for pin) in USC units, short tons = $(YS_{\min}) (A_p) / (SF_D \times 2)$

Tensile load rating (for box) in USC units, short tons = $(YS_{\min}) (A_{bt}) / (SF_D \times 2)$

where

$YS_{\min}$ is the specified minimum yield strength, MPa (ksi);

SF_D is the design safety factor (see 4.7);

A_p is the pin cross sectional area as defined by:

$$A_p = \frac{\pi}{4} \left[(C - B)^2 - ID^2 \right] \quad \text{mm}^2 \text{ (in.}^2\text{), without stress-relief groove (see API 7-2, Figure 1),}$$

or

$$A_p = \frac{\pi}{4} \left[D_{\text{SRG}}^2 - ID^2 \right] \quad \text{mm}^2 \text{ (in.}^2\text{), with stress-relief groove (see API 7-2, Figure 9);}$$

A_{bt} is the box cross sectional area as defined by

$$A_{\text{bt}} = \frac{\pi}{4} \left[OD^2 - D_{\text{CB}}^2 \right] \quad \text{mm}^2 \text{ (in.}^2\text{), without stress-relief groove, with or without boreback stress-relief contour (see API 7-2, Figure 2 and Figure 8),}$$

or

$$A_{\text{bt}} = \frac{\pi}{4} \left[OD^2 - D_{\text{BG}}^2 \right] \quad \text{mm}^2 \text{ (in.}^2\text{), with stress-relief groove (see API 7-2, Figure 10);}$$

C is the pitch diameter of thread at gauge point, mm (in.), (see API 7-2, Table 1, or Table A.1);

ID is the inside diameter of the pin, mm (in.);

D_{SRG} is the diameter of the pin stress-relief groove, mm (in.), (see API 7-2, Table 5, or Table A.5);

OD is the outside diameter of the box, mm (in.);

D_{CB} is the diameter of the cylinder of the box boreback stress-relief contour, mm (in.), (see API 7-2, Table 5, or Table A.5);

D_{BG} is the diameter of the box stress-relief groove, mm (in.), (see API 7-2 Table 5 or Table A.5);

$$B = 2 \left(\frac{H}{2} - f_r \right) + T \times (3.175) \quad \text{in SI units, mm,}$$

or

$$B = 2 \left(\frac{H}{2} - f_r \right) + T \times \left(\frac{1}{8} \right) \times \left(\frac{1}{12} \right) \quad \text{in USC units, in.};$$

H is the thread height not truncated, mm (in.), (see API 7-2, Table 2, or Table A.2);

f_r is the root truncation, mm (in.), (see API 7-2, Table 2 or Table A.2);

T is the taper, mm/mm (in./ft), (see API 7-2, Table 2 or Table A.2).

Alternatively, the tensile load rating of the rotary shouldered connection can be established by performing an alternative design verification test in accordance with 5.5.

4.4 Size Class

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

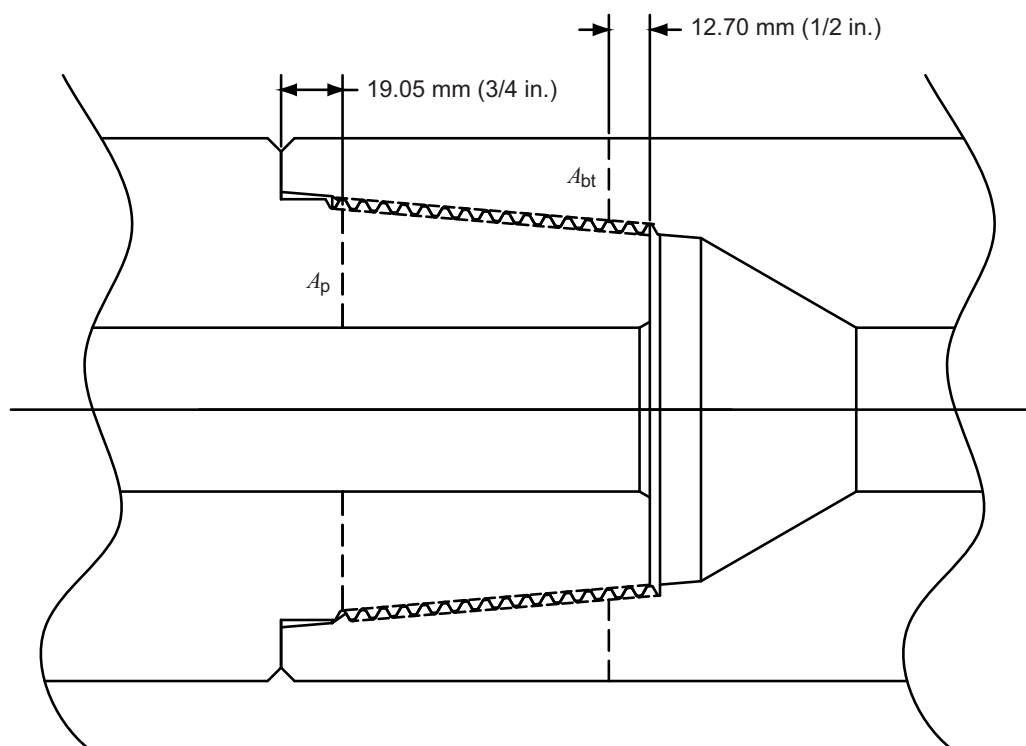


Figure 1—Locations of Tensile Areas for RSC Load Rating—Case without SRG's Shown

4.5 Contact Surface Radii

Figure 8, Figure 9, Figure 10, 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

4.6.1 All hoisting equipment furnished under this 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.

4.6.2 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.

4.6.3 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.

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

4.7 Design Safety Factor

The design safety factor shall be established from Table 1.

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.

Table 1—Design Safety Factor

Load rating R kN (ton)	Design safety factor SF_D
1334 kN (150 short tons) and less	3.00
1334 kN (150 short tons) to 4448 kN (500 short tons) inclusive	$3.00 - [0.75 \times (R - 1334)/3114]^a$ $(3.00 - [0.75 \times (R - 150)/350])^b$
Over 4448 kN (500 short tons)	2.25
^a In this formula, the value of R shall be in kilonewtons.	
^b In this formula, the value of R shall be in short tons.	

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 Dropped Objects

4.9.1 All components of hoisting equipment furnished under this Standard shall be designed and manufactured for prevention of potential dropped/falling objects.

4.9.2 The causes considered shall as a minimum include: vibration, improper maintenance, corrosion, shock load, and collision.

4.9.3 The potential for dropped/falling objects shall be addressed by prevention techniques, which include but are not limited to:

- design;
- specialty fasteners;
- lanyards, cabling or safety wire;
- guarding;
- integrated secondary barriers;
- other secondary retention devices or methods.

4.10 Specific Equipment

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

4.11 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, mitigation of potential for dropped objects, 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

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

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

5.1.3 Equipment which, by virtue of its simple geometric form, permits accurate stress analysis through calculation shall be exempted from design verification testing provided the accuracy of the calculation is confirmed by the performance of alternative calculations or by comparing the new design to similar proven designs. The design documents shall be reviewed and approved by a qualified person who is independent of the design function.

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 ⁸

5.3.2.1 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.

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

- a) For load ratings up to, and including 11,120 kN (1250 short tons),

$$\text{Design verification test load} = 0.8 \times R \times SF_D, \text{ but not less than } 2R \quad (3)$$

where

R is the load rating in kilonewtons (short tons);

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

⁸ The test load factor is adjusted to make development and qualification of equipment with ratings above 11,120 kN (1250 short tons) practical.