

Drilling and Production Hoisting Equipment

(PSL 1 and PSL 2)

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This is a marked up document for the 6th edition Addendum 1. The reason for these work item changes are documented in the SR3 that was approved on Aug 14, 2026.

The document is not open for full review. Comments on content outside the proposed changes may not be addressed during this ballot cycle. Such comments will be recorded for consideration during development of the next editions.

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DRAFT FOR COMMITTEE REVIEW

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1 Scope

This specification provides general principles and specifies requirements for design, manufacture, and testing of new hoisting equipment suitable for use in drilling and production operations and for replacement primary load-carrying components of such equipment manufactured subsequent to the publication of this specification. Refer to Annex C for required information with inquiry or order.

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

- a) hoisting sheaves;
- b) traveling blocks, hook blocks, or a combination thereof;
- c) block-to-hook adapters;
- d) connectors, link adapters, drill pipe elevator adapters, or a combination thereof;
- e) elevator links;
- f) casing elevators, tubing elevators, drill pipe elevators, drill collar elevators, sucker rod elevators, or a combination thereof;
- g) drilling hooks, tubing hooks, sucker rod hooks, or a combination thereof;
- h) rotary swivel-bail adapters;
- i) rotary swivels;
- j) power swivels;
- k) power subs;
- l) spiders, if capable of being used as elevators;
- m) wire line anchors;
- n) drill string motion compensators;
- o) kelly spinners, if capable of being used as hoisting equipment;
- p) pressure vessels, piping mounted onto hoisting equipment, or a combination thereof;
- q) safety clamps, if capable of being used as hoisting equipment;
- r) guide dollies for traveling equipment (e.g., hooks, blocks, etc.);
- s) casing running tools;
- t) top drives;
- u) hydraulic hoisting cylinders used in hoisting and pull down applications of the drill string; and
- v) hoisting equipment adapters.

This specification 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 stated herein.

Supplementary requirements apply only when specified. Annex A gives several standardized supplementary requirements.

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2 Normative References

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any addenda) applies.

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

API Specification 5CT, *Casing and Tubing*

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

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

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

ASME B31.3, ¹ *Process Piping*

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

ASTM A370, ² *Standard Test Methods and Definitions for Mechanical Testing of Steel Products*

ASTM A388, *Standard Practice for Ultrasonic Examination of 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, *Standard Practices for Force Calibration and Verification of Testing Machines*

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

ASTM E127, *Standard Practice for Fabrication and Control of Flat Bottomed Hole Ultrasonic Standard Reference Blocks*

ASTM E165, *Standard Practice for Liquid Penetrant Testing for General Industry*

ASTM E709, *Standard Guide for Magnetic Particle Testing*

ASTM E1417/E1417M, *Standard Practice for Liquid Penetrant Testing*

ASNT, SNT-TC-1A, ³ *Personnel Qualification and Certification in Nondestructive Testing*

AWS D1.1, ⁴ *Structural Welding Code*

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

ISO 15614-1, ⁵ *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*

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

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

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

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

⁵International Organization for Standardization, 1, ch. de la Voie-Creuse, Case postale 56, CH-1211, Geneva 20, Switzerland, www.iso.org.

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ISO 9606-1, *Qualification Testing of Welders—Fusion Welding*

MSS SP-55,⁶ *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 rated load

Calculated maximum load for bearings subjected to the primary load.

3.1.2

critical area

Highly stressed regions of a primary load-carrying component

3.1.3

design load

Sum of static and dynamic loads that would induce maximum stress in an item.

3.1.4

design safety factor

Factor to account for a safety margin between maximum allowable stress and specified minimum yield strength of a material.

3.1.5

design validation

Process of proving a product design by testing to demonstrate conformity of the product to design requirements.

NOTE Design validation can include one or more of the following (this is not an all-inclusive list):

- a) prototype tests;
- b) functional tests of production products, operational tests of production products, or a combination thereof;
- c) tests specified by industry standards, regulatory requirements, or a combination thereof;
- d) field performance tests and reviews.

3.1.6

drill stem assembly

Typically consists of an upper and lower section that includes subs, kelly valves, drill pipe, drill collar, a bit, or a combination thereof.

3.1.7

dynamic load

Load applied to the equipment due to acceleration effects.

3.1.8

equivalent round

ER

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.

3.1.9

identical design concept

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

3.1.10

linear indication

A feature revealed by NDE, having a length of at least three times the width.

3.1.11

maximum allowable stress

⁶Manufacturers Standardization Society of the Valve and Fittings Industry, Inc., 127 Park Street, NE, Vienna, Virginia 22180-4602, www.mss-hq.com.

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The specified minimum yield strength divided by design safety factor.

3.1.12

maximum operating temperature

The highest equipment temperature for which the equipment is designed to be operated.

3.1.13

minimum design temperature

The lowest specified temperature for which the primary load carrying component is intended.

3.1.14

minimum operating temperature

The lowest temperature of the equipment at which it can be used/operated.

3.1.15

operating temperature range

The temperature range between minimum and maximum operating temperatures at which the equipment can be used/operated.

NOTE: this may differ from ambient / environmental temperatures, manufacturer will provide procedures for warming and cooling equipment

3.1.16

primary load

Axial load that equipment is subjected to in operations.

3.1.17

primary load-carrying component

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

3.1.18

product specification level

PSL

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."

3.1.19

production lot

Castings of the same part number manufactured from one single heat of material.

3.1.20

proof load test

Production load test performed to validate the rated load of the equipment.

3.1.21

rated load

Maximum operating load, both static and dynamic, to be applied to the equipment

3.1.22

rated working pressure

The maximum internal pressure that equipment is designed to contain and control.

3.1.23

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 specification, applies only to the repair of defects in materials during the manufacture of new equipment.

3.1.24

rotary shouldered connection

RSC

Connection used on drill stem elements, which has coarse, tapered threads and sealing shoulders.

3.1.25

rounded indication

A feature revealed by NDE, with a circular or elliptical shape and having a length of less than three times the width.

3.1.26

RSC hoisting rated load

Rated load for the top drive/rotary swivel/power swivel RSC when supporting API 8C rated hoisting equipment (see 4.3.8.3 and Figure 12, panel c).

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3.1.27

safe working load

The design load minus the dynamic load.

3.1.28

size class

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

3.1.29

size range

Range of tubular diameters covered by an assembly.

3.1.30

special process

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

3.1.31

strain measurement system

Quantitative strain measurement method.

NOTE Strain measurement systems include but are not limited to strain gauges or digital image correlation.

3.1.32

test unit

Prototype unit upon which a design validation test is conducted.

3.1.33

top drive hoisting rated load

Rated load for the axial tensile load applied to the top drive through the elevator link ears.

3.2 Abbreviations

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

ER	equivalent round
FEA	finite element analysis
HAZ	heat affected zone
NDE	nondestructive examination
PSL	product specification level
PWHT	post-weld heat treatment
RSC	rotary shouldered connection
PQR	procedure qualification record
WPS	welding procedure specification

4 Design

4.1 General

Hoisting equipment shall be designed, manufactured, and tested such 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 apply.

- a) The design load and the safe working load shall be as defined in Section 3.

NOTE The owner/user of the equipment is responsible for determination of the safe working load for any hoisting operation.

- b) Unless changed by supplementary requirement SR 2 (see A.3), the minimum design temperature for primary load carrying components shall be $-20\text{ }^{\circ}\text{C}$ ($-4\text{ }^{\circ}\text{F}$).

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NOTE 1: The operator of the equipment is responsible for determination of the safe working load for any hoisting operation;

NOTE 2: The operating temperature range shall be specified by the manufacturer. This range may not be the same for all parts of the equipment, where differences exist, they may be specified separately or the most restrictive range shall be used.

WARNING Use of equipment covered by this specification at rated loads at temperatures below the design and test temperature can result in bodily injury, death, equipment failure, or a combination thereof (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 based on the elastic theory, unless an ultimate strength (plastic) analysis is justified by the design documentation. Finite element analysis (FEA) in conjunction with analytical methods may be used.

4.3.1.3 All forces that govern the design shall be taken into account in the design documentation. 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 are based on sufficiently comprehensive experience or tests.

4.3.3 Empirical Relationships

In cases where empirical relationships are used in lieu of analysis, the empirical relationships shall be supported by documented industry-accepted calibratable strain measurement system test results that verify the stresses within the component. Equipment or components that by their design do not permit the implementation of a strain measurement system to verify the design shall be qualified by testing in accordance with 5.4.

4.3.4 Equivalent Stress

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). In areas of geometric discontinuities, high-stress gradient, high-strain gradient, or a combination thereof, further analysis shall be performed in accordance with 4.3.5.

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

where

$AS_{\max}$ is the maximum allowable stress;

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YS_{min} is the specified minimum yield strength;

SF_D is the design safety factor (see 4.8).

4.3.5 Analysis of Areas of Geometric Discontinuity or High-stress Gradient

4.3.5.1 Localized Stresses—Classical Analysis

For designers using classical (closed-form equation) analysis, the localized equivalent stresses may exceed the limits of 4.3.4 in the areas around geometric discontinuities or high-stress gradients subject to the following:

- In local areas of geometric discontinuities or high-stress gradient, the calculated peak equivalent stress shall not exceed YS_{min} . The calculated peak equivalent stress shall account for the stress concentration factor from a recognized industry source.
- Surface stresses resulting from contact are considered local and shall be exempt from the requirements of 4.3.4 and all other requirements of 4.3.5.1.

4.3.5.2 Localized Stresses—Mathematical Modeling

In the case where the analysis uses sophisticated mathematical modeling tools (e.g., FEA), the localized equivalent stresses may exceed the limits of 4.3.4 in the areas around geometric discontinuities or high-stress gradients subject to the following:

- If the analysis tool uses a linear material model or linear analysis of the stresses/strains then the maximum allowable total equivalent strain in local areas of geometric discontinuities or high-stress gradient shall not exceed 1 %.
- If the analysis tool used considers nonlinear analysis of the stresses/strains and a nonlinear or multilinear material model, then the maximum allowable total equivalent strain in local areas of geometric discontinuities or high-stress gradient shall not exceed ES_{all} calculated by Equation (2).

$$ES_{all} = Elong / SF_D \quad (2)$$

where

ES_{all} is the allowable strain in mm/mm (in./in.);

$Elong$ is the minimum elongation in mm/mm (in./in.) defined in the material specification (refer to 6.2 and 6.3.2);

SF_D is the design safety factor (see 4.8);

- surface stresses/strains resulting from contact are considered local and shall be exempt from the requirements of 4.3.4 and 4.3.5.2.

NOTE 4.3.5.2 applies only to ferrous materials.

The elastic analysis shall govern for all areas outside of those noted in a), b), and c) above.

4.3.5.3 Loads to Be Evaluated

For any analysis completed under 4.3.5, the analysis shall include load cases at the design load for comparison with the allowable stresses and strains specified above and at the design validation test load, if applicable, to allow comparison of the measured stress/strain with those predicted by the analysis.

The stresses and strains at the design load shall be compared with the allowable stresses and strains as specified in the sections above.

The strains measured during the design validation test shall not exceed the strains predicted by more than the uncertainty of the testing apparatus specified in 5.5, at either of these loads.

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4.3.6 Stability Analysis

The stability analysis shall be performed 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.

For wear parts (those parts that are intended to be replaced during the operating life of the tool), the fatigue life shall be no less than two times the predicted wear life up to a maximum of 20 years.

The fatigue analysis shall be performed according to generally accepted theories. A method that may be used is defined in Reference [2].

The fatigue analysis shall show consideration for the stresses/strains predicted by the analysis done in 4.3.5. The fatigue analysis may use industry-recognized hot spot stress methods as applicable.

4.3.8 Rotary Shouldered Connections (RSCs)

4.3.8.1 Design Conditions

The following design conditions shall apply:

- API RSCs shall be exempt from design validation testing as described in 5.2.
- The manufacturer shall provide a make-up torque range.

NOTE A method for determining make-up torque range can be found in API 7G-1.

4.3.8.2 Rotary Shouldered Connections Supporting Drill Stem Assembly

Rotary shouldered connections (RSCs) supporting a drill stem assembly shall be designed in accordance with API 7-1 and API 7-2. Rotary shouldered connections supporting a drill stem assembly do not require a rated load (see Figure 12, panel b).

4.3.8.3 Rotary Shouldered Connections Supporting Hoisting Equipment

API RSC hoisting rated load shall be:

- Calculated as in Equation (3) through Equation (12); see Figure 12, panel c; or
- Established by performing an alternative design validation test in accordance with 5.4

NOTE See Figure 1 for locations of tensile areas.

$$\text{Tensile rated load (for pin) in SI units, kN} = (YS_{\min}) (A_p) / (SF_D \times 1000) \quad (3)$$

$$\text{Tensile rated load (for box) in SI units, kN} = (YS_{\min}) (A_{bt}) / (SF_D \times 1000) \quad (4)$$

or

$$\text{Tensile rated load (for pin) in USC units, short tons} = (YS_{\min}) (A_p) / (SF_D \times 2) \quad (5)$$

$$\text{Tensile rated load (for box) in USC units, short tons} = (YS_{\min}) (A_{bt}) / (SF_D \times 2) \quad (6)$$

where

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

SF_D is the design safety factor (see 4.8);

A_p is the pin cross-sectional area as defined by:

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

or

$$A_p = \frac{\pi}{4} \left[D_{\text{SRG}}^2 - ID^2 \right] \text{ mm}^2 (\text{in.}^2), \text{ with stress-relief groove (see API 7-2);} \quad (8)$$

where

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

$$A_{\text{bt}} = \frac{\pi}{4} \left[OD^2 - D_{\text{CB}}^2 \right] \text{ mm}^2 (\text{in.}^2), \text{ without stress-relief groove, with or without boreback stress-relief contour (see API 7-2);} \quad (9)$$

or

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

where

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

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);

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);

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

$$B = 2 \left(\frac{H}{2} - f_r \right) + T \times (3.175) \text{ in metric (SI) units, mm;} \quad (11)$$

or

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

where

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

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

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

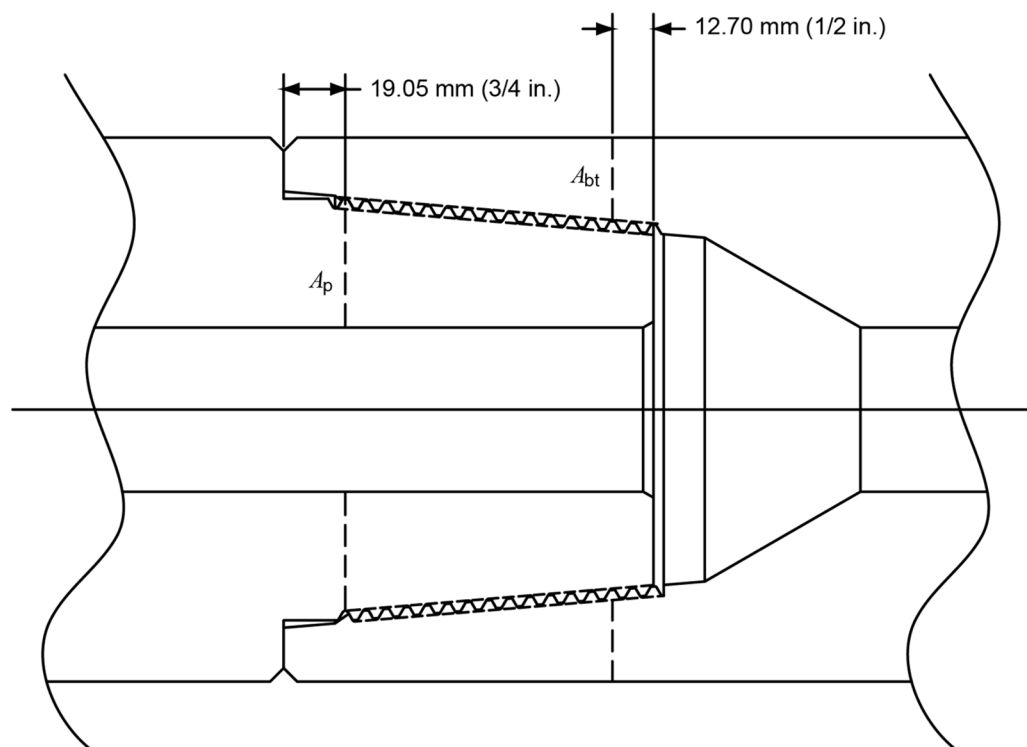


Figure 1—Locations of Tensile Areas for RSC Rated Load—Case Without SRGs Shown

4.4 Size Class Designation

The size class designation for equipment shall represent the dimensional interchangeability and the rated load of equipment.

4.5 Contact Surface Radii

Contact radii/envelope limits for hoisting tools shown in Figure 8, Figure 9, and Figure 10 shall conform to the limits in Table 9. Equipment with rated loads lower than those in Table 9 are excluded from this requirement.

NOTE: Envelope limits apply to ratings 1251 Short Tons and higher.

4.6 Rating

4.6.1 Hoisting equipment shall have a primary load path rating.

4.6.2 Hoisting equipment with bearings in the primary load path shall have a bearing rated load.

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

4.6.3 Hoisting equipment that contains pressure shall have a pressure rated load.

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

4.7 Basis of Rated Load

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The rated load shall be based on the design safety factor as specified in 4.8. The specified minimum yield strength of the material used in the primary load-carrying components, the specified minimum acceptable elongation of the material used in the primary load-carrying components, and the stress distribution as determined by design calculations, data developed in a design validation load test, or a combination thereof shall be as specified in 5.4.

4.8 Design Safety Factor

The minimum design safety factor shall be established from Table 1.

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

Table 1—Minimum Design Safety Factor

Rated Load R kN (short ton)	Minimum Design Safety Factor SF_D
< 1334 kN (150 short tons)	3.00
1334 kN to 4448 kN (150 short tons to 500 short tons) inclusive	$3.00 - \left[0.75 \times (R - 1334) / 3114 \right]^a$ $3.00 - \left[0.75 \times (R - 150) / 350 \right]^b$
> 4448 kN (500 short tons)	2.25
^a In this formula, the value of R shall be expressed in SI units of kilonewtons.	
^b In this formula, the value of R shall be expressed in USC units of short tons.	

4.9 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.

4.10 Dropped Objects

4.10.1 Evaluation of Potential for Dropped Objects

Potential of dropped/falling objects and any unintended, unplanned separation of parts that could cause human injury, fatality, economic damage, environmental consequences, or a combination thereof during installation, removal, maintenance, or intended usage of the equipment shall be evaluated and documented by the manufacturer for all components of equipment furnished under this specification.

4.10.2 Causes

Possible causes of dropped/falling objects shall at a minimum include:

- a) vibration;
- b) improper maintenance;
- c) corrosion;
- d) shock load;

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- e) collision.

Other causes that may be considered include release of stored energy, wind loading, and movement of equipment.

4.10.3 Mitigation

The potential for dropped/falling objects, as determined per 4.10.1, shall be mitigated by methods or techniques which may include, but are not limited to:

- a) design;
- b) specialty fasteners;
- c) lanyards, cabling, or safety wire;
- d) guarding;
- e) integrated secondary barriers.

4.11 Specific Equipment

Additional equipment-specific design requirements shall be in accordance with Section 9.

4.12 Design Verification

Design verification shall be performed in accordance with API Q1, an equivalent international standard, or a combination thereof.

4.13 Design Documentation

Documentation of the design shall include methods, assumptions, calculations, and design requirements. Design requirements shall include, at a minimum, criteria for:

- a) size;
- b) test and operating pressures;
- c) material, environment;
- d) mitigation of potential for dropped objects;
- e) specification requirements; and
- f) other pertinent requirements as specified by the designer.

The requirements shall also apply to design change documentation.

5 Design Validation

5.1 General

5.1.1 To ensure the integrity of the equipment design and supporting calculations, equipment shall be subject to design validation testing as specified below.

5.1.2 Design validation testing shall be performed in accordance with documented procedures.

5.1.3 Design validation testing of equipment shall be carried out by qualified personnel, certified by qualified personnel, or a combination thereof who are independent of those having direct responsibility for the design of the product.

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

5.1.5 It shall be acceptable if the name or nomenclature of a prototype test carried out before the effective date of this document contains the word “verification” instead of “validation.”

5.2 Design Validation Load test

5.2.1 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, one of the following sampling options shall be applied:

- a) A minimum of three units of the design shall be subjected to design validation testing. The test units shall be selected from the lower end, middle, and upper end of the size/rating range.
- b) 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 Option b) generally applies to limited product size/rating ranges.

5.2.2 Test Procedure

5.2.2.1 The test unit shall be loaded to the design load. After this load has been released, the unit shall be checked to verify that the function(s) of the equipment and its components have not been impaired by this loading.

5.2.2.2 A strain measurement system shall be used in the test unit at all places where high stresses are anticipated, provided that the configuration of the units permits such techniques. Tools such as FEA, models, brittle lacquer, etc. should be used to confirm the proper location of the strain measurement system. A strain measurement system capable of triaxial strain evaluation should be used in critical areas to permit determination of the shear stresses.

5.2.2.3 The design validation test load shall be in accordance with Table 2.

5.2.2.4 The test unit shall be loaded to the design validation test load. This test load should be applied with active monitoring of the strains and observing for evidence of yielding. The test unit should be loaded as many times as necessary to obtain adequate data as defined by the manufacturer.

Table 2—Determination of Design Validation Test Loads

Rated Load <i>R</i> kN (short tons)	Design Validation Test Load
$\leq 11,120 \text{ kN}$ (1250 short tons), and all torque ratings	$0.8 \times R \times SF_D$, but not less than $2R$
$> 11,120 \text{ kN} \leq 14,678 \text{ kN}$ ($> 1250 \text{ short tons} \leq 1650 \text{ short tons}$)	$C \times R$
$> 14,678 \text{ kN}$ (1650 short tons)	$1.5 \times R$
in SI units $C = 2 - 0.5 \times \left(\frac{R - 11,120}{3558} \right), \text{ in kilonewtons}^a$	

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or, in USC units

$$C = 2 - 0.5 \times \left(\frac{R - 1250}{400} \right), \text{ in short tons }^b$$

where

R is the rated load.

SF_D is the design safety factor as defined in 3.1.4 and 4.8.

NOTE To make development and qualification of equipment with rated loads above 11,120 kN (1250 short tons) practical, the test load factor is adjusted, largely because of geometry and material limitation for test fixtures.

^aIn this formula, the value of R shall be expressed in SI units of kilonewtons.

^bIn this formula, the value of R shall be expressed in USC units of short tons.

5.2.3 Qualification

5.2.3.1 The stress values computed from the strain **measurement system** readings shall not exceed the values obtained from design calculations (based on the design validation test load) by more than the uncertainty of the testing apparatus specified in 5.5. 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.

5.2.3.2 Upon completion of the design validation test, the test unit shall be disassembled, and each primary load-carrying component shall be dimensionally checked for evidence of yielding. Evidence of yielding shall be documented and reviewed by the manufacturer.

5.2.4 Individual Parts

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

5.3 Determination of Rated Load

The rated load shall be determined from the results of the design validation test, the design and stress distribution calculations required by Section 4, or a combination thereof. 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 validation tested, the critical permanent deformation determined by strain measuring system or other suitable methods shall not exceed the allowable values established in 4.3.5, except in areas of contact, geometric discontinuities, and high-stress gradients. If the stresses or strains exceed the allowable values, the affected part or parts shall be redesigned to obtain the desired rating. Stress distribution calculations may be used to establish the rated load of equipment only if the results of the analysis are shown to be within acceptable engineering allowances as verified by the design validation test prescribed by Section 5.

5.4 Alternative Design Validation 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:

- a) using tensile-test specimens of the same heat and heat treatment lot as the parts represented that meet the requirements of ISO 6892-1 or ASTM A370, and
- b) determining the yield-to-ultimate strength ratio.

Each component of an assembly shall be qualified under the most unfavorable loading configuration. Components may be qualified using either of the following methods:

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- a) The ratio T_R shall be computed for each component in the assembly. The smallest of these ratios shall be used in the equations.
- b) Each component may be load tested separately if the holding fixtures duplicate the loading conditions applicable. In this case, the ratio T_R used for each test shall be that computed for the specific component tested.

The ratio is then used to rate the equipment as shown in Equation (13) and Equation (14):

$$R = L_B \frac{T_R}{SF_D} \quad (13)$$

$$T_R = \frac{YS_m}{TS_a} \quad (14)$$

where

- SF_D is the design safety factor (see 4.8);
 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 rated load.

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

5.5 Load Test Apparatus

The loading apparatus used to simulate the working load on the test unit shall be calibrated in accordance with ISO 7500-1 or ASTM E4 to ensure that the prescribed test load is obtained. For loads exceeding 3558 kN (400 short tons), the load testing apparatus shall be verified with calibration devices that are traceable to a Class A calibration device and that have an uncertainty of less than 2.5 %.

Test fixtures shall load the test unit (or part):

- in the same manner as in actual service, and
- with areas of contact on the load-bearing surface that simulate actual service.

All equipment used to load the test unit (or part) shall be verified as to its capability to perform the test.

5.6 Design Changes

When a change in design or manufacturing method changes the rated load, a supportive design validation test in conformance with Section 5 shall be performed. The manufacturer shall evaluate changes in design or manufacturing methods to determine whether the rated load is affected. This evaluation shall be documented.

5.7 Records

Design validation records and supporting data shall be subject to the same controls specified for design documentation in 11.2.

6 Materials Requirements

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6.1 General

All materials shall be suitable for the intended service.

The remainder of Section 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 that shall, as a minimum, define the following parameters and limitations:

- a) mechanical property requirements;
- b) material qualification;
- c) processing requirements, including permitted melting, working, and heat treatment;
- d) chemical composition and tolerances;
- e) repair welding requirements.

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

6.3 Metallic Materials

6.3.1 Mechanical Properties

6.3.1.1 General

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

6.3.1.2 Impact Toughness

6.3.1.2.1 Impact testing shall be in accordance with ISO 148-1 (V-notch Charpy) or ASTM A370 (V-notch Charpy).

6.3.1.2.2 The impact toughness shall be determined from the average of three tests. Full-size test pieces shall be used if the size of the component permits. Where subsize impact test pieces are used, the acceptance criteria for impact values shall be those stated in 6.3.1.2.3 and 6.3.1.2.4, multiplied by the appropriate adjustment factor listed in Table 4. Subsize test pieces of width less than 5 mm (0.20 in.) shall not be used.

6.3.1.2.3 For materials of a specified minimum yield strength of at least 310 MPa (45 ksi), the average impact toughness shall be 42 J (31 ft-lb) at -20°C (-4°F), with no individual value less than 32 J (24 ft-lb).

6.3.1.2.4 For materials with a 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 (-4°F) with no individual value less than 20 J (15 ft-lb).

6.3.1.2.5 For design temperatures below -20°C (-4°F), supplementary impact toughness requirements shall apply, in accordance with A.3, SR 2 Low-temperature Test

6.3.1.3 Through-thickness Properties

Where the design requires through-thickness properties, materials shall be tested for reduction of area in the through-thickness direction in accordance with ASTM A770. The minimum reduction shall be 25 %.

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6.3.1.4 Ductility

PSL 2 components shall be fabricated from materials meeting the applicable requirements for ductility specified in Table 3.

Table 3—Elongation Requirements (PSL 2)

Yield Strength		Elongation, Minimum %	
MPa	(ksi)	$L_o = 4d^a$	$L_o = 5d^a$
< 310	(< 45)	23	20
310 through 517	(45 through 75)	20	18
> 517 through 758	(> 75 through 110)	17	15
> 758	(> 110)	14	12
^a Where L_o is the gauge length and d is the diameter.			

Table 4—Adjustment Factors for Subsize Impact Specimens

Specimen Dimensions (mm)	Adjustment Factor
10.0 × 7.5	0.833
10.0 × 5.00	0.667

6.3.2 Material Qualification

6.3.2.1 General

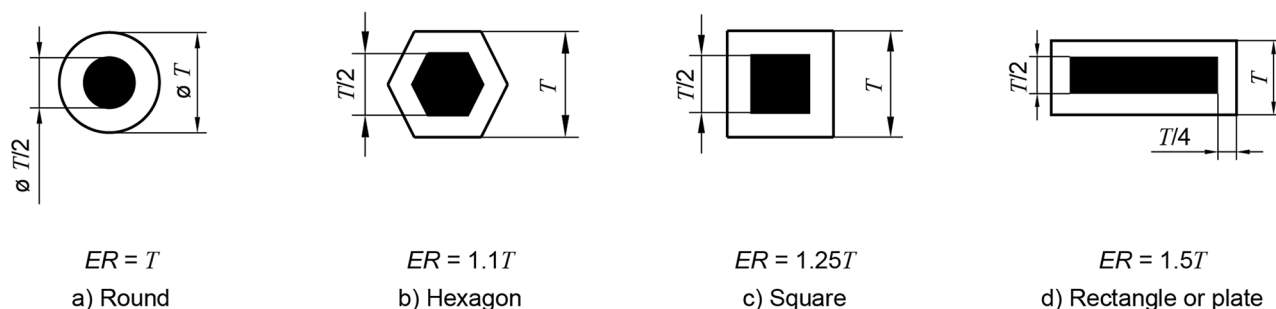
The mechanical tests required by this specification shall be performed on qualification test coupons representing the heat and heat treatment lot used in the manufacture of the component. Tests shall be performed in accordance with the requirements of ISO 6892-1, ISO 148-1, ASTM A370, or equivalent standards, using material in the final heat-treated condition. For the purposes of material qualification testing, post-weld heat treatment (PWHT) is not considered heat treatment, provided that the PWHT temperature is below that which changes the heat-treated condition of the base material. Material qualification tests may be performed before the stress-relieving process, provided that the stress-relieving temperature is below that which changes the heat-treatment condition.

6.3.2.2 Equivalent Rounds

Determine the size of the qualification test coupon for a part using the equivalent round (ER) method. Figure 2 and Figure 3 illustrate the basic models for determining the ER 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 ER of a part, using the actual dimensions of the part in the “as heat-treated” condition. The ER of the qualification test coupon shall be equal to or greater than the ER

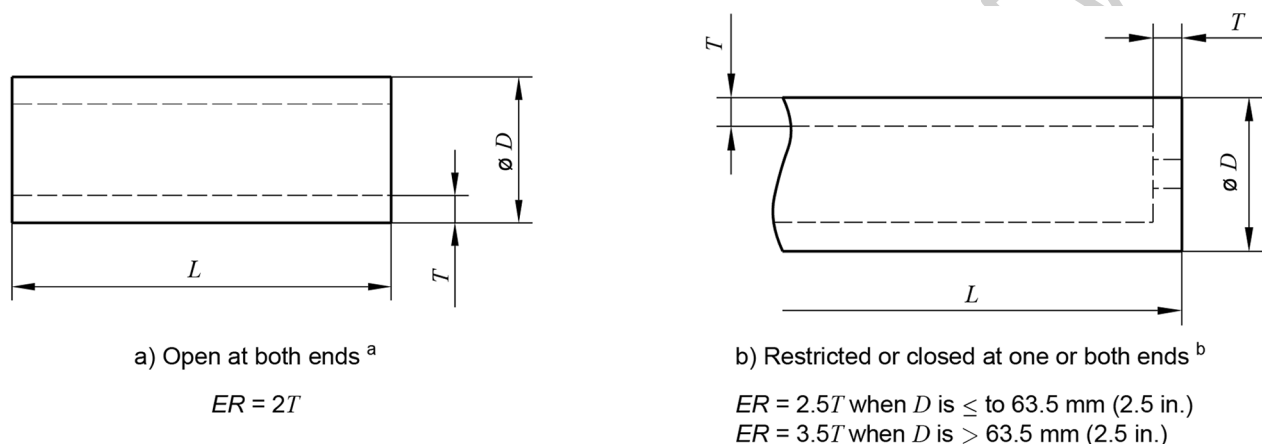
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dimensions of the part it qualifies, except that the ER is not required to exceed 125 mm (5 in.). Figure 5 and Figure 6 illustrate the procedure for determining the required dimensions of an ASTM A370 keel block.



NOTE When L is $< T$, consider section as a plate of thickness L .

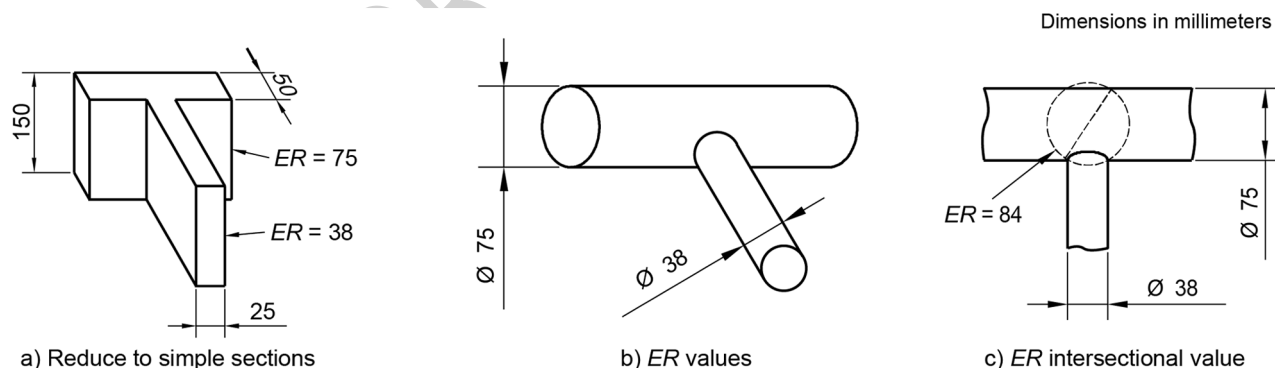
Figure 2—Equivalent Round (ER) Models, Solids of Length L



^a When L is $< D$, consider as a plate of thickness T . When L is $< T$, consider as a plate of thickness L .

^b Use maximum thickness, T , in the calculation.

Figure 3—Equivalent Round (ER) Models, Tube (Any Section)

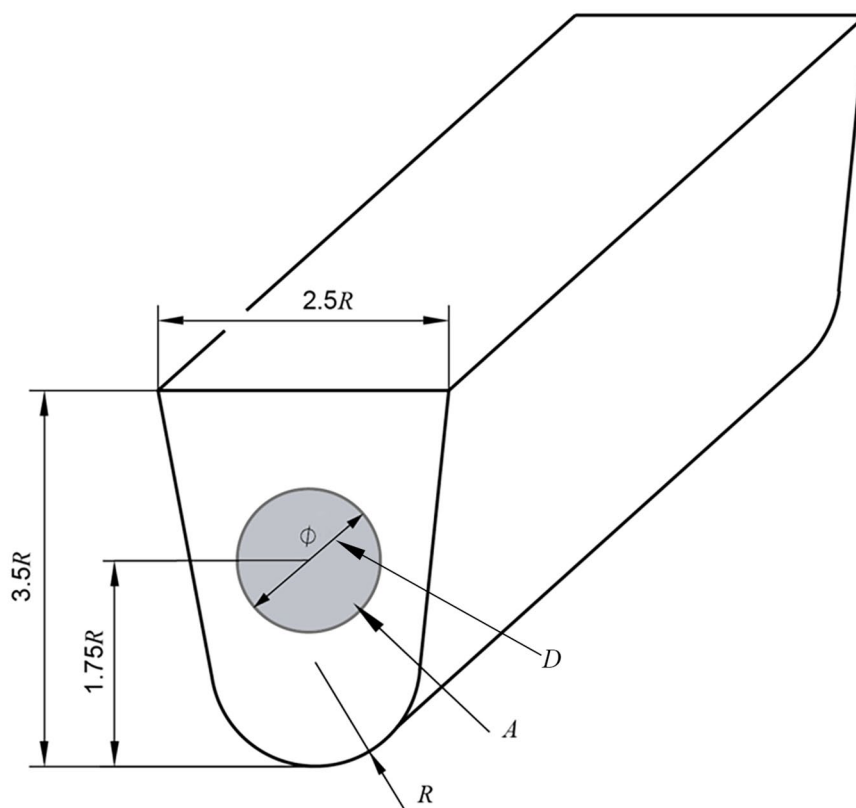


The following steps should be used in determining the governing ER for complex sections:

- Reduce the component to simple sections.
- Convert each simple section to an equivalent round.
- Calculate the diagonal through the circle that would circumscribe the intersection of the ER values.

Use the maximum ER value, whether for a single section or an intersection as the ER of the complex section.

Figure 4—Equivalent Round (ER) Models, Complex Shapes

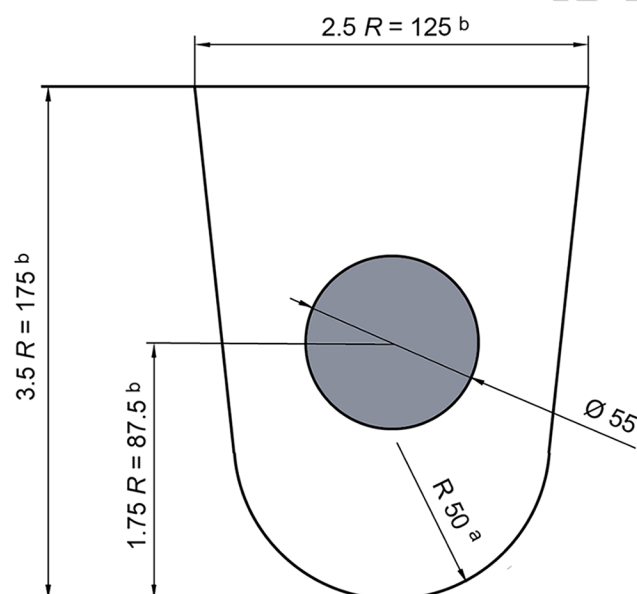


$$R = ER/2.3$$

$$D = 1.1R$$

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

Figure 5—Equivalent Round (ER) Models, Keel Block Configuration



To develop a keel block for $ER = 115$ mm:

- Note that $R = ER/2.3 = 50$ mm and $D = 1.1R$.
- Construct a keel block as illustrated in Figure 3 using multiples of R .

^a $R = ER/2.3 = 50$ mm.

^b Keel block dimensions.

^c Diameter D .

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Figure 6—Example of Development of Keel Block Dimensions

6.3.2.3 Material Test Coupons

6.3.2.3.1 Qualification test coupons shall either be integral with the components they represent, 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.

6.3.2.3.2 Test specimens shall be removed from integral or separate qualification test coupons so that their longitudinal centerline axis is entirely within the center core $\frac{1}{4}T$ thickness ($\frac{1}{4}T$) envelope for a solid test coupon or within 3 mm ($\frac{1}{8}$ 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 $\frac{1}{4}T$ from the ends of the test coupon.

6.3.2.3.3 Test specimens taken from sacrificed production parts shall be removed from the center core $\frac{1}{4}T$ envelope location of the thickest section of the part.

6.3.2.3.4 For components to be machined entirely from wrought material that has been fully heat treated as a solid or tubular bar (whereby the standard $\frac{1}{4}T$ envelope is either wholly or partly outside the volume of the critical or noncritical areas of the finished component), the test specimens, cut from the bar, may alternatively be taken from a more representative volume:

- a) volume OD shall be defined by a one-third thickness ($\frac{1}{3}T$) envelope determined by using the maximum finished OD and the minimum finished ID of the final component;
- b) volume ID shall be equal to, or greater than, the minimum finished ID of the component.

EXAMPLE 152.4 mm (6.0 in.) OD bar of AISI 4330V material, normalized, quenched, and tempered (NQT); part final dimensions have maximum OD of 139.7 mm (5.5 in.), minimum ID of 63.5 mm (2.5 in.):

$$T = (\text{OD} - \text{ID}) / 2 \quad (15)$$

where

T is the maximum thickness mm (in.)
 OD is the maximum outer diameter mm (in.)
 ID is the minimum inner diameter mm (in.)

Example Calculations in Metric (SI) Units

$$T = (139.7 \text{ mm} - 63.5 \text{ mm}) / 2 = 38.1 \text{ mm}$$

$$\frac{1}{3}T = 38.1 \text{ mm} / 3 = 12.7 \text{ mm}$$

$$139.7 \text{ mm} - (2 \times 12.7 \text{ mm}) = 114.3 \text{ mm}$$

Example Calculations in U.S. Customary (USC) Units

$$T = (5.5 \text{ in.} - 2.5 \text{ in.}) / 2 = 1.5 \text{ in.}$$

$$\frac{1}{3}T = 1.5 \text{ in.} / 3 = 0.5 \text{ in.}$$

$$5.5 \text{ in.} - (2 \times 0.5 \text{ in.}) = 4.5 \text{ in.}$$

The $\frac{1}{3}T$ envelope of the finished part would have 114.3 mm (4.5 in.) OD. Therefore, the specimens could be removed from anywhere within the volume defined by 114.3 mm $\times$ 63.5 mm (4.5 in. OD $\times$ 2.5 in.) ID (the $\frac{1}{3}T$ outer envelope and the finished ID of the component).

6.3.3 Manufacture

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

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

6.3.3.3 All heat treatment operations shall be performed using 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 See Annex B for recommendations on qualification of heat-treating equipment.

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

6.3.4 Chemical Composition

The material composition of each heat shall be analyzed in accordance with the requirements of ASTM A751 (see ISO TR 9769 for further information) or equivalent national standard, 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.

6.4 Nonmetallic and Composite Materials

6.4.1 General

The use of nonmetallic and composite materials to manufacture primary load-carrying components shall be permitted provided that the materials meet the properties required for the design.

6.4.2 Mechanical Properties

6.4.2.1 General

The mechanical property requirements for all nonmetallic materials shall be specified with appropriate limits for properties critical to the function of the equipment.

6.4.2.2 Test Temperature

The material properties shall be qualified at a minimum temperature of $-20\text{ }^{\circ}\text{C}$ ($-4\text{ }^{\circ}\text{F}$) unless otherwise specified in Section 9 and at a specified maximum temperature corresponding to the maximum recommended operating temperature. A lower minimum test temperature is required if SR 2 is specified (see A.3).

6.4.2.3 Test Specimen Orientation

Test specimens taken from materials exhibiting anisotropic behavior shall be tested in the direction that would result in the worst case, limiting value of the mechanical property in question.

6.4.2.4 Creep, Stress Relaxation, and Rate Effects

Materials susceptible to creep, stress relaxation, or a combination thereof shall be tested for resistance to these effects under the most severe conditions encountered in service, including, but not limited to, time, temperature,

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stress, and strain. The presence of creep, stress relaxation, or a combination thereof shall not cause loss of function for the component under operating conditions.

Materials for which mechanical properties are dependent upon the rate of loading shall be tested at the most severe rate of loading encountered in service.

6.4.2.5 Equivalent Yield Strength

For materials that do not exhibit a well-defined yield strength, the value of the ultimate strength multiplied by 0.80 or 5 % of the elastic modulus, whichever is less, shall be used as the equivalent yield strength.

6.4.3 Environmental Factors

Nonmetallic materials shall be tested for chemical attack by any chemicals likely to be encountered in service. At a minimum, the testing shall indicate which chemicals affect the serviceability of the equipment or its ability to be used at the rated load.

Nonmetallic materials shall be evaluated for the effect of ultraviolet radiation and other environmental factors. The evaluation shall include exposure likely to be encountered in service over the expected life of the component.

6.4.4 Material Qualification

6.4.4.1 General

The mechanical tests required by this specification shall be performed on qualification test coupons representing each unique batch of finished material used in the manufacture of the component. Nonmetallic components manufactured from the same lot of materials with the same chemistry within the same lot for all processes shall be considered a unique batch. Nonmetallic materials may be prequalified for temperature, orientation, creep, stress relaxation, load rate effects, and chemical properties. The properties of a prequalified material shall meet or exceed the values required for design. Prequalification shall not be applied to mechanical properties. Mechanical properties shall be tested for each batch.

6.4.4.2 Material Test Coupons

Qualification test coupons shall be from the same unique batch as the components they qualify, subjected to the same manufacturing operations and exposed to the same environmental conditions as the components they qualify.

6.4.4.3 Manufacture

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

All thermal operations shall be performed using equipment qualified in accordance with the requirements specified by the manufacturer or processor. The loading of the material within furnaces and ovens shall be such that the presence of any part does not adversely affect the response of any other part within the same load. The temperature and time requirements shall be performed according to the manufacturer's written specification.

NOTE See Annex B for recommendation on qualification of thermal processing equipment.

6.4.5 Documentation

The manufacturer shall provide specific procedures for the inspection of all nonmetallic materials (including frequency, methods, equipment, and acceptance and rejection criteria) to the user/owner in an inspection and maintenance manual upon delivery of the equipment under a purchase agreement. These procedures shall also include recommendations for maximum intervals for replacement due to aging and shelf life of replacement

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components. The manufacturer shall also provide instructions and information regarding the material's resistance to chemical attack, along with a list of what types of chemicals will affect the serviceability of the equipment or its ability to be used at its designated rated load. In addition, the manufacturer shall provide the minimum and maximum temperatures at which the equipment can be used at its designated rated load, plus any other ambient conditions that could adversely affect the ability of the equipment to be operated at its designated rated load.

6.4.6 Additional Requirements

6.4.6.1 Polymers and polymer composites, including polymer matrix and polymer fiber composites, with a glass transition temperature above the minimum design operating temperature shall not be used.

6.4.6.2 Ceramic and ceramic matrix composites shall only be used as compression members in primary load-carrying components.

6.4.6.3 The requirements of this section shall only apply to aramid fiber cordage with unbonded elastomeric coating loaded in simple tension. The material shall be qualified and controlled for conformance to the manufacturer's written specification. The material specification shall contain, as a minimum with appropriate limits, the uncoated cordage diameter, the denier of the cordage, the coated cord diameter, the twist density, and the tensile strength. The tensile strength shall be tested in accordance with CI-1500A. All mechanical testing is to be performed on no less than a single fully encapsulated cord.

6.4.6.4 The material shall be prequalified for cyclical loading. A sample of the material as described above shall be loaded in tension to a load corresponding to the rated load and have load completely removed for a minimum of 1500 cycles or the number of cycles corresponding to the design life of the component, whichever is greater. The same specimen shall then be loaded in tension until fracture. The load to fracture the specimen after cyclic testing shall not be less than the specified tensile strength.

7 Welding Requirements

7.1 General

This section describes requirements for the fabrication and repair welding, where permitted by the manufacturer or processor only, of primary load-carrying components and pressure-containing components, including attachment welds. Repair welding shall be performed in accordance with the manufacturer's welding procedure specifications (WPSs).

7.2 Welding Qualifications

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

- a) PSL 1: ASME B31.3, ASME *BPVC* Section IX, AWS D1.1, ISO 15614-1, ASTM A488 or equivalent standards;
- b) PSL 2: ASME *BPVC* Section IX or equivalent standards.

This welding shall only be performed by welders or welding operators who are qualified in accordance with the aforementioned standards in this section or ISO 9606-1.

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 *BPVC* Section 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 taken from the weld test coupon shall then be capable of being bent to within 5° of the angle thus determined.

7.3 Written Documentation

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Welding, including repair welding, shall be performed in accordance with WPSs written and qualified in accordance with the applicable standard. The WPS shall describe all the essential, nonessential, and supplementary essential (when required) variables as listed in the applicable standard. Written prequalified welding procedures in accordance with the applicable standard may be used.

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

7.4 Control of Consumables

Welding consumables shall conform to American Welding Society (AWS) or 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 have a welding procedure qualification requirement. Results of testing in the weld and heat affected zone (HAZ) shall meet the minimum requirements of the base material. For attachment welds, only the HAZ of material 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 (PWHT)

PWHT of components shall be in accordance with the applicable qualified WPS.

7.7 Quality Control Requirements

Requirements for quality control of welds shall be in accordance with Section 8.

7.8 Specific Requirements—Fabrication Welds

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

7.9 Specific Requirements—Repair Welds

7.9.1 Access

There shall be adequate access to evaluate, remove, and inspect the nonconforming condition that is the cause for the repair.

7.9.2 Fusion

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

7.9.3 Forgings and Castings

All repair welding shall be performed in accordance with the manufacturer's welding procedure specifications. WPS 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:

- a) defect type;
- b) defect size limits;
- c) definition of major/minor repairs.

The following shall meet the quality control requirements specified in Section 8:

- all excavations prior to repair, and
- all weld repairs conducted subsequently.

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 Section 11.

7.9.4 Tubulars

Repair welding on wrought tubular goods shall not be allowed.

7.9.5 Heat Treatment

The WPS used for qualifying a repair shall reflect the actual sequence of weld repair and pre- and post-heat treatment performed on the repaired item.

8 Quality Control

8.1 General

This section specifies the quality control requirements for equipment, parts, 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 nondestructive examination (NDE) activities shall be sufficiently detailed regarding the requirements of this specification and those of all applicable referenced specifications. All NDE instructions shall be approved by an ASNT SNT-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 in accordance with ASNT SNT-TC-1A, ISO 9712, or an equivalent standard.

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

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- a) AWS QC1 or equivalent standard; or
- b) the manufacturer's documented training program (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 ^[3] or ISO 10012 ^[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 pressure-containing equipment and components unless specified otherwise.

8.4.2 Chemical Analysis

Methods and acceptance criteria for chemical analysis of metallic materials shall be in accordance with 6.3.4.

8.4.3 Tensile Testing

Methods and acceptance criteria for tensile analysis of metallic materials shall be in accordance with 6.3.1 and 6.3.2.

8.4.4 Impact Testing

Methods and acceptance criteria for impact testing of metallic materials shall be in accordance with 6.3.1 and 6.3.2.

8.4.5 Traceability

Components shall be traceable by heat and heat treatment lot. Heat lot and heat treatment lot identification shall be marked on the component.

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

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Accessible surfaces of each finished component shall be inspected in accordance with 8.4.7 after completion of all final heat treatment and final machining operations.

If the equipment is subjected to a load test, the qualifying NDE shall be performed after the load test. For materials susceptible to delayed cracking, as identified by the manufacturer, NDE shall be done no earlier than 24 hours after the load test. The equipment shall be disassembled for this inspection. Conductive surface coatings shall be removed prior to examination. Nonconductive surface coating shall be removed prior to examination unless it has been demonstrated that the smallest relevant indications as defined in 8.4.7.3 can be detected through the maximum applied thickness of the coating.

8.4.7.2 Method

Ferromagnetic materials shall be examined by the magnetic particle method in accordance with ASME *BPVC* Section V, Subsection A, Article 7, and Subsection B, Article 25 or ASTM E709. Machined surfaces shall be examined by the wet fluorescent method; other surfaces shall be examined by a wet method or dry method.

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

Non-ferromagnetic materials shall be examined by the liquid penetrant method in accordance with ASME *BPVC* Section V, Subsection A, Article 6, and Subsection B, Article 24 or ASTM E165.

8.4.7.3 Evaluation of Indications

Only those indications with major dimensions greater than 1.6 mm ($\frac{1}{16}$ 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, nonmetallic stringers, etc.) shall be considered nonrelevant. If magnetic particle indications greater than 1.6 mm ($\frac{1}{16}$ in.) are believed to be nonrelevant, they shall either be examined by the liquid penetrant method to confirm they are nonrelevant or they shall be removed and reinspected to confirm they are nonrelevant.

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 Critical Area Drawings

The manufacturer shall establish and maintain critical area drawings, identifying high-stress areas, which shall be used in conjunction with this section. For purposes of this section, critical areas shall be defined as all areas where the stress in the component exceeds the value calculated in Equation (16):

$$\text{high stress} \geq \frac{YS_{\min}}{1.33 SF_D} \quad (16)$$

where

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

SF_D is the design safety factor.

Areas with stresses below the high-stress magnitude defined in Equation (16) are considered noncritical areas.

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 or where the stress level is less than the result of Equation (17) shall be exempt from the critical area acceptance criteria defined in Table 5, Table 6, Table 7, and Table 8. The low-stress areas, thus defined, may be identified on the critical area map.

$$\text{low stress} \leq \frac{0.1 YS_{\min}}{SF_D} \quad (17)$$

where

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

SF_D is the design safety factor.

8.4.7.4.2 Ferromagnetic Castings

ASTM E125 shall be applied as a reference standard for the evaluation of magnetic particle indications on castings. The acceptance criteria for ferromagnetic castings shall be as specified in Table 5 for PSL 1 and Table 6 for PSL 2.

Table 5—PSL 1 (Castings Indication Acceptance Criteria)

Type	Maximum Allowable Degree		
	Discontinuity Descriptions	Critical Areas	Noncritical 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 6—PSL 2 (Castings Indication Acceptance Criteria)

Type	Maximum Allowable Degree		
	Discontinuity Descriptions	Critical Areas	Noncritical 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

8.4.7.4.3 Non-ferromagnetic Castings

Non-ferromagnetic castings shall be liquid penetrant inspected in accordance with ASTM E1417/E1417M with a sensitivity level 2 or higher. The acceptance criteria for non-ferromagnetic castings shall be as specified in Table 7 for PSL 1 and Table 8 for PSL 2.

Table 7—PSL 1 (Maximum Allowable Indications ^{a, b, c, d})

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Type	Critical Areas	Noncritical Areas
Nonlinear random individual discontinuities (gas holes, inclusions, discrete shrinkage cavities) ^{e, f}	$\frac{1}{3}$ T or 1.6 mm ($\frac{1}{16}$ in.), whichever is less	$\frac{1}{3}$ T or 7.6 mm (0.30 in.), whichever is less
Cracks, hot tears, cold shuts, or through-wall discontinuities	None	7.6 mm (0.30 in.)
Nonlinear microshrinkage or shrinkage sponge ^g	3.2 mm ($\frac{1}{8}$ in.) diameter	9.5 mm ($\frac{3}{8}$ in.) diameter
Linear microshrinkage or shrinkage sponge ^a	0	3.2 mm ($\frac{1}{8}$ in.) diameter
Number of random individual discontinuities allowed within a 50 mm × 50 mm (2 in. × 2 in.) area ^h	3	4
Number of microshrinkage or shrinkage sponge discontinuities allowed within a 50 mm × 50 mm (2 in. × 2 in.) area	1	1

^aLinear discontinuities are not allowed except linear dendritic shrinkage or linear shrinkage sponge indications shall be evaluated in accordance with this table and shall not be allowed to break over an edge, extend through a wall, or be located in internal corners or radii.

^bDiscontinuities that are visible under white light without the use of penetrant may be evaluated to the criteria of this table.

^cSize limits shown are for actual discontinuity size as opposed to bleed-out from the penetrant inspection. Indications may be inspected by measuring their size after wiping with a solvent-dampened cloth, cotton swab, or brush. Immediately evaluate the discontinuity for size as soon as the solvent has evaporated.

^d"T" is the casting section thickness.

^eFor random individual discontinuities, the minimum resolvable size shall be 0.4 mm ($\frac{1}{64}$ in.). Discontinuities smaller than these sizes shall be considered uninterpretable.

^fIndividual discontinuities shall be separated by a distance equal to twice the maximum dimension of the larger discontinuity. However, if the total length of the discontinuities that violate this spacing requirement does not exceed the maximum length permitted for a single discontinuity, then these discontinuities shall be considered as one and shall not be cause for rejection.

^gMicroshrinkage is also called "dendritic shrinkage."

^hThe limits for random individual discontinuities do not apply if the discontinuities are smaller than one-half their maximum allowable size and they meet the minimum spacing requirement of footnote f.

Table 8—PSL 2-Maximum Allowable Indications^{a, b, c, d}

Type	Critical Areas	Noncritical Areas
Nonlinear random individual discontinuities (gas holes, inclusions, discrete shrinkage cavities) ^{e, f}	$\frac{1}{4}$ T or 0.8 mm ($\frac{1}{32}$ in.), whichever is less	$\frac{1}{3}$ T or 7.6 mm (0.30 in.), whichever is less
Cracks, hot tears, cold shuts, or through-wall discontinuities	None	7.6 mm (0.30 in.)
Nonlinear microshrinkage or shrinkage sponge ^g	0	9.5 mm ($\frac{3}{8}$ in.) diameter
Linear microshrinkage or shrinkage sponge ^a	0	3.2 mm ($\frac{1}{8}$ in.) diameter
Number of random individual discontinuities allowed within a 50 mm × 50 mm (2 in. × 2 in.) area ^h	2	4
Number of microshrinkage or shrinkage sponge discontinuities allowed within a 50 mm × 50 mm (2 in. × 2 in.) area	0	1

^aLinear discontinuities are not allowed except linear dendritic shrinkage or linear shrinkage sponge indications shall be evaluated in accordance with this table and shall not be allowed to break over an edge, extend through a wall, or be located in internal corners or radii.

^bDiscontinuities that are visible under white light without the use of penetrant may be evaluated to the criteria of this table.

^cSize limits shown are for actual discontinuity size as opposed to bleed-out from the penetrant inspection. Indications may be inspected by measuring their size after wiping with a solvent-dampened cloth, cotton swab, or brush. Immediately evaluate the discontinuity for size as soon as the solvent has evaporated.

^d"T" is the casting section thickness.

^eFor random individual discontinuities, the minimum resolvable size shall be 0.4 mm (1/64 in.). Discontinuities smaller than these sizes shall be considered uninterpretable.

^fIndividual discontinuities shall be separated by a distance equal to twice the maximum dimension of the larger discontinuity. However, if the total length of the discontinuities that violate this spacing requirement does not exceed the maximum length permitted for a single discontinuity, then these discontinuities shall be considered as one and shall not be cause for rejection.

^gMicroshrinkage is also called "dendritic shrinkage."

^hThe limits for random individual discontinuities do not apply if the discontinuities are smaller than one-half their maximum allowable size and they meet the minimum spacing requirement of footnote f.

8.4.7.4.4 Wrought Materials

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

- a) no relevant indications with a major dimension equal to or greater than 5 mm ($3/16$ in.);
- b) no more than ten relevant indications in any continuous 40 cm² (6 in.²) area;
- c) no more than three relevant indications in a line separated by less than 2 mm ($1/16$ in.) edge-to-edge;
- d) no relevant indications in pressure-sealing areas, in the root area of rotary threads, or in the stress-relief features of threaded joints.

8.4.7.4.5 Nonmetallic Components

The manufacturer shall have written specifications defining the maximum discontinuity size, orientation, grouping, etc. for each type of discontinuity expected. The discontinuity types considered are to be, at a minimum, voids, cuts, cracks, delaminations, and tears.

The methods for detection and measurement of the expected discontinuity shall be specified and proven effective in detecting discontinuities as small as 75 % of the maximum allowable size or severity.

8.4.8 Volumetric NDE

Primary load-carrying components which require volumetric NDE shall be examined in both critical and noncritical areas.

8.4.8.1 Volumetric NDE of Wrought Material

Volumetric NDE of wrought material shall be performed if supplementary requirement SR 5 (see Annex A.6) is specified in the purchase order.

8.4.8.2 Volumetric NDE of Castings

8.4.8.2.1 Method

Radiographic examination of castings shall be in accordance with ASME *BPVC* Section V, Subsection A, Article 2, and Subsection B, Article 22 with the restriction that fluorescent intensifying screens shall not be used.

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Ultrasonic examination shall be in accordance with ASME *BPVC* Section V, Subsection A, Article 5, and Subsection B, Article 23. The component(s) shall be examined by the straight beam method in accordance with SA-609 of Subsection B, Article 23, supplemented by S1 angle beam examination requirements 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°.

8.4.8.2.2 Sampling

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

- a) 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.
- b) 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 8.4.8.2.3, 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 nonconforming casting shall be repaired or scrapped.

8.4.8.2.3 Acceptance Criteria

8.4.8.2.3.1 Volumetric Examination Exemptions

Areas of components where the stress is compressive or where the stress level is less than the value of low stress (as calculated in Equation [17]) shall be exempt from volumetric examination.

8.4.8.2.3.2 Radiography

The acceptance criteria for radiographic examination are based on the standard reference radiographs of ASTM E446, ASTM E186, or ASTM E280, 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 noncritical 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.

8.4.8.2.3.3 Ultrasonic Examination

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

- a) PSL 1: Quality Level 3;
- b) PSL 2:
 - 1) Quality Level 1 for casting thicknesses up to 50 mm (2 in.);
 - 2) Quality Level 2 for casting thicknesses from 50 mm (2 in.) to 100 mm (4 in.);
 - 3) Quality Level 3 for casting thicknesses over 100 mm (4 in.);
- c) PSL 1 and PSL 2: 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.

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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 ($\frac{1}{2}$ 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 performed after final heat treatment.

8.4.9.2 Fabrication Welding

8.4.9.2.1 Visual Examination

Fabrication welds shall be visually examined in accordance with ASME *BPVC* Section V, Subsection 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 ($\frac{1}{8}$ in.) of sealing surfaces.

8.4.9.2.2 Surface NDE

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

The following acceptance criteria shall apply:

- a) no relevant linear indications (see 3.1.10);
- b) no rounded indications (see 3.1.21) with a major dimension greater than 4 mm ($\frac{1}{8}$ in.) for welds whose depth is 17 mm ($\frac{5}{8}$ in.) or less;
- c) no rounded indications with a major dimension greater than 5 mm ($\frac{3}{16}$ in.) for welds whose depth is greater than 17 mm ($\frac{5}{8}$ in.);
- d) no more than three relevant indications in a line separated by less than 2 mm ($\frac{1}{16}$ in.) edge to edge.

8.4.9.2.3 Volumetric NDE

Primary load-bearing and pressure-containing welds shall be examined by either ultrasonic or radiographic methods. Ultrasonic examination shall be in accordance with ASME *BPVC* Section V, Subsection A, Article 4, and radiographic examination shall be in accordance with ASME *BPVC* Section V, Subsection A, Article 2.

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 *BPVC* Section VIII, Div. 1, UW-51 and Appendix 12, as appropriate.

8.4.9.3 Repair Welds

8.4.9.3.1 Weld Excavations

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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 (1 in.) 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 8.4.8.

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

For PSL 1, verification of dimensions shall be performed on a sample basis in accordance with ISO 2859-1 or ANSI/ASQ Z1.4, Level II, 4.0 AQL (acceptance quality limit).

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 performed on each component, assembly, or a combination thereof as relevant.

8.6 Proof Load Test

8.6.1 Extent

Each production unit of the following equipment shall be subject to proof load testing in accordance with 8.6.2:

- a) elevators, including all primary load-carrying components (bushings, insert carriers, jaws, etc.);
- b) elevator links;
- c) spiders (if capable of being used as elevators);
- d) safety clamps (if capable of being used as hoisting equipment);
- e) slips for elevators and spiders (if capable of being used as elevators).

Equipment not listed above shall be subject to proof load testing if supplementary requirement SR 1 (see Annex A.2) 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. Rolling-element bearings that would be damaged by the test may be replaced by a load transfer device.

A test load equal to 1.5 times the rated load shall be applied and held for a period of not less than five minutes.

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.

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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

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

8.7.2 Test Sequence

The hydrostatic test shall be performed 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.

Both pressure-holding periods shall not be less than three minutes, the timing of which shall not start until the test pressure has stabilized and the equipment and pressure-monitoring devices have been isolated from the pressure source.

Specific hydrostatic testing requirements are included under the relevant equipment headings of Section 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 Section 9.

8.9 Processes Requiring Validation

8.9.1 General

The following processes shall require validation when the specified properties of the final product cannot be verified after the process completion:

- a) NDE;
- b) welding;
- c) heat treating;
- d) bolt pretensioning.

8.9.2 Heat Treating

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Where the properties required are specified in the design and production, no further validation is required if production material qualification (e.g., material test reports, testing of qualification test coupons, etc.) is performed to verify that the required properties are achieved in each production heat/heat treatment lot. Where a heat treatment process is specified but the results are not verified by testing of each production heat/heat treatment lot of material subjected to the process(es), the process(es) shall be validated by testing of samples, which demonstrate that the process will consistently produce the properties required by the design. Validation method and results shall be documented.

8.9.3 Bolt Pretensioning

When a specific preload value is required by the design, the method of establishing preload shall be validated.

9 Equipment

9.1 General

The requirements of Section 4 through Section 8 shall apply to the primary load-carrying components and pressure-containing components unless specifically noted otherwise in this section. The equipment manufactured under this specification shall be in conformance with the requirements of Sections 4 through 11. The equipment designer shall determine the primary load path through the equipment and 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 are 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) are exempt from surface NDE.

9.2.3 Sheave Diameter

The sheave diameter shall be the overall diameter (D) shown in Figure 7. Sheave diameters shall whenever practicable be determined in accordance with API 9B.

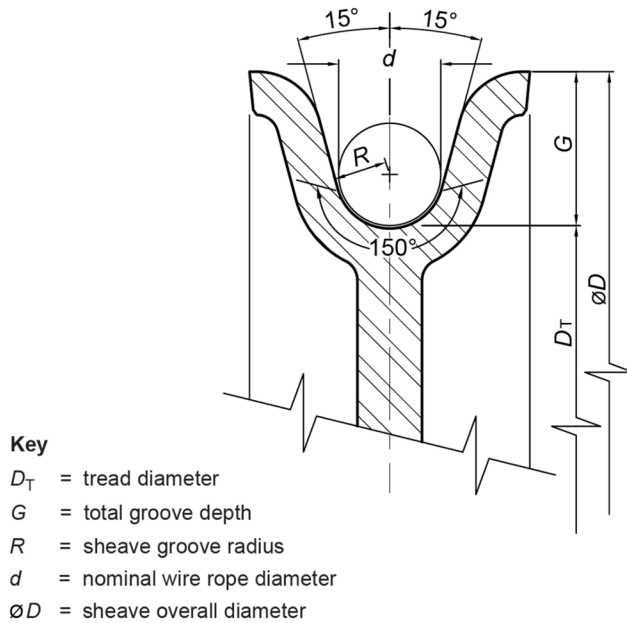


Figure 7—Sheave Grooves

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 Equation [18] and Equation [19]) subtending an arc of 150° . The sides of the groove shall be tangent to the ends of the bottom arc. Total groove depth, G , 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 7.

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 Equation [18] and Equation [19]) subtending an arc of 150° . The sides of the groove shall be tangent to the ends of the bottom arc. Total groove depth, G , shall be a minimum of $1.75 d$ and a maximum of $3 d$, where d is the nominal rope diameter shown in Figure 7.

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

$$R_{\min} = R_{\text{rope}} \times 1.06 \quad (18)$$

$$R_{\max} = R_{\text{rope}} \times 1.10 \quad (19)$$

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 nominal wire rope diameter, and the sheave outside diameter. These markings shall be cast or stamped on the side of the outer rim or on the web near the outer rim of the sheave.

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Hoisting sheaves shall be exempt from the marking requirements of 10.2.

EXAMPLE 914 mm (36 in.) sheave with a 28.6 mm (1 1/8 in.) wire rope diameter manufactured by the XYZ Company is marked as follows:

- XYZ CO 28.6 API Spec 8C 914 PSL level or
- XYZ CO 1-1/8 API Spec 8C 36 PSL level or
- XYZ CO 1.125 API Spec 8C 36 PSL level

9.2.7 Sheave Fatigue Life

Hoisting sheaves are exempt from the 20-year requirement in 4.3.7.

The fatigue life for sheaves shall be calculated based on defined number of cycles and associated load spectrum. Sheave bearings are exempted from this requirement and are to be calculated as per Equation (20).

The minimum number of cycles shall be taken as 1,000,000 cycles at 50 % of the rated load unless otherwise agreed between the purchaser and the manufacturer.

9.3 Traveling Blocks

9.3.1 Sheaves

Traveling block sheaves shall conform with the applicable requirements of 9.2.

9.3.2 Sheave Bearing Rating

The bearing rating of traveling blocks shall be determined using Equation (20) or Equation (21):

In SI units:

$$W_B = \frac{N \times W_R}{357} \quad (20)$$

In USC units:

$$\left(W_B = \frac{N \times W_R}{714} \right) \quad (21)$$

where

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

N is the number of sheaves in the block;

W_R is the individual sheave bearing rating at 100 r/min for 3000 h minimum life for 90 % of bearings, expressed in newtons (N) (pounds force).

For antifriction bearing design and manufacturing requirements, see 9.15.

9.3.3 Contact-surface Radii

Contact-surface radii for traveling blocks shall conform with the dimensions in Table 9 and Figure 8. Contact-surface radii for hook blocks shall conform with the dimensions in Table 9 and Figure 8, Figure 9, and Figure 10.

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9.3.4 Hook Blocks

The method of connection between the traveling block component and the hook component shall be at the discretion of the manufacturer.

9.3.5 Traveling-block Hood-eye

The traveling block hood-eye is a lifting eye located at the top of the traveling block and is used for lifting and hanging off the weight of the traveling block and the attachments underneath. The rated load of the hood-eye shall be established with a minimum safety factor of 2.25. The rated load of the hood-eye shall be marked near the top handling member of the traveling block.

Table 9A—Hoisting Tool Contact Radii/ Envelope Limits—Part 1

Rated Load		Traveling Block and Hook Bail Radius ^a mm (in.)				Hook and Swivel Bail Radius ^b mm (in.)			
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 (2 ³ / ₄)	69.85 (2 ³ / ₄)	82.55 (3 ¹ / ₄)	76.20 (3)	50.80 (2)	38.10 (1 ¹ / ₂)	76.20 (3)	76.20 (3)
357 to 578	41 to 65	69.85 (2 ³ / ₄)	69.85 (2 ³ / ₄)	82.55 (3 ¹ / ₄)	76.20 (3)	50.80 (2)	44.45 (1 ³ / ₄)	88.90 (3 ¹ / ₂)	88.90 (3 ¹ / ₂)
579 to 890	66 to 100	69.85 (2 ³ / ₄)	69.85 (2 ³ / ₄)	82.55 (3 ¹ / ₄)	76.20 (3)	57.15 (2 ¹ / ₄)	50.80 (2)	101.60 (4)	101.60 (4)
891 to 1334	101 to 150	69.85 (2 ³ / ₄)	69.85 (2 ³ / ₄)	82.55 (3 ¹ / ₄)	76.20 (3)	63.50 (2 ¹ / ₂)	57.15 (2 ¹ / ₄)	114.30 (4 ¹ / ₂)	114.30 (4 ¹ / ₂)
1335 to 2224	151 to 250	101.60 (4)	101.60 (4)	82.55 (3 ¹ / ₄)	76.20 (3)	69.85 (2 ³ / ₄)	63.50 (2 ¹ / ₂)	114.30 (4 ¹ / ₂)	114.30 (4 ¹ / ₂)
2225 to 3114	251 to 350	101.60 (4)	101.60 (4)	82.55 (3 ¹ / ₄)	76.20 (3)	76.20 (3)	69.85 (2 ³ / ₄)	114.30 (4 ¹ / ₂)	114.30 (4 ¹ / ₂)
3115 to 4448	351 to 500	101.60 (4)	101.60 (4)	88.90 (3 ¹ / ₂)	82.55 (3 ¹ / ₄)	88.90 (3 ¹ / ₂)	82.55 (3 ¹ / ₄)	114.30 (4 ¹ / ₂)	114.30 (4 ¹ / ₂)
4449 to 5782	501 to 650	101.60 (4)	101.60 (4)	88.90 (3 ¹ / ₂)	82.55 (3 ¹ / ₄)	88.90 (3 ¹ / ₂)	82.55 (3 ¹ / ₄)	114.30 (4 ¹ / ₂)	114.30 (4 ¹ / ₂)
5783 to 6672	651 to 750	152.40 (6)	152.40 (6)	88.90 (3 ¹ / ₂)	82.55 (3 ¹ / ₄)	107.95 (4 ¹ / ₄)	101.60 (4)	114.30 (4 ¹ / ₂)	114.30 (4 ¹ / ₂)
6673 to 11,120	751 to 1250	152.40 (6)	152.40 (6)	158.75 (6 ¹ / ₄)	152.40 (6)	133.35 (5 ¹ / ₄)	127.00 (5)	127.00 (5)	127.00 (5)
^a See Figure 8.									
^b See Figure 9.									

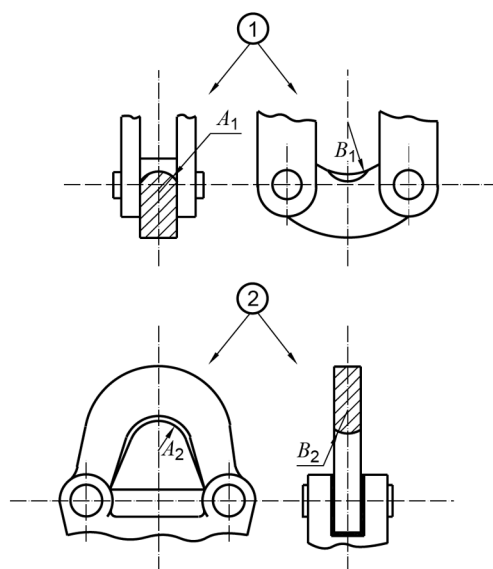
Table 9B—Hoisting Tool Contact Radii/ Envelope Limits —Part II

Rated Load		Elevator Link Upper Eye and Hook Link Ear Radius ^a mm (in.)				Elevator Link Lower Eye and Elevator Link Ear Radius ^a mm (in.)			
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.

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222 to 356	25 to 40	38.10 (1½)	38.10 (1¼)	31.75 (1¼)	22.23 (7⁄8)	—	25.40 (1)	—	50.80 (2)
357 to 578	41 to 65	63.50 (2½)	63.50 (2½)	31.75 (1¼)	22.23 (7⁄8)	—	25.40 (1)	—	50.80 (2)
579 to 890	66 to 100	63.50 (2½)	63.50 (2½)	38.10 (1½)	28.58 (1¹⁄₈)	—	25.40 (1)	—	50.80 (2)
891 to 1334	101 to 150	63.50 (2½)	63.50 (2½)	38.10 (1½)	28.58 (1¹⁄₈)	23.82 (15⁄16)	38.10 (1½)	50.80 (2)	50.80 (2)
1335 to 2224	151 to 250	101.60 (4)	101.60 (4)	44.45 (1¾)	34.93 (1¾)	30.94 (17⁄32)	47.63 (17⁄8)	69.85 (2¾)	69.85 (2¾)
2225 to 3114	251 to 350	101.60 (4)	101.60 (4)	44.45 (1¾)	34.93 (1¾)	37.31 (115⁄32)	47.63 (17⁄8)	69.85 (2¾)	69.85 (2¾)
3115 to 4448	351 to 500	101.60 (4)	120.65 (4¾)	57.15 (2¼)	47.63 (17⁄8)	47.63 (17⁄8)	50.80 (2)	82.55 (3¼)	82.55 (3¼)
4449 to 5782	501 to 650	101.60 (4)	120.65 (4¾)	57.15 (2¼)	47.63 (17⁄8)	57.15 (2¼)	60.32 (2¾)	127.00 (5)	127.00 (5)
5783 to 6672	651 to 750	101.60 (4)	127.00 (5)	63.50 (2½)	63.50 (2½)	57.15 (2¼)	60.32 (2¾)	127.00 (5)	127.00 (5)
6673 to 11,120	751 to 1250	114.30 (4½)	127.00 (5)	76.20 (3)	69.85 (2¾)	69.85 (2¾)	73.03 (27⁄8)	158.75 (6¼)	158.75 (6¼)

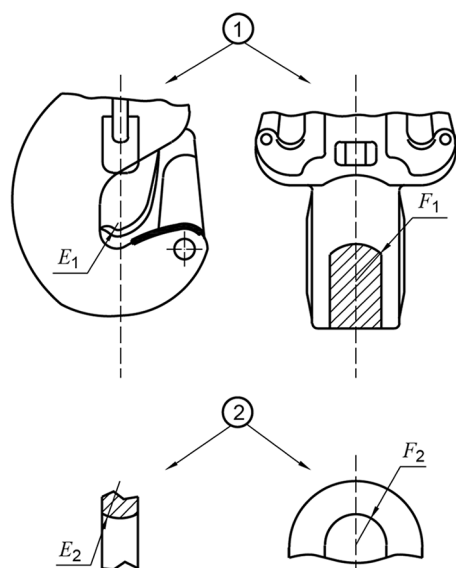
^aSee Figure 10.



Key

- 1 traveling block becket
- 2 hook bail

Figure 8—Traveling Block and Hook Bail Contact



Key
1 hook
2 swivel bail

Figure 9—Hook and Swivel Bail Contact

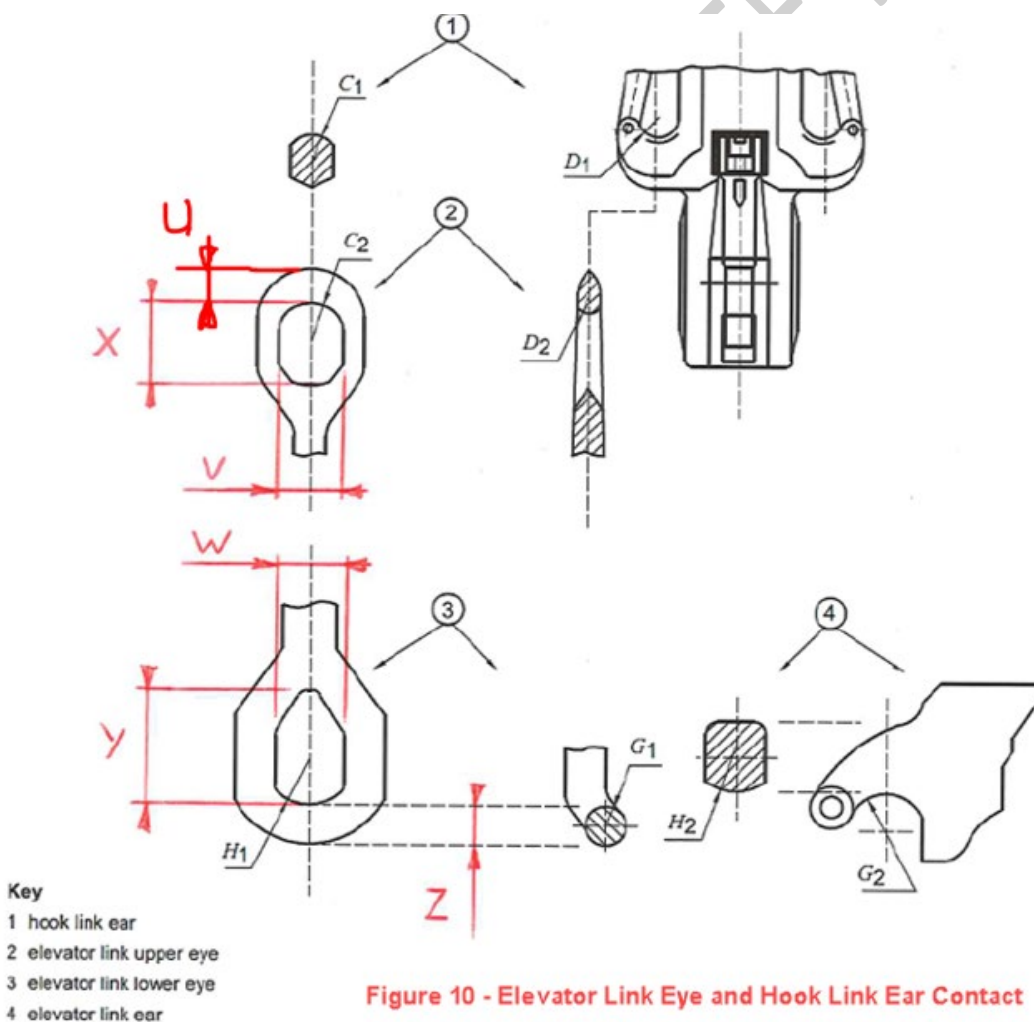


Figure 10 - Elevator Link Eye and Hook Link Ear Contact

~~Figure 10—Elevator Link Eye and Hook Link Ear Contact-Surface Radii~~

Figure 10—Elevator Link Eye and Hook Link Ear Contact-

9.3.6 Traveling Block Marking

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Marking shall be in accordance with Section 10.

9.4 Block-to-hook Adapters

Block-to-hook adapters shall have the same rated load 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. The drill pipe elevator adapter shall have its elevator link ears designed to conform with the contact radii in Table 9 and Figure 10.

The contact radii of link adapters shall conform with the dimensions in Table 9 and Figure 8, Figure 9, and Figure 10.

9.6 Drilling, Tubing, and Sucker Rod Hooks

Sucker rod hook is a specialty hook for latching onto the bail of a sucker rod elevator.

Tubing hook is a specialty hook used for workover handling of tubulars and associated equipment.

Contact-surface radii of drilling hooks shall conform with the dimensions in Table 9 and Figure 8, Figure 9, and Figure 10.

9.7 Elevator Links

Elevator links shall conform to the dimensions in Table 9 and Figure 10.

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 ($\frac{1}{8}$ in.). Links over 4.25 m (14 ft) in length shall match within 7 mm ($\frac{1}{4}$ in.).

Elevator link interfaces with the elevator link ears shall not exceed the radii/envelope limits described in Table 9 and Figure 10.

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 10.

Casing elevators and tubing elevators shall be suitable for use with casing and tubing manufactured in accordance with ISO 11960 or API 5CT. Casing elevators and tubing elevators shall have bore dimensions as specified in Table 11 and Table 12 (see Figure 11).

Requirements of Sections 4 through 8, Section 10, and Section 11 apply for sucker rod elevators.

Drill collar elevators shall interface with elevator grooves in drill collars manufactured as per API 7-1.

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

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Table 10—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		Elevator Bore		Neck Diameter D_{SE} max		Elevator Bore		
		mm	in.	mm	in.	mm	in.	mm	in.	
NC 26 (2 $\frac{3}{8}$ IF)	2 $\frac{3}{8}$ EU	65.09	2 $\frac{9}{16}$	67.47	2 $\frac{21}{32}$	a	a	a	a	2 $\frac{3}{8}$ EU
NC 31 (2 $\frac{7}{8}$ IF)	2 $\frac{7}{8}$ EU	80.96	3 $\frac{3}{16}$	83.34	3 $\frac{9}{32}$	80.96	3 $\frac{3}{16}$	85.73	3 $\frac{3}{8}$	2 $\frac{7}{8}$ EU
NC 31	3 $\frac{1}{2}$ IU	93.66 ^b	3 $\frac{11}{16}$ ^b	96.04 ^b	3 $\frac{25}{32}$ ^b	a	a	a	a	3 $\frac{1}{2}$ IU
NC 38 (3 $\frac{1}{2}$ IF)	3 $\frac{1}{2}$ EU	98.43	3 $\frac{7}{8}$	100.81	3 $\frac{31}{32}$	98.43	3 $\frac{7}{8}$	103.19	4 $\frac{1}{16}$	3 $\frac{1}{2}$ EU
NC 40 (4 FH)	3 $\frac{1}{2}$ EU	98.43	3 $\frac{7}{8}$	100.81	3 $\frac{31}{32}$	98.43	3 $\frac{7}{8}$	103.19	4 $\frac{1}{16}$	
NC 40 (4 FH)	4 IU	106.36	4 $\frac{3}{16}$	108.74	4 $\frac{9}{32}$	104.78	4 $\frac{1}{8}$	109.54	4 $\frac{5}{16}$	4 IU
NC 46 (4 IF)	4 EU	114.30	4 $\frac{1}{2}$	121.44	4 $\frac{25}{32}$	114.30	4 $\frac{1}{2}$	122.24	4 $\frac{13}{16}$	4 EU, or 4 $\frac{1}{2}$ IU, or 4 $\frac{1}{2}$ IEU
NC 46 (4 IF)	4 $\frac{1}{2}$ IU	119.06	4 $\frac{11}{16}$	121.44	4 $\frac{25}{32}$	117.48	4 $\frac{5}{8}$	122.24	4 $\frac{13}{16}$	
NC 46 (4 IF)	4 $\frac{1}{2}$ IEU	119.06	4 $\frac{11}{16}$	121.44	4 $\frac{25}{32}$	117.48	4 $\frac{5}{8}$	122.24	4 $\frac{13}{16}$	
4 $\frac{1}{2}$ FH	4 $\frac{1}{2}$ IU	119.06	4 $\frac{11}{16}$	121.44	4 $\frac{25}{32}$	117.48	4 $\frac{5}{8}$	122.24	4 $\frac{13}{16}$	
4 $\frac{1}{2}$ FH	4 $\frac{1}{2}$ IEU	119.06	4 $\frac{11}{16}$	121.44	4 $\frac{25}{32}$	117.48	4 $\frac{5}{8}$	122.24	4 $\frac{13}{16}$	
NC 50 (4 $\frac{1}{2}$ IF)	4 $\frac{1}{2}$ EU	127.00	5	133.35	5 $\frac{1}{4}$	127.00	5	134.94	5 $\frac{5}{16}$	4 $\frac{1}{2}$ EU, or 5 IEU
NC 50 (4 $\frac{1}{2}$ IF)	5 IEU	130.18	5 $\frac{1}{8}$	133.35	5 $\frac{1}{4}$	130.18	5 $\frac{1}{8}$	134.94	5 $\frac{5}{16}$	
5 $\frac{1}{2}$ FH	5 IEU	130.18	5 $\frac{1}{8}$	133.35	5 $\frac{1}{4}$	130.18	5 $\frac{1}{8}$	134.94	5 $\frac{5}{16}$	
5 $\frac{1}{2}$ FH	5 $\frac{1}{2}$ IEU	144.46	5 $\frac{11}{16}$	147.64	5 $\frac{13}{16}$	144.46	5 $\frac{11}{16}$	149.23	5 $\frac{3}{8}$	5 $\frac{1}{2}$ IEU
6 $\frac{5}{8}$ FH	6 $\frac{5}{8}$ IEU	176.21	6 $\frac{15}{16}$	178.59	7 $\frac{1}{32}$	a	a	a	a	6 $\frac{5}{8}$ IEU
Tolerances: Bore: $\begin{matrix} +0.80 \\ -0 \end{matrix}$ mm $\left(\begin{matrix} +\frac{1}{32} \\ -0 \end{matrix} \text{ in.} \right)$ Taper: $\begin{matrix} +2^{\circ} \\ -0 \end{matrix}$										
NOTE Elevators with the same bores are the same elevators.										
^a Not manufactured. ^b Denotes dimensions that are commonly used that are not covered by API 5DP.										

Table 11—Elevator Bores for Non-upset Casing and Tubing

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Nominal Casing or Tubing Size D	Formula for New Top Bore $T_B^{a, b}$ (see Figure 11)			
$D < 4\frac{1}{2}$ in.	$1.001 \times (D \times 25.4) + 1.88 \text{ mm } (1.001 \times D + 0.074 \text{ in.})$			
$4\frac{1}{2}$ in. $\leq D < 9\frac{5}{8}$ in.	$1.0125 \times (D \times 25.4) + 1.22 \text{ mm } (1.0125 \times D + 0.048 \text{ in.})$			
$9\frac{5}{8}$ in. $\leq D < 12\frac{7}{8}$ in.	$1.0125 \times (D \times 25.4) + 0.89 \text{ mm } (1.0125 \times D + 0.035 \text{ in.})$			
$12\frac{7}{8}$ in. $\leq D \leq 20$ in.	$1.0125 \times (D \times 25.4) + 0.56 \text{ mm } (0.0125 \times D + 0.022 \text{ in.})$			
20 in. $< D < 42$ in.	$1.010 \times (D \times 25.4) + 1.90 \text{ mm } (1.010 \times D + 0.075 \text{ in.})$			
42 in. $\leq D$	$1.010 \times (D \times 25.4) + 3.18 \text{ mm } (1.010 \times D + 0.125 \text{ in.})$			
Tolerances:				
$T_B \leq 254 \text{ mm}$	$\pm 0.40 \text{ mm}$	$B_B \leq 254 \text{ mm}$	$+0.80$ -0.40 mm	
$(T_B \leq 10 \text{ in.}$	$\pm \frac{1}{64} \text{ in.})$	$(B_B \leq 10 \text{ in.}$	$+\frac{1}{32} \text{ in.}$ $-\frac{1}{64} \text{ in.})$	
$254 \text{ mm} < T_B \leq 508 \text{ mm}$	$+0.80$ -0.40 mm	$254 \text{ mm} < B_B \leq 508 \text{ mm}$	$+1.60$ -0.40 mm	
$(10 \text{ in.} < T_B \leq 20 \text{ in.}$	$+\frac{1}{32} \text{ in.}$ $-\frac{1}{64} \text{ in.})$	$(10 \text{ in.} < B_B \leq 20 \text{ in.}$	$+\frac{1}{16} \text{ in.}$ $-\frac{1}{64} \text{ in.})$	
$T_B > 508 \text{ mm}$	$+1.60$ -0.80 mm	$B_B > 508 \text{ mm}$	$+1.60$ -0.80 mm	
$(T_B > 20 \text{ in.}$	$+\frac{1}{16} \text{ in.}$ $-\frac{1}{32} \text{ in.})$	$(B_B > 20 \text{ in.}$	$+\frac{1}{16} \text{ in.}$ $-\frac{1}{32} \text{ in.})$	
NOTE 1 Refer to Figure 11 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 into 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.				
NOTE 4 See API 8B for maximum allowable wear for square shouldered elevator bores in-service.				
^a Bottom bore BB is optional; some elevator designs do not have a bottom bore.				
^b New bottom bore, BB may be the same at manufacturer's option.				

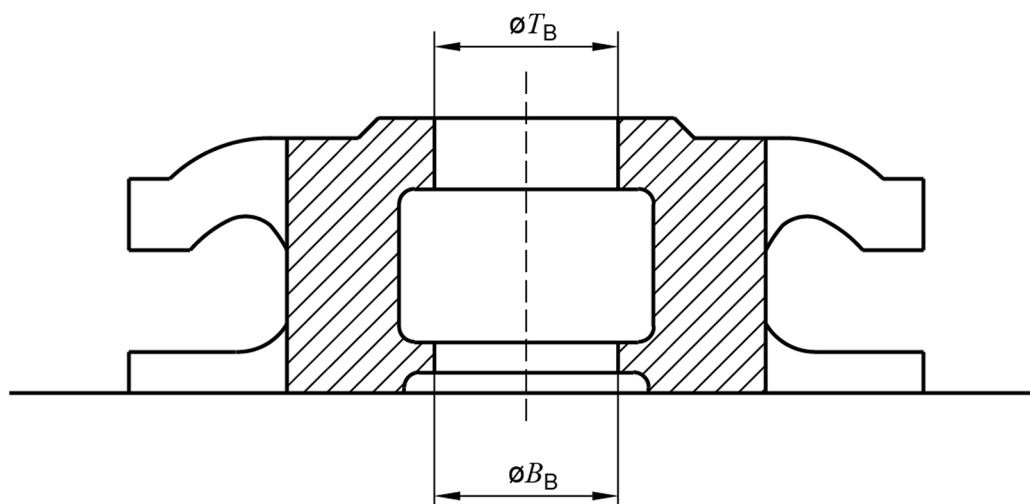


Figure 11—Casing and Tubing Elevator Bores

Table 12—Elevator Bores for Upset Casing and Tubing—Straight Bore, Square Shoulder Only

Nominal Upset Diameter D_U	Formula for New Top Bore $T_B^{b c d}$
$D_U < 114 \text{ mm}^a$ ($D_U < 4 \frac{1}{2} \text{ in.})^a$	$1.0010 \times D_U + 2.74 \text{ mm}$ ($1.0010 \times D_U + 0.108 \text{ in.}$)
$114 \text{ mm} \leq D_U < 244 \text{ mm}$ ($4 \frac{1}{2} \text{ in.} \leq D_U < 9 \frac{5}{8} \text{ in.}$)	$1.0125 \times D_U + 1.22 \text{ mm}$ ($1.0125 \times D_U + 0.048 \text{ in.}$)
$244 \text{ mm} \leq D_U < 327 \text{ mm}$ ($9 \frac{5}{8} \text{ in.} \leq D_U < 12 \frac{7}{8} \text{ in.}$)	$1.0125 \times D_U + 0.89 \text{ mm}$ ($1.0125 \times D_U + 0.035 \text{ in.}$)
$327 \text{ mm} \leq D_U < 508 \text{ mm}$ ($12 \frac{7}{8} \text{ in.} \leq D_U < 20 \text{ in.}$)	$1.0125 \times D_U + 0.56 \text{ mm}$ ($1.0125 \times D_U + 0.022 \text{ in.}$)
$508 \text{ mm} \leq D_U < 1067 \text{ mm}$ ($20 \text{ in.} \leq D_U < 42 \text{ in.}$)	$1.0100 \times D_U + 1.90 \text{ mm}$ ($1.0100 \times D_U + 0.075 \text{ in.}$)
$1067 \text{ mm} \leq D_U$ ($42 \text{ in.} \leq D_U$)	$1.0100 \times D_U + 3.18 \text{ mm}$ ($1.0100 \times D_U + 0.125 \text{ in.}$)
Tolerances:	

$T_B \leq 254 \text{ mm}$	$\pm 0.40 \text{ mm}$	$B_B \leq 254 \text{ mm}$	$+0.80 \text{ mm}$ -0.40 mm
$(T_B \leq 10 \text{ in.})$	$\pm \frac{1}{64} \text{ in.}$	$(B_B \leq 10 \text{ in.})$	$+\frac{1}{32} \text{ in.}$ $-\frac{1}{64} \text{ in.}$
$254 \text{ mm} < T_B \leq 508 \text{ mm}$	$+0.80 \text{ mm}$ -0.40 mm	$254 \text{ mm} < B_B \leq 508 \text{ mm}$	$+1.60 \text{ mm}$ -0.40 mm
$(10 \text{ in.} < T_B \leq 20 \text{ in.})$	$+\frac{1}{32} \text{ in.}$ $-\frac{1}{64} \text{ in.}$	$(10 \text{ in.} < B_B \leq 20 \text{ in.})$	$+\frac{1}{16} \text{ in.}$ $-\frac{1}{64} \text{ in.}$
$T_B > 508 \text{ mm}$	$+1.60 \text{ mm}$ -0.80 mm	$B_B > 508 \text{ mm}$	$+1.60 \text{ mm}$ -0.80 mm
$(T_B > 20 \text{ in.})$	$+\frac{1}{16} \text{ in.}$ $-\frac{1}{32} \text{ in.}$	$(B_B > 20 \text{ in.})$	$+\frac{1}{16} \text{ in.}$ $-\frac{1}{32} \text{ in.}$

NOTE See API RP 8B for maximum allowable wear for square shoulder upset elevators bores in service.

^a**CAUTION** Do not use external-upset tubing elevators on non-upset tubing; otherwise, equipment may be damaged.

^bNew bottom bore, B_B , may be the same, at manufacturer's option.

^cBottom bore, B_B , is optional; some elevator designs do not have a bottom bore.

^dRefer to Figure 11 for the relationship of T_B and B_B .

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 10.

9.8.3 Elevators and Spiders Testing

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

9.8.3.2 Alternative design validation testing of a single bore size in the bore size range of a given elevator frame may be qualified by testing that single bore size. All bore sizes in the bore size range of the given elevator frame may be qualified by testing the bore size that will result in the highest stress.

9.8.3.3 The slips' activating mechanism(s) shall be functionally tested on each production unit, demonstrating full conformance with design requirements.

9.8.3.4 Inserts shall be exempt from mechanical testing and traceability requirements.

9.8.3.5 Primary load-carrying components of elevators (except for elevator slips) shall meet the impact testing requirements of 8.4.4. Elevator slips shall be made from materials possessing a minimum impact toughness (average of three tests) of 33 J (25 ft-lb) with no individual value less than 26 J (19 ft-lb) at a maximum test temperature of -20°C (-4°F).

9.8.3.6 The manufacturer of the equipment shall provide, in the documentation delivered with the equipment (see 11.3c), frequency of inspection and acceptance criteria for NDE of slip-type elevator setting rings.

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9.8.3.7 Proof load testing, as described in 8.6, shall apply. Additionally, the following shall apply.

- a) Hinge pins or latch pins manufactured from wrought material are exempt from proof load testing requirements.
- b) Replacement hinge pins and latch pins shall meet or exceed the original manufacturer's specifications;

9.9 Rotary Swivels

9.9.1 Swivel Bearing Rated Load

The bearing rated load of swivels shall be determined by using Equations (22) or (23):

In SI units:

$$W_S = \frac{W_R}{800} \quad (22)$$

In USC units:

$$W_S = \frac{W_R}{1600} \quad (23)$$

where

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

W_R is the main bearing thrust rating at 100 r/min for 3000 h minimum life for 90 % of bearings, expressed in newtons (N) (pounds force).

For antifriction bearing design and manufacturing requirements, see 9.15.

9.9.2 Rotary Swivel Prototype Pressure Testing

The rotary swivel shall:

- a. Be hydrostatically pressure tested as an assembled prototype, or
- b. Have the individual pressure-containing components of the swivel tested separately if the holding fixtures simulate the load condition applicable to the component in the assembled swivel

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 at least 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 pressure-holding periods shall be no 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 visible leakage shall be allowed. Throughout the test, the pressure shall not drop below the specified test pressure, nor shall it change by more than 2.5 % of the test pressure or 3.45 MPa (500 psi), whichever is less.

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Washpipes containing mechanical seals (designed to have a controlled leak) are exempt from the 'no visible leakage shall be allowed' requirement as described above. The leakage rate shall not exceed the seal manufacturer's limits.

9.9.3 Rotary Swivel Production Pressure Testing

Pressure-containing cast components of the rotary swivel shall be hydrostatically pressure tested in production. The production pressure test shall be performed according to the requirements defined in 9.9.2.

The working pressure shall be marked on the cast member.

9.9.4 Swivel Gooseneck Connection

9.9.4.1 Dimensions

The end connection of the gooseneck or the connecting member shall be agreed upon by the purchaser and manufacturer.

The agreed upon end connection of the gooseneck or the connecting member shall be specified in the purchase order.

The purchase order shall include:

- a) type and size;
- b) location on the top drive or swivel;
- c) angle between connection centerline and the vertical (see Figure 12).

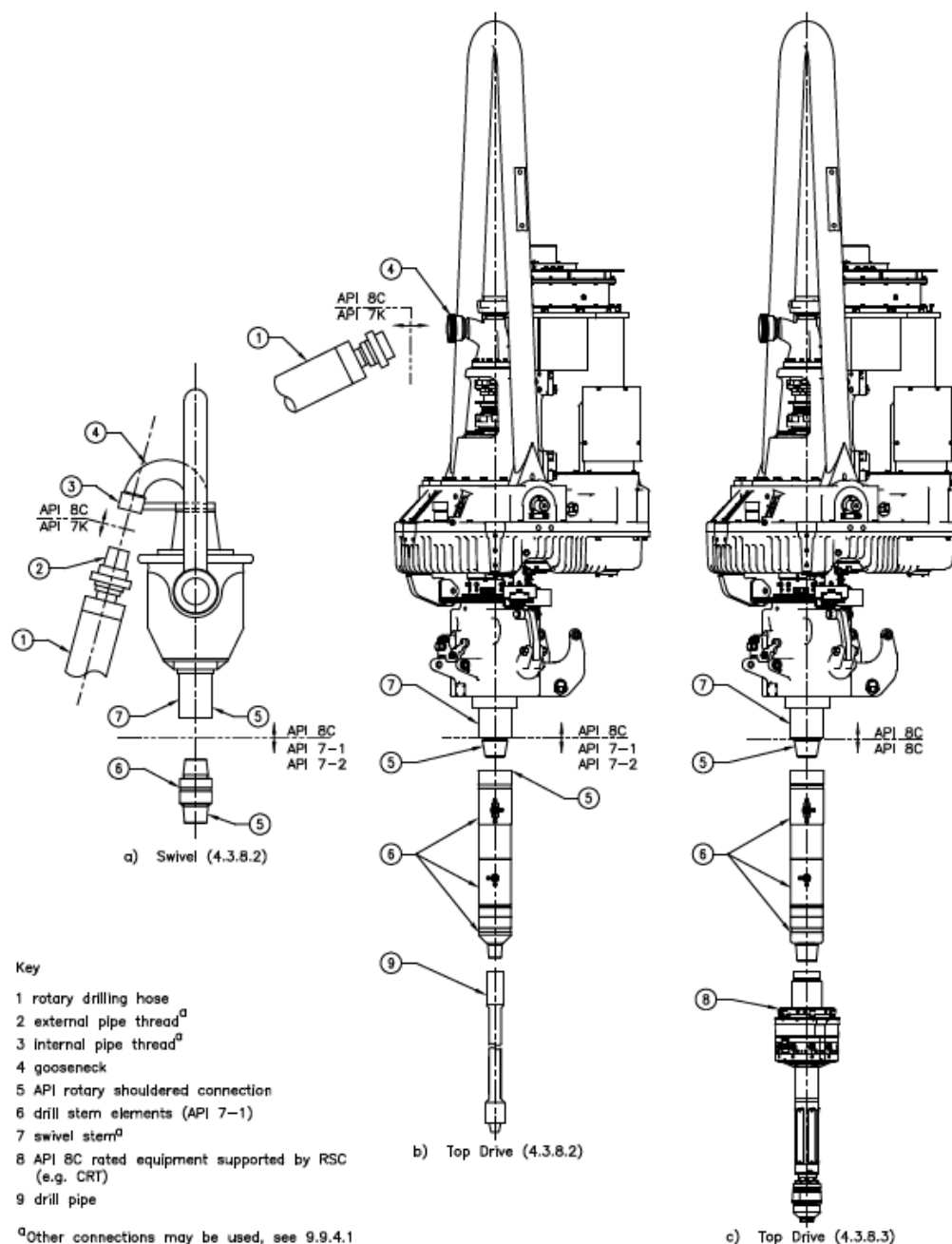


Figure 12—Rotary Swivel and Top Drive Connections

Figure 12—Rotary Swivel/Top Drive Connections

9.9.4.2 Threads

If gooseneck connections are threaded, the threads shall be in conformance with API 5B.

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

See Section 10 for further marking requirements.

9.9.5 Rotary-shouldered Connections

All rotary swivel and power swivel connections that make up to subs or other drill string components shall conform with the applicable requirements, including gauging and marking, as specified in API 7-1 and API 7-2. For RSCs used in hoisting applications, see 4.3.8.3 (Figure 12, panel c).

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9.9.6 Rotary Hose Safety Attachment

Rotary hose gooseneck or S-pipe connections shall be provided with a safety connection lug containing a 28.6 mm (1 $\frac{1}{8}$ in.) diameter hole for attaching a safety chain or wire rope sling. The lug shall be designed to accommodate a safety chain or wire rope sling, as specified in API 7K. The lug and its supporting structure shall have a minimum breaking strength of 71.1 kN (16,000 lb) when used with hoses of 101.6 mm (4 in.) internal diameter or less and a minimum breaking strength of 142.3 kN (32,000 lb) when used with hoses of internal diameter greater than 101.6 mm (4 in.).

9.9.7 Swivel Washpipes

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

9.10 Power Swivels

A power swivel is a device which moves with a hoisting system and is designed to provide rotary power to the top of the tubular/drill string. It replaces the rotary swivel and includes a rotary seal and bearing for supporting the tubular/drill string weight.

The bearing rated load shall be calculated using Equation (22) or Equation (23) 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 attachments shall be in accordance with 9.9.4.2, 9.9.5, and 9.9.6.

9.11 Power Subs

9.11.1 General

A power sub is a device which moves with a hoisting system and is designed to provide rotary power to the top of the tubular/drill string. It attaches to the bottom of the rotary swivel, but does not include a rotary seal or bearing for supporting the tubular/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 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) or 1000 pound-force (Kips).

The rated load of wireline anchors shall be in conformance with 4.6. The minimum design safety factor shall conform to Table 13.



Table 13—Rated Load and Minimum Design Safety Factor of Wireline Anchors

Rated Load R	Minimum Design Safety Factor SF_D
$R \leq 178 \text{ kN (40 Kips)}$	3.00
$178 \text{ kN (40 Kips)} < R \leq 445 \text{ kN (100 Kips)}$	$3.00 - 0.75 (R - 178) / 267^a$ $3.00 - 0.75 (R - 40) / 60^b$
$R > 445 \text{ kN (100 Kips)}$	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 Kips.	

9.13 Drill String Motion Compensators

9.13.1 General

The purpose of a Drill-string Motion Compensator is to reduce the Weight-On-Bit (WOB) variation during drilling operations performed from a floating, heaving drillship or semi-submersible. Other operations may be utilized such as pin or lock to bottom operation, landing the BOP, etc. This is accomplished by compensating for the heaving movement of the vessel using a hydro-pneumatic spring type design. Other types of compensation may be used however this section is applicable to the hydro-pneumatic type design. Drill-string Motion Compensators can be suspended from the traveling block, traveling vertically in the derrick or be mounted to the top of the derrick.

This specification shall apply to mechanical, hydraulic, and pneumatic components of Drill-string Motion Compensators.

NOTE 1 Drill-String Motion Compensator PID control systems and algorithms are outside the scope of this section.

NOTE 2 Heave compensating drawworks, cylinder hoisting, and deadline type compensators are not within the scope of this section.

9.13.2 Design

9.13.2.1 Design Safety Factor

9.13.2.1.1 Drill-string Motion Compensators suspended from the traveling block

Design safety factors for components in the load path shall be determined as specified in 4.7 and Table 1.

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9.13.2.1.2 Drill-string Motion Compensators mounted to the top of the derrick

Design safety factors are dependent on the function and location of the components comprising the Drill-string Motion Compensator. The following bullet points shall be used to determine these design safety factors.

- Steel structures shall be designed in accordance with API 4F.— Design safety factors for wire rope sheaves in the load path shall be determined as specified in 4.7 and Table 1.
- Crown shafts, including fastline and deadline sheave support shafts, shall be designed using an allowable stress method with a minimum allowed bending moment using Equation (1)

$$M_b = 0.60 F_y S \quad (1)$$

Where

M_b is the maximum bending moment, Nm (in-lbs)

F_y is the specified minimum yield strength, Pa (psi)

S is the elastic section modulus, mm³ (in³)

9.13.2.2 Load Ratings

Three primary types of loads shall be associated with a Drill-string Motion Compensator. The load rating shall be taken at the crown block for top mounted compensators and at the becket for inline compensators.

- Compensating Load (CL)
- Non-compensating Load (NCL)
- Hydraulically Locked Load (HLL).

NOTE 1 CL, NCL, and HLL are further described in Section 9.13.2.2.1 through 9.13.2.2.3

NOTE 2 Load ratings of Drill-string Motion Compensators shall be determined in compliance with the requirements of 5.4 and 9.13.2.2.1 through 9.13.2.2.3.

9.13.2.2.1 Compensating Load (CL).

Drill-string Motion Compensators shall be rated by the maximum Compensating Load (MCL) that can be applied when the compensator is at the 50% stroke position.

The CL shall be defined as the weight that can be supported by the Drill-String Motion Compensator while compensating for the movement of the drilling vessel (see Figure 1).

NOTE: The CL does not include allowance for the weight of the drill string and any additional tools such as Top Drives or other attachments suspended from the Drill-String Compensator.

9.13.2.2.2 Mechanically locked Load (MLL).

The MLL shall be defined as the load supported by the Drill-string Motion Compensator structure when the load is not supported hydraulically or pneumatically. The Drill-string Motion Compensator shall not provide motion compensation in this configuration. NCL can be achieved by either mechanically locking the cylinders out of the load path or by geometric design of the structure.

NOTE The MLL capacity is typically higher than the LL capacity.

9.13.2.2.3 Hydraulically Locked Load (HLL).

Drill-string Motion Compensators that are provided with the ability to hydraulically lock the cylinders at any stroke position shall report in the documentation the maximum **HLL** that can be applied when the cylinders are hydraulically locked.

NOTE 1 The capability to hydraulically lock the cylinders is not a requirement of this specification.

9.13.2.3 Rated Compensator Stroke

The full range of stroke, including stroke that is used for end cushioning, that can be accommodated by the Drill-string Motion Compensator cylinder(s) shall determine the rated stroke.

NOTE: Compensator cylinder stroke may not equal compensator stroke by design.

9.13.2.4 Pneumatic Operating Medium

The gas used in the Drill-string Motion Compensator system shall be either air or nitrogen. The Drill-string Motion Compensator manufacturer shall specify the gas to be used.

The gas quality requirements shall be specified by the manufacturer.

9.13.2.5 Hydraulic Fluids

Hydraulic fluid shall:

- a. be specified by the drill-string motion compensator manufacturer as suitable for the compensator; or,
- b. Otherwise approved by the manufacturer.

NOTE important considerations are:

- Viscosity (with temperature relation),
- pH value,
- corrosion properties
- lubricity value,

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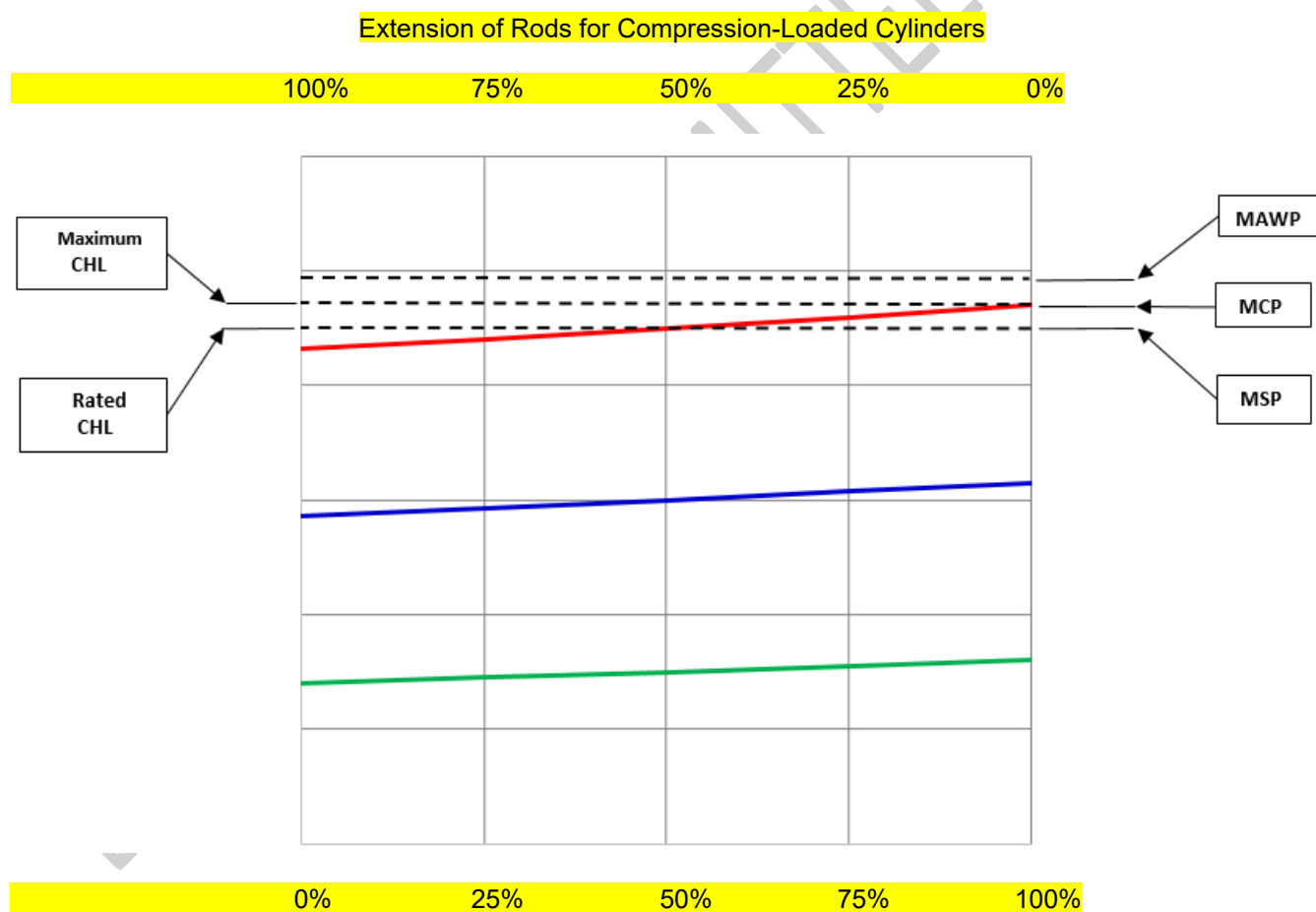
- ignition characteristics
- operating temperature range,
- foaming characteristics,
- color so as to permit ready detection of leaks,
- material compatibility,
- cleanliness

Warning – Mineral based hydraulic fluids shall not be used when air is used as the compressible gas. High gas pressures may allow auto-ignition to occur.

9.13.2.6 Compensating Load and Pressure vs Stroke

9.13.2.6.1 Performance Curves

The manufacturer shall provide plots of CL vs stroke for the full stroke range of the Drill-string Motion Compensator. At a minimum, curves shall be provided that correspond to 50%, 75%, and 100% of CL as shown in Figure 1.



Extension of Rods for Tension-Loaded Cylinders

— 100% — 75% — 50%

Figure 13

NOTE Figure 13 shows an example plot. Annex D shows example calculations.

The calculations shall include compression and expansion characteristics of real gas using one of the real gas methods defined below:

- 1) NIST (National Institute of Standards and Technology) data,
- 2) Benedict-Webb-Rubin equation of state (EOS),
- 3) Van der Waals EOS,
- 4) Polytropic constant table per Annex E,
- 5) An alternate polytropic constant if justified and documented through testing.

Adiabatic behavior shall be assumed for Methods 1) through 3). Since Method 5 is time dependent, the minimum applicable duration shall be stated.

9.13.2.6.2 Allowable Compensating Load Variation due to Gas Volume Change

NOTE The CL variation with stroke, exclusive of mechanical friction and hydraulic inefficiencies, is directly related to the total working air pressure vessel volume connected to the Drill-string Motion Compensator. Fewer APV's provide larger CL variation as the vessel heaves.

9.13.2.7 Pressure

The Drill-string Motion Compensator system safety relief valve's set pressure shall not exceed the maximum allowable working pressure (MAWP) of the system.

The maximum compression pressure (MCP) shall be limited to no more than 93 % of the MAWP to accommodate for safety relief valve tolerances.

The maximum supply pressure (MSP) shall be less than or equal to the MCP minus the potential increase in pressure that can be caused by real gas compression due to changes in cylinder stroke (see Figure 1). Given the actual Drill-string Compensator cylinder stroke position, the Drill-string Motion Compensator pressure shall be limited so that the maximum pressure achieved at the cylinder stroke extents shall not exceed MCP.

NOTE: Pressure settings above MSP are allowed depending on the actual stroke of the cylinders provided that the 100% performance curve is not exceeded.

9.13.3 Design Standards

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9.13.3.1 Pressure Vessels

Pressure vessels shall be designed, fabricated, and tested in accordance with ASME *BPVC*, section VIII, Division 1 or Division 2; ISO 11120; or other nationally or internationally recognized standard. A corrosion allowance shall be included in the design pressure wall thickness. The increase in thickness shall be selected either to achieve the desired life of the vessel or by agreement between the manufacturer and the purchaser. The corrosion allowance shall be documented in the data book. Each vessel shall be equipped with a shut-off valve, condensate drain valve, and pressure-relief device.

9.13.3.2 Cylinders

Cylinders shall be designed, fabricated, and tested to conform to the requirements of ASME *BPVC*, Section VIII, Division 1 or Division 2, or other nationally or internationally recognized standards. Any associated non-pressure boundary components such as solid rods, rams, or like elements shall be designed in accordance with AISC or other nationally or internationally recognized standard.

9.13.3.3 Bolting

Bolting for Drill-string Motion Compensator cylinders and pressure vessels shall conform to the requirements of ASME *BPVC* Sec VII, Division 1 or Division 2, or other nationally or internationally recognized standard.

Bolting for piping shall conform to the requirements of ASME B31.3 or other nationally or internationally recognized standard.

Bolting used for mounting equipment and accessories to the Drill-String Motion Compensator shall meet industry standard or OEM requirements.

9.13.3.4 Piping

Piping shall be designed in accordance with ASME B31.3 or other nationally or internationally recognized standard.

For interconnect piping that is outside the Drill-string Motion Compensator manufacture's scope of supply, the manufacturer shall provide recommended pipe size and maximum equivalent length to minimize hydraulic and pneumatic inefficiencies during operation.

9.13.3.5 Wire Rope

Wire rope used in Drill-string Motion Compensator assemblies, exclusive of the drilling wire, shall conform to API 9A or other recognized wire rope standard. The rope shall be sized to have a minimum design safety factor of 3.0 on breaking strength. The design safety factor shall be determined by dividing the wire rope breaking strength by the maximum load that can be applied.

9.13.3.6 Sheaves

Sheave diameters shall be determined in accordance with recommendations given in API 9B. The sheave diameter factor shall meet or exceed "Condition B." Otherwise, the sheaves shall conform to API 8C section 9.2.

9.13.3.7 Electrical Wiring

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Electrical equipment and wiring shall conform to API 500, API 505, or other national or international recognized standard such as NFPA 70, *National Electrical Code*, Class I, Division 2 or IEC 61892.

9.13.3.8 Drill-string Compensator Mounting

The manufacturer shall provide the mounting and installation information to purchaser, including design load, orientation, alignment, allowable fleet angle if wire rope is utilized, and minimum clearances.

Traveling type Drill-string Motion Compensators shall be capable of being maintained over the well centerline throughout its travel

9.13.4 Operational Controls

The Drill-string Motion Compensator system shall, at a minimum, include equipment to control and monitor the following

- Hook load
- Stroke position
- System pressure
- Locked/unlocked condition
- APV storage pressure.

9.13.5 Temperature Considerations

The manufacturer shall state the appropriate service temperature range of the Drill-string Motion Compensator system.

NOTE Cited design codes may not address extreme low-temperature service.

9.13.6 Rod Materials and Coatings

Cylinder rods shall be made from a corrosion-resistant material or have a corrosion-resistant coating.

NOTE 1 Typically, rod material or coatings are selected to provide suitable corrosion resistance, hardness, wear, seal compatibility, and durability.

NOTE 2 Advance corrosion-resistant coatings are now widely available in addition to the traditional industrial hard chrome over steel. These may include laser clad alloys, high-velocity oxygenated fuel (HVOF) compounds, or ceramics. When advanced corrosion-resistant coatings are used, careful selection of appropriate seal and bearing materials are required to ensure adequate wear and life results.

NOTE 3 Ceramic-coated rods may be subject to corrosion in the underlying base material if using a water-glycol hydraulic fluid. In the presence of some materials and design configurations, some fluids may act as an electrolyte and thus produce an electrical potential across the rod.

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9.13.7 Energy Control Provisions

A Drill-string Motion Compensator stores a large amount of potential energy in the form of a compressed gas. The Drill-string Motion Compensator shall include energy control provisions that will arrest, reduce, or eliminate the energy in a controlled manner in the event the compensator experiences a sudden loss of hook load. The Drill-string motion compensator energy control provision shall include design features that prevent structural damage to the Drill-String motion compensator during the dissipation of energy.

Note 1: Examples of design features include but are not limited to, orifice plates, cylinder cushions, speed limiting valves and/or servo controlled valves.

Note 2: This is normally accomplished by controlling the acceleration of the cylinder rods to a velocity that will not overcome the cylinder integrity.

9.13.7.1 Loss of Gas Pressure Due to Hose Rupture

A device that automatically closes in response to a sudden loss of gas pressure due to a hose rupture shall be installed at each end of the hose to maintain support of the drill string.

Note: The Drill-string Motion Compensator can experience a sudden loss of pressure due to a rupture or failure of a high pressure hose. Support of the drill string and stored gas pressure and air pressure vessels can suddenly be lost in this kind of event.

9.13.7.2 Loss of Control System

The Drill-string Motion compensator system shall be designed to continue in its last commanded state without an increase or decrease in motion compensation tension levels either compensating or remaining locked until the control system has been restored.

9.13.7.3 Emergency Disconnects

The energy control provisions included shall allow for the drill string to lift up in a controlled manner with the full available stroke of the drill-string compensator. A loss of electrical power to the drill string compensator system shall not prevent the completion of this operation.

9.13.8 Marking

The marking requirements of this section shall supersede the marking requirements in section 10. The manufacturer shall attach a nameplate to each Drill-string Compensator. The nameplate shall include the following information.

- Name of manufacturer
- Unique serial number
- Max Compensating Load
- Max Non-Compensating Load
- Hydraulically locked load
- Maximum allowable working pressure

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- Compensating stroke
- API 8C

9.13.9 Materials

9.13.9.1 General

The material requirements of section 9.13.9 shall be used for primary load carrying components and are not intended to overrule material requirements of Drill-string Motion Compensator components covered by other API specifications or other design codes when specified in section 9.13.

NOTE: Other design code examples are ASME BPVC, Sec VIII, Div I, ASME B31.3 or other national or internationally recognized design codes.

9.13.9.2 Materials Selection

Material selection for primary-load-carrying components and pressure-containing components shall include the following evaluations in the design review documentation.

- type of loading
- temperature range
- fatigue (if a factor in the design)
- environmental conditions
- Strength requirements,

Material selection for nonmetallic materials shall include the following evaluations in the design review documentation

- type of loading,
- temperature range
- explosive decompression resistance (if appropriate)
- environmental conditions
- strength and ductility requirements.

9.13.9.3 Written Specifications

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All materials (including nonmetallic) shall conform to a written specification. The written specification shall be a nationally or internationally recognized standard, or the manufacturer's document.

Specifications for metallic components used for primary-load-carrying components or pressure-containing components shall at a minimum contain requirements for the following.

- Material chemical composition limits and tolerances;
- forming practices – forgings, etc.;
- heat treatment procedures when required, including cycle time and temperature with tolerances, heat-treating equipment, and cooling media;
- nondestructive examination (NDE) requirements;
- mechanical property requirements including yield strength, tensile strength, elongation, reduction of area, hardness range, and if required, impact toughness properties.

Specifications for nonmetallic components used in primary-load-carrying components or pressure-containing components shall define the following:

- material type;
- service temperature range;
- tensile strength, elongation, and elastic modulus;
- acceptable hardness range – shore, in accordance with ASTM D2240;
- density, compression set, and fluid compatibility;
- fiber reinforcement – type, composition, and properties.

9.13.9.4. Impact Testing

Inline Drill-string motion compensator primary load path materials shall follow the requirements of section 6.3. Top mounted Drill-string motion compensators shall follow the requirements of this section.

Impact testing shall be conducted when the minimum design temperature is 0° C (32° F) or lower.

Charpy V-notch impact tests shall be conducted in accordance with ASTM A370, ASTM E23, or equivalent industry standard using full-size specimens if the component size permits. When full size specimens are not practical, subsize specimens shall be tested and meet the criteria per method defined by ASTM A370.

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Impact testing shall be conducted at temperatures of -20°C (-4°F) or lower, and no higher than minimum design temperature. Specimens tested with orientation transverse to the major grain flow shall exhibit 20 J (15 ft-lb) minimum average value and 14 J (10 ft-lb) for a minimum of a set of three specimens. Specimens tested with orientation parallel to major grain flow shall exhibit 27 J (20 ft-lb) minimum average value and 20 J (15 ft-lb) for a single minimum of a set of three specimens.

9.13.9.5 Hardness

Material shall meet the hardness requirements specified in the nationally or internationally recognized standard, or the manufacturer's document.

9.13.10 Quality Control

Drill-string Motion Compensators are composed of various components that are designed and manufactured to comply with specific codes, rules, and regulations as required by Section 9.13. The components listed below identifies the corresponding quality control requirements as applicable.

- Pressure vessels shall comply with the quality control requirements of ASME BPVC, Section VIII, Division 1 or Division 2 or other recognized standard to which the pressure vessel was designed and manufactured.
- Cylinders shall comply with the quality control requirements of ASME BPVC, Section VIII, Division 1 or Division 2 or other recognized standard to which the cylinders are designed and manufactured.
- Piping shall comply with the quality control requirements of ASME B31.3 or the quality requirements of an alternative recognized piping code as specified by the equipment manufacturer.
- Wire rope shall comply with the quality control requirements of API 9A or an alternative recognized code as specified by the equipment manufacturer.
- Sheave and sheave shafts shall comply with the quality control requirements of API 8C Section 9.
- Crown block structures designed for top of derrick mounted Drill-string Compensators shall comply with the quality control requirements of API 4F.

9.14 Pressure Vessels and Piping

Pressure vessels forming part of the equipment shall be designed and manufactured in accordance with a recognized standard such as ASME *BPVC* Section VIII, Div 1 or Div 2. Piping shall be designed and manufactured in accordance with a recognized standard such as ASME B31.3.

9.15 Antifriction Bearings

Antifriction bearings used as primary load path components shall be designed and manufactured in accordance with a recognized bearing industry code or standard such as AFBMA bearing code. Antifriction bearings shall be exempt from the requirements of Section 4 through Section 8.

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9.16 Safety Clamps 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 rated load.

9.16.3 Lifting Lugs

Manufacturers shall state the minimum number of lifting lugs for each maximum load.

9.17 Guide Dollies

9.17.1 General

The purpose of the guide dolly is to hold the traveling equipment in the correct position relative to the derrick during the various operations and to react drilling torque. A retractable guide dolly is able to move the traveling equipment horizontally between the drilling position and the retracted position.

The guide dolly is not a primary load-carrying component, because the primary load will not pass through it. Still, as a consequence of the functions described above, the guide dolly will be subjected to considerable forces.

The requirements of Section 4 through Section 8 shall apply unless specifically noted otherwise in this section.

PSL 2 is not applicable to guide dollies.

9.17.2 Design

9.17.2.1 Design Safety Factor

Guide dollies are exempt from the design safety factors as specified in 4.8. Minimum design safety factors for guide dollies shall conform to Table 14.

9.17.2.2 Principal Loading Conditions and Corresponding Safety Factors

9.17.2.2.1 Members and cross sections, including hydraulic cylinders and connected equipment used for structural support, shall be designed for the most unfavorable of the following three PLCs using the associated design safety factors in Table 14.

9.17.2.2.2 The loads and load combinations to be considered in each of the PLCs defined in 9.17.2.3 shall conform to 9.17.2.3.1, 9.17.2.3.2, and 9.17.2.3.3.

Table 14—Design Safety Factors

PLC No.	Description of Condition	Safety Factor
I	Equipment working without environmental loads	1.5

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II	Equipment working with environmental loads	1.33
III	Exceptional loads	1.1

9.17.2.3 Loads and Load Combinations

9.17.2.3.1 In PLC I, the following load combinations (LC) shall be analyzed and documented:

a) LC I, 1: Drilling

This includes the effect of weight of the traveling equipment and guide dolly and the drilling torque generated by the traveling equipment.

b) LC I, 2: Braking

This includes the effect of the weight of the traveling equipment, including the guide dolly, multiplied by a minimum factor of two.

c) LC I, 3: Retraction/Extension

This applies to retractable guide dollies only, and shall at least cover acceleration/retardation in the extended position and in the retracted position. Simultaneous effects of weight and possible vertical accelerations shall be included.

d) LC I, 4: Horizontal Pull

If normal operations can involve a horizontal force component acting on the traveling equipment, this shall be analyzed together with the effects of weight.

9.17.2.3.2 In PLC II, the four LCs defined in 9.17.2.3.1 shall be analyzed together with appropriate "operating environmental conditions." For a fixed installation (e.g., land rig), this will include only wind, acting in the most unfavorable direction. For a floating platform/installation (e.g., drill ship, semisubmersible), the effects of heel, trim, and movements shall also be included.

NOTE Platform/installation movement may include heave, pitch, and roll.

9.17.2.3.3 In PLC III, the following LCs shall be analyzed and documented:

a) LC III, 1: Exceptional Vertical Accelerations

These are jarring or drill string failure. The LC shall include the effect of the weight of the traveling equipment and the guide dolly, multiplied by a minimum factor of four.

b) LC III, 2: Exceptional Environmental Conditions

This LC for floating installations shall, in addition to the weight, include environmental loads having a 100-year return period. For a fixed installation, the environmental load should be only wind.

c) LC III, 3: Accidental Heel

This applies only in the case of a floating installation (or drill ship). A static heel of at least 35° shall be applied.

d) LC III, 4: Setback Conditions

This LC shall include the weight of the traveling equipment supported by the guide dolly. This condition normally occurs during installation or maintenance of the traveling equipment when the entire weight of the traveling equipment and guide dolly may be supported by a guide rail stop.

9.17.2.4 Special Safety Precautions

The hydraulic system of a retractable guide dolly shall be equipped with the necessary devices to control the maximum active and passive oil pressures and the acceleration of the traveling equipment.

The manufacturer shall prepare a maintenance and operation manual in accordance with 11.3.

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9.17.3 Design Validation Test

Guide dollies shall be exempt from design validation testing.

9.17.4 Materials Requirements

Guide dolly materials are exempt from the requirements of Section 6.

Materials used in the manufacture of components supporting or transmitting forces critical to the functionality as documented by the manufacturer of the guide dolly shall conform to written specifications that meet the design requirements of the equipment, i.e., strength, ductility, weldability.

9.17.5 Quality Control

For surface NDE of welds, welds shall be inspected using magnetic particle (MP) or liquid penetrate (LP) method in accordance with AWS D1.1.

For volumetric NDE of welds, full or partial penetration welds loaded in tension to 70 % or greater of their allowable stress, as determined by design, shall be ultrasonic or radiograph inspected in accordance with AWS D1.1.

9.17.6 Marking

Guide dollies are exempt from the requirements in 10.2.

9.18 Casing Running Tools

The casing running tool is attached to the power swivel or top drive for means of moving casing in a wellbore by:

- hoisting without rotating;
- lowering without rotating;
- hoisting while rotating;
- lowering while rotating; or
- rotating without lowering or hoisting.

It may have the ability to pick up a single joint or a stand of casing and stab it onto the string. It uses the power swivel or top drive to rotate, torque, hoist, and lower the casing string.

By its nature, the casing running tool is both a hoisting tool and torque tool. It can also provide a means of transferring the drilling fluid and therefore can be subject to pressure from this fluid. All possible combined loads applied to the casing running tool shall be evaluated and documented when calculating stresses (see 4.3).

Axial load design validation testing of casing running tools shall be performed in accordance with Section 5. Torsion design validation testing shall be completed to 1.1 times the tool's rated torque as a separate test with no applied axial load. The axial and torsion tests shall be performed independently so as to eliminate any possible beneficial effect of combined loading.

Inserts shall be exempt from mechanical testing and traceability requirements.

The gripper actuating mechanism shall be functionally tested on each production unit, demonstrating full conformance with design requirements.

Casing running tool subconnections shall be in accordance with 9.9.5.

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NOTE An insert is a consumable gripping element that may have on the face opposite to the gripping surface, a flat, cylindrical, conical, or other geometry.

9.19 Top Drives

9.19.1 General

A top drive is either a power swivel or a power sub, with integrated pipe handling and hoisting capabilities below the drive.

At a minimum, the pipe handler shall consist of a means to support the elevator links and a pipe gripper mechanism to assist in making and breaking connections.

The requirements of 9.10 and 9.11 shall apply.

9.19.2 Marking

In addition to the markings specified in Section 10, rated loads shall be marked on top drives as follows:

- a) top drive hoisting rated load;
- b) RSC hoisting rated load.

EXAMPLE A top drive with a top drive hoisting rated load of 1000 tons and an RSC hoisting rated load of 674 tons.

RSC hoisting rated load is calculated per 4.3.8.3, and would be marked:

- top drive hoisting rated load: 1000 ton;
- RSC hoisting rated load: 674 ton.

Marking method shall conform with 10.6, or marking shall be provided on a permanently attached nameplate.

9.20 Hydraulic Hoisting Cylinders

9.20.1 General

This specification shall apply to fluid-powered hoisting cylinders that are primary load-carrying components if failure of the cylinder causes a loss of control of the load. Hydraulic hoisting cylinders will be exempt from the requirements of Section 5 unless elected by the manufacturer for design validation under 9.20.3.1 or if supplementary requirement SR 7 (see Annex A.8) is specified. Hydraulic hoisting cylinders shall be exempt from the requirements of 8.7.

9.20.2 Design

9.20.2.1 General

The loss of fluid power supply to the hydraulic hoisting cylinder shall not cause uncontrolled movement of the primary load.

WARNING Uncontrolled movement of the primary load may result in injury or catastrophic failure.

9.20.2.2 Design Safety Factor

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Primary load-carrying components of a hydraulic hoisting cylinder as defined by this specification shall conform with the design requirements of Section 4 based on hook load.

The sealing system shall be designed to sustain a static pressure of 1.5 times the rating. The sealing system shall be designed to operate within the seal manufacturer's written specifications or recognized industry standards.

9.20.2.3 Retention of Components

Each connection between components shall be evaluated and documented to determine if additional retention is required to conform with 4.10.

9.20.2.4 Loads and Load Combinations

Relevant load cases and load combinations (e.g., buckling, bending, pressure, tension, shear, and/or any combination) shall be evaluated and documented.

9.20.3 Test Procedures

9.20.3.1 Design Validation

The accuracy of the specified design ratings of the cylinder shall be verified by either design validation testing or by a computer model such as FEA or other appropriate calculation methods. The analysis should verify the cylinder for the specified design loadings. Methods and assumptions shall be documented.

The design validation documents shall be reviewed and approved by a qualified person who is independent of the design function.

9.20.3.2 Design Validation Test

Design validation testing may be specified by including supplementary requirement SR 7 (see Annex A.8) in the purchase order.

9.20.3.3 Production Pressure Test

Hydraulic hoisting cylinders as defined by this specification shall be subject to a production pressure test. The test shall be performed by pressurizing the assembled cylinders and shall consist of the following steps for the extending and retracting rod and piston sides:

- a) placing the hydraulic hoisting cylinder assembly in a test fixture capable of supporting the assembly during the pressure test (specific orientation of the hydraulic hoisting cylinder within the test fixture is not required unless noted on the test procedure);
- b) a primary internal pressure-holding period;
- c) reduction of the pressure to zero;
- d) thorough drying of all external surfaces of the components;
- e) a secondary internal pressure-holding period.

The test pressure shall be 1.5 times the rated working pressure. The pressure-holding periods shall be not less than five minutes for b) and 15 minutes for e), 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 visible leakage shall be allowed. Throughout the test, the pressure shall not drop below the specified production test pressure nor shall it change by more than 2.5 % of the test pressure or 3.45 MPa (500 psi), whichever is less.

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Following the test, the design function of the equipment shall be checked. Proper functioning of the equipment shall not be impaired by this test.

Critical areas in the primary load-carrying components accessible without disassembly shall be subjected to visual examination in accordance with 8.4.6. Welds accessible without disassembly shall be subjected to magnetic particle examination in accordance with 8.4.7.

9.20.4 Marking

The hydraulic hoisting cylinders shall conform to the marking requirements in Section 10.

9.21 Hoisting Equipment Adapters

Hoisting equipment adapters are adapters connected to a component of hoisting equipment listed in the Scope of this specification and transmitting the primary load from that component to another piece of hoisting equipment, such as rotary swivel-bail adapters.

Contact surface radii of hoisting equipment adapters shall conform with the dimensions in Table 9, and Figure 8, Figure 9, and Figure 10.

This section is applicable to any hoisting equipment adapter that is located above the swivel stem and not specified elsewhere within this specification.

9.22 Kelly Spinners

A relatively low-torque device used for the initial makeup of the threaded tool joint.

10 Marking

10.1 Product Marking

Each **product** of hoisting equipment shall be marked with “API Spec 8C” or “API 8C”, license number (if applicable), the manufacturer’s name or mark, date of manufacture (MM/YYYY), the relevant PSL number and the rating specified in 10.2. Additional markings shall be applied in accordance with Section 9 and 10.4. Equipment for which supplementary requirements apply shall be marked with the relevant “SR” numbers.

10.2 Rating Marking

Each **product** of hoisting equipment shall be marked with rated load/pressure rating unless otherwise specified in the individual equipment requirements.

EXAMPLE A PSL 1 traveling block with a rated load of 8000 kN (899 short tons), manufactured by the XYZ Company is marked as follows: **XYZ CO 899 ton API Spec 8C PSL 1**

10.3 Composite Equipment Marking

For assemblies having multipurpose attachments such as tubing blocks, hook-block combination, etc., each unit shall be marked separately with its rated load.

10.4 Component Traceability

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Primary load-carrying components and pressure-containing components shall be marked as specified in 8.4.5.

10.5 Serialization

Each complete item of equipment shall be marked with a unique serial number that shall provide traceability to its manufacturing history.

10.6 Marking Method

Marking referred to in 10.1 to 10.3 and 10.5 shall be applied using low-stress, hard die-stamps or other suitable low-stress method, or be cast into components. It shall be visible, legible, and at least 9.5 mm ($\frac{3}{8}$ in.) high where the physical dimensions of the component will permit.

NOTE Machine engraving is considered a low-stress method.

11 Documentation

11.1 General

Records of the documentation specified in Section 11 shall be kept by the manufacturer for a period of ten years after the equipment has been manufactured and sold.

Documentation shall be clear, legible, reproducible, retrievable, and protected from damage, deterioration, and loss.

All quality records shall be signed and dated.

NOTE Electronic signatures or equivalent are acceptable.

The manufacturer shall make available all records and documentation for examination by the purchaser or agent to demonstrate conformance with this specification.

11.2 Documentation to Be Kept by the Manufacturer

The following documentation shall be kept by the manufacturer:

- a) design documentation (see 4.13);
- b) design validation documentation (see 5.7);
- c) written specifications (see Sections 6, 7, and 8);
- d) qualification records, such as:
 - 1) weld procedure qualification records;
 - 2) welder qualification records;
 - 3) NDE personnel qualification records;
 - 4) measuring and test equipment calibration records;
- e) inspection and test records traceable to the equipment or components including:
 - 1) material test reports covering the following tests, as applicable:
 - i) chemical analysis;
 - ii) tensile tests;
 - iii) impact tests;

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- iv) hardness tests;
- 2) NDE records covering the surface NDE requirements of Section 6 or volumetric NDE requirements of Section 6, or a combination thereof;
- 3) performance test records including:
 - i) proof load test records;
 - ii) hydrostatic pressure testing records,
 - iii) functional testing records,
- 4) special process records.

These records shall be traceable to the applicable components and shall be maintained by the manufacturer or by the party carrying out the special process if the work is subcontracted.

NOTE Special process records include actual heat treatment time/temperature charts and weld repair records as specified in Section 7.

11.3 Documentation to Be Delivered with the Equipment

A comprehensive data book may be specified by supplementary requirement SR 3 (see Annex A.4) in the purchase order; otherwise, the following documentation shall be delivered with the equipment:

- a) the manufacturer's certificate of conformance, attesting to full conformance with the requirements of this specification and any other requirements stipulated by the purchase order (the certificate shall identify any noted deviations from the specified requirements);
 - b) proof load test record (as applicable);
 - c) operations/maintenance manuals, which shall include, but not be limited to:
 - 1) assembly drawings and critical-area drawings;
 - 2) list of components;
 - 3) nominal capacities and ratings;
 - 4) **Operating procedures and temperature limits;**
 - 5) applicable wear limits, including but not limited to:
 - i) elevator bore wear limits (see API 8B for method of computing and limitations on wear limits);
 - ii) hoisting sheave wear limits (groove profile, tread wear, or a combination thereof);
- NOTE See API 8B and API 9B for groove profile and tread allowable wear.
- 6) recommended categories and frequency of field inspection and preventive maintenance, methods, and acceptance criteria;
 - 7) dropped object prevention guidelines;
 - 8) itemized spare parts (not applicable to single-component equipment) and recommended stock levels;
 - 9) applicable load capacity changes as a result of wear;
- d) welding procedure specifications and qualification records (to be available for review without permission to copy upon purchaser request).

Annex A

(normative)

Supplementary Requirements

A.1 General

If specified in the purchase order, one or more of the following supplementary requirements shall apply.

A.2 SR 1 Proof Load Test

The equipment shall be given a proof load test and subsequently examined in accordance with 8.6.2.

The equipment shall be marked "SR 1" using low-stress, hard die-stamps near the rated load identification. Marking "SR 1" is not required on equipment for which proof load testing is normally required under Section 8 or Section 9.

A.3 SR 2 Low-temperature Test

The maximum impact test temperature for materials used in primary load-carrying components with a required minimum **design** temperature below -20°C (-4°F) shall be specified by the purchaser.

Impact testing shall be performed in accordance with:

- a) both 6.3.1 and ASTM A370 together, or
- b) both 6.3.1 and ISO 148-1 together.

The minimum average Charpy impact energy of three full-size test pieces, tested at the specified (or lower) temperature, shall be 27 J (20 ft-lb) with no individual value less than 20 J (15 ft-lb).

Each primary load-carrying component shall be marked "SR 2" to indicate that low-temperature testing has been performed. Each primary load-carrying component shall also be marked to show the actual design and test temperature in degrees Celsius.

A.4 SR 3 Data Book

If specified by the purchaser, records shall be prepared, gathered, and properly collated by the manufacturer into a data book. The data book for each unit shall include at least the following:

- a) certificate of conformance;
- b) equipment designation/serial number, with exception of pressure vessels and piping mounted onto hoisting equipment;
- c) wear limits and nominal capacities and ratings, with exception of pressure vessels and piping mounted onto hoisting equipment;
- d) list of components;
- e) traceability codes and systems (marking on parts/records on file);
- f) steel grades;
- g) heat treatment records, with exception of pressure vessels and piping mounted onto hoisting equipment;

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- h) material test reports, with exception of pressure vessels and piping mounted onto hoisting equipment;
- i) NDE records;
- j) performance test records, including functional hydrostatic and load testing certificates (when applicable);
- k) supplementary requirements certificates as required.

A.5 SR 4 Additional Volumetric Examination of Castings

The requirements for SR 4 shall be identical to the requirements of 8.4.8 except that all critical areas of each primary load-carrying casting shall be examined.

A.6 SR 5 Volumetric Examination of Wrought Material

The entire volume of primary load-carrying wrought components shall be examined by the ultrasonic method. If examination of the entire volume is impossible due to geometric factors, such as radii at section changes, the maximum practical volume shall suffice.

Ultrasonic examination shall be in accordance with ASTM A388 (the immersion method may be used) and ASTM E127. Straight-beam calibration shall be performed using a distance-amplitude curve based on a flat-bottomed hole with a diameter of 3.2 mm ($\frac{1}{8}$ in.) or smaller.

Wrought components examined by the ultrasonic method shall meet the following acceptance criteria.

- a) For both straight and angle beam examination, any discontinuity resulting in an indication which exceeds the calibration reference line is not allowed. Any indication interpreted as a crack or thermal rupture is also not allowed.
- b) Multiple indications (i.e., two or more indications), each exceeding 50 % of the reference distance-amplitude curve and located within 13 mm ($\frac{1}{2}$ in.) of one another, are not allowed.

A.7 SR 6 Boreback Stress-relief Feature

When requested by the purchaser, the boreback box stress-relief feature shall be a supplementary requirement for 9.9.5, 9.10, and 9.11.3. The connection shall conform to the applicable requirements as specified in API 7-1 and API 7-2 for the drill collar boreback box stress-relief feature.

A.8 SR 7 Design Validation Test—Hydraulic Cylinders

When specified, hydraulic cylinders as defined by this specification shall conform with the design validation test in Section 5. For the purpose of the design validation test, the hydraulic cylinder and its components shall not be considered to be of simple geometric forms.

The assembly shall be loaded in the same manner as in actual service and with areas of contact on the load-bearing surfaces that simulate actual service.

If any of the intended primary load paths for the cylinder include a compressive loading of the cylinder, the loading supports of the test fixture(s) shall simulate the constraints intended in service. The cylinder shall be within 1 % of full extension (as limited by the working range with the minimum length of stop tube specified in the design) before application of the compressive design validation test (DVT) load.

If the cylinder is used as a production unit, the manufacturer shall dismantle and inspect all components. Elastomeric seals and other components shall be discarded and replaced if the testing process exceeded the design rating of those components.

Annex B

(informative)

Qualification of Heat Treatment Equipment

B.1 Temperature Tolerance

The temperature at any point in the working zone shall not vary by more than $\pm 14^{\circ}\text{C}$ ($\pm 25^{\circ}\text{F}$) from the furnace set-point temperature after the furnace working zone has been brought up to temperature. Furnaces used for tempering, aging, PWHT, or a combination thereof shall not vary by more than $\pm 14^{\circ}\text{C}$ ($\pm 25^{\circ}\text{F}$) from the furnace set-point temperature after the furnace working zone has been brought up to temperature.

B.2 Furnace Calibration

B.2.1 General

Heat treatment of production parts shall be performed with heat treatment equipment that has been calibrated and surveyed.

B.2.2 Records

Records of furnace calibration and surveys shall be maintained for a period of not less than two years.

B.2.3 Batch-type Furnace Methods

These methods include the following.

- a) A temperature survey within the furnace working zone(s) shall be performed on each furnace at the maximum and minimum temperatures for which each furnace is to be used.
- b) A minimum of nine thermocouple test locations shall be used for furnaces having a working zone greater than 0.29 m^3 (10 ft^3). For rectangular furnaces, one of the nine thermocouple test locations shall be placed near each of the eight corners of the furnace. The ninth shall be placed near the

center of the furnace. For cylindrical furnaces, the nine thermocouple test locations shall be placed at three elevations and approximately 120° apart as shown in Figure B.1.

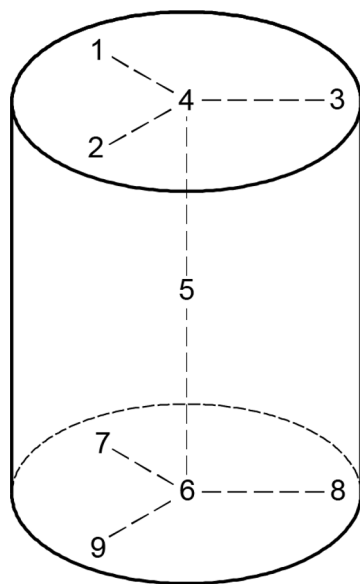


Figure B.1—Thermocouple Locations in Cylindrical Furnaces

- c) For each 3.54 m³ (125 ft³) of furnace working zone surveyed, at least one thermocouple test location shall be used, up to a maximum of 60 thermocouples. The additional thermocouples shall be distributed within the working zone of the furnace.
- d) For furnaces having a working zone less than 0.29 m³ (10 ft³), the temperature survey may be made with a minimum of three thermocouples located at the front, center, and rear or at the top, center, and bottom of the furnace working zone.
- e) After insertion of the temperature-sensing devices, readings shall be taken at least once every three minutes to determine when the temperature of the furnace working zone approaches the bottom of the temperature range being surveyed.
- f) Once the furnace temperature has reached the set-point temperature, the temperature of all test locations shall be recorded at two-minute intervals maximum, for at least 10 minutes. Then, readings shall be taken at five-minute intervals maximum for sufficient time to determine the recurrent temperature pattern of the furnace working zone for at least 30 minutes.
- g) Before the furnace set-point temperature is reached, none of the temperature readings shall exceed the set-point temperature by more than 14 °C (25 °F).
- h) After the furnace control set-point temperature is reached, no temperature readings shall exceed the limits specified. Each furnace shall be surveyed within one year prior to heat treatment.
- i) If a furnace is repaired or rebuilt, a new survey shall be performed before heat treatment.

B.2.4 Continuous-type Furnace Method

Continuous heat treatment furnaces shall be calibrated in accordance with procedures specified in AMS-H-6875C or equivalent.

B.3 Instruments

B.3.1 General

Automatic controlling and recording instruments shall be used. Thermocouples shall be located in the furnace working zone(s) and protected from furnace atmospheres by means of suitable protective devices.

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B.3.2 Accuracy

The controlling and recording instruments used for the heat treatment processes shall possess an accuracy of 1 % of their full-scale range.

B.3.3 Calibration

Temperature controlling and recording instruments shall be calibrated no more than three months prior to each use. Equipment used to calibrate the production equipment shall possess an accuracy of ± 0.25 % of full-scale.

DRAFT FOR COMMITTEE REVIEW

Annex C

(informative)

Information with Inquiry or Order

C.1 The following information should be provided by the purchaser when making an enquiry or placing an order:

- a) API Monogram-required (yes or no);
- b) reference to this international specification;
- c) reference to any requirement for third-party certification, name of the third-party agency and if applicable the level of certification;
- d) reference to Annex A for optional supplemental requirements (SR) for proof load testing, low-temperature impact testing, data book requirements, additional volumetric examinations of castings, volumetric examinations of wrought material, boreback stress relief features, and design validation test—hydraulic cylinders.

C.2 For the following equipment listed below, additional information should be provided with the inquiry or order.

- a) hoisting sheaves:
 - 1) wire rope size;
 - 2) sheave diameter;
 - 3) sheave bore;
 - 4) with or without bearings;
 - 5) make, model, and rating of equipment on which the sheave will be used;
- b) traveling blocks:
 - 1) number and diameter of sheaves;
 - 2) wire rope size;
 - 3) rated load;
 - 4) rated load of the hood-eye for hang off capacity;
 - 5) any connections required to mate the block with a power swivel, power sub, top drive or motion compensator other than a standard surfaced clevis;
 - 6) any connections required to mate the block with a guide dolly;
- c) block-to-hook adapters, connectors, and link adapters:
 - 1) rated load;
 - 2) type of equipment on which adapters and connectors will be used;
- d) hooks—drilling, tubing, and sucker rod:
 - 1) rated load;
 - 2) max opening of hook;
- e) elevator links:
 - 1) rated load;
 - 2) length;

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- 3) link size;
- 4) link type/style;
- f) drill pipe, casing and tubing elevators:
 - 1) rated load;
 - 2) pipe size and style (or ranges of sizes and styles);
 - 3) type of elevator:
 - i) center latch;
 - ii) side door;
 - iii) slip type;
 - iv) actuation (hydraulic, air or manual);
 - 4) interfacing requirements (link/elevator/ears compatibility);
- g) sucker rod elevators:
 - 1) rated load;
 - 2) rod size;
 - 3) rod type (steel or fiberglass);
 - 4) bale type (standard or long);
 - 5) body (solid or plate type);
- h) rotary swivel - bail adapters:
 - 1) rated load;
 - 2) tool joint size/style;
 - 3) type of equipment on which adapters will be used;
- i) rotary swivels:
 - 1) rated load(s);
 - 2) pressure rating;
 - 3) size and type of connection from the gooseneck to the rotary drilling hose;
 - 4) size and type of threaded connections on swivel stem and on saver sub if provided with swivel;
- j) top drive/power swivel/power subs:
 - 1) rated load(s);
 - 2) torque speed and power ratings;
 - 3) pressure rating;
 - 4) min internal bore (water course);
 - 5) size and type of connection from the gooseneck or s-pipe to the rotary drilling hose;
 - 6) size and type of threaded connections on main stem and on saver sub if provided;
 - 7) if no integral block is provided, the type of connection and orientation of unit with respect to the reeving of lines on the traveling block;
 - 8) electrical and hydraulic requirements;
 - 9) torque transfer method (torque track, tube, or wire line);
- k) spiders, if capable of being used as elevators:
 - 1) rated load;
 - 2) size or range of sizes;
 - 3) actuation (hydraulic, air or manual);

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- 4) interfacing requirements;
- l) wireline anchors:
 - 1) single line rated load;
 - 2) mounting arrangement (floor, leg mounted, or derrick mounted);
 - 3) wireline size;
 - 4) number of wraps on drum;
 - 5) fixed drum or rotating drum;
 - 6) right hand or left-hand windings on drum;
 - 7) load cell type (tension, compression, electronic, hydraulic or none);
 - 8) line anchoring method (plate, clamp, or other);
- m) drill string motion compensators:
 - 1) type: crown mounted or in-line/below traveling block;
 - 2) wireline size, number of lines;
 - 3) compensating rated load;
 - 4) mechanically locked rated load (max);
 - 5) compensator stroke length;
 - 6) orientation of crown/block reeving in reference to guide rails;
 - 7) interface equipment;
 - 8) hose bundle location if in-line compensator;
 - 9) maximum allowable working pressure;
- n) kelly spinners, if capable of being used as hoisting equipment:
 - 1) rated load;
 - 2) connection type;
 - 3) drive method (hydraulic or air);
- o) pressure vessels and piping mounted onto hoisting equipment:
 - 1) max pressure rating;
 - 2) type of equipment with which to be used;
 - 3) pipe size (if applicable);
- p) safety clamps, if capable of being used as hoisting equipment:
 - 1) rated load;
 - 2) size range;
- q) casing running tool:
 - 1) casing load;
 - 2) required torque;
 - 3) casing/tubing specs (size, weight, grade, connection);
 - 4) mud line pressure;
 - 5) minimum internal bore/water course (if applicable);
 - 6) upper connection—size and type of connection on top of tool (if applicable);
 - 7) electrical, pneumatic, and hydraulic utility requirements (if applicable);
 - 8) type of tool (mechanical, hydraulic, etc.);
- r) hydraulic hoisting cylinders:

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- 1) bore size;
 - 2) rod size;
 - 3) pressure rating;
 - 4) stroke;
 - 5) single acting or double acting;
 - 6) mounting requirements;
 - 7) piston seal requirements;
 - 8) lateral loads (if any);
- s) hoisting equipment adapters:
- 1) rated load;
 - 2) type of equipment on which adapters and connectors will be used.

Annex D

(informative)

Example Calculations for Drill-string Motion Compensator

D.1 General

The following (Table C.1) is a spreadsheet based calculation that displays the input data and the calculated Drill-string Motion Compensator performance as a function of compensator stroke. In this example, real gas characteristics are imported from the National Institute of Standards and Technology (NIST) as listed in 9.12.2.5.1. Other forms of calculations are acceptable as long as similar data and results are depicted.

Table D.1 – Drill-string Motion Compensator Calculations

API 8C Summary Data:			Calculation Method	
Maximum Supply Pressure (MSP)	3,000	Psig	Method	Real Gas, Isentropic-NIST
Maximum Compression Pressure (MCP)	3,869	Psig	Gas	Air
Maximum Allowable Working Pressure (MAWP)	4,150	Psig	Temperature	80 °F
Maximum Compensating Hook Load (Max CHL)	619	Kips	Base Entropy	1.2482 BTU/lbm-R
Rated Compensating Hook Load (Rated CHL)	600	Kips		

Drill-String Motion Compensator Rating Calculation				
Maximum Supply Pressure (MSP)	3.000	psig	This is the maximum pressure that can be applied to the system	
PRV Tolerance Factor	93	%	This is the PRV tolerance factor to allow for inaccuracies with	
Net Volume (BE)	386,737	In3	Includes APV, pipe, and HP accumulator air volume	
Net Volume (RE)	23,991	In3	Includes LP accumulator and rod side annulus volume, less min oil volume	
Area BE	355	In2	This is the area of the blind end of the compensator cylinder	
Area RE	75	In2	This is the annulus area of the rod end of the compensator cylinder	
HP Accumulator Diameter	22.83	In		
HP Accumulator volume	58.827	In3		
HP Accumulator Min Oil Volume	62,247	In3	This is equal to compensator cylinder total volume	
Compensator Cylinder ID	19.5	In		
Rod OD	11	In		
Stroke	300	In	This is the compensator cylinder total stroke	
Number of line parts	0		This is the number of line falls/mechanical advantage	
Min LP Accumulator Oil Volume	0	In3	This is the LP accumulators minimum oil volume	
Min LP Accumulator pressure	7.55	Psig	This is the LP accumulator's minimum pressure	
LP Accumulator volume	12.816	In3	This is the LP accumulator's total volume	
APV Volume	366,142	In3	APV volume per compensator cylinder	
Air Line Volume	15,015	In3	Pipeline volume to compensator from APVs	
Hose Line Volume	13,154	In3	This is the hose volume from the valve manifold to the compensator	
Dead Weight	22,753	Lb	Total dead load on compensator	
Polytropic Gas Exponent (n)	1.4		Polytropic constant for use with gas compressor calculation for low pressure	

Table D.1—Drill-string Motion Compensator Calculations (Continued)

STROKE POSITION (in)	VESSEL HEAVE (ft)	DSC PRESS (psig)	TOTAL DEAD WT (lb)	I CSL (lb)	EFFECTIVE POLYTROPIC CONSTANT	I T (°F)	LOAD VARIATION (%)
0	-12.5	2,927.68	11,468.83	573,827.40	1.945	74.2	5.3
10	-11.7	2,937.71	11,468.83	575,870.57	1.945	75.6	4.9
20	-10.8	2,947.79	11,468.83	577,925.33	1.946	76.9	4.6
30	-10.0	2,957.92	11,468.83	579,991.79	1.946	78.3	4.2
40	-9.2	2,968.12	11,468.83	582,070.03	1.947	79.7	3.9
50	-8.3	2,978.37	11,468.83	584,160.14	1.947	81.1	3.6
60	-7.5	2,988.69	11,468.83	586,262.20	1.948	82.4	3.2
70	-6.7	2,999.06	11,468.83	588,376.31	1.948	83.8	2.9
80	-5.8	3,009.49	11,468.83	590,502.56	1.949	85.2	2.5
90	-5.0	3,019.98	11,468.83	592,641.03	1.949	86.5	2.2
100	-4.2	3,030.53	11,468.83	594,791.83	1.950	87.9	1.8
110	-3.3	3,041.14	11,468.83	596,955.05	1.950	89.3	1.4
120	-2.5	3,051.82	11,468.83	599,130.78	1.951	90.6	1.1
130	-1.7	3,062.55	11,468.83	601,319.11	1.951	92.0	0.7
140	-0.8	3,073.35	11,468.83	603,520.14	1.952	93.4	0.4
150	0.0	3,084.21	11,468.83	605,733.98	1.952	94.8	0
160	0.8	3,095.14	11,468.83	607,960.71	1.952	96.1	0.4
170	1.7	3,106.12	11,468.83	610,200.44	1.953	97.5	0.7
180	2.5	3,117.18	11,468.83	612,453.27	1.953	98.9	1.1
190	3.3	3,128.29	11,468.83	614,719.29	1.954	100.2	1.5
200	4.2	3,139.48	11,468.83	616,998.61	1.954	101.6	1.9
210	5.0	3,150.72	11,468.83	619,291.34	1.955	103.0	2.2
220	5.8	3,162.04	11,468.83	621,597.57	1.955	104.3	2.6
230	6.7	3,173.42	11,468.83	623,917.42	1.956	105.7	3.0
240	7.5	3,184.87	11,468.83	626,250.98	1.956	107.1	3.4
250	8.3	3,196.38	11,468.83	628,598.36	1.957	108.5	3.8
260	9.2	3,207.97	11,468.83	630,959.68	1.957	109.8	4.2
270	10.0	3,219.62	11,468.83	633,335.04	1.958	111.2	4.6
280	10.8	3,231.34	11,468.83	635,724.55	1.958	112.6	5.0
290	11.7	3,243.14	11,468.83	638,128.32	1.959	113.9	5.3
300	12.5	3,255.00	11,468.83	640,546.47	N.A.	115.3	5.7

DRAFT

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D.2 Performance Plot

Figure C.1 is produced from the calculated data shown in C.1 for the 100% rated compensated hook load. Separate plots may be made for the 50% and 75% curves or all curves may be shown on a single plot. See 9.13.2.5.1 for detailed compensator performance curve requirements.

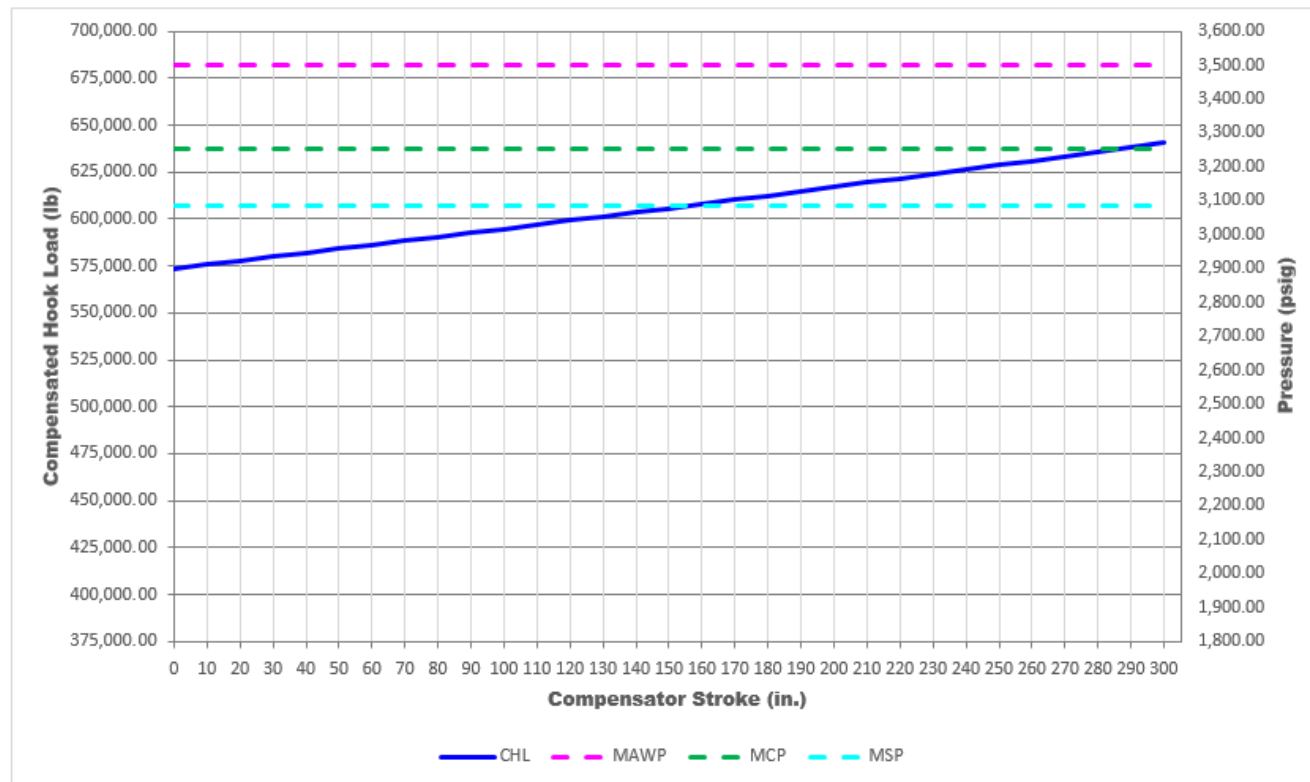


Figure D.1 – Compensated Hook Load and Pressure vs Stroke

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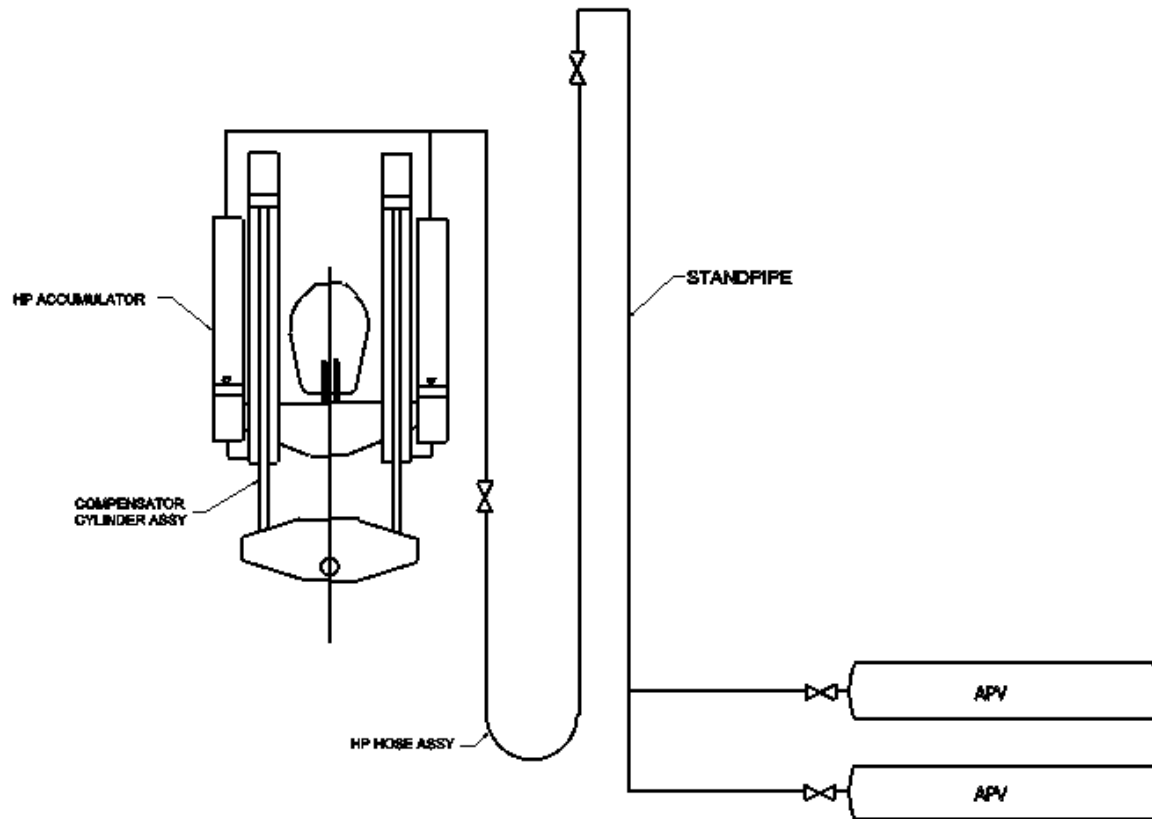


Figure D.2 Typical Drill-string Motion Compensator System

Annex E (informative)

Effective Polytropic Constants for Isentropic Compression and Expansion of Air and Nitrogen

Tables E.1 through E.12 are polytropic constants that can be used for Drill-string Motion Compensator performance curves as an alternative to the NIST, Benedict–Webb–Rubin EOS, van der Waals EOS, or actual test data as described in 9.13.2.5.1.

NOTE Use Tables E.1 through E.6 for compressed air or Tables E.7 through E.12 for compressed nitrogen.

Table E.1—Polytropic Constant Table—Air Compressed to 85 % of Initial Volume

Isentropic Compression of Air to 85 % of Initial Volume										
Initial Pressure (psig)	Final Pressure					Effective Polytropic Constant				
	Initial Temperature (°F)					Initial Temperature (°F)				
	-40	-4	40	80	120	-40	-4	40	80	120
500	640	639	639	638	638	1.4772	1.4720	1.4663	1.4617	1.4573
1000	1302	1296	1292	1289	1286	1.6009	1.5763	1.5549	1.5401	1.5279
1500	2009	1988	1972	1961	1954	1.7831	1.7190	1.6684	1.6363	1.6119
2000	2784	2728	2687	2662	2645	2.0226	1.8985	1.8053	1.7491	1.7079
2500	3642	3527	3444	3396	3362	2.3039	2.1071	1.9616	1.8757	1.8142
3000	4588	4390	4248	4166	4110	2.6039	2.3331	2.1312	2.0125	1.9284
3500	5617	5317	5099	4975	4888	2.9014	2.5646	2.3078	2.1557	2.0479
4000	6719	6305	5998	5821	5698	3.1825	2.7922	2.4858	2.3015	2.1703
4500	7882	7348	6942	6705	6539	3.4400	3.0094	2.6606	2.4469	2.2934
5000	9093	8438	7928	7624	7411	3.6718	3.2126	2.8293	2.5896	2.4154

Table E.2—Polytropic Constant Table—Air Compressed to 90 % of Initial Volume

Isentropic Compression of Air to 90 % of Initial Volume										
Initial Pressure (psig)	Final Pressure					Effective Polytropic Constant				
	Initial Temperature (°F)					Initial Temperature (°F)				
	-40	-4	40	80	120	-40	-4	40	80	120
500	586	586	586	586	585	1.4739	1.4690	1.4638	1.4594	1.4553
1000	1185	1182	1180	1178	1177	1.5916	1.5686	1.5485	1.5346	1.5232
1500	1810	1798	1789	1783	1779	1.7648	1.7045	1.6569	1.6267	1.6036
2000	2471	2440	2418	2404	2394	1.9928	1.8756	1.7876	1.7345	1.6956
2500	3177	3114	3069	3043	3024	2.2617	2.0748	1.9369	1.8555	1.7973
3000	3929	3823	3746	3702	3671	2.5503	2.2914	2.0992	1.9865	1.9066
3500	4726	4566	4449	4381	4334	2.8391	2.5146	2.2688	2.1238	2.0211
4000	5559	5341	5177	5081	5015	3.1148	2.7353	2.4403	2.2639	2.1386
4500	6425	6144	5929	5801	5712	3.3701	2.9475	2.6096	2.4042	2.2571
5000	7315	6972	6702	6540	6426	3.6022	3.1477	2.7738	2.5422	2.3748

Table E.3—Polytropic Constant Table—Air Compressed to 95 % of Initial Volume

Isentropic Compression of Air to 95 % of Initial Volume										
Initial Pressure (psig)	Final Pressure					Effective Polytropic Constant				
	Initial Temperature (°F)					Initial Temperature (°F)				
	-40	-4	40	80	120	-40	-4	40	80	120
500	540	540	540	540	540	1.4708	1.4663	1.4615	1.4574	1.4535
1000	1086	1085	1084	1083	1082	1.5832	1.5616	1.5428	1.5296	1.5188
1500	1642	1637	1633	1631	1629	1.7484	1.6916	1.6466	1.6180	1.5961
2000	2214	2201	2192	2186	2182	1.9659	1.8550	1.7717	1.7214	1.6844
2500	2804	2778	2759	2749	2741	2.2233	2.0456	1.9146	1.8374	1.7820
3000	3413	3369	3338	3319	3306	2.5011	2.2536	2.0703	1.9630	1.8869
3500	4039	3974	3927	3899	3879	2.7812	2.4687	2.2333	2.0948	1.9969
4000	4680	4592	4526	4486	4459	3.0509	2.6826	2.3988	2.2298	2.1099
4500	5334	5221	5134	5082	5046	3.3031	2.8897	2.5627	2.3651	2.2240
5000	5997	5860	5752	5686	5639	3.5346	3.0863	2.7224	2.4988	2.3377

Table E.4—Polytropic Constant Table—Air Expanded to 105 % of Initial Volume

Isentropic Expansion of Air to 105 % of Initial Volume										
Initial Pressure (psig)	Final Pressure					Effective Polytropic Constant				
	Initial Temperature (°F)					Initial Temperature (°F)				
	-40	-4	40	80	120	-40	-4	40	80	120
500	464	465	465	465	465	1.4655	1.4617	1.4574	1.4538	1.4503
1000	925	926	927	927	928	1.5688	1.5496	1.5328	1.5210	1.5113
1500	1378	1382	1384	1386	1387	1.7202	1.6692	1.6288	1.6030	1.5831
2000	1820	1829	1836	1840	1843	1.9196	1.8195	1.7442	1.6986	1.6651
2500	2249	2267	2280	2288	2294	2.1566	1.9951	1.8761	1.8059	1.7555
3000	2665	2695	2717	2730	2739	2.4145	2.1875	2.0201	1.9222	1.8528
3500	3070	3113	3147	3166	3180	2.6774	2.3879	2.1714	2.0445	1.9549
4000	3465	3524	3569	3597	3616	2.9342	2.5888	2.3257	2.1700	2.0599
4500	3852	3926	3986	4021	4047	3.1781	2.7852	2.4796	2.2965	2.1663
5000	4232	4323	4396	4441	4474	3.4058	2.9738	2.6305	2.4220	2.2727

Table E.5—Polytropic Constant Table—Air Expanded to 110 % of Initial Volume

Isentropic Expansion of Air to 110 % of Initial Volume										
Initial Pressure (psig)	Final Pressure					Effective Polytropic Constant				
	Initial Temperature (°F)					Initial Temperature (°F)				
	-40	-4	40	80	120	-40	-4	40	80	120
500	433	433	433	433	434	1.4632	1.4596	1.4557	1.4523	1.4489
1000	860	861	862	863	864	1.5625	1.5444	1.5285	1.5173	1.5080
1500	1272	1278	1283	1286	1289	1.7079	1.6595	1.6210	1.5964	1.5775
2000	1666	1682	1693	1700	1706	1.8995	1.8041	1.7323	1.6887	1.6566
2500	2038	2069	2092	2105	2115	2.1274	1.9730	1.8594	1.7922	1.7440
3000	2389	2439	2477	2500	2516	2.3762	2.1585	1.9982	1.9044	1.8379
3500	2720	2794	2850	2884	2908	2.6310	2.3522	2.1443	2.0225	1.9365
4000	3036	3135	3212	3258	3291	2.8810	2.5470	2.2935	2.1438	2.0380
4500	3339	3463	3562	3623	3667	3.1201	2.7381	2.4427	2.2662	2.1410
5000	3631	3781	3903	3979	4034	3.3449	2.9225	2.5894	2.3879	2.2440

Table E.6—Polytropic Constant Table—Air Expanded to 115 % of Initial Volume

Isentropic Expansion of Air to 115 % of Initial Volume										
Initial Pressure (psig)	Final Pressure					Effective Polytropic Constant				
	Initial Temperature (°F)					Initial Temperature (°F)				
	-40	-4	40	80	120	-40	-4	40	80	120
500	405	405	405	406	406	1.4610	1.4578	1.4540	1.4508	1.4476
1000	802	804	805	807	808	1.5567	1.5396	1.5245	1.5138	1.5049
1500	1180	1188	1194	1198	1201	1.6967	1.6506	1.6139	1.5904	1.5723
2000	1534	1554	1569	1578	1585	1.8811	1.7899	1.7213	1.6796	1.6489
2500	1860	1899	1929	1946	1959	2.1006	1.9528	1.8440	1.7796	1.7334
3000	2159	2223	2272	2301	2322	2.3409	2.1319	1.9780	1.8880	1.8242
3500	2433	2527	2599	2642	2673	2.5877	2.3192	2.1193	2.0022	1.9196
4000	2688	2813	2911	2971	3013	2.8311	2.5081	2.2638	2.1197	2.0179
4500	2927	3083	3210	3287	3343	3.0651	2.6941	2.4085	2.2383	2.1176
5000	3153	3341	3496	3593	3664	3.2864	2.8742	2.5512	2.3564	2.2175

Table E.7—Polytropic Constant Table—Nitrogen Compressed to 85 % of Initial Volume

Isentropic Compression of Nitrogen to 85 % of Initial Volume										
Initial Pressure (psig)	Final Pressure					Effective Polytropic Constant				
	Initial Temperature (°F)					Initial Temperature (°F)				
	-40	-4	40	80	120	-40	-4	40	80	120
500	640	640	639	638	638	1.4823	1.4765	1.4706	1.4660	1.4617
1000	1304	1298	1294	1290	1288	1.6121	1.5864	1.5642	1.5489	1.5365
1500	2014	1993	1976	1966	1958	1.7968	1.7329	1.6817	1.6491	1.6241
2000	2788	2734	2694	2669	2651	2.0319	1.9126	1.8208	1.7646	1.7231
2500	3640	3533	3453	3405	3372	2.3012	2.1170	1.9767	1.8923	1.8311
3000	4573	4391	4256	4177	4121	2.5840	2.3348	2.1435	2.0285	1.9458
3500	5582	5310	5106	4986	4901	2.8625	2.5556	2.3151	2.1694	2.0645
4000	6657	6284	5999	5831	5712	3.1253	2.7712	2.4865	2.3116	2.1851
4500	7788	7308	6935	6711	6552	3.3665	2.9763	2.6538	2.4523	2.3053
5000	8964	8377	7908	7624	7421	3.5841	3.1679	2.8145	2.5896	2.4238

Table E.8—Polytropic Constant Table—Nitrogen Compressed to 90 % of Initial Volume

Isentropic Compression of Nitrogen to 90 % of Initial Volume										
Initial Pressure (psig)	Final Pressure					Effective Polytropic Constant				
	Initial Temperature (°F)					Initial Temperature (°F)				
	-40	-4	40	80	120	-40	-4	40	80	120
500	587	586	586	586	586	1.4787	1.4734	1.4679	1.4635	1.4595
1000	1187	1184	1181	1179	1178	1.6024	1.5784	1.5574	1.5430	1.5313
1500	1812	1801	1791	1786	1781	1.7782	1.7181	1.6698	1.6390	1.6154
2000	2473	2444	2421	2408	2398	2.0022	1.8895	1.8027	1.7495	1.7102
2500	3176	3118	3074	3048	3030	2.2599	2.0848	1.9518	1.8717	1.8137
3000	3922	3824	3751	3708	3677	2.5321	2.2939	2.1116	2.0022	1.9236
3500	4707	4562	4453	4388	4342	2.8026	2.5068	2.2765	2.1375	2.0376
4000	5528	5330	5178	5087	5023	3.0603	2.7161	2.4420	2.2744	2.1535
4500	6377	6124	5925	5805	5720	3.2993	2.9168	2.6043	2.4104	2.2694
5000	7249	6941	6693	6541	6432	3.5172	3.1057	2.7610	2.5435	2.3840

Table E.9—Polytropic Constant Table—Nitrogen Compressed to 95 % of Initial Volume

Isentropic Compression of Nitrogen to 95 % of Initial Volume										
Initial Pressure (psig)	Final Pressure					Effective Polytropic Constant				
	Initial Temperature (°F)					Initial Temperature (°F)				
	-40	-4	40	80	120	-40	-4	40	80	120
500	540	540	540	540	540	1.4754	1.4705	1.4654	1.4612	1.4575
1000	1086	1085	1084	1083	1083	1.5936	1.5711	1.5514	1.5378	1.5267
1500	1643	1638	1635	1632	1630	1.7615	1.7047	1.6591	1.6299	1.6075
2000	2215	2203	2193	2188	2183	1.9755	1.8686	1.7864	1.7359	1.6986
2500	2804	2780	2762	2751	2743	2.2224	2.0558	1.9293	1.8531	1.7980
3000	3410	3370	3340	3322	3309	2.4846	2.2566	2.0826	1.9784	1.9035
3500	4032	3973	3928	3901	3882	2.7469	2.4621	2.2414	2.1085	2.0132
4000	4668	4588	4526	4489	4462	2.9989	2.6652	2.4012	2.2405	2.1248
4500	5315	5214	5133	5084	5049	3.2349	2.8610	2.5586	2.3720	2.2367
5000	5971	5848	5748	5686	5642	3.4520	3.0467	2.7112	2.5011	2.3475

Table E.10—Polytropic Constant Table—Nitrogen Expanded to 105 % of Initial Volume

Isentropic Expansion of Nitrogen to 105 % of Initial Volume										
Initial Pressure (psig)	Final Pressure					Effective Polytropic Constant				
	Initial Temperature (°F)					Initial Temperature (°F)				
	-40	-4	40	80	120	-40	-4	40	80	120
500	464	464	465	465	465	1.4698	1.4655	1.4610	1.4573	1.4540
1000	925	926	927	927	928	1.5786	1.5585	1.5408	1.5286	1.5186
1500	1377	1381	1383	1385	1387	1.7327	1.6817	1.6405	1.6141	1.5938
2000	1819	1828	1834	1839	1842	1.9293	1.8327	1.7582	1.7123	1.6784
2500	2249	2266	2278	2286	2292	2.1571	2.0053	1.8902	1.8209	1.7707
3000	2667	2694	2715	2728	2737	2.4009	2.1915	2.0324	1.9371	1.8687
3500	3074	3114	3145	3164	3178	2.6472	2.3832	2.1800	2.0580	1.9706
4000	3473	3526	3569	3595	3614	2.8869	2.5742	2.3294	2.1811	2.0746
4500	3863	3931	3986	4020	4045	3.1147	2.7601	2.4773	2.3042	2.1792
5000	4248	4330	4398	4440	4471	3.3278	2.9383	2.6218	2.4257	2.2832

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Table E.11—Polytropic Constant Table—Nitrogen Expanded to 110 % of Initial Volume

Isentropic Expansion of Nitrogen to 110 % of Initial Volume										
Initial Pressure (psig)	Final Pressure					Effective Polytropic Constant				
	Initial Temperature (°F)					Initial Temperature (°F)				
	-40	-4	40	80	120	-40	-4	40	80	120
500	433	433	433	433	433	1.4674	1.4634	1.4591	1.4556	1.4524
1000	859	860	862	863	864	1.5720	1.5530	1.5362	1.5246	1.5150
1500	1271	1277	1282	1285	1287	1.7202	1.6716	1.6324	1.6072	1.5878
2000	1665	1680	1691	1698	1704	1.9093	1.8170	1.7459	1.7021	1.6696
2500	2038	2067	2089	2102	2112	2.1285	1.9833	1.8732	1.8069	1.7587
3000	2392	2438	2474	2496	2512	2.3639	2.1630	2.0104	1.9191	1.8535
3500	2728	2795	2848	2880	2903	2.6026	2.3484	2.1531	2.0359	1.9520
4000	3049	3139	3210	3255	3287	2.8361	2.5336	2.2976	2.1550	2.0526
4500	3358	3471	3563	3620	3662	3.0592	2.7146	2.4412	2.2743	2.1539
5000	3657	3793	3906	3978	4030	3.2692	2.8888	2.5818	2.3922	2.2547

Table E.12—Polytropic Constant Table—Nitrogen Expanded to 115 % of Initial Volume

Isentropic Expansion of Nitrogen to 115 % of Initial Volume										
Initial Pressure (psig)	Final Pressure					Effective Polytropic Constant				
	Initial Temperature (°F)					Initial Temperature (°F)				
	-40	-4	40	80	120	-40	-4	40	80	120
500	405	405	405	405	406	1.4651	1.4614	1.4574	1.4541	1.4510
1000	801	803	804	806	807	1.5660	1.5480	1.5320	1.5209	1.5118
1500	1178	1186	1192	1196	1199	1.7088	1.6625	1.6250	1.6009	1.5823
2000	1532	1551	1566	1576	1583	1.8909	1.8027	1.7346	1.6926	1.6615
2500	1860	1897	1925	1942	1955	2.1023	1.9632	1.8576	1.7940	1.7478
3000	2162	2222	2268	2296	2317	2.3297	2.1367	1.9902	1.9025	1.8395
3500	2442	2528	2596	2637	2667	2.5611	2.3161	2.1282	2.0156	1.9348
4000	2704	2818	2909	2966	3007	2.7884	2.4959	2.2683	2.1309	2.0323
4500	2951	3093	3210	3283	3337	3.0067	2.6720	2.4077	2.2466	2.1305
5000	3186	3356	3499	3590	3658	3.2132	2.8422	2.5445	2.3612	2.2284

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Bibliography

- [1] ISO 10012, *Quality Assurance Requirements for Measuring Equipment—Part 1: Metrological Confirmation System for Measuring Equipment*
- [2] FEM,⁷ *Rules for the Design of Hoisting Appliances*
- [3] MIL-STD-120,⁸ *Gage Inspection*
- [4] ASTM A668, *Standard Specification for Steel Forgings, Carbon and Alloy, for General Industrial Use*
- [5] ASTM A781, *Standard Specification for Castings, Steel and Alloy, Common Requirements for General Industrial Use*
- [6] ASTM A788, *Standard Specification for Steel Forgings, General Requirements*
- [7] AMS-H-6875C, *Heat treatment of Steels, Aircraft Practice Process*
- [8] API Recommended Practice 8B, *Recommended Practice for Procedures for Inspections, Maintenance, Repair, and Remanufacture of Hoisting Equipment*
- [9] ASTM E186, *Standard Reference Radiographs for Heavy-Walled (2 to 4 1/2-in. (51 to 114-mm)) Steel Castings*
- [10] ASTM E280, *Standard Reference Radiographs for Heavy-Walled (4 1/2 to 12-in. (114 to 305-mm)) Steel Castings*
- [11] ASTM E446, *Standard Reference Radiographs for Steel Castings Up to 2 in. (51 mm) in Thickness*

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