Drilling and Well Servicing Equipment

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Drilling and Well Servicing Equipment

1 Scope

This specification provides general principles and specifies requirements for design, manufacture, and testing of new drilling and well-servicing equipment and of replacement primary load-carrying components manufactured subsequent to the publication of this specification.

This specification is applicable to the following equipment:
a) rotary tables;
b) rotary bushings;
c) standard rotary slips designed for use in standard rotary bowls with a 33.333 cm/m (4 in./ft) API taper;
d) nonstandard rotary slips without a taper of 33.333 cm/m (4 in./ft) for use in manual spiders as described in Item i);
e) high-pressure mud and cement hoses;
f) piston mud-pump components;
g) drawworks components;
h) manual spiders that use standard rotary slips as described in Item c) that are not capable for use as elevators and are installed on or above the master bushing/rotary table;
i) manual spiders that use nonstandard rotary slips not having a taper of 33.333 cm/m (4 in./ft) not capable of use as elevators, and installed on or above the master bushing/rotary table;
j) spring, pneumatic, or hydraulic spiders with integral slips not capable for use as elevators and are installed on or above the master bushing/rotary table;
k) spring, pneumatic or hydraulic spiders with integral slips not capable for use as elevators and are installed in, or partly in, the rotary table;
l) manual tongs;
m) safety clamps not used as hoisting devices;
n) power tongs, including spinning wrenches;
o) blowout preventer (BOP) handling systems;
p) pressure-relieving devices for high-pressure drilling fluid circulating systems;
q) snub-lines for manual and power tongs.

2 Normative References
The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.
API Specification 5B, Specification for Threading, Gauging and Thread Inspection of Casing, Tubing, and Line Pipe Threads
API Specification 6A, Specification for Wellhead and Christmas Tree Equipment
API Specification 9B, Recommended Practice on Application, Care, and Use of Wire Rope for Oilfield Service
AGMA 2004-C08 1, Gear Materials, Heat Treatment and Processing Manual
AISC 360-05 2, Specification for Structural Steel Buildings
ASME B1.1-2003 3, Unified Inch Screw Threads (UN and UNR Thread Form)
ASME B1.2, Gages and Gaging for Unified Inch Screw Threads
ASME B16.34, Valves Flanged, Threaded, and Welding End
ASME B30.9, Slings
ASME B31.3, Process Piping
ASME Boiler and Pressure Vessel Code, Section V: Nondestructive Examination
ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, Rules for Construction of High Pressure Vessels
ASME Boiler and Pressure Vessel Code, Section VIII, Division 2: Rules for Construction of High Pressure Vessels
- Alternative Rules
ASME Boiler and Pressure Vessel Code, Section IX: Welding and Brazing Qualifications
3 Terms, Definitions, and Acronyms

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

3.1 Terms and Definitions

3.1.1 BOP handling systems and equipment

Equipment designed for the purpose of storing, lifting, lowering, and transporting BOP stacks used on drilling and/or production facilities or rigs.

3.1.2 BOP stack

BOPs assembled as a unit, including all attachments.
3.1.4 design load
Sum of the static and dynamic loads that would induce the maximum allowable stress in the equipment.

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

3.1.6 design verification test
Test undertaken to validate the integrity of the design calculations used.

3.1.7 drilling liquids
Liquid solutions (referred to as mud) conveyed at high pressure through the high-pressure mud piping system, mud standpipe, rotary hose, rotary swivel stem, drill string, and drill bit to accommodate the drilling process.
NOTE For the purpose of this specification, drilling liquids do not include fluids containing pressurized air or gasses of any kind.

3.1.8 dynamic load
Load applied to the equipment due to acceleration effects.

3.1.9 end connector
A fitting located at the end of a hose assembly featuring line pipe threads that allows a hose assembly to be connected to a piping system.
EXAMPLE A flange or hub, as specified in API 6A, or a hammer lug union that is butt-welded to, or is manufactured as an integral part of the hose coupling material.
NOTE 1 See API 5B for line pipe thread specifications.
NOTE 2 See Figure 11.

3.1.10 equivalent round ER
Standard for comparing variously shaped sections to round bars, used in determining the response to hardening characteristics when heat treating low-alloy and martensitic corrosion-resistant steels.

3.1.11 hazardous area or zone
A location where fire or explosion hazards may exist due to flammable gases or vapors, flammable liquids, combustible dust, or ignitable fibers or flyings.

3.1.12 high pressure
Working pressure values ranging from 10.3 MPa to 103.4 MPa (1500 psi to 15,000 psi).
NOTE See Table 9.
3.1.13  
high-pressure cement hose  
A hose used strictly for the conveyance of cement slurries at high pressure.

3.1.14  
high-pressure mud hose  
A rotary hose, vibrator hose, or jumper hose.

3.1.15  
hose assembly  
Consists of hose body and hose coupling.  
NOTE See Figure 11.

3.1.16  
hose body  
Plain end hose with no hose couplings or end connectors attached.

3.1.17  
hose coupling  
Fitting attached to the ends of the hose body.

3.1.18  
hose end connector  
A fitting located at the end of a hose assembly featuring line pipe threads as specified in API 5B, or for example a flange or hub as specified in API 6A, or hammer lug union, that is butt-welded to or is manufactured as an integral part of the hose coupling material that allows a hose assembly to be connected to a piping system.  
NOTE See Figure 11.

3.1.19  
hose design family  
Hose assemblies of different internal diameters and working pressures with the same number of reinforcing plies and utilizing the same method of hose coupling attachment and designed to the same design methodology and maximum allowable stress criteria.

3.1.20  
identical design concept  
Property of a family of units whereby all units of the family have similar geometry in the primary load-carrying areas.

3.1.21  
jumper hose  
A flexible hose assembly used to convey high-pressure drilling liquids that is located anywhere in the high-pressure mud piping system between the mud-pump discharge outlet and the mud standpipe manifold on the drill floor to accommodate relative movement between them.

3.1.22  
linear indication  
An indication, revealed by NDE, having a length at least three times its width.

3.1.23  
loose gear  
Off-the-shelf equipment including, but not limited to, shackles, chain, hooks, connecting links, tumbuckles, binders, sheave blocks, and swivels used in an assembly to suspend, secure, or lift a load.

3.1.24  
maximum allowable stress  
Specified minimum yield strength divided by the design safety factor.

3.1.25  
maximum working temperature  
The upper limit of the temperature range specified in 9.6.3.
3.1.26 minimum bend radius
MBR
The minimum hose bending radius dimension measured from the centerline of the hose specified in Table 9.
NOTE See Figure 11.
3.1.27 moonpool guidance system
Structure installed to prevent contact between the BOP stack and the structure of a floating MODU during the deployment and retrieval of the BOP stack.
3.1.28 multiple load paths
Two or more independent mechanical or structural primary load-carrying components incorporated in a BOP handling system that collectively support the static and dynamic load simultaneously.
3.1.29 primary load
Load that arises within the equipment when the equipment is performing its primary design function.
3.1.30 primary load-carrying component
Component of the equipment through which the primary load is carried.
3.1.31 proof load test
Production load test undertaken to validate the structural soundness of the equipment.
3.1.32 rated load
Maximum operating load, both static and dynamic, to be applied to the equipment.
NOTE The rated load is numerically equivalent to the design load.
3.1.33 rated speed
Rate of rotation, motion, or velocity as specified by the manufacturer.
3.1.34 repair
Removal of defects from, and refurbishment of, a component or assembly by welding during the manufacturing process.
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.
3.1.35 rotary hose
A flexible hose assembly used to convey high-pressure drilling liquids between the top of the mud standpipe and the rotary swivel.
3.1.36 rounded indication
Indication, revealed by NDE, with a circular or elliptical shape and having a length less than three times its width.
3.1.37 safe working load
Design load reduced by the dynamic load.
3.1.38 size class
Designation of the dimensional interchangeability of equipment specified herein.
3.1.39 size range
Range of tubular diameters to which an assembly is applicable.

3.1.40
sling
An assembly typically manufactured from wire rope, chain, or synthetic material used for lifting when connected between a load and a lifting mechanism.

3.1.41
snub-line
Wire rope, one end of which is fastened to the end of a pipe tong handle attachment point and the other end secured to hold the tong stationary while the tong is in use.
NOTE Snub-lines do not work over a sheave or bend.

3.1.42
special process
Operation that may change or affect the mechanical properties, including toughness, of the materials used in the equipment.

3.1.43
static load
The load exerted on the BOP handling system by the static weight of the BOP stack.

3.1.44
test unit
Prototype unit upon which a design verification test is conducted.

3.1.45
vibrator hose
A flexible hose assembly used to convey high-pressure drilling liquids between two piping systems or between the mud-pump discharge outlet and the high-pressure mud piping system for the purpose of attenuating noise and/or vibration, or compensating for misalignment and/or thermal expansion.

3.1.46
wire rope design factor
The ratio between documented minimum breaking strength and the working load limit as applied to wire rope and slings.
NOTE This term should not be confused with design safety factor defined in 3.1.5.

3.1.47
working load limit
A load value assigned to loose gear by the manufacturer that is a fraction of the breaking load value which should not be exceeded during use of BOP handling systems and equipment.

3.2 Acronyms
BOP blowout preventer
HAZ heat-affected zone
MODU mobile offshore drilling unit
NDE nondestructive examination
PWHT post-weld heat treatment
TIR total indicated runout

4 Design
4.1 Design Conditions
Drilling 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 safe operation.
The following design conditions shall apply.
The design load and the safe working load are defined as in Section 3. The operator of the equipment shall be
responsible for the determination of the safe working load for specific operations; Unless changed by a supplementary requirement (see Annex A, SR2 and SR2A), the design and minimum operating temperature for rotary tables, rotary slips, power tongs and drawworks is 0 °C (32 °F). The design and minimum operating temperature for safety clamps, spiders, and manual tongs is ≥ 20 °C (≥ 4 °F), unless changed by a supplementary requirement.

Caution—Use of equipment covered by this specification at rated loads and temperatures below the design temperatures noted above is not recommended unless appropriate materials with the required toughness properties at lower design temperatures have been used in the manufacture of the equipment (see Annex A, SR2 and SR2A).

4.2 Strength Analysis

4.2.1 General
The equipment design analysis shall address excessive yielding, fatigue or buckling as possible modes of failure. The strength analysis shall be based on the elastic theory. Alternatively, ultimate strength (plastic) analysis may be used where justified by design documentation. All forces that may govern the design shall be taken into account. For each cross-section to be considered, the most unfavorable combination, position, and direction of forces shall be used.

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

4.2.3 Empirical Relationships
Empirical relationships may be used in lieu of analysis, provided such relationships are supported by documented strain gauge test results that verify the stresses within the component. Equipment or components which, by their design, do not permit the attachment of strain gauges to verify the design shall be qualified by testing in accordance with 5.6.

4.2.4 Equivalent Stress
The strength analysis shall be based on elastic theory. The nominal equivalent stress, according to the Von Mises-Hencky theory, caused by the design load shall not exceed the maximum allowable stress calculated by Equation (1).

\[ \sigma_{\text{allow}} = \frac{F_{DS} \cdot S_{Y_{\text{min}}}}{\varphi} \]  

where 
- \( S_{Y_{\text{min}}} \) is the specified minimum yield strength; 
- \( F_{DS} \) is the design safety factor.

4.2.5 Ultimate Strength (Plastic) Analysis
An ultimate strength (plastic) analysis may be performed under any one of the following conditions:

a) for contact areas;
b) for areas of highly localized stress concentrations caused by part geometry, and other areas of high stress gradients where the average stress in the section is less than or equal to the maximum allowable stress as defined in 4.2.4.

In such areas, the elastic analysis shall govern for all values of stress below the average stress. In the case of plastic analysis, the nominal equivalent stress according to the Von Mises-Hencky theory shall not exceed the maximum allowable stress $\sigma_{\text{allow}}$ as calculated by Equation (2).

\[ \sigma_{\text{allow}} = \frac{S}{F} \]

where

- $S$ is the specified minimum ultimate tensile strength;
- $F$ is the design safety factor.

### 4.2.6 Stability Analysis

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

### 4.2.7 Fatigue Analysis

The fatigue analysis shall be based on a time period of not less than 20 years, unless otherwise agreed. The fatigue analysis shall be carried out according to generally accepted theories. A method that may be used is defined in Reference [13].

### 4.3 Size Class Designation

The size class designation for equipment shall represent dimensional interchangeability in accordance with Section 9.

### 4.4 Rating

#### 4.4.1 Rotary tables, spiders, manual and power tongs furnished under this specification shall be rated in accordance with the requirements specified herein.

#### 4.4.2 The static ratings for all bearings within the primary load path shall meet or exceed the rated load for the equipment.

#### 4.4.3 Power and manual tongs shall be assigned torque ratings by the manufacturer for all configurations for which the tong is designed.

### 4.5 Load Rating Basis

The load rating shall be based on:

- a) the design safety factor (DSF) as specified in 4.6;
- b) the minimum specified yield strength of the material used in the primary load-carrying components;
- c) the stress distribution as determined by design calculations and/or data developed in a design verification load test as specified in 5.6.

### 4.6 Design Safety Factor (DSF)

#### 4.6.1 DSF for spiders shall be established as specified in Table 1.

#### Table 1—Safety Factors for Spiders

<table>
<thead>
<tr>
<th>Load Rating</th>
<th>Design Safety Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R$</td>
<td></td>
</tr>
<tr>
<td>$&lt; 1334 \text{ kN (150 short tons)}$</td>
<td>3.00</td>
</tr>
<tr>
<td>$1334 \text{ kN to 4448 \text{ kN (150 short tons to 500 short tons)}}$</td>
<td>$3.00 - 0.75 \left( \frac{1334}{R} - 150 \right)$</td>
</tr>
<tr>
<td>$3.00 - 0.75 \left( \frac{1334}{150} \right)$</td>
<td>$\leq 150$ b</td>
</tr>
<tr>
<td>$&gt; 4448 \text{ kN (500 short tons)}$</td>
<td>2.25</td>
</tr>
</tbody>
</table>
In this formula, the value of $R$ shall be expressed in SI units of kilonewtons.

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

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

4.6.2 The minimum DSF of structural components in the primary load path of rotary tables shall be 1.67.

4.6.3 The minimum DSF for manual tongs, jaws, and snub-line attachments of power tongs shall be established as specified in Table 2.

4.7 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.

4.8 Specific Equipment

See Section 9 for equipment-specific design requirements.

4.9 Design Documentation

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

The requirements also apply to design change documentation.

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Table 2—Minimum Design Safety Factors

<table>
<thead>
<tr>
<th>Torque Rating</th>
<th>Design Safety Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\leq 41$ kN•m (30 . . . 103 ft-lb)</td>
<td>3.00</td>
</tr>
<tr>
<td>$&gt; 41$ kN•m (30 . . . 103 ft-lb) to $136$ kN•m (100 . . . 103 ft-lb)</td>
<td>$3.00 - 0.75 (R - 41)/95$ a</td>
</tr>
<tr>
<td>$3.00 - 0.75 (R - 30 . . . 10)/70 . . . 10$ b</td>
<td></td>
</tr>
<tr>
<td>$\geq 136$ kN•m (100 . . . 103 ft-lb)</td>
<td>2.25</td>
</tr>
</tbody>
</table>

a In this formula, the value of $R$ shall be expressed in SI units of kilonewton meters.

b In this formula, the value of $R$ shall be expressed in USC units of foot-pounds.

5 Design Verification

5.1 General

To ensure the integrity of the design and supporting calculations, equipment shall be subject to design verification testing when required in Section 9.

Design verification testing shall be performed in accordance with documented procedures. Design verification testing shall be carried out or certified by personnel who are independent of those having direct responsibility for the design and manufacture of the product and are qualified to perform their task. Design verification testing may consist of one or more of the listed tests as required by the specific equipment sections of this specification:

- function testing;
- pressure testing;
- load testing.

5.2 Design Verification Function Test

5.2.1 Sampling of Test Units

One unit of each model of equipment shall be subjected to function testing if the equipment transmits force, motion, or energy by means of continued movement of the equipment parts.

5.2.2 Test Procedure

The manufacturer shall establish a procedure documenting the duration, applied load and speed of the test. For
equipment designed for continuous operation, the test unit shall be operated at rated speed for a minimum of 2 hours. For equipment designed for intermittent or cyclical operation, the test unit shall be operated at rated speed and established duty cycles equivalent to 2 hour operation or 10 duty cycles, whichever is greater, unless otherwise specified by Section 9.

5.2.3 Qualification
The unit shall operate without noted loss of power. The temperature of the bearings and lubrication oil shall be within acceptable limits as established by the design and documented in the test procedure.

5.3 Design Verification Pressure Test

5.3.1 Sampling of Test Units
Each design of pressure-containing items or, as defined in Section 9, primary load-carrying components, where the primary load is pressure, shall be hydrostatically tested for design verification. Hydraulic power transmission components are excluded from this test.

5.3.2 Test Procedure
The test pressure shall be 1.5 times the maximum rated operating pressure. Cold water, water with additives, or the fluid normally used in actual service shall be used as the test fluid. Tests shall be performed on the completed part or assembly before painting.

The hydrostatic test shall be applied for two cycles. Each cycle shall consist of the following four steps:

a) the primary pressure-holding period;
b) the reduction of the test pressure to zero;
c) thorough drying of all external surfaces of the item being tested;
d) the secondary pressure-holding period.

The pressure-holding periods shall not start until the test pressure has been reached, and the equipment and pressure-monitoring gauge isolated from the pressure source. The pressure-holding periods shall not be less than 3 minutes.

5.3.3 Qualification
After each test cycle, the test item shall be carefully inspected for the absence of leakage or permanent deformation. Failure to meet this requirement, or premature failure, shall be the cause for a complete reassessment of the design, followed by repetition of the test.

5.3.4 Individual Parts
Individual parts of the unit may be tested separately if the test fixture duplicates the loading conditions applicable to the part in the assembled unit.

5.4 Design Verification Load Test

5.4.1 General
When required by the specific equipment paragraphs of Section 9, equipment shall be subjected to a design verification load test.

5.4.2 Sampling of Test Units
To qualify design stress calculations applied to a family of units with an identical design concept but of varying sizes and ratings, one of the following options shall apply.

a) A minimum of three units of the design shall be subjected to design verification load testing. The test units shall be selected from the lower end, middle, and upper end of the load rating range.
b) Alternatively, the required number of test units can be established on the basis that each test unit also
qualifies one load rating above and one below that of the selected test unit. (This option would generally apply to limited product rating ranges.)

5.4.3 Test Procedure
The test procedure is as follows.

a) An assembled test unit shall be loaded to the maximum rated load. After this load has been released, the unit shall be checked for its intended design functions. The function of all of the equipment parts shall not be impaired by this loading.

b) Strain gauges shall be applied to the test unit at all places where high stresses are anticipated, provided that the configuration of the unit permits such techniques. The use of finite-element analysis, models, brittle lacquer, and so forth, is recommended to confirm the proper location of the strain gauges. Three-element strain gauges are recommended in critical areas to permit determination of the shear stresses and to eliminate the need for exact orientation of the gauges.

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

\[ \text{Design verification test load} = 0.8 \times R \times F_{DS} \text{, but not less than } 2R \]

where

- \( R \) is the load rating in kilonewtons (short tons) or kilonewton meters (foot-pounds), as applicable;
- \( F_{DS} \) is the design safety factor as defined in 3.1.5 and 4.6.

d) The test unit shall be loaded to the design verification test load. This test load should be applied incrementally, reading the strain gauge values and observing for evidence of yielding. The test unit may be loaded as many times as necessary to obtain adequate data.

e) The stress values computed from the strain gauge readings shall not exceed the values obtained from design calculations (based on the design verification test load) by more than the uncertainty of the testing apparatus specified in 5.7. Failure to meet this requirement, or premature failure of any test unit, shall be a cause for 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 load rating as the one that failed.

f) Upon completion of the design verification load test, the test unit shall be disassembled and the dimensions of each primary load-carrying component checked for evidence of permanent deformation.

g) Individual parts of a test unit may be load-tested separately if the holding fixtures duplicate the loading conditions applicable to the part in the assembled unit.

5.5 Determination of Rated Load
The rated load shall be determined from the results of the design verification load test and/or stress distribution calculations required by Section 4. The stresses at that rating shall not exceed the maximum allowable stress. Localized yielding shall be permitted at areas of contact. In a unit that has been design verification load-tested, the critical permanent deformation determined by strain gauges or other suitable means shall not exceed 0.2 % except in contact areas. If the stresses exceed the allowable values, the affected part or parts shall be redesigned to obtain the desired rating. Stress distribution calculations may be used to load-rate the equipment only if the stress values determined in the analysis are no less than the stresses observed during the design verification load test.
5.6 Alternative Design Verification Test Procedure and Rating

Destructive testing of the test unit may be used, provided the yield and tensile strengths of the material used in the equipment have been determined. This may be accomplished using tensile test specimens from the same heat and heat-treatment lot as the parts represented, and meeting the requirements of ISO 6892 or ASTM A370.

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

- a) The ratio $TR$ 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, $TR$, used for each test shall be that computed for the specific component tested.

\[
DS \leq \frac{R}{T} \leq R_L
\]

\[
F = \frac{L_b}{Y \cdot RS_{UL}} \tag{4}
\]

\[
= \text{min} \left( \frac{L_b}{YS_{UL}} \right) \tag{5}
\]

where

- $L_b$ is the breaking load;
- $YS_{min}$ is the specified minimum yield strength;
- $S_{UL}$ is the actual tensile strength;
- $DS$ is the design safety factor (4.6);
- $R$ is the load rating.

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

5.7 Load Test Apparatus

The loading apparatus used to duplicate the working load on the test unit shall be calibrated in accordance with ISO 7500-1 or ASTM E4 so as to ensure that the prescribed test load is obtained. For loads exceeding 3560 kN (400 tons), the load-testing apparatus may be verified with calibration devices traceable to a Class A calibration device and having an uncertainty of less than 2.5%.

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

5.8 Design Changes

When any change in design or manufacture is made that result in changes to the calculated load rating,
supportive design verification testing in conformance with this section shall be carried out. The manufacturer shall evaluate all changes in design or manufacture to determine whether the calculated load ratings are affected. This evaluation shall be documented.

5.9 Records
All design verification records and supporting data shall be subject to the same controls as specified for design documentation in Section 11.

6 Materials Requirements
6.1 General
This section describes the various material qualification, property, and processing requirements for primary load-carrying and pressure-containing components unless otherwise specified.

6.2 Written Specifications
Materials used in the manufacture of primary load-carrying components of equipment to which this specification is applicable shall conform to a written specification that meets or exceeds the design requirements.

6.3 Mechanical Properties
6.3.1 Impact Toughness
Impact testing shall be in accordance with ISO 148 (V-notch Charpy) or ASTM A370 (V-notch Charpy). When it is necessary for subsize impact test pieces to be used, the acceptance criteria shall be multiplied by the appropriate adjustment factor listed in Table 3. Subsize test pieces of width less than 5 mm (3/16 in.) are not permitted.

For design temperatures below those specified in 4.1, supplementary impact toughness requirements may apply. See Annex A, Supplementary Requirements SR2 and SR2A.

Table 3—Adjustment Factors for Subsize Impact Specimens

<table>
<thead>
<tr>
<th>Specimen Dimensions</th>
<th>Adjustment Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>mm x mm</td>
<td></td>
</tr>
<tr>
<td>10.0 x 7.5</td>
<td>0.833</td>
</tr>
<tr>
<td>10.0 x 5.0</td>
<td>0.667</td>
</tr>
</tbody>
</table>

6.3.2 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%.

6.4 Material Qualification
6.4.1 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, ISO 148 or ASTM A370, or equivalent national standards, using material in the final heat-treated condition. For the purposes of material qualification testing, stress relief following welding 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.

6.4.2 Determine the size of the qualification test coupon for a part using the equivalent-round method. Figure 1 and Figure 2 illustrate the basic models for determining the equivalent round (ER) of simple solid and hollow parts.
Any of the shapes shown may be used for the qualification test coupon. Figure 3 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 equivalent-round dimensions of the part it qualifies, except that the ER is not required to exceed 125 mm (5 in.). Figure 4 and Figure 5 illustrate the procedure for determining the required dimensions of an ASTM A370 keel block.

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

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

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

6.4.6 For components to be machined entirely from wrought material which has been fully heat treated as a solid or tubular bar, whereby the standard 1/4T envelope is either wholly or partly outside the volume of the critical and/or non-critical areas of the finished component, the test specimens, cut from the bar, may alternatively be taken from a more representative volume as defined by:

a) volume OD defined by a 1/3T envelope determined by using the maximum finished OD and the minimum finished ID of the final component;
b) the volume ID shall be equal to, or greater than, the minimum finished ID of the component.

EXAMPLE
6 in. OD 4340 mod bar, non-quenched tempered (NQT); part final dimensions have maximum OD of 5.5 in., minimum ID of 2.5 in.;

\[ T = \frac{5.5 - 2.5}{2} = 1.5 \text{ in.}, \quad \frac{1}{3}T = 0.5 \text{ in.} \]

The \(1/3T\) envelope of the finished part would have a 4.5 in. OD; therefore, the specimens could be removed from anywhere within the volume defined by 4.5 in. OD .2.5 in. ID;

6.5 Manufacture

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

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

6.5.3 All heat-treatment operations shall be performed utilizing equipment qualified in accordance with the
requirements specified by the manufacturer or processor. The loading of the material within heat-treatment furnaces shall be such that the presence of any one part does not adversely affect the heat-treating 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.

6.6 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.

\[
ER = \frac{t}{a}
\]

a) Round
ER = 1.1t

b) Hexagon
ER = 1.25t

c) Square
ER = 1.5t

d) Rectangle or Plate
NOTE When \(L < t\), consider section as a plate of thickness \(L\).

Figure 1—Equivalent Round (ER) Models—Solids of Length \(L\)

Figure 2—Equivalent Round (ER) Models—Tube (Any Section)

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

a) reduce the component to simple sections;

b) convert each simple section to an equivalent round;

c) 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 3—Equivalent Round (ER) Models—Complex Shapes

\[
R = \frac{ER}{2.3}
\]

D = 1.1R

NOTE Shaded area \(A\) indicates 1/4\(A\) envelope for test specimen removal.

Figure 4—Equivalent Round (ER) Models—Keel Block Configuration

To develop a keel block for \(ER = 115\) mm:

a) noting from Figure 5 that \(R = ER/2.3 = 50\) mm and \(D = 1.1R\),

b) 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 \(D\).

Figure 5—Development of Keel Block Dimensions

7 Welding Requirements
7.1 General
This section describes requirements for the fabrication and repair welding of primary load-carrying and pressure-containing components, including attachment welds.

7.2 Welding Qualification
All welding undertaken on components shall be performed using welding procedures that are qualified in accordance with ASME BPVC, Section IX, AWS D1.1, and/or ASTM A488. This welding shall only be carried out by welders or welding operators who are qualified in accordance with the aforementioned standards or BS EN 287.
Welding procedures for base materials that are not listed in the above standards shall be qualified individually or as a group based on weldability, tensile properties, or composition. Where the ductility of the parent metal is such as to render it incapable of meeting the bend test requirements of ASME BPVC, Section IX, the bend test 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
Welding shall be performed in accordance with welding procedure specifications (WPS) written and qualified in accordance with the applicable standard. The WPS shall describe all the essential, non-essential, 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 weld 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 consumable manufacturer’s specifications.
The manufacturer shall have a written procedure for storage and control of weld consumables. Materials of low hydrogen type shall be stored and used as recommended by the consumable manufacturer to retain their original low hydrogen properties.

7.5 Weld Properties
The mechanical properties of the weld, as determined by the procedure qualification test, shall at least meet the minimum specified mechanical properties required by the design. When impact testing is required for the base material, it shall also be a procedure qualification requirement. Results of testing in the weld and base material HAZ shall meet the minimum requirements of the base material. In the case of attachment welds, only the HAZ of material requiring impact testing shall meet the above requirements.
All weld testing shall be undertaken with the test weldment in the applicable post-weld heat-treated condition.

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
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 of the repair.

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

7.9.3 Forgings and Castings
All repair welding shall be performed in accordance with the manufacturer's written welding specifications. WPSs shall be documented and shall be supplied at the purchaser's request. The manufacturer shall document the following criteria for permitted repairs:
- defect type;
- defect size limits;
- definition of major/minor repairs.
All excavations, prior to repair, and the subsequent weld repair shall meet the quality control requirements specified in Section 8.

7.9.4 Heat Treatment
The WPS used for qualifying a repair shall reflect the actual sequence of weld repair and heat treatment imparted to the repair item.

8 Quality Control
8.1 General
This section specifies the quality control requirements for equipment and material. All quality control work shall be controlled by the manufacturer's documented instructions, which shall include appropriate methodology, quantitative and qualitative acceptance criteria. Instructions for 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 examiner qualified to an ASNT SNT-TC-1A, Level III examiner. The acceptance status of all equipment, parts, and materials shall be indicated either on the equipment, parts, or materials or in the records traceable to the equipment, parts, or materials.

8.2 Quality Control Personnel Qualifications
NDE personnel shall be qualified and/or certified in accordance with ASNT SNT-TC-1A. Personnel performing visual inspection of welding operations and completed welds shall be qualified in accordance with:
- AWS QC1 or equivalent standard; or
- the manufacturer's documented training program (to be equivalent to 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. ISO 10012-1 [2], MIL STD 120 [10]), 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-bearing and/or pressure-containing equipment and components unless specified otherwise.

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 is:

\[ \sigma = \frac{F_D S}{Y_S} \] (6)

where

- \( S_{\text{min}} \) is the specified minimum yield strength;
- \( F_D \) is the design safety factor.

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

Areas of components in which the stress is compressive, and/or where the stress level is:

\[ \sigma = \frac{F_D S}{Y_S} \] (7)

where

- \( S_{\text{min}} \) is the specified minimum yield strength;
- \( F_D \) is the design safety factor;

shall be exempt from the acceptance criteria defined in 8.4.7.4. The low stress areas thus defined may be identified on the critical area map.

8.4.2 Chemical Analysis

Methods and acceptance criteria shall be in accordance with 6.6.

8.4.3 Tensile Testing

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

8.4.4 Impact Testing

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

8.4.5 Traceability

Components shall be traceable by heat, and heat-treatment lot, identification. Identification shall be maintained on materials and components through all stages of manufacturing and on the finished components or assembly. Manufacturer’s documented traceability requirements shall include provisions for maintenance and replacement of identification marks and identification control records. Fasteners and pipe fittings shall be exempt from the traceability requirements, provided they are marked in accordance with a recognized industry standard.
8.4.6 Visual Examination
Components shall be visually examined. Visual examination of castings shall meet the requirements of MSS SP-55. Examination of wrought material shall be in accordance with the manufacturer’s documented procedures.

8.4.7 Surface NDE
8.4.7.1 General
All accessible surfaces of each finished component shall be inspected in accordance with 8.4.7 after final heat treatment and final machining operations.
If the equipment is subjected to a load test, the qualifying NDE shall be carried out after the load test. For materials susceptible to delayed cracking, as identified by the manufacturer, NDE shall be carried out no earlier than 24 hours after the load test. The equipment shall be disassembled for this inspection. Conducting surface coatings shall be removed prior to examination. Non-conducting surface coatings 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.
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.
The use of prods should be avoided if possible. If prods are used, all prod burn marks shall be removed by grinding and the affected areas re-examined by the liquid penetrant method.

8.4.7.3 Evaluation of Indications
Only those indications with major dimensions greater than 2 mm (1/16 in.) and associated with a surface rupture shall be considered relevant. Inherent indications not associated with a surface rupture (i.e. magnetic permeability variations, non-metallic stringers, etc.) shall be considered non-relevant. If magnetic particle indications greater than 2 mm (1/16 in.) are believed to be non-relevant, they shall either be examined by the liquid penetrant method to confirm they are non-relevant, or they shall be removed and re-inspected to confirm they are non-relevant.
Relevant indications shall be evaluated in accordance with the acceptance criteria specified in 8.4.7.4.

8.4.7.4 Acceptance Criteria
8.4.7.4.1 Castings
ASTM E125 shall be applied as a reference standard for the evaluation of magnetic particle indications on castings. The acceptance criteria shall be as specified in Table 4.

<table>
<thead>
<tr>
<th>Type Discontinuity Descriptions</th>
<th>Maximum Permitted Degree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critical Areas</td>
<td>Non-critical Areas</td>
</tr>
<tr>
<td>Hot tears, cracks</td>
<td>None Degree 1</td>
</tr>
<tr>
<td>Shrinkage</td>
<td>Degree 2</td>
</tr>
<tr>
<td>Inclusions</td>
<td>Degree 2</td>
</tr>
<tr>
<td>Internal chillis, chaplets</td>
<td>Degree 1</td>
</tr>
</tbody>
</table>

Table 4—Castings Indication Acceptance Criteria
V Porosity Degree 1 Degree 2

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

- no relevant indications with a major dimension equal to or greater than 5 mm (3/16 in.);
- no more than 10 relevant indications in any continuous 40 cm² (6 in.²) area;
- no more than three relevant indications in a line separated by less than 2 mm (1/16 in.) edge-to-edge;
- no relevant indications in pressure-sealing areas, in the root area of rotary threads or in the stress-relief features of threaded joints.

8.4.8 Volumetric NDE of Castings

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

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 Article 23 and shall be supplemented by angle beam examination as in T-534.2 of Article 5 in areas where a back reflection cannot be maintained during the straight-beam examination, or where the angle between the two surfaces of the component is more than 15°.

8.4.8.2 Sampling

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

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

8.4.8.3 Acceptance Criteria

8.4.8.3.1 General
Areas of components where the stress level is less than the value of low stress [as calculated in Equation (7)] shall be exempt from volumetric examination.

8.4.8.3.2 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 non-critical areas. Critical areas shall be as defined in 8.4.1. If critical areas are not identified on critical-area drawings, then all areas of the component shall be considered critical.

8.4.8.3.3 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, Quality Level 3, with the exception that Quality Level 1 shall apply within 50 mm (2 in.) of the casting surface. Discontinuities indicated as having a change in depth of 25 mm (1 in.) or half the thickness, whichever is the lesser, are not permitted.

8.4.9 NDE of Welds

8.4.9.1 General

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

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

8.4.9.2 Fabrication Welding

8.4.9.2.1 Visual Examination

All fabrication welds shall be visually examined in accordance with ASME 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 (1/8 in.) of, sealing surfaces.

8.4.9.2.2 Surface NDE

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

Acceptance criteria shall apply:

- no relevant linear indications (see 3.1.22);
- no rounded indications (see 3.1.36) with a major dimension greater than 4 mm (1/8 in.), for welds whose depth is 17 mm (5/8 in.) or less;
- no rounded indications with a major dimension greater than 5 mm (3/16 in.) for welds whose depth is greater than 17 mm (5/8 in.);
- no more than three relevant indications in a line separated by less than 2 mm (1/16 in.) edge-to-edge.

8.4.9.2.3 Volumetric NDE

Primary load-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 5, and radiographic examination shall be in accordance with ASME BPVC, Section V, Subsection A, Article 2. This applies to full-penetration welds only.

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

8.4.9.3 Repair Welds

8.4.9.3.1 Weld Excavations

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

8.4.9.3.2 Repair Welds in Castings

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

8.4.9.3.3 Repair of Welds

NDE of the repairs of weld defects shall be identical to that of the original weld (see 8.4.9.2).
8.5 Dimensional Verification
Verification of dimensions shall be carried out on a sample basis as defined and documented by the manufacturer. All main load-bearing and pressure-sealing threads shall be gauged to the requirements of the relevant thread specification(s).

8.6 Proof Load Testing
When proof load testing is required, as indicated under the relevant equipment headings of Section 9, the following requirements shall apply:

a) Each production unit or primary load-carrying component shall be load-tested in accordance with the requirements of this section.
b) The equipment shall be mounted in a test fixture capable of loading the equipment in the same manner as in actual service and with 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.
c) A test load equal to 1.5 times the rated load shall be applied and held for a period of not less than 5 minutes.
d) 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.
e) Assembled equipment shall be subsequently stripped down to a level that will permit full surface NDE of all primary load-bearing parts (excluding bearings).
f) All critical areas of the primary load-bearing parts shall be subjected to magnetic particle examination in conformance with 8.4.7. Equipment normally exempt from load-bearing parts shall be given a proof load test if supplementary requirement SR1 (see Annex A) is specified in the order.

8.7 Hydrostatic Testing
8.7.1 General
When hydrostatic testing is required, as indicated under the relevant equipment headings of Section 9, the requirements of 8.7 shall apply.

8.7.2 Test Sequence
The hydrostatic test shall be carried out in three steps:
a) the primary pressure-holding period;
b) the reduction of the pressure to zero;
c) the secondary pressure-holding period.
Both pressure-holding periods shall not be less than 3 minutes, the timing of which shall not start until the test pressure has been reached, the equipment and the pressure-monitoring gauge have been isolated from the pressure source, and the external surfaces of the body members have been thoroughly dried. 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.

9 Equipment

9.1 General

The requirements of Section 4 through Section 8 apply to the primary load-carrying components of the covered equipment unless specifically noted otherwise. It is the equipment designer’s responsibility to determine the primary load path through the equipment and to define primary load-carrying components. Slip inserts and tong dies are exempt from testing, NDE, and traceability requirements of 6.3, 6.4, 6.5, 8.4, and 8.6.

9.2 Rotary Tables

9.2.1 General

The requirements of 4.2.7, 5.4, 5.5, 6.3.1, 8.4.4, 8.4.5, 8.4.7, 8.4.8, and 8.6 shall not apply. For antifriction bearing design and manufacturing requirements, see 9.19.

9.2.2 Primary Load

The primary load is the axial load through the center of the rotary table. Rotary torque is not taken as a primary load.

9.2.3 Design Verification Function Test

Design verification function test, as described in 5.2, shall apply.

9.2.4 Static Load Rating

The static load rating, or primary load rating, for a rotary table shall be equal to or less than the static load capacity of the main bearing.

9.2.5 Rotary Table Pinion-shaft Extension

Rotary tables, with straight pinion-shaft extensions, shall be furnished in the sizes shown in Table 5 and shall conform to the dimensions and tolerances shown in Table 5 and Figure 6. This section does not preclude alternative drive input configurations (e.g. other straight or tapered pinion-shaft extensions, hydraulics drives, etc.).

9.2.6 Drive Sprocket

The distance, $L$, between the center of the rotary table and the center of the first row of sprocket teeth (see Figure 7) shall be 1353 mm (53 1/4 in.) for machines that will pass a 510 mm (20 in.) bit or larger, and shall be 1118 mm (44 in.) for machines that will not pass a 510 mm (20 in.) bit, except that, by agreement between the manufacturer and purchaser, the distance of 1353 mm (53 1/4 in.) may be used on machines that will not pass a 510 mm (20 in.) bit. The distance, $L$, shall be either 1353 mm or 1651 mm (53 1/4 in. or 65 in.) for the 1257 mm (49 1/2 in.) nominal rotary table. The distance, $L$, shall be 1840 mm (72 in.) for the 60 1/2 in. nominal rotary table. These distances may be stamped on the nameplate (if used) attached to the rotary table.

**Table 5—Rotary Table Pinion-straight Shaft Extension**

Dimensions in millimeters (inches)

<table>
<thead>
<tr>
<th>Size No.</th>
<th>Diameter of Extension</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>C</td>
<td>Width</td>
</tr>
<tr>
<td>Depth</td>
<td></td>
</tr>
<tr>
<td>0.005</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>0.001 +0.025</td>
</tr>
</tbody>
</table>

---

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NOTE See Figure 6 for illustration of dimension symbols.

9.2.7 Rotary Table Openings
Rotary tables for use with square-drive master bushings shall conform to the requirements of Table 6 and Figure 8. Rotary tables for use with the four-pin-drive master bushings shall conform to the requirements in Table 7 and Figure 9. This section does not preclude rotary tables of other nominal sizes.

9.2.8 Demountable Rotary Table Sprockets
Demountable rotary table sprockets are shown in Table 8 and Figure 10. The sprockets, both single-strand and double-strand, have a common bolt circle.

9.3 Rotary Bushings
9.3.1 General
Rotary bushings and bushing adapters are included for the purpose of dimensional interchangeability only, and load rating is not required. The requirements of 6.3.1, 8.4.5, 8.4.7, 8.4.8, and 8.4.9 shall not apply.

9.3.2 Kelly Bushings
Square-drive kelly bushing dimensions are shown in Figure 7. Pin-drive kelly bushing dimensions are shown in Figure 9 and Table 7.

9.3.3 Master Bushing
Square-drive master bushings and rotary table square-drive master bushings shall conform to the requirements of Table 6 and Figure 8. Dimensions for four-pin-drive master bushings shall conform to the requirements in Table 7 and Figure 9.

Figure 6—Rotary Table Pinion-straight Shaft Extension

9.4 Standard Rotary Slips

Figure 7—Rotary Table with Square-drive Bushings

9.3.4 Bushing Adapters
Bushing adapters are used to reduce the openings of rotary tables so that a smaller-size master bushing may be used.
9.4.1 Standard rotary slips shall have a taper of 33.33 mm/m (4 in./ft) and other suitable dimensions to permit operations in standard master bushings. Refer to 9.2.7 and Figure 7.

9.4.2 Load rating of standard rotary slips is not required.

9.4.3 The requirements of 8.4.4, 8.4.5, 8.4.8, and 8.4.9 shall not apply.

9.4.4 The requirements of 8.4.7 apply to API rotary slips, with the exception of the method and acceptance criteria of MSS SP-53 shall apply.

9.5 Nonstandard Rotary Slips

9.5.1 Nonstandard rotary slips without a taper of 33.333 cm/m (4 in./ft) shall have a taper to match the manual spider in which it is intended to be used, as defined in 1 i).

9.5.2 Load rating of nonstandard rotary slips is not required.

9.5.3 The requirements of 8.4.4, 8.4.5, 8.4.8, and 8.4.9 shall not apply.

9.5.4 The requirements of 8.4.7 apply to nonstandard rotary slips, with the exception of the method and acceptance criteria of MSS SP-53 shall apply.

Table 6—Rotary Table Opening and Square-drive Master Bushing
Dimensions in millimeters (inches)

<table>
<thead>
<tr>
<th>Nominal Table Size</th>
<th>Rotary Table Opening</th>
<th>Square-drive Master Bushing</th>
<th>Concentricity</th>
<th>TIR</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td></td>
</tr>
<tr>
<td>±0.38</td>
<td>±0.015</td>
<td>±0.015</td>
<td>±0.76</td>
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</tr>
<tr>
<td>±0.38</td>
<td>±0.030</td>
<td>max. max.</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>±0.76</td>
<td>±0.015</td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>±0.030</td>
<td>±0.35</td>
<td></td>
<td>±0.250</td>
<td></td>
</tr>
</tbody>
</table>

(17 1/2) 444.5 444.50 (17 1/2) 461.96 (18 3/16) 133.3 5 1/4 44.45 (1 3/4) 442.91 (17 7/16) 460.38 (18 1/8) 133.35 (5 1/4) 44.45 (1 3/4) 0.79 (1/16) (20 1/2) 520.7 520.70 (20 1/2) 538.16 (21 3/16) 133.3 5 1/4 44.45 (1 3/4) 519.11 (20 7/16) 536.58 (21 1/8) 133.35 (5 1/4) 44.45 (1 3/4) 0.79 (1/16) (27 1/2) 698.5 698.50 (27 1/2) 715.96 (28 3/16) 133.3 5 1/4 44.45 (1 3/4) 696.91 (27 7/16) 712.79 (28 1/16) 133.35 (5 1/4) 44.45 (1 3/4) 0.79 (1/16) (37 1/2) 952.5 952.50 (37 1/2) 955.00 (37 1/2) 950.91 (37 7/16) — — — — — — — — — — — — — — — — — — (49 1/2) 1257.3 1257.30 (49 1/2) — — — — — — — — — — — — — — — — — — (60 1/2) 1536.7 1536.70 (60 1/2) — — — — — — — — — — — — — — — — — — NOTE See Figure 7 and Figure 8 for illustration of symbols.

Table 7—Four-pin-drive Master Bushing and Kelly Bushing
Dimensions in millimeters (inches)

<table>
<thead>
<tr>
<th>Nominal Table Size</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
<th>J</th>
<th>K</th>
</tr>
</thead>
<tbody>
<tr>
<td>±1.59</td>
<td>±0.13 (±0.005) ±0.13 (±0.005) ±1.59</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>±0.13 (±0.005) ±0.13 (±0.005)</td>
<td>0</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>±1.59</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>±0.13 (±0.005) ±0.13 (±0.005)</td>
<td>+1.59</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>±0.13 (±0.005) ±0.13 (±0.005)</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>±0.13 (±0.005) ±0.13 (±0.005)</td>
<td>+1.59</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(17 1/2) 444.5 482.60 (19) 65.15 (2.565) 107.95 (4 1/4) 62.79 (2.472) 365.13 (14 3/8) 257.18 (10 1/6)

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Key

1 optional relief
2 relief

NOTE See 9.2.7, 9.3.3 and Table 6 for dimensions.

a Chamfer ≥ 6.35 mm (0.250 in.) 45°.

b b ≤ 0.40 mm (0.016 in.) eccentricity.

c (333.33 ± 1.5) mm/m [(4 ± 0.018) in./ft] taper on diameter (9°27’45 “± 2’30” taper per side).

Figure 8—Rotary Table Opening and Square-drive Master Bushing

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Key

1 pin-drive kelly bushing
2 pin-drive master bushing

NOTE See 9.2.7, 9.3.2, 9.3.3 and Table 6 and Table 7 for dimensions.

a (333.33 ± 1.5) mm/m [(4 ± 0.018) in./ft] taper on diameter (9°27’45 “± 2’30” taper per side).

b Diameter of drive hole.

Figure 9—Pin-drive Master Bushing and Kelly Bushing

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Key

1 hub
2 single sprocket
3 double sprocket

NOTE See 9.2.8 and Table 8 for dimensions.

a Maximum hub diameter to allow for chain clearance.

b Chamfer 1.59 mm (0.063 in.) 45°.

c Eight holes equally spaced on 228.6 mm (9 in.) bolt circle diameter.

d Applies to sprockets with minimum number of teeth. This can be increased for sprockets with more than the minimum

number of teeth to as much as the dimensions A minus B.

Figure 10—Demountable Rotary Sprocket

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Table 8—Demountable Rotary Sprocket Data

<table>
<thead>
<tr>
<th>Sprocket Type</th>
<th>Number of Teeth on Sprocket</th>
<th>Sprocket Groove Diameter</th>
<th>Sprocket Thickness at Groove Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>min.</td>
<td>max.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>A R</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 3/4 P single</td>
<td>23 —</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>2 P single</td>
<td>21 —</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>2 1/2 P single</td>
<td>17 —</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>1 3/4 P double</td>
<td>25 306.39 (12 7/16) 10.32 (13/32)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 P double</td>
<td>22 301.63 (11 7/16) 7.94 (5/16)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 1/2 P double</td>
<td>19 315.91 (12 7/16) 15.08 (19/32)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NOTE See 9.2.6, 9.2.8 and Figure 10 for explanation and illustration of symbols.

9.6 High-pressure Mud and Cement Hoses

9.6.1 General
This specification applies to high-pressure flexible mud and cement hose assemblies as defined in 9.6.2.1 and listed in Table 9. This specification shall not apply to choke and kill flexible lines covered by API 16C. In addition, this specification shall not apply to flexible hoses or pipes for gas service, air drilling, and well completion or workover operations where it is intended or likely that hoses will be exposed to well bore effluents. Such hoses are covered by API 17B. See API 7L, Annex A, for information on operating limits, inspection, care, and use of cement hose, drilling mud vibrator and jumper hose, and rotary hose covered by this specification.

9.6.2 Exceptions to Requirements Specified in Section 1 Through Section 8

9.6.2.1 Definitions

Consistent with the definitions of the following terms specified in Section 3, the following clarifications are provided below as they shall apply to the hose assemblies covered by this specification:

a) the primary load shall be the internal pressure;
b) the primary load-carrying components shall be the reinforcing cables, wires, metal armors, and hose couplings;
c) the design load shall be the same as the working pressure of the hose assembly specified in Table 9;
d) the dynamic load shall be comprised of additional loads exerted on the hose assembly that are separate from that which is created by static pressure, such as pressure pulsations, and dynamic bending or flexing.

9.6.2.2 Design Conditions

Exceptions to the requirements specified in 4.1 are provided in the following.

a) The minimum operating temperature of hose assemblies covered by this specification is –4 °F (–20 °C).

b) With regard to the cautionary note in 4.1, operation of the hose assemblies covered by this specification at temperatures below the minimum specified is not recommended under any circumstances. In the event that the requirements of the purchase agreement dictate lower minimum operating temperatures than those specified above, the hose assembly shall be qualified by conducting a low-temperature bending test at the temperature specified in the purchase agreement in addition to those other tests that are required to establish the temperature range and FSL level specified in 9.6.3. In addition, when supplementary requirements SR2 and SR2A are specified in the purchase agreement, they shall only apply to the hose coupling.

Table 9—Rotary Drilling and Vibrator Hoses, Cement Hoses, Mud Delivery Hoses Dimensions and Pressures

<table>
<thead>
<tr>
<th>Inside Diameter (mm (in.))</th>
<th>API Grade</th>
<th>Working Pressure (MPa (psi))</th>
<th>Test Pressure (MPa (psi))</th>
<th>Safety Factor</th>
<th>Minimal Burst Pressure (MPa (psi))</th>
<th>MBR</th>
<th>Operational (m (in.))</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Key
1 safety clamp
2 end connector
3 inboard end of the coupling
\( \delta \) inside diameter
L nominal length
\( R \) bending radius

NOTE See Table 9 for dimensions.

a Hose manufacturers shall mark the hose with the notation “Attach Safety Clamp Here.”
b For rotary drilling hose, this dimension shall be 150 mm (6 in.) to 460 mm (18 in.) from the inboard end of the coupling. For vibrator hose, this dimension shall be 150 mm (6 in.) to 250 mm (10 in.) from the inboard end of the coupling.

Figure 11—Rotary Vibrator and Drilling Hose Dimensions

9.6.2.3 Strength Analysis

The requirements specified in 4.2.7 shall not apply.

9.6.2.4 Size Class Designation

Size class designation shall be in accordance with the hose assembly diameters and corresponding working pressures specified in Table 9.

9.6.2.5 Rating

The rating of hose assemblies covered by this specification shall be in accordance with the working pressure specified in Table 9, and the temperature range and FSL level specified in 9.6.3.

9.6.2.6 Load Rating Basis
The load rating basis of hose assemblies covered by this specification shall be based on the maximum allowable stress of the reinforcing wires, the critical areas of the hose coupling, and the interfacing materials utilized between them if employed in the design.

9.6.2.7 Design Safety Factor (DSF)
The DSF for hose assemblies covered by this specification shall be the ratio of the minimum required burst pressure specified in 9.6.7.2 and the working pressure of the hose assembly specified in Table 9.

9.6.2.8 Design Verification
The design verification requirements are specified in 9.6.10; Section 5 shall not apply.

9.6.2.9 Surface NDE
Surface NDE specified in 8.4.7 shall be limited to the hose coupling. Surface NDE of welds specified in 8.4.9 shall apply to the weld and HAZ between the hose coupling and the end connector if such connection is achieved by welding.

9.6.2.10 Proof Load Testing
Proof-load testing required by 8.6 shall not apply.

9.6.2.11 Hydrostatic Testing
Hydrostatic testing requirements specified in 8.7.2 shall not apply. Hydrostatic testing shall be in accordance with 9.6.7.

9.6.3 Temperature Range and Flexible Specification Level (FSL)
If known at the time of the purchase agreement, the purchaser shall specify the characteristics of the drilling liquids intended to be conveyed in the high-pressure mud hose assembly.

9.6.3.1 Temperature Ranges
Each hose assembly shall be rated by the manufacturer to operate in one of the three temperature ranges specified as follows:
- Temperature Range I: –20 °C to +82 °C (–4 °F to +180 °F);
- Temperature Range II: –20 °C to +100 °C (–4 °F to +212 °F);
- Temperature Range III: –20 °C to +121 °C (–4 °F to +250 °F).

9.6.3.2 Flexible Specification Levels (FSLs)
This specification establishes requirements for three FSLs for the hoses covered by this specification. The FSL designations specified below define different levels of design verification requirements specified in 9.6.10.

a) FSL 0: This shall be specified by the purchaser in the purchase agreement for cement hoses only. This includes all design verification requirements of 9.6.10, excluding the pulsating pressure tests in 9.6.10.4 and 9.6.10.5.

b) FSL 1: This shall be specified by the purchaser in the purchase agreement for rotary, vibrator, and jumper hoses for normal service conditions only. This includes all design verification requirements of 9.6.10, excluding the high-frequency pulsating pressure test in 9.6.10.5.

c) FSL 2: This shall be specified by the purchaser in the purchase agreement for rotary, vibrator, and jumper hoses that are likely to incur high-frequency pressure pulsations with an amplitude exceeding 6.9 MPa (1000 psi) during operation. This includes all design verification requirements of 9.6.10, excluding the low-frequency pulsation test specified in 9.6.10.4.

9.6.4 Sizes and Lengths
All hose assemblies shall comply with the sizes specified in Table 9. The length of each hose assembly shall
comply with the dimension specified in the purchase agreement within the tolerances specified in 9.6.5. For rotary hose applications, the purchaser should refer to the hose length calculation specified in API 7L, Section A.1.1, to determine the optimum length of a rotary hose for any given application to avoid over-bending, high axial load or compression during operation. For vibrator and jumper hose applications, the purchaser shall take into account the change in length of the hose when it is pressurized as specified in 9.6.5 when specifying the overall length of the hose assemblies in the purchase agreement.

9.6.5 Dimensions and Tolerances

9.6.5.1 Dimensions of the hose assemblies shall conform to the requirements of Table 9, and Figure 11.

9.6.5.2 For hose assembly lengths up to 6 m (20 ft), the finished un-pressurized hose length tolerance shall be ±65 mm (±2 1/2 in.). For hose assembly lengths up to 6 m (20 ft), the length of the hose assembly after pressurization to its specified working pressure shall not be different by more than 65 mm (2 1/2 in.) + 0.01L (L is the length of the hose assembly, see Figure 11).

9.6.5.3 For hose assembly lengths exceeding 6 m (20 ft), the finished un-pressurized hose length tolerance shall not exceed ±1 %. For hose assembly lengths exceeding 6 m (20 ft), the length of the hose assembly after pressurization to its specified working pressure shall not change by more than ±2 %.

9.6.5.4 The manufacturer shall specify the MBR if it is less than the values listed in Table 9.

9.6.6 Hose Couplings and End Connectors

9.6.6.1 Hose Couplings

Hose couplings shall be designed and manufactured so they are fit for purpose with the hose assembly they are attached to. In the event the hose assembly manufacturer elects to substitute or replace the hose couplings with those of different materials of construction or different physical properties, the hose assembly manufacturer shall take one or more of the following actions as appropriate:

a) conduct the design verification testing again to qualify the new hose coupling; or,

b) arrange for a qualified third party to evaluate the new hose coupling materials and physical properties and determine that the new hose coupling is fit for purpose with the hose assembly as previously qualified. Furthermore, if the hose assembly manufacturer elects to alter the nature by which the hose coupling is attached to a previously qualified hose assembly, the manufacturer shall conduct the design verification testing again to requalify the hose assembly.

9.6.6.2 End Connectors

High-pressure mud and cement hose assemblies shall be furnished with end connectors as specified in the purchase agreement. Although the design and manufacture of end connectors are not covered by this specification, the hose assembly manufacturer shall select end connectors that are fit for purpose for the hose assembly they are attached to. End connectors that are attached to the hose couplings with line pipe threads in accordance with API 5B shall not be used in hose assemblies with working pressures exceeding 34.5 MPa (5000 psi). For hose assemblies with working pressures exceeding 34.5 MPa (5000 psi), the end connector shall either be butt-welded onto the hose coupling, or it may be machined from the same piece of material that the hose
coupling is made of (integral).

9.6.7 Test Pressure and Burst Pressure

9.6.7.1 Test Pressure

9.6.7.1.1 Each high-pressure mud hose assembly shall be hydrostatically tested to two times the working pressure (see Table 9). The test medium shall be water.

9.6.7.1.2 Each cement hose assembly having a working pressure less than 69 MPa (10,000 psi) shall be hydrostatically tested to two times working pressure. Each cement hose assembly having a working pressure of 69 MPa (10,000 psi) or higher shall be hydrostatically tested to 1.5 times working pressure. Test pressure shall be held for a minimum of 15 minutes. The test medium shall be water.

9.6.7.1.3 The pressure test shall be recorded on chart or graph and kept on file by the manufacturer for a minimum of 10 years.

9.6.7.2 Burst Pressure

High-pressure mud hose assemblies shall be designed to have a minimum burst pressure of 2.5 times the working pressure (see Table 9). Cement hoses with a working pressure less than 69 MPa (10,000 psi) shall be rated with a minimum burst pressure of 2.5 times working pressure. Cement hoses with a working pressure of 69 MPa (10,000 psi) and higher shall be rated with a minimum burst pressure of 2.25 times the working pressure (see Table 9).

9.6.8 Working Pressure

The maximum working pressure of the hose assembly is specified in Table 9. Maximum surge pressures encountered in the hose shall be included in the working pressure.

9.6.9 Marking

9.6.9.1 The hose assembly manufactured to comply with this specification shall be marked with API 7K, month, and year of manufacture, the working pressure, the test pressure, the working temperature range, FSL level, and the manufacturer's identification. Additionally, when the hose assembly manufacturer does not install safety clamps, each hose end shall be marked (at the locations specified in Figure 11) with the notation “Attach Safety Clamp Here.” Each hose assembly shall have a longitudinal lay line of a different color than the hose cover. Markings, whether embossed or printed in distinctive colors, shall be vulcanized or similarly affixed into the hose cover.

9.6.9.2 Additional information may be marked on the hose assemblies at the discretion of the manufacturer or on request of the purchaser.

9.6.9.3 Rings may be used above one of the couplings as a mark to identify the hose assembly grade. If applied, the rings shall be of a different color than the hose cover. The number of rings for each grade shall be as follows and in accordance with the grade designations specified in Table 9:

a) Grade A—1;
b) Grade B—2;
c) Grade C—3;
d) Grade D—4;
e) Grade E—5.

9.6.10 Design Verification Testing
9.6.10.1 General

9.6.10.1.1 Design verification testing shall be performed to prove the integrity of each hose design family in accordance with the requirements of each FSL level defined in 9.6.3.2. High-temperature pulsating pressure tests specified in 9.6.10.4 and 9.6.10.5 are not required for cement hoses. Design verification testing shall be carried out by an independent testing laboratory or witnessed by a third party agency.

9.6.10.1.2 All of the tests specified below shall be performed on the largest internal diameter size hose for a given hose design family.

9.6.10.1.3 Successful completion of verification testing shall qualify the same size and smaller sizes of the design family for the same or lower working pressure for the full temperature range specified in 9.6.3 that was used for the tests.

9.6.10.1.4 The minimum length of the hose assembly shall be 3.05 m (10 ft).

9.6.10.1.5 The tests in 9.6.10.2 through 9.6.10.7 shall be performed on the same hose assembly in accordance with the FSL requirements specified in 9.6.3.2. The sequence of tests shall follow the order specified below.

9.6.10.1.6 In the case where a hose design family is qualified to meet FSL 1, FSL 2 qualification can be carried out on a different hose assembly of the same design family by performing the tests specified in 9.6.10.5, 9.6.10.6, and 9.6.10.7. Three temperature ranges are specified in 9.6.3.1. All three temperature ranges have the same low-temperature limit of –20 °C (–4 °F), which corresponds to the required temperature of the low-temperature bending test specified in 9.6.10.3.2. However, each temperature range has different high-temperature limits, starting with Range I at 82 °C (180 °F), Range II at 100 °C (212 °F), and Range III at 121 °C (250 °F). If the low-frequency pulsation test specified in 9.6.10.4 is carried out at the upper limit of Temperature Range III as part of qualifying a hose design family to FSL 1, the hose shall be rated at that temperature. Such a rating will automatically qualify the hose to meet the lower Temperature Ranges I and II. This also applies to a hose that is tested to the upper limit of Temperature Range II; i.e. this automatically qualifies the hose to meet Temperature Range I. The above also applies to the high-frequency pulsation test specified in 9.6.10.5 when qualifying a hose design family to meet FSL 2. Therefore, high-pressure mud hoses that meet FSL 1 or FSL 2 requirements can have different temperature range ratings.

9.6.10.1.7 If the minimum operating temperature specified by the manufacturer is lower than –20 °C (–4 °F), the low-temperature bending test 9.6.10.3.2 shall be carried out at the minimum operating temperature specified by the manufacturer.

9.6.10.2 Deformation Test Under Pressure

The test consists of the following steps at ambient temperature:

a) the length of the hose assembly shall be measured before pressurization;

b) test pressure shall meet or exceed that which is specified in Table 9 for at least 15 minutes;

c) the pressure shall be lowered to the working pressure of the assembly as specified in Table 9, with a tolerance of +0 % and –5 %;

d) the hose length of the pressurized hose shall be measured again.

Acceptance criteria: the percentage of the length change calculated for the free hose body length between the inside ends of the couplings shall not exceed ±2 %.
9.6.10.3 Bending Test
9.6.10.3.1 Ambient Temperature Bending Test
Bend the hose assembly to its MBR 100 times with the hose at working pressure and ambient temperature. The angle of the hose ends in bent position shall be less than 90° as shown in Figure 11. The acceptance criteria are no leakage, no visible damage, and no collapse or kinking.

9.6.10.3.2 Low-temperature Bending Test
The hose assembly shall be emptied and conditioned at or below –20 °C (–4 °F), or at the minimum operating temperature specified for 24 hours. The hose assembly shall then be bent to its MBR 100 times at –20 °C (–4 °F) degrees or at the minimum operating temperature specified. The angle of the hose ends in the bent position shall be less than 90° as shown in Figure 11. The acceptance criteria are no visible damage and no collapse or kinking.

9.6.10.4 Low-frequency Pulsation Test
Perform 1000 cycles pulsating pressure test. The fluid temperature in the hose assembly shall not be less than the maximum working temperature of the temperature range specified in 9.6.3.1. The upper pressure limit of the pulsating pressure test shall not be less than the working pressure, and the amplitude of the pressure pulsation shall be at least 90 % of the working pressure. One pressure cycle of raising and lowering the pressure shall not last longer than 5 minutes. The acceptance criterion is no visible leakage.

9.6.10.5 High-frequency Pulsation Test
Perform 10,000 cycles pulsating pressure test. The fluid temperature in the hose assembly shall not be less than the maximum working temperature of the temperature range specified in 9.6.3.1. The upper pressure limit of the pulsating pressure test shall not be less than the working pressure, and the amplitude of the pressure pulsations shall be at least 90 % of the working pressure. One pressure cycle of raising and lowering the pressure shall not last longer than 10 seconds. The acceptance criterion is no visible leakage.

9.6.10.6 Hydrostatic Pressure Test
Hydrostatic pressure test shall be performed at ambient temperatures at no less than the required factory acceptance test pressure specified in Table 9, and shall be held for a period not less than 4 hours. The test medium shall be water. Acceptance criteria are no visible leakage, and no pressure loss due to all occurrences, excluding external temperature fluctuations, which shall not exceed 2 % of the pressure at the start of the 4-hour period. The test medium shall be water.

9.6.10.7 Burst Pressure Test
A burst pressure test at ambient temperature shall be performed after completion of the tests listed above. Acceptance criteria: the burst pressure shall not be less than the value specified in Table 9 for the hose assembly tested.
9.7.1.1 The primary load-bearing components for a mud pump shall be defined as those containing the discharge pressure, with the exception of expendable items and closure components such as liners, pistons, piston rods, packing, packing glands, valves and seats, covers, heads, clamps, bushings, plugs, and fasteners. The requirements of 4.2.7, 5.3, 5.4, 5.5, 5.6, 6.3.1, 8.4.4, 8.4.5, 8.4.7 and 8.4.8 shall not apply. For antifriction bearing design and manufacturing requirements, see 9.19.

9.7.1.2 Pressure-rated items, as defined in 9.7.1.1, shall be pressure-tested in production to 1.5 times the working pressure. Hydrostatic testing shall be performed in accordance with 8.7.

9.7.1.3 Cast components of the mud-pump suction hydraulic circuit shall be hydrostatically tested in production to twice the manufacturer’s rated suction pressure. The test procedure shall be the same as for discharge components described in 9.7.1.2.

9.7.2 Mud-pump Piston Rod and Piston Body Bore, Fluid End (see Annex C for Guidance on Mud-pump Nomenclature)

9.7.2.1 Sizes and Dimensions
For double-acting pumps, fluid ends of mud-pump piston rods and bores of piston bodies shall be in accordance with Table 10 and Figure 12 and Figure 13. For single-acting pumps, the fluid ends of the piston rods and bores of the piston bodies shall conform to Table 11 and Figure 14.

9.7.2.2 Threads
Threads on rod ends and in retainer nuts shall conform to the dimensions given in Table 10 and Table 11, and shall be controlled by Class X gauges conforming to the stipulations in ASME B1.2. If supplementary production or working gauges are used, they shall be accurate copies of the master gauges.

9.7.2.3 Piston and Rod Shoulders
For 5 HP, 6 HP and single-acting pistons, shoulder faces M and N of pistons and rods shall be square to the centerline within 0.03 mm (0.001 in.) total indicator reading (TIR). Piston shoulder face, P, shall be square to the centerline within 0.13 mm (0.005 in.) TIR.

9.7.2.4 Marking
Marking shall be as follows.

a) Pistons, double-acting, with a taper conforming to this specification shall be marked with the manufacturer’s name or mark, and the taper number. High-pressure pistons numbered 5 HP and 6 HP are dimensionally interchangeable with pistons 5 and 6. It is permissible to stamp both tapers on shoulder P.

b) Pistons, single-acting, with straight bores conforming to this specification shall be marked with the manufacturer’s name or mark, API 7K and the connection number.

c) Piston rods, double-acting, conforming to this specification shall be marked with the manufacturer’s name or mark, API 7K, and the taper number. The crosshead extension end of the piston rod shall be marked with API 7K and the taper thread number or the straight thread number from Table 12 or Table 13.

d) Piston rods, single-acting, conforming to this specification on the fluid end shall be marked with the manufacturer’s name or mark, API 7K, and the connection number. If the crosshead extension end of the piston rod conforms to 9.7.3.1 or 9.7.3.2, this end shall be marked with API 7K and the taper thread number or the straight thread number from Table 12 or Table 13.
9.7.3 Duplex Mud-pump Crosshead, Crosshead Extension, and Piston Rod Connections—
Tapered
Thread Type

9.7.3.1 Sizes
Tapered thread type connections between crossheads, crosshead extensions, and piston rods shall
be 8 threads per inch (TPI), Series UN, Class 2A-2B modified, in the sizes given in Table 12. Requirements for
gauges and gauging practice are given in 9.7.3 and 9.7.4.

Key
1 centerline of piston (hand-tight position)
2 piston
NOTE See Table 10 for dimensions.

a 3.2 mm (0.125 in.) id at each shoulder.
b Break corner.
c Taper.

Figure 12—Tapers 1 Through 6

Table 10—Fluid End of Double-acting Mud-pump Piston Rods and Piston Body Bores
Dimensions in millimeters (inches)

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<th>Range of Rod End</th>
<th>Major Diam. Rod</th>
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25.40
(1.000)
38.1
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44.5
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24.37
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34.9
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63.33
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(1/4)

— 7/8-9UNC-2A
2 31.8 to 37.3
(1 1/4 to 1 15/32)
130.2
(5 1/8)
31.75
(1.250)
63.5
(2 1/2)
60.3
(2 3/8)
— 31.22
(1.229)
26.2
(1 1/32)
47.8
(1 7/8)
83.33
(1.000)
6.4
(1/4)

— 1-8UNC-2A
3 38.1 to 46.8
(1 1/2 to 1 27/32)
191.0
(7 1/8)
38.10
(1.500)
60.3
(2 3/8)
88.9
(3 1/2)
— 37.44
(1.474)
32.5
(1 9/32)
68.3
(2 11/16)
104.17
(1.250)
6.4
(1/4)

— 1 1/4-8UN-2A
4 47.6 to 56.4
(1 7/8 to 2 7/32)
203.2
(8)
47.63
(1.875)
101.6
(4)
88.9
(3 1/2)
— 47.09
(1.854)
39.7
(1 9/16)
74.6
(2 15/16)
83.33
(1.000)
6.4
(1/4)
— 1 1/2-8UN-2A
5 57.2 to 69.1
(2 1/4 to 2 3/32)
219.1
(8 5/8)
57.15
(2.250)
101.6
(4)
104.8
(4 1/8)
— 56.82
(2.229)
49.2
(1 15/16)
74.6
(2 15/16)
83.33
(1.000)
6.4
(1/4)
— 1 7/8-8UN-2A
6 69.9 to 75.4
(2 3/4 to 2 31/32)
231.8
(9 1/8)
69.85
(2.750)
114.3
(4 1/2)
104.8
(4 1/8)
— 69.32
(2.279)
60.3
(2 3/8)
74.6
(2 15/16)
83.33
(1.000)
6.4
(1/4)
— 2 1/4-8UN-2A
5HP b 69.9 to 88.9
(2 3/4 to 3 1/2)
219.1
(8 5/8)
57.15
(2.225)
95.3
(3 3/4)
111.1
(4 3/8)
42.9
(1 11/16)
56.62
(2.229)
49.2
(1 15/16)
68.3
(2 11/16)
83.33
1. Selected diameter tolerances for ISO/API rod numbers 1 and 2: ± 0.25
   0.125 in. For rod number 3 and larger: ± 0.25
   0.010 in.
   "Dimension E relates to dimension S min. only (standoff)."

2. Recommended as a substitute for ISO/API 6HP piston for reduced liner sizes only.
   Dimension C relates to dimension S min. only (standoff).

3. Break ≤ 0.4 mm (0.016 in.).

4. Fillets and undercut diameter to be prestressed by coldworking.

5. Maximum optional end extension 3.2 mm (0.125 in.).

Figure 13—Tapers 5 HP and 6 HP

Table 11—Fluid End of Single-acting Mud-pump Piston Rods and Piston Body Bores

<table>
<thead>
<tr>
<th>Dimensions in millimeters (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Piston and Rod</strong></td>
</tr>
<tr>
<td><strong>Connection</strong></td>
</tr>
<tr>
<td><strong>Number</strong></td>
</tr>
<tr>
<td><strong>Diameter</strong></td>
</tr>
</tbody>
</table>
Nominal

Piston Rod

Rod Diameter

A

Length

Rod End

±1.6

(±1/16)

B

Start of

thread

from

Shoulder

max.

C

Shoulder

Diameter

±0.4

(±1/64)

D

Thread

Designation Piston Bore

SA-2 25.4 (1) 106.4

4 3/16

38.1

(1 1/2)

50.8

(2)

1-8UNC-2A 25.40 to 25.48

(1,000 to 1,003)

SA-4 38.1 (1 1/2).4 138.1

5 7/16

47.6

(1 7/8)

82.6

(3 1/4)

1-1/2-8UN-2A 38.10 to 38.18

(1,500 to 1,503)

NOTE See Figure 14 for illustration of dimension symbols.

Key

1 shoulder N, piston shoulder, rod end

2 seal required, dimensions are the option of manufacturer

3 piston

4 shoulder P, piston shoulder, thread end

5 shoulder M, rod shoulder

6 thread relief feature, details at option of manufacturer

7 last full thread

NOTE See Table 11 for dimensions.

a Optional feature.

Figure 14—Fluid End of Single-acting Mud-pump Piston Rod and Piston Body Bore

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9.7.3.2 Thread Dimensions and Tolerances

Tapered thread type connections shall conform to dimensions given in Table 12, Figure 15 and Figure 16 and the following tolerances.

a) **Taper**: Tapered threads shall have a taper of 166.67 mm/m (2 in./ft) on the pitch cone diameter with a tolerance of

\[ 0 \]

0.51 mm (0.002 in.)
0.020 in. for internal threads and ( ) +0.51

0 mm ( ) Y ‘+’

0.020

0 in. for external threads.
b) **Concentricity:** Threads shall be concentric with rod design axis. Angular misalignment of thread axis with rod design axis shall not exceed 0.5 mm/m (0.0005 in./in.) of length.
c) **Length:**

\[ \text{LET} = B + C (8) \]

\[ B = 1.25 \cdot A (9) \]

where \( \text{LET} \) is the total length of external threads (see Figure 15 for \( A, B \) and \( C \)).
d) **Perpendicularity:** Face of internal thread member shall be perpendicular to thread axis within 0.001 mm/mm (0.001 in./in.) of face diameter.
e) **Lead:** Lead tolerance shall be ±0.0022 mm/mm (±0.0022 in./in.). Cumulative lead tolerance shall be ±0.056 mm (±0.0022 in.).
f) **Thread angle:** Half-angle tolerance of thread angle shall be ±1°.
g) **Truncation:** Crest on both internal and external threads shall be truncated parallel to taper to produce a flat 0.76 mm (0.030 in.) wide. Root on both internal and external threads shall be truncated parallel to thread axis to produce a flat of width 0.38 mm (0.015 in.). Roots of internal threads may be truncated parallel to taper of thread at the option of manufacturer. Straight threads are to be truncated the same as tapered threads.
h) **Pitch diameter:** Pitch diameter and pitch diameter tolerance of straight threads shall be as designated in ASME B1.1, Table 4.1.
i) **Standoff:** In gauging tapered threads, standoff of product from plain and threaded plug and ring gauges shall be maintained within a tolerance of ±1.6 mm (±1/16 in.) (see Figure 17).

**Caution—Do not damage threads, as this will cause misalignment and failure.**

9.7.3.3 **Locknuts**

Crosshead extension and piston rod locknuts shall be furnished in accordance with 9.7.3.2 and Figure 18.

9.7.4 **Duplex Mud-pump Crosshead, Crosshead Extension, and Piston Rod Connections—Straight**

**Thread Type**

9.7.4.1 **Sizes**

Straight thread type connections between crossheads, crosshead extensions, and piston rods shall be 8 TPI,

Series UN, Class 2A-2B modified, in the sizes given in Table 13.
### Table 13—Crosshead, Crosshead Extension, and Piston Rod Connections—Straight Thread

<table>
<thead>
<tr>
<th>Type</th>
<th>Number</th>
<th>Nominal Size</th>
<th>(A)</th>
<th>(B)</th>
<th>(C)</th>
<th>(D)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Straight</td>
<td>25.4 (1)</td>
<td>31.8 (1 1/4)</td>
<td>57.2 (2 1/4)</td>
<td>19.1 (3/4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thread</td>
<td>28.6 (1 1/4)</td>
<td>35.7 (1 3/16)</td>
<td>61.1 (2 1/16)</td>
<td>19.1 (3/4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>31.8 (1 1/4)</td>
<td>39.7 (1 15/32)</td>
<td>65.1 (2 1/4)</td>
<td>22.2 (7/8)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>34.9 (1 3/8)</td>
<td>43.7 (1 7/32)</td>
<td>69.1 (2 15/32)</td>
<td>22.2 (7/8)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>38.1 (1 1/2)</td>
<td>47.6 (1 7/16)</td>
<td>79.4 (3 1/16)</td>
<td>25.4 (1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>41.3 (1 3/8)</td>
<td>51.6 (1 11/16)</td>
<td>83.3 (3 3/16)</td>
<td>25.4 (1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>44.5 (1 3/4)</td>
<td>55.6 (2 1/2)</td>
<td>87.3 (3 11/16)</td>
<td>28.6 (1 1/8)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>47.6 (1 7/8)</td>
<td>59.5 (2 13/32)</td>
<td>91.3 (3 19/32)</td>
<td>28.6 (1 1/8)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>50.8 (2)</td>
<td>63.5 (2 1/2)</td>
<td>101.6 (4)</td>
<td>31.8 (1 1/4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>57.2 (2 1/4)</td>
<td>71.4 (2 3/16)</td>
<td>109.5 (4 1/16)</td>
<td>34.9 (1 3/4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>63.5 (2 1/2)</td>
<td>79.4 (3 1/4)</td>
<td>123.8 (4 1/2)</td>
<td>38.1 (1 1/2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>69.9 (2 3/4)</td>
<td>87.3 (3 3/16)</td>
<td>151.8 (5 3/16)</td>
<td>41.3 (1 5/8)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>76.2 (3)</td>
<td>95.3 (3 1/8)</td>
<td>191.1 (7 3/16)</td>
<td>47.6 (1 7/16)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>82.6 (3 1/4)</td>
<td>103.2 (4 3/8)</td>
<td>209.3 (8 1/2)</td>
<td>50.8 (2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>88.9 (3 1/2)</td>
<td>111.1 (4 1/2)</td>
<td>231.8 (9 1/2)</td>
<td>50.8 (2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>69.9 (2 3/4)</td>
<td>87.3 (3 3/16)</td>
<td>151.8 (5 3/16)</td>
<td>41.3 (1 5/8)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>76.2 (3)</td>
<td>95.3 (3 1/8)</td>
<td>191.1 (7 3/16)</td>
<td>47.6 (1 7/16)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>82.6 (3 1/4)</td>
<td>103.2 (4 3/8)</td>
<td>209.3 (8 1/2)</td>
<td>50.8 (2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>88.9 (3 1/2)</td>
<td>111.1 (4 1/2)</td>
<td>231.8 (9 1/2)</td>
<td>50.8 (2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>101.6 (4)</td>
<td>127.0 (5)</td>
<td>190.5 (7 1/2)</td>
<td>50.8 (2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>114.3 (4 1/2)</td>
<td>142.9 (5 1/8)</td>
<td>215.9 (8 1/2)</td>
<td>50.8 (2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>127.0 (5)</td>
<td>158.8 (6 1/16)</td>
<td>231.8 (9 1/2)</td>
<td>50.8 (2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>139.7 (5 1/2)</td>
<td>174.6 (6 7/8)</td>
<td>251.5 (10)</td>
<td>50.8 (2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>152.4 (6)</td>
<td>190.5 (7 1/2)</td>
<td>251.5 (10)</td>
<td>50.8 (2)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**NOTE** See Figure 20 for illustration of dimension symbols.

- All threads are 8 TPI, Series UN, Class 2A-2B modified.
3 crosshead extension
4 piston rod
NOTE See Table 12 for dimensions.
a 3.175 mm thread pitch (8 TPI) and 166.7 mm/m (2 in./ft) taper on pitch cone diameter.

Figure 15—Crosshead, Crosshead Extension, and Piston Rod Connections—Tapered Thread Type

Key
1 internal thread
2 external thread
3 thread axis

NOTE See 9.7.3.2 for description.

Figure 16—Tapered Thread Form

a) Tapered Thread Gauges
Key
1 ring gauge
2 plug gauge
3 product box
4 product pin

b) Tapered Plain Gauges
P extension of ring beyond end of product pin/plug gauge at full engagement

NOTE See 9.7.9.2 for descriptions.

Figure 17—Gauging Practice for Crosshead, Crosshead Extension, and Piston Rod Connections—

Tapered Thread Type

a Contact face shall be perpendicular to thread axis with a tolerance of ±0.001 mm/mm (0.001 in./in.) of face diameter.

Figure 18—Crosshead Extension and Piston Rod Locknut

9.7.4.2 Thread Dimensions and Tolerances
Straight-thread type connections shall conform to the dimensions and tolerances given in Table 13, Figure 19 and Figure 20, and ASME B1.1, and shall be gauged in accordance with ASME B1.2. The following requirements are also applicable.

a) Concentricity: Threads shall be concentric with rod design axis. Angular misalignment of thread axis with rod design axis shall not exceed 0.5 mm/m (0.0005 in./in.) of length.

b) Length (see Table 13):
1) internal: \[ B = 1.25 \cdot A \] (10)
2) external: \[ C = B + D + 6.4 \text{ mm} \] (11)

c) Perpendicularity: Face of internal thread member shall be perpendicular to thread axis within 1 mm/m (0.001 in./in.) of face diameter.

9.7.4.3 Locknuts
Crosshead extension and piston rod locknuts shall be furnished in accordance with Figure 20.

9.7.4.4 Taper Threads
Locknut threads for the taper type connection shall conform to the requirements of 9.7.3.2.

9.7.4.5 Threads
Locknut threads for the straight type connection shall conform to the requirements of 9.7.4.2.

9.7.5 Mud-pump Valve Pots
9.7.5.1 Sizes and Dimensions
Mud-pump valve pots shall be furnished in the sizes and dimensions given in Table 14 and Figure 21, or as
specified on the purchase order. API valve pots for caged valves shall provide a minimum \( G \) dimension. See Table 14 for cage clearance.

9.7.5.2 Spring Mounting Dimensions

Valve-pot spring mounting dimensions shall conform to dimensions \( L \), \( M \) and \( N \) in Figure 21 and Table 14.

Key
1 Internal thread
2 External thread
3 Thread axis

NOTE See 9.7.4.2 for description.

Figure 19—Straight Thread Form

NOTE See Table 14 for dimensions.

a Imperfect thread.

Figure 20—Crosshead, Crosshead Extension, and Piston Rod Connections—Straight Thread

Type

Table 14—Mud-pump Valve Pots

Dimensions in millimeters (inches)

<table>
<thead>
<tr>
<th>Pot Size</th>
<th>Valve Pot Dimensions</th>
<th>Spring Mounting Dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bflt</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.73</td>
<td>(2 7/8) in.</td>
<td>(44.5 mm)</td>
</tr>
<tr>
<td>2.54</td>
<td>(1 3/4) in.</td>
<td>(64.5 mm)</td>
</tr>
<tr>
<td>2.86</td>
<td>(1 1/8) in.</td>
<td>(72.6 mm)</td>
</tr>
<tr>
<td>3.17</td>
<td>(1 1/4) in.</td>
<td>(80.0 mm)</td>
</tr>
<tr>
<td>3.49</td>
<td>(1 3/8) in.</td>
<td>(87.9 mm)</td>
</tr>
<tr>
<td>3.81</td>
<td>(1 1/2) in.</td>
<td>(96.9 mm)</td>
</tr>
<tr>
<td>4.13</td>
<td>(1 5/8) in.</td>
<td>(104.8 mm)</td>
</tr>
<tr>
<td>4.45</td>
<td>(1 3/4) in.</td>
<td>(112.7 mm)</td>
</tr>
<tr>
<td>4.77</td>
<td>(1 7/8) in.</td>
<td>(120.7 mm)</td>
</tr>
<tr>
<td>5.10</td>
<td>(2) in.</td>
<td>(127.0 mm)</td>
</tr>
<tr>
<td>5.42</td>
<td>(2 1/8) in.</td>
<td>(133.4 mm)</td>
</tr>
<tr>
<td>5.74</td>
<td>(2 3/8) in.</td>
<td>(139.7 mm)</td>
</tr>
<tr>
<td>6.06</td>
<td>(2 1/4) in.</td>
<td>(146.1 mm)</td>
</tr>
<tr>
<td>6.38</td>
<td>(2 1/2) in.</td>
<td>(152.4 mm)</td>
</tr>
<tr>
<td>6.70</td>
<td>(2 5/8) in.</td>
<td>(158.8 mm)</td>
</tr>
<tr>
<td>7.03</td>
<td>(2 3/4) in.</td>
<td>(165.1 mm)</td>
</tr>
<tr>
<td>7.35</td>
<td>(3) in.</td>
<td>(171.5 mm)</td>
</tr>
<tr>
<td>7.67</td>
<td>(3 1/8) in.</td>
<td>(178.0 mm)</td>
</tr>
<tr>
<td>8.00</td>
<td>(3 1/4) in.</td>
<td>(184.2 mm)</td>
</tr>
<tr>
<td>8.32</td>
<td>(3 3/16) in.</td>
<td>(190.4 mm)</td>
</tr>
<tr>
<td>8.64</td>
<td>(3 1/2) in.</td>
<td>(196.4 mm)</td>
</tr>
<tr>
<td>8.96</td>
<td>(3 5/8) in.</td>
<td>(202.6 mm)</td>
</tr>
<tr>
<td>9.28</td>
<td>(3 3/4) in.</td>
<td>(208.8 mm)</td>
</tr>
<tr>
<td>9.60</td>
<td>(4) in.</td>
<td>(215.9 mm)</td>
</tr>
<tr>
<td>9.92</td>
<td>(4 1/8) in.</td>
<td>(222.5 mm)</td>
</tr>
<tr>
<td>10.24</td>
<td>(4 1/4) in.</td>
<td>(229.0 mm)</td>
</tr>
<tr>
<td>10.56</td>
<td>(4 1/2) in.</td>
<td>(235.4 mm)</td>
</tr>
<tr>
<td>10.88</td>
<td>(4 5/8) in.</td>
<td>(241.9 mm)</td>
</tr>
<tr>
<td>11.20</td>
<td>(4 3/4) in.</td>
<td>(248.3 mm)</td>
</tr>
<tr>
<td>11.52</td>
<td>(5) in.</td>
<td>(254.9 mm)</td>
</tr>
<tr>
<td>11.84</td>
<td>(5 1/8) in.</td>
<td>(261.4 mm)</td>
</tr>
<tr>
<td>12.16</td>
<td>(5 1/4) in.</td>
<td>(267.9 mm)</td>
</tr>
<tr>
<td>12.48</td>
<td>(5 3/8) in.</td>
<td>(274.3 mm)</td>
</tr>
<tr>
<td>12.80</td>
<td>(5 1/2) in.</td>
<td>(280.8 mm)</td>
</tr>
<tr>
<td>13.12</td>
<td>(5 5/8) in.</td>
<td>(287.3 mm)</td>
</tr>
<tr>
<td>13.44</td>
<td>(6) in.</td>
<td>(293.8 mm)</td>
</tr>
<tr>
<td>13.76</td>
<td>(6 1/8) in.</td>
<td>(300.3 mm)</td>
</tr>
<tr>
<td>14.08</td>
<td>(6 1/4) in.</td>
<td>(306.8 mm)</td>
</tr>
<tr>
<td>14.40</td>
<td>(6 3/8) in.</td>
<td>(313.3 mm)</td>
</tr>
<tr>
<td>14.72</td>
<td>(6 1/2) in.</td>
<td>(319.8 mm)</td>
</tr>
<tr>
<td>15.04</td>
<td>(6 5/8) in.</td>
<td>(326.3 mm)</td>
</tr>
<tr>
<td>15.36</td>
<td>(7) in.</td>
<td>(332.8 mm)</td>
</tr>
<tr>
<td>15.68</td>
<td>(7 1/8) in.</td>
<td>(339.3 mm)</td>
</tr>
<tr>
<td>16.00</td>
<td>(7 1/4) in.</td>
<td>(345.8 mm)</td>
</tr>
<tr>
<td>16.32</td>
<td>(7 3/8) in.</td>
<td>(352.3 mm)</td>
</tr>
<tr>
<td>16.64</td>
<td>(7 1/2) in.</td>
<td>(358.8 mm)</td>
</tr>
<tr>
<td>16.96</td>
<td>(7 5/8) in.</td>
<td>(365.3 mm)</td>
</tr>
<tr>
<td>17.28</td>
<td>(8) in.</td>
<td>(371.8 mm)</td>
</tr>
<tr>
<td>17.60</td>
<td>(8 1/8) in.</td>
<td>(378.3 mm)</td>
</tr>
<tr>
<td>17.92</td>
<td>(8 1/4) in.</td>
<td>(384.8 mm)</td>
</tr>
<tr>
<td>18.24</td>
<td>(8 3/8) in.</td>
<td>(391.3 mm)</td>
</tr>
<tr>
<td>18.56</td>
<td>(8 1/2) in.</td>
<td>(397.8 mm)</td>
</tr>
<tr>
<td>18.88</td>
<td>(9) in.</td>
<td>(404.3 mm)</td>
</tr>
<tr>
<td>19.20</td>
<td>(9 1/8) in.</td>
<td>(410.8 mm)</td>
</tr>
<tr>
<td>19.52</td>
<td>(9 1/4) in.</td>
<td>(417.3 mm)</td>
</tr>
<tr>
<td>19.84</td>
<td>(9 3/8) in.</td>
<td>(423.8 mm)</td>
</tr>
</tbody>
</table>

NOTE See Figure 21 for illustration of dimension symbols.
9.7.5.3 Marking
Mud-pump valve pots furnished in accordance with this specification shall be marked with the manufacturer’s name or mark, with “API 7K,” and the valve pot size number. Markings shall be cast or die stamped on the fluid cylinder or applied to a plate securely affixed to the fluid cylinder. Markings shall be applied in a location visible after installation of the fluid cylinder on the pump and may be applied to either pot. For pumps having divided fluid ends, each section shall be marked.

9.7.6 Mud-pump Pistons

9.7.6.1 Sizes and Dimensions
Mud-pump pistons shall be bored to fit standard taper of piston rods as given in Figure 12, Figure 13 and Table 10. Piston outside diameters shall be suitable for use in liners or cylinders having increments of diameter change as noted in 9.7.7.1 and Figure 22.

9.7.6.2 Marking
Pistons conforming to this specification shall be marked with the manufacturer’s name or mark, the number of this specification (API 7K), the corresponding API rod number, and standard bore. Markings shall be stamped in letters 3.2 mm (1/8 in.) high on the end face of piston core at the large end of the piston-rod hole.

9.7.7 Mud-pump Liners

9.7.7.1 Liner Bores
Bores of mud-pump liners 152.4 mm (6 in.) in diameter and larger shall be supplied in 6.35 mm (1/4 in.) increments. Bores smaller than 152.4 mm (6 in.) in diameter shall be supplied in 12.7 mm (1/2 in.) increments. Bore tolerances shall be as noted in Figure 22 or as specified on the purchase order.

9.7.7.2 Chamfer
The inside edge of the piston entering end of mud-pump liners shall be chamfered as shown in Figure 22.

9.7.7.3 Marking
Mud-pump liners conforming to this specification shall be marked with the manufacturer’s name or mark, the number of this specification (API 7K), and the size (standard bore) of the liner. Markings shall be stamped in letters 3.2 mm (1/8 in.) high on the outer end of the liner.

9.7.8 Mud-pump Gear Ratings

9.7.8.1 Provisions
Ratings are based on surface durability (which is independent of pitch). However, the gear manufacturer shall assume responsibility for selecting a pitch sufficiently coarse to provide adequate tooth strength.

9.7.8.2 Design
Gears shall be single reduction, either helical or herringbone. Gear materials shall be in accordance with AGMA 2004-C08. Gear strength and durability shall be determined in accordance with a national standard or code. Any practical combination of tooth height, pressure angle, or helix angle may be used. However, American Gear Manufacturers Association (AGMA) standards are recommended. The mud-pump manufacturer shall be responsible for adequate shafting and support to maintain proper alignment under load.

9.7.8.3 Nameplate Rating
The nameplate rating of a mud pump shall not exceed the (power) rating of the gears.
1 piston entering end
2 liner bore

*a Nominal diameter tolerance: +0.130
0 mm (+0.005)
0 in.

Figure 22—Mud-pump Liner

9.7.9 Gauges and Gauging Practice for Mud-pump Components

9.7.9.1 General
The gauges for the straight portion of tapered thread crosshead, crosshead extension, and piston rod connection, should not be used for the straight thread crosshead, crosshead extension, and piston rod connections, because of the difference in length of engagement. Longer gauges are required for the straight thread connections.

9.7.9.2 Working Gauges
The manufacturer shall provide working gauges for use in gauging product threads, and shall maintain all working gauges in such condition as to ensure that product threads, gauged as specified herein, are acceptable under this specification. See Appendix C in API 7 for recommended practices for care and use of working gauges. Working gauges shall be of such accuracy and construction as to ensure that the product threads conform to the requirements specified herein. The relationship between working gauges and product threads shall be as shown in Figure 17.

The mating standoffs, S, of the plain and threaded tapered ring gauges from the plug gauges are intended primarily as the basis for establishing the limits of wear or secular change in the gauges. Deviations from the initial S values should be taken into account in establishing working-gauge standoff values.

9.7.9.3 Lead
The lead of thread plug and ring gauges shall be measured parallel to the thread axis along the pitch line, over the full threaded length, omitting one full thread at each end. The lead error between any two threads shall not exceed the tolerances specified in Table 15 except that, in the case of setting plugs, the tolerance applies to a length of thread equal to that in the mating ring gauge.

9.7.9.4 Taper
The included taper of tapered thread gauges shall be measured on the diameter along the pitch line over the full threaded length, omitting approximately one full thread at each end. The taper determined as above, and computed to the length \( L_{1r} \) (see Table 16) shall conform to the basic taper within the tolerances specified in Table 15. The included taper of plain tapered plug and ring gauges shall be measured on the diameter over the full length, omitting approximately 1.6 mm (1/16 in.) of length at each end. The taper as determined above, and computed to the length \( L_{ar} \) (see Table 16 and Table 17), shall conform to the basic taper within the tolerances specified in Table 15. The taper of straight thread setting plugs shall not exceed 0.0038 mm (0.00015 in.) over the length, \( L_{TS} \) (see Table 18, Table 19 and Figure 24). The permissible taper shall be back taper (largest diameter at the entering end) and shall be confined within the pitch diameter limits.

9.7.9.5 Fit
Go and no-go adjustable straight-thread ring gauges shall be set to snug-fit at full engagement on their mating plugs. An adjustable ring gauge shall be set initially on either the full form or the truncated portion of the setting plug. When screwed onto the other portion of the setting plug, there shall be only a slight change in fit, if any. If there is perceptible shake or play in the looser fit, the ring and, if necessary, the plug shall be reconditioned.

9.7.9.6 Root Form
The roots of tapered-thread plug and ring gauges shall be approximately sharp with a radius not exceeding 0.25 mm (0.010 in.), or undercut to a maximum width equivalent to the basic root truncation given in Table 22. The undercut shall be substantially symmetrical with respect to the adjoining thread flanks and of such depth as to clear the basic sharp thread; otherwise, the shape of the undercut shall be optional with the gauge manufacturer.

9.7.9.7 Thread Roots
The thread roots of go thread plug and ring gauges, no-go thread plug and ring gauges, and setting thread plug gauges for the straight thread on the pin and the thread in the locknut shall be as specified in ASME B1.2. See Table 15, Table 16, Table 17, Table 18, Table 19, Figure 24, Figure 25, and Figure 26 for dimensional tolerances.

Table 15—Tolerances on Gauge Dimensions
Dimensions in millimeters (inches) at 20 °C (67 °F), except as otherwise indicated

<table>
<thead>
<tr>
<th>Tapered Gauges (Threaded and Plain)</th>
<th>Plug Gauge Ring Gauge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pitch diameter at gauge point ±0.010</td>
<td>Diameter of plain plug at large end, $D_{PL}$ ±0.010</td>
</tr>
<tr>
<td>Minor diameter at gauge point ±0.051</td>
<td>Diameter of counterbore, $D_{CO}$ ±0.381</td>
</tr>
<tr>
<td>Major diameter at gauge point ±0.051</td>
<td>Diameter of fitting plate, $D_{FP}$ ±0.381</td>
</tr>
<tr>
<td>Outside diameter, $D_{O}$ ±0.381</td>
<td>Diameter of fitting plate, $D_{FP}$ ±0.381</td>
</tr>
<tr>
<td>(±0.015)</td>
<td>(±0.015)</td>
</tr>
<tr>
<td>Diameter of plain plug at large end, $D_{PL}$ ±0.010</td>
<td>(±0.015)</td>
</tr>
<tr>
<td>Diameter of counterbore, $D_{CO}$ ±0.381</td>
<td>(±0.015)</td>
</tr>
<tr>
<td>Diameter of fitting plate, $D_{FP}$ ±0.381</td>
<td>(±0.015)</td>
</tr>
<tr>
<td>Taper Number</td>
<td>Tapered Plug</td>
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<tr>
<td>Thread</td>
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<td>Number</td>
<td>Plug</td>
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</tbody>
</table>
T1 to T15: ±0.01
(±0.0004)
(±0.0002)
±0.015
(±0.0006)
T16 to T18: ±0.013
(±0.0005)
±0.008
(±0.0003)
±0.013
(±0.0005)
±0.030
T19 and T20
±0.018
(±0.0007)
±0.010
(±0.0004)
±0.018
(±0.0007)
T16 to T18: ±0.013
(±0.0005)
±0.008
(±0.0003)
±0.020
(±0.0008)
Half-angle of thread ±7 min: 0.038
(±0.0015)
Length, \(L_{PT}\) and \(L_{PP}\): ±0.051
(±0.002)
T19 and T20
±0.018
(±0.0007)
±0.010
(±0.0004)
±0.025
(±0.0010)
±0.053
(±0.0021)
Half-angle of thread ±15 min:
Length, \(L_{RT}\) and \(L_{RP}\): ±0.051
(±0.002)
Mating standoff ±0.051
(±0.002)

Straight Thread Gauges

Tolerances for straight thread plug and ring gauges to gauge the straight thread portion of the tapered type connection shall be as specified in ASME B1.2 for Class W gauges.

The ends of plug and ring gauges shall be square with the thread axis within a tolerance of 0.025 mm (0.001 in.).

A Tolerances for taper apply to the full gauge length.

Table 16—Tapered Thread and Plain Gauges a
Dimensions in millimeters at 20 °C

<table>
<thead>
<tr>
<th></th>
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<th></th>
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</thead>
<tbody>
<tr>
<td>Taper Number</td>
<td>Nom. Size</td>
<td>Outside Diam. of Ring</td>
<td></td>
<td></td>
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<tr>
<td>-------------</td>
<td>-----------</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>T1</td>
<td>1 1/4</td>
<td>66.7 28.2753 29.7017 26.8488</td>
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<tr>
<td>T2</td>
<td>1 1/8</td>
<td>63.5 25.1016 26.5280 23.6751</td>
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<td></td>
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<td>T3</td>
<td>1 1/16</td>
<td>60.3 21.9304 23.3568 20.5039</td>
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<tr>
<td>T4</td>
<td>1 1/32</td>
<td>59.1 18.7500 20.1761 17.3328</td>
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<tr>
<td>T5</td>
<td>1 1/64</td>
<td>58.0 15.5625 16.9888 14.1453</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T6</td>
<td>1 1/128</td>
<td>57.0 12.3750 13.7912 10.9479</td>
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<tr>
<td>T7</td>
<td>1 1/256</td>
<td>56.0 9.1875 10.6039 7.7505</td>
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<tr>
<td>T8</td>
<td>1 1/512</td>
<td>55.0 6.0000 7.4167 4.5625</td>
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<td>T9</td>
<td>1 1/1024</td>
<td>54.0 3.9062 5.3208 2.4667</td>
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<tr>
<td>T10</td>
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<td>53.0 2.8125 4.2222 1.3681</td>
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<td>49.0 0.2156 0.5156 0.1211</td>
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</tbody>
</table>

NOTE: See Figure 23 for illustration of dimension symbols.

Taper Pitch Diameter at Gauge Point Major Diameter at Gauge Point Minor Diameter of Fitting Plate Length of Plug and Ring Diameter of Counterbore Diameter of Plug at Large End Diameter of Ring at Large End Length of Plug and Ring

Table 17—Tapered Thread and Plain Gauges a

Dimensions in inches at 68 °F

<table>
<thead>
<tr>
<th>Taper Number</th>
<th>Nom. Size</th>
<th>Outside Diam. of Ring</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>1 1/4</td>
<td>66.7 28.2753 29.7017 26.8488</td>
</tr>
<tr>
<td>T2</td>
<td>1 1/8</td>
<td>63.5 25.1016 26.5280 23.6751</td>
</tr>
<tr>
<td>T3</td>
<td>1 1/16</td>
<td>60.3 21.9304 23.3568 20.5039</td>
</tr>
<tr>
<td>T4</td>
<td>1 1/32</td>
<td>59.1 18.7500 20.1761 17.3328</td>
</tr>
<tr>
<td>T5</td>
<td>1 1/64</td>
<td>58.0 15.5625 16.9888 14.1453</td>
</tr>
<tr>
<td>T6</td>
<td>1 1/128</td>
<td>57.0 12.3750 13.7912 10.9479</td>
</tr>
<tr>
<td>T7</td>
<td>1 1/256</td>
<td>56.0 9.1875 10.6039 7.7505</td>
</tr>
<tr>
<td>T8</td>
<td>1 1/512</td>
<td>55.0 6.0000 7.4167 4.5625</td>
</tr>
<tr>
<td>T9</td>
<td>1 1/1024</td>
<td>54.0 3.9062 5.3208 2.4667</td>
</tr>
<tr>
<td>T10</td>
<td>1 1/2048</td>
<td>53.0 2.8125 4.2222 1.3681</td>
</tr>
<tr>
<td>T11</td>
<td>1 1/4096</td>
<td>52.0 1.7188 3.1250 0.9536</td>
</tr>
<tr>
<td>T12</td>
<td>1 1/8192</td>
<td>51.0 0.8625 2.0625 0.4844</td>
</tr>
<tr>
<td>T13</td>
<td>1 1/16384</td>
<td>50.0 0.4312 1.0312 0.2422</td>
</tr>
<tr>
<td>T14</td>
<td>1 1/32768</td>
<td>49.0 0.2156 0.5156 0.1211</td>
</tr>
</tbody>
</table>

NOTE: See Figure 23 for illustration of dimension symbols.

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Licensee=National Oilwell Varco/5899681102, User=sthallros, per
<table>
<thead>
<tr>
<th>Taper for all sizes is 2.0000 in./ft on diameter.</th>
</tr>
</thead>
<tbody>
<tr>
<td>a All threads are 8 TPI, pitch = 0.1250 in.</td>
</tr>
</tbody>
</table>

Table 18—Pin Go and No-go Gauges a

<table>
<thead>
<tr>
<th>Table 18—Pin Go and No-go Gauges a</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOTE See Table 16 and Table 17 for dimensions.</td>
</tr>
<tr>
<td>a 9.5 mm to 19.1 mm (0.375 in. to 0.75 in.). Dimension varies with gauge size.</td>
</tr>
<tr>
<td>Figure 23—Tapered-thread and Plain Gauges</td>
</tr>
</tbody>
</table>

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### Table 19—Pin Go and No-go Gauges a
(for Straight-threaded Portion of Tapered-thread Connection)

Dimensions in inches at 68 °F

<table>
<thead>
<tr>
<th>Taper</th>
<th>Thread Number</th>
<th>Nom. Size</th>
<th>Full Form</th>
<th>Major Diam.</th>
<th>Go Gauges</th>
<th>No-go Gauges</th>
</tr>
</thead>
<tbody>
<tr>
<td>T2</td>
<td>1/2</td>
<td>27.889</td>
<td>27.455</td>
<td>26.998</td>
<td>26.284</td>
<td>25.029</td>
</tr>
<tr>
<td>T3</td>
<td>3/4</td>
<td>31.064</td>
<td>30.630</td>
<td>30.170</td>
<td>29.456</td>
<td>28.128</td>
</tr>
<tr>
<td>T4</td>
<td>1</td>
<td>34.237</td>
<td>33.802</td>
<td>33.338</td>
<td>32.624</td>
<td>31.910</td>
</tr>
<tr>
<td>T5</td>
<td>1 1/2</td>
<td>37.411</td>
<td>36.977</td>
<td>36.510</td>
<td>35.961</td>
<td>35.082</td>
</tr>
<tr>
<td>T6</td>
<td>1 5/8</td>
<td>40.587</td>
<td>40.152</td>
<td>39.727</td>
<td>39.262</td>
<td>38.769</td>
</tr>
<tr>
<td>T7</td>
<td>1 3/4</td>
<td>43.759</td>
<td>43.325</td>
<td>42.852</td>
<td>42.309</td>
<td>41.823</td>
</tr>
<tr>
<td>T8</td>
<td>1 7/8</td>
<td>46.934</td>
<td>46.500</td>
<td>46.022</td>
<td>45.539</td>
<td>45.055</td>
</tr>
<tr>
<td>T9</td>
<td>2</td>
<td>49.675</td>
<td>49.247</td>
<td>48.769</td>
<td>48.309</td>
<td>47.835</td>
</tr>
<tr>
<td>T10</td>
<td>2 1/4</td>
<td>53.975</td>
<td>53.537</td>
<td>53.062</td>
<td>52.593</td>
<td>52.119</td>
</tr>
<tr>
<td>T11</td>
<td>2 1/2</td>
<td>57.276</td>
<td>56.838</td>
<td>56.369</td>
<td>55.899</td>
<td>55.425</td>
</tr>
<tr>
<td>T12</td>
<td>2 3/4</td>
<td>60.573</td>
<td>60.135</td>
<td>59.666</td>
<td>59.197</td>
<td>58.723</td>
</tr>
<tr>
<td>T13</td>
<td>3</td>
<td>63.870</td>
<td>63.432</td>
<td>62.964</td>
<td>62.495</td>
<td>62.020</td>
</tr>
<tr>
<td>T14</td>
<td>3 1/4</td>
<td>67.167</td>
<td>66.729</td>
<td>66.261</td>
<td>65.791</td>
<td>65.317</td>
</tr>
<tr>
<td>T15</td>
<td>3 1/2</td>
<td>70.464</td>
<td>69.996</td>
<td>69.528</td>
<td>68.958</td>
<td>68.484</td>
</tr>
<tr>
<td>T16</td>
<td>4</td>
<td>73.761</td>
<td>73.293</td>
<td>72.825</td>
<td>72.356</td>
<td>71.882</td>
</tr>
<tr>
<td>T17</td>
<td>4 1/4</td>
<td>77.058</td>
<td>76.589</td>
<td>76.121</td>
<td>75.651</td>
<td>75.177</td>
</tr>
<tr>
<td>T18</td>
<td>4 1/2</td>
<td>80.355</td>
<td>79.887</td>
<td>79.419</td>
<td>78.949</td>
<td>78.475</td>
</tr>
<tr>
<td>T19</td>
<td>5</td>
<td>83.652</td>
<td>83.183</td>
<td>82.715</td>
<td>82.245</td>
<td>81.771</td>
</tr>
<tr>
<td>T20</td>
<td>5 1/4</td>
<td>86.949</td>
<td>86.481</td>
<td>86.013</td>
<td>85.543</td>
<td>85.070</td>
</tr>
<tr>
<td>T21</td>
<td>5 1/2</td>
<td>90.246</td>
<td>89.777</td>
<td>90.309</td>
<td>89.440</td>
<td>89.309</td>
</tr>
<tr>
<td>T22</td>
<td>6</td>
<td>93.542</td>
<td>93.073</td>
<td>92.605</td>
<td>92.136</td>
<td>91.667</td>
</tr>
</tbody>
</table>

**NOTE:** See Figure 24 for illustration of dimension symbols.

---

*a All threads are 8 TPI, pitch = 3.175 mm.

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<table>
<thead>
<tr>
<th>Taper</th>
<th>Thread</th>
<th>Number</th>
<th>Nominal</th>
<th>Size</th>
<th>Go Gauges</th>
<th>No-go Gauges</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major</td>
<td>Diameter</td>
<td>Pitch</td>
<td>Diameter</td>
<td>Thread</td>
<td>Length</td>
<td>Major</td>
</tr>
<tr>
<td>1</td>
<td>T</td>
<td>24.768</td>
<td>23.338</td>
<td>25.4</td>
<td>24.275</td>
<td>25.361</td>
</tr>
</tbody>
</table>
| NOTE See Figure 24 for illustration of dimension symbols.
| All threads are 8 TPI, pitch = 0.1250 in. |
### Table 21—Box Go and No-go Gauges a (for Locknut)
Dimensions in inches at 68 °F

<table>
<thead>
<tr>
<th>Tapered Thread</th>
<th>Length</th>
<th>Nominal Size</th>
<th>Go Gauges</th>
<th>No-go Gauges</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Major Diameter</td>
<td>Pitch</td>
<td>Diameter</td>
</tr>
<tr>
<td>T1 1/8</td>
<td>0.9751</td>
<td>0.9188</td>
<td>1.0957</td>
<td>0.9276</td>
</tr>
<tr>
<td>T2 1/4</td>
<td>1.1001</td>
<td>1.0438</td>
<td>1.1669</td>
<td>1.0528</td>
</tr>
<tr>
<td>T3 1/4</td>
<td>1.2251</td>
<td>1.1688</td>
<td>1.2061</td>
<td>1.1780</td>
</tr>
<tr>
<td>T4 3/8</td>
<td>1.3501</td>
<td>1.2938</td>
<td>1.3312</td>
<td>1.3031</td>
</tr>
<tr>
<td>T5 1/2</td>
<td>1.4751</td>
<td>1.4188</td>
<td>1.4564</td>
<td>1.4283</td>
</tr>
<tr>
<td>T6 5/8</td>
<td>1.6001</td>
<td>1.5438</td>
<td>1.5816</td>
<td>1.5535</td>
</tr>
<tr>
<td>T7 7/8</td>
<td>1.7251</td>
<td>1.6688</td>
<td>1.7067</td>
<td>1.6786</td>
</tr>
<tr>
<td>T8 2</td>
<td>1.8501</td>
<td>1.7938</td>
<td>1.8319</td>
<td>1.8038</td>
</tr>
<tr>
<td>T9 2</td>
<td>1.9751</td>
<td>1.9188</td>
<td>1.9570</td>
<td>1.9289</td>
</tr>
<tr>
<td>T10 2</td>
<td>2.2251</td>
<td>2.1688</td>
<td>2.2073</td>
<td>2.1792</td>
</tr>
<tr>
<td>T11 2</td>
<td>2.4751</td>
<td>2.4188</td>
<td>2.4575</td>
<td>2.4294</td>
</tr>
<tr>
<td>T12 3/4</td>
<td>2.7251</td>
<td>2.6688</td>
<td>2.7077</td>
<td>2.6796</td>
</tr>
<tr>
<td>T13 1/2</td>
<td>2.9751</td>
<td>2.9188</td>
<td>3.0190</td>
<td>2.9889</td>
</tr>
<tr>
<td>T14 1/2</td>
<td>3.2251</td>
<td>3.1688</td>
<td>3.2082</td>
<td>3.1801</td>
</tr>
<tr>
<td>T15 3/4</td>
<td>3.4751</td>
<td>3.4188</td>
<td>3.4584</td>
<td>3.4303</td>
</tr>
<tr>
<td>T16 5/8</td>
<td>3.7251</td>
<td>3.6688</td>
<td>3.7672</td>
<td>3.7390</td>
</tr>
<tr>
<td>T17 7/8</td>
<td>4.4751</td>
<td>4.4188</td>
<td>4.4490</td>
<td>4.4210</td>
</tr>
<tr>
<td>T18 2</td>
<td>4.9751</td>
<td>4.9188</td>
<td>5.0190</td>
<td>4.9889</td>
</tr>
<tr>
<td>T19 2</td>
<td>5.4751</td>
<td>5.4188</td>
<td>5.5190</td>
<td>5.4889</td>
</tr>
<tr>
<td>T20 2</td>
<td>5.9751</td>
<td>5.9188</td>
<td>6.0190</td>
<td>5.9889</td>
</tr>
</tbody>
</table>

NOTE: See Figure 25 for illustration of dimension symbols.

a All threads are 8 TPI, pitch = 0.375 mm.
Dimensions in millimeters (inches) at 20 °C (68 °F)

Thread Element Tapered a b Thread Gauges Straight c Thread Gauges

\[
egin{align*}
F_n, f_n, f_{cn}, f_{nc} & = 0.658 \, 4 (0.02592) \, 0.659 \, 9 (0.02598) \\
h_1 & = 1.426 \, 5 (0.05616) \, 1.429 \, 8 (0.05629) \\
h & = 2.743 \, 2 (0.10800) \, 2.749 \, 6 (0.10825)
\end{align*}
\]

NOTE See Figure 26 for illustration of dimension symbols.

a The effect of taper has been taken into account in computing thread height and truncation.
b Taper = 166.67 mm/m (2.000 in./ft) on diameter. pitch = 3.175 mm (0.1250 in.).
c Pitch = 3.175 mm (0.1250 in.).

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NOTE See Table 18 and Table 19 for dimensions.

Figure 24—Pin Go and No-go Gauges (for Straight-threaded Portion of Tapered-thread Connection)

NOTE See Table 20 and Table 21 for dimensions.

Figure 25—Box Go and No-go Gauges (for Locknut)

Key
1 internal thread
2 external thread
3 thread axis
4 pitch

NOTE See Table 22 for dimensions.

Figure 26—Gauge Thread Form

9.7.9.8 Pitch Diameter

In computing pitch diameter, the effect of helix angle shall be disregarded.

9.7.9.9 Initial Standoff

The large ends of tapered-thread gauges shall be flush within ±0.05 mm (±0.002 in.). The standoff of plain tapered gauges shall be 17.117 ± 0.05 mm (0.6739 ± 0.002 in.).

9.7.10 Determination of Standoff

Mating standoff (as illustrated in Figure 17 and Figure 23) shall be determined as follows.

a) During the test all pieces entering into the measurement shall be at a uniform temperature near 20 °C (68 °F).
b) Gauges shall be benzene-cleaned before mating. Gauges shall be made up within a thin film of white mineral oil of grade and viscosity such as Nujol 12, Squibb's liquid petrolatum 12 or equivalent, wiped onto threads with a clean chamois skin or bristle brush.
c) The pair shall be mated hand-tight without spinning into place, and complete register shall be accomplished with the torque hammer as shown in Figure 27 using the following weights:

\[
\begin{align*}
\downarrow & \text{ for gauges T1 to T9, use a 0.45 kg (1 lb) weight;} \\
\downarrow & \text{ for gauges T10 to T13, use a 0.91 kg (2 lb) weight;} \\
\downarrow & \text{ for gauges T14 to T17, use a 1.36 kg (3 lb) weight;}
\end{align*}
\]

12 This term is used as an example only, and does not constitute an endorsement of this product by API.

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DRILLING AND WELL SERVICING EQUIPMENT 73

\[
\begin{align*}
\downarrow & \text{ for gauges T18 to T20, use a 1.81 kg (4 lb) weight.}
d) The number of torque hammer blows is unimportant. Sufficient number should be made so that continued hammering will not move the ring relative to plug. When testing, the plug gauge should be rigidly held, preferably in a vice mounted on a rigid workbench. When so held, 12 torque hammer blows should be sufficient to make complete register.
\end{align*}
\]

Key
1 gauge
2 weight

Figure 27—Torque Hammer

9.7.11 Maintenance of Gauges
The maintenance of gauges within the specified limits shall be the responsibility of the gauge user. Tapered thread gauges shall be tested for standoff by the procedures listed herein, the interval between tests being dependent on use. A pair of tapered gauges may be considered safe for continued use provided the mating standoff does not differ from the original standoff by more than 0.13 mm (0.005 in.).

9.7.10 Triplex Mud-pump Crosshead, Crosshead Extension, and Piston Rod Connection—Contacting Flat

**Faces and Pilot Diameters**

On triplex mud pumps, all rod connections between the crosshead and piston hub that affect rod alignment shall have tolerances that do not exceed those shown in Figure 28.

- **Key**
  - a Contacting flat faces or mating rod connections, and crosshead extension shall be perpendicular to centerline of rod with a tolerance of 0.0005 m/m (0.0005 in./in.) of face diameter.
  - b Concentricity tolerance between pilot diameter’s centerline and theoretical centerline of rod shall not exceed 0.13 mm (0.005 in.).

**Figure 28—Contacting Flat Faces and Pilot Diameters on Mating Connections from Crosshead Extension to Piston Hub on Mud Pumps**

9.8 Drawworks Components

**9.8.1 Primary Load Path**

The primary load-path components for a drawworks shall be limited to those loaded by the fast-line load when the main drum brake is engaged. The manufacturer/designer shall use accepted design practices and shall determine factors of safety, except as otherwise specified within this specification.

**9.8.2 Requirements**

The requirements of 4.2.7, 5.4, 5.5, 5.6, 6.3.1, 8.4.4, 8.4.5, 8.4.7, and 8.4.8 shall not apply, except as noted below.

For antifriction bearing design and manufacturing requirements, see 9.19.

**9.8.3 Line-shaft Extension for Cathead**

Line-shaft extensions for catheads shall be furnished as specified on the purchase order unless the drawworks is furnished with integral catheads.

**9.8.4 Brake Bands for Main Drum**

**9.8.4.1 General**

Main drum brakes are generally band or disk types, but other designs are not precluded by this specification.

**9.8.4.2 Design Safety Factor (DSF)**

The minimum DSF for the structural strength of main drum brake bands shall be 3.0, based on the drawworks’ rated design fast-line pull at the median drum working radius, or the second layer of working rope, whichever is greater.

**9.8.4.3 Weldments**

- **9.8.4.3.1** The design load capacity of the weldment shall not be less than the minimum design load capacity of the band only.
- **9.8.4.3.2** Weldments shall be reviewed for the effect of weld stress concentration as it affects fatigue life of the weldments.

**9.8.4.4 Quality Control**

- **9.8.4.4.1** All castings and welds shall be inspected in accordance with 8.4.7.
9.8.4.4.2 All accessible surfaces of the band shall be visually inspected after all manufacturing operations are completed. Indications with a length of less than three times the width are acceptable, provided the major dimension is less than 4 mm (1/8 in.) and they meet other criteria established in 8.4.7.4 for wrought material. No indications with a length equal to or greater than three times the width are acceptable. No indications at the edges, including hole edges, of the band are acceptable.

9.8.4.4.3 The inside radius on a band, between tangent points, shall not deviate more than ±0.5 % from the design radius. The inside radii measured at the edges of a band at any circumferential point on the band shall not vary more than ±0.5 % of the bandwidth at that point.

9.8.4.4.4 Maximum allowable weld undercut shall be in accordance with AWS D1.1, except that there shall be none for any transverse welds.

9.9 Manual Spiders that use Standard Rotary Slips
9.9.1 General Spider bodies furnished in conformance with this specification that use standard rotary slips not capable of use as elevators and installed on or above the master bushing/rotary table (see 1 c)), shall be marked with the manufacturer’s name or mark and the rating.

9.9.2 Component Traceability Primary load-carrying components shall be uniquely marked as specified in 8.4.5.

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

9.9.4 Impact Toughness The following impact toughness values apply to primary load-carrying components of spiders.

a) Components with a specified minimum yield strength of at least 310 MPa (45,000 psi) shall be made from materials possessing a minimum impact toughness of 33 J (25 ft-lb) at –20 °C (–4 °F). The specified minimum impact toughness shall be an average of three tests, with no individual value less than 26 J (19 ft-lb).

b) For components with a specified minimum yield strength of less than 310 MPa (45,000 psi), the –20 °C (–4 °F) minimum impact toughness shall be 27 J (20 ft-lb) with no individual value less than 20 J (15 ft-lb).

9.9.5 Design Verification Test The design verification load test, as described in Section 5, shall apply.

9.9.6 Proof Load Test Proof load testing, as described in 8.6, shall apply. The following shall apply to spiders and manual tongs:

a) replacement hinge pins and latch pins shall meet or exceed the original manufacturer’s specifications;

b) replacement hinge pins and latch pins manufactured from wrought material are exempt from proof load testing requirements.

9.10 Manual Spiders that use Nonstandard Rotary Slips
9.10.1 General Spider bodies furnished in conformance with this specification that use rotary slips with a nonstandard taper, not capable of use as elevators, and installed on or above the master bushing/rotary table, shall be marked with the manufacturer’s name or mark and the rating.

9.10.2 Component Traceability
Primary load-carrying components shall be uniquely marked as specified in 8.4.5.

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

9.10.4 Impact Toughness
The following impact toughness values apply to primary load-carrying components of spiders.
   a) Components with a specified minimum yield strength of at least 310 MPa (45,000 psi) shall be made from materials possessing a minimum impact toughness of 33 J (25 ft-lb) at –20 °C (–4 °F). The specified minimum impact toughness shall be an average of three tests, with no individual value less than 26 J (19 ft-lb).
   b) For components with a specified minimum yield strength of less than 310 MPa (45,000 psi), the –20 °C (–4 °F) minimum impact toughness shall be 27 J (20 ft-lb) with no individual value less than 20 J (15 ft-lb).

9.10.5 Design Verification Test
The design verification load test, as described in Section 5, shall apply.

9.10.6 Proof Load Test
Proof load testing, as described in 8.6, shall apply. The following shall apply to spiders and manual tongs:
   a) replacement hinge pins and latch pins shall meet or exceed the original manufacturer’s specifications;
   b) replacement hinge pins and latch pins manufactured from wrought material are exempt from proof load testing requirements.

9.11 Spring, Pneumatic, or Hydraulic Spiders Installed on or above the Master Bushing/Rotary Table

9.11.1 General
Spider bodies furnished in conformance with this specification with integral slips not capable of use as elevators, installed on or above the master bushing/rotary table shall be marked with the manufacturer’s name or mark and the rating.

9.11.2 Component traceability
Primary load-carrying components shall be uniquely marked as specified in 8.4.5.

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

9.11.4 Impact Toughness
The following impact toughness values apply to primary load-carrying components of spiders.
   a) Components with a specified minimum yield strength of at least 310 MPa (45,000 psi) shall be made from materials possessing a minimum impact toughness of 33 J (25 ft-lb) at –20 °C (–4 °F). The specified minimum impact toughness shall be an average of three tests, with no individual value less than 26 J (19 ft-lb).
   b) For components with a specified minimum yield strength of less than 310 MPa (45,000 psi), the –20 °C (–4 °F) minimum impact toughness shall be 27 J (20 ft-lb) with no individual value less than 20 J (15 ft-lb).

9.11.5 Design Verification Test
The design verification load test, as described in Section 5, shall apply.

9.11.6 Proof Load Test
Proof load testing, as described in 8.6, shall apply. The following shall apply to spiders and manual tongs:
   a) replacement hinge pins and latch pins shall meet or exceed the original manufacturer’s specifications;
   b) replacement hinge pins and latch pins manufactured from wrought material are exempt from proof load testing
requirements.

9.12 Spring, Pneumatic, or Hydraulic Spiders Installed in, or partly in, the Rotary Table

9.12.1 General
Spider bodies furnished in conformance with this specification with integral slips not capable of use as elevators, installed in, or partly in, the rotary table shall be marked with the manufacturer’s name or mark and the rating.

9.12.2 Component Traceability
Primary load-carrying components shall be uniquely marked as specified in 8.4.5.

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

9.12.4 Impact Toughness
The following impact toughness values apply to primary load-carrying components of spiders.

a) Components with a specified minimum yield strength of at least 310 MPa (45,000 psi) shall be made from materials possessing a minimum impact toughness of 33 J (25 ft-lb) at –20 °C (–4 °F). The specified minimum impact toughness shall be an average of three tests, with no individual value less than 26 J (19 ft-lb).

b) For components with a specified minimum yield strength of less than 310 MPa (45,000 psi), the –20 °C (–4 °F) minimum impact toughness shall be 27 J (20 ft-lb) with no individual value less than 20 J (15 ft-lb).

9.12.5 Design Verification Test
The design verification load test, as described in Section 5, shall apply.

9.12.6 Proof Load Test
Proof load testing, as described in 8.6, shall apply.

9.13 Manual Tongs

9.13.1 Product Marking
Manual tongs furnished in conformance with this specification shall be marked with the manufacturer’s name or mark and the rated load.

9.13.2 Size Class Designation
The size class designation for manual tongs shall represent the diameter, or range of diameters, for which the tong is designed.

9.13.3 Impact Toughness

9.13.3.1 The following impact toughness values apply to primary load-path components except hinge pins.

a) Components with a specified minimum yield strength of at least 310 MPa (45,000 psi) shall be from materials possessing a minimum impact toughness of 42 J (31 ft-lb) at 20 °C (4 °F). The specified minimum impact toughness shall be an average of three tests, with no individual values less than 32 J (24 ft-lb).

b) For components with a specified minimum yield strength of less than 310 MPa (45,000 psi), the 20 °C (4 °F) minimum impact toughness shall be 27 J (20 ft-lb) with no individual values less than 20 J (15 ft-lb).

9.13.3.2 Hinge pins shall have a minimum impact toughness of 15 J (11 ft-lb) at 20 °C (4 °F). The specified minimum impact toughness shall be an average of three tests, with no individual value less than 12 J (8.5 ft-lb).

9.13.4 Component Traceability
Primary load-carrying components shall be uniquely marked as specified in 8.4.5.

9.13.5 Design Verification Load Tests
The design verification load test, as described in Section 5, shall apply.
9.13.6 Proof Load Testing
Proof load testing, as described in 8.6, shall apply. Jaw hinge pins of wrought material shall be exempt from this requirement.

9.14 Safety Clamps Not Used as a Hoisting Device
9.14.1 Load rating of safety clamps is not required.
9.14.2 The requirements of 6.3.1, 8.4.4, 8.4.5, 8.4.8, and 8.4.9 shall not apply.
9.14.3 The requirements of 8.4.7 apply to safety clamps except that the method and acceptance criteria of MSS SP-53 shall apply.

9.15 Power Tongs
9.15.1 Product Marking
Power tongs furnished in conformance with this specification shall be marked with the manufacturer’s name or mark and size class.

9.15.2 Size Class Designation
The size class designation for power tongs shall represent the diameter, or range of diameters, for which the tong is designed.

9.15.3 Requirements
The requirements of 4.2.7, 5.3, 5.4, 5.5, 5.6, 6.3, and Section 8 in its entirety shall not apply.

9.15.4 Primary Load Path
The primary load path shall be considered to be the mechanical elements (exclusive of hydraulic power transmission components) through which the torque is applied or resisted.

9.16 BOP Handling Systems and Equipment
9.16.1 Applicability of the Requirements in Section 1 Through 8
9.16.1.1 Sections 4.1, 4.5, and 4.6 covering design requirements and DSFs shall not apply to this equipment.
Such requirements for this equipment shall be in accordance with 9.16.3, 9.16.4, and 9.16.5.
9.16.1.2 Section 4.2.7 regarding fatigue life shall apply to this equipment, or as specified by the manufacturer.
9.16.1.3 Section 4.4.1 covering rotary tables, spiders, manual, and power tongs shall not apply to this equipment.
9.16.1.4 Section 4.4.3 covering torque ratings for power and manual tongs shall not apply to this equipment.
9.16.1.5 Production proof load testing required in 8.6, and as further specified in 9.16.6, shall be required unless it is waived by the purchaser in the purchase agreement.

9.16.2 Requirements for Purchaser-defined Information and Specifications in Purchase Agreements for BOP Handling Systems
9.16.2.1 General
The requirements in 9.16.2.2 and 9.16.2.3 shall be specified by the purchaser in purchase agreements issued for BOP handling systems covered by this standard.

9.16.2.2 Control System Features
The purchaser shall specify control system features, such as load monitoring and logging (specify USC or SI units), audio/visual alarms, operational displays and ergonomics, any fail-safe shut-downs or other safety features not specified in this standard, and control system functionality such as defaults, interlocks, and detents, redundancy features, manual overrides, trouble-shooting devices, and back-up power supplies and software, etc.
Control systems shall be designed so as to prevent unexpected movement of the system when power is interrupted, and when restored after interruption, of power (e.g. electrical, pneumatic, and hydraulic). The controls shall be designed to prevent unexpected movement regardless of whether one source, or multiple sources, of power are interrupted and subsequently restored.

9.16.2.3 Ambient Conditions

The purchaser shall specify the environment in which the system is anticipated to operate in terms of maximum and minimum temperatures and humidity levels, the corrosiveness of the atmosphere such as whether the system will be used offshore or onshore, and any other ambient conditions that could affect the design or manufacture of the system that would be reasonably anticipated.

9.16.2.4 Other Systems Interface Requirements

9.16.2.4.1 The purchaser shall identify the other systems that the BOP handling system will interface with physically as well as functionally. This type of interface may include but not be limited to rig system control and monitoring systems (including software compatibility), BOP stack storage structure(s), moonpool guidance systems, and/or structural interface required to distribute and support the primary load of the handling system.

The latter requirement should include a transmittal of relevant rig structural drawings to the manufacturer needed to design appropriate system structure to interface with the rig structure.

9.16.2.4.2 When it is intended that the system is to receive power supplies from the rig after it is installed, the purchaser shall specify the sources of electrical, hydraulic, and/or pneumatic power that is to be made available to supply power to the system.

9.16.2.4.3 The purchaser shall specify the applicable codes, standards, and regulatory requirements that shall apply to electrical equipment, components, fittings, and cabling and their installation, including applicable requirements for hazardous area or zone classifications in which the BOP handling system is to be installed.

9.16.2.4.4 The purchaser, at his/her option, shall specify the type of third party certification required for the system.

9.16.2.4.5 The purchaser shall specify whether a production proof-load test in accordance with 8.6 and 9.16.6 shall be performed by the manufacturer prior to delivery.

9.16.2.5 Loading Conditions

9.16.2.5.1 The purchaser shall specify the anticipated maximum static load that will be handled by the system, which shall include the entire BOP stack and all of its attachments, including but not limited to bell nipple assembly, work platforms, conductor tensioner system components, drilling spools, high-pressure risers, wellhead spools, choke and kill valves and piping, etc.

9.16.2.5.2 The purchaser shall specify the dynamic factors that the system will be exposed to, including, but not limited to maximum wind velocity, accelerations caused during transportation if the system is portable, accelerations caused by offshore vessel motion criteria, side loading and/or operation requirements at angles
misaligned with the normal load path, and/or other dynamic forces that would be anticipated during system operation.

9.16.3 Subsystem Design Requirements

9.16.3.1 General

Design requirements and specifications of subsystems and/or system components are specified as follows.

9.16.3.2 Piping Systems

Valve DSFs shall meet or exceed those required by ASME B16.34 and NFPA T2.12.10 R1. For piping systems, safety factors shall meet or exceed the requirements specified in ASME B31.3. Hydraulic circuit design shall incorporate features that will allow isolation of components such as pressure relief, pressure regulating, and counter-balance valves for replacement and maintenance without having to drain the system of hydraulic fluid. Functional redundancy and bypass circuits shall also be employed to increase reliability. Flexible hoses shall only be utilized where there is a requirement to address misalignment, relative movement between components, thermal expansion and contraction, and vibration. Otherwise, rigid-piping/tubing shall be utilized.

9.16.3.3 Wire Rope

For wire rope components other than slings covered by 9.16.3.4, the working load limit shall be based on a wire rope design factor of 5. If the end termination used with the wire rope develops the full wire rope strength (100 % efficient) then the working load limit is the wire rope’s published minimum breaking force divided by five. If the wire rope termination used with the wire rope is less than 100 % efficient, then the working load limit is the wire rope’s published minimum breaking force times the termination efficiency divided by five. Similarly, the published wire rope breaking strength shall be de-rated for bending over sheaves or drums in accordance with API 9B or other manufacturer’s data. For any type of termination, the equation for determining the working load limit is:

\[
DF \times MBF \times Eff \times \frac{1}{5}
\]

where

\( WLL \) is the working load limit;
\( MBF \) is the minimum breaking force of wire rope;
\( Eff \) is the end termination efficiency;
\( DF \) is the design factor.

NOTE Typical efficiencies for properly designed, applied, and maintained wire rope end terminations are:
- a) open or closed spelter sockets, 100 %;
- b) open or closed swaged sockets, 100 %;
- c) wire rope clips, 80 %;
- d) wedge sockets, 75 % to 80 %.

9.16.3.4 Slings

Slings made from wire rope, chain, or synthetic materials shall be fabricated and certified per ASME B30.9 or equivalent. Wire rope slings incorporate the end termination efficiency and a wire rope design factor of five in their rated capacity. The rated capacity of each sling is shown on the tag attached to the sling.

9.16.3.5 Off-the-shelf Loose Gear

Off-the-shelf loose gear selected for use in BOP handling systems, such as shackles, hooks, chain, binders,
swivels, turnbuckles, sheave blocks, and connecting links, shall have a working load limit published by
the manufacturer that equals or exceeds the design load of the load path they are used in.

9.16.3.6 Single Sheave Blocks
The resultant load on a single sheave block as illustrated below in Figure 29 and its attachment to
supporting structure shall not exceed the working load limit of the sheave block as specified by the manufacturer
Figure 29—Illustration of the Resultant Load on a Single Sheave Block

9.16.3.7 Flexible Hoses
9.16.3.7.1 The use of flexible hoses shall be kept to an absolute minimum required to compensate for vibration,
thermal expansion and contraction, misalignment, or relative movement required between the hose end
terminations.
9.16.3.7.2 Flexible hoses shall have a working pressure equal to or exceeding the piping system into
which they are installed. The minimum burst pressure of flexible hoses shall be a minimum of four times the
working pressure of the hose, as specified by the hose manufacturer.
9.16.3.7.3 Only hydraulically-crimped type hose end fittings shall be used. Swivel-type end fittings that
are widely available are recommended to be installed at each end of the hose to prevent hose twisting
during installation and removal. No galvanized end fittings shall be used, and no Teflon 13 tape shall be
applied to any pressure sealing threaded connections, such as national pipe thread (NPT) threads.
9.16.3.7.4 Raw hose body material used to fabricate hose assemblies shall not be older than 5 years
from the date of manufacture, and shall be suitable and compatible with the media being conveyed.
9.16.3.7.5 The outer cover of the hose body of all hose assemblies shall not be painted.
9.16.3.7.6 All hose assemblies shall be internally cleaned after pressure testing to ensure that any
contamination inside the hose assembly will not adversely affect system operation. Hose assemblies shall be
capped and sealed after pressure testing and cleaning.
9.16.3.7.7 When installing hose assemblies, they shall be routed and secured in such a manner that will avoid
kinking or bends in the hose body that are less than the published minimum bending radius. Additional
protection shall be provided to the outer cover of the hose in way of contact with surfaces subject to vibration.
9.16.3.7.8 Each hose assembly shall be pressure tested to a minimum of 1.5 times the working pressure of the
hose body prior to cleaning. Water should be used as the pressure testing media.
9.16.3.7.9 A list of all hose assemblies utilized in the system shall be provided in an attachment to the
system parts manual, which shall specify as a minimum, the hose manufacturer and part number, type, size,
and part number of the end fittings, overall length, and the working pressure of the hose assembly.

9.16.3.8 Mechanical Components
The design of mechanical components including but not limited to shafting, clevis linkages, gears of all
types, keyways, splines, etc. shall meet the requirements of 9.16.4 to determine the design load. A DSF shall then
be applied in accordance with 9.16.5.

9.16.3.9 Attachments to Rig Structure
The manufacturer shall provide maximum load values, load/force vectors, and load concentrations for each

Comment [CRP3]: Change to "Fluid"
attachment to the rig structure that is necessary for the purchaser to be able to design supporting structure for mounting and/or founding the system on the rig.

**9.16.3.10 Electrical Power and Control System Components**

The specifications for electrical power and control system components such as AC or DC motors, variable frequency drives, electrical enclosures, switches, relays, circuit breakers, and other components, as well as electrical cabling, etc., and the suitability of such components for installation in hazardous areas or zones shall meet the requirements of all applicable requirements specified in the purchase agreement.

**9.16.3.11 BOP Stack Storage Structures**

The design of BOP stack storage structures shall be based on the following:

a) survival conditions specified in the operating manual for the MODU on which the system is to be installed;

b) for fixed installations, the same maximum wind velocity used for the design of the derrick shall be taken into account in addition to the criteria used to determine the rated load in 9.16.4, and the application of a DSF in accordance with the requirements of 9.16.

**9.16.3.12 BOP Stack Lifting Attachment Points**

BOP attachment points for lifting BOPs and/or BOP stacks should be specified by the original equipment manufacturer including any limitations. In the event that such information is not made available for whatever reason, alternative lifting methods which do not incorporate specific attachment points on the BOP or BOP stack, such as wrapping it with a sling may be used if designed and fabricated in accordance with specifications and instructions provided by licensed engineer or a person who by education, training, and experience can demonstrate the knowledge and skills required.

**9.16.3.13 Control System Features**

Controls for raising, lowering, and transporting the load shall be designed such that they will return to neutral when the operator releases the control, which shall cause the brakes and/or load holding device to be set automatically. Controls for the brakes and/or load holding devices shall be designed such that they shall not disengage until such time as the operator of the system activates the function on which the brake and/or load holding device is engaged. If the load holding device is activated as a result of a power loss, the control system shall be designed to ensure that it shall remain engaged when power is restored.

**9.16.3.14 Sheave/Winch Drum Diameter to Wire Rope Diameter Ratios**

The ratio of wire rope sheave diameter to the wire rope diameter used with the sheave shall be a minimum of 18 to 1. The drum pitch diameter to the wire rope diameter wrapped on a drum that is part of a BOP handling system shall be a minimum of 18 to 1. Exception to these requirements may be taken when space constraints and other circumstances dictate smaller ratios. In these cases, sheaves and/or drums should be provided that have the largest ratio that can be installed, operated, and maintained in the space provided. For systems that are supplied with sheaves and/or drums having smaller ratios than 18 to 1, the manufacturer shall include a statement in the system operating and maintenance manual to the effect that the purchaser should be aware of the reduced
fatigue life of the wire rope utilized with such sheaves and/or drums.

**9.16.3.15 Wire Rope Hoist Features**

Wire rope hoists shall incorporate a brake and/or load holding device as described in 9.16.3.21. Level-wind devices shall be considered when fleet angles exceed those specified in the DNV Rules for Certification of Lifting Appliances.

**9.16.3.16 Maximum Beam Deflection**

The maximum vertical deflection of a beam or girder produced by the design load on such girders or beams shall not exceed 1/888 of the span. Inertial forces caused by dynamics shall not be considered in determining deflection.

**9.16.3.17 Wear and Corrosion Allowances**

An allowance for wear and corrosion shall be accounted for in determining the maximum allowable stress in primary load-carrying components in applications where wear and corrosive ambient conditions will most likely prevail and act to increase the unit stress above maximum allowable limits within the life expectancy of the system as specified by the manufacturer as specified in 9.16.8. In this regard, the manufacturer shall specify the maximum loss of material due to wear and/or corrosion that is allowed in measurable terms to provide a means for the user for accepting or rejecting such components from further service as a result of measurements taken during routine inspections. In lieu of providing a corrosion allowance, the manufacturer may opt to incorporate corrosion-resistant materials, or offer other means of corrosion prevention in the form of coating systems or cathodic protection as appropriate. The maintenance requirements of such coating systems and/or cathodic protection systems shall be prescribed by the manufacturer in the recommended maintenance requirements published in the operation and maintenance manuals to be provided with the BOP handling systems upon delivery to the purchaser.

**9.16.3.18 Side Loading**

Load path design shall accommodate whatever side loading that is likely to occur as determined by the designer or as specified by the purchaser, whichever case is the most severe during system operation for a given installation. Side loading can be in the form of one or more load force vectors, which in combination with the primary load, will cause a moment of force resulting in torsional or twisting forces to be exerted on components in the primary load path. These combined loads shall not result in exceeding the maximum allowable stress in the component.

**9.16.3.19 Accelerations Caused by System Operation**

System design shall incorporate a means of minimizing the forces created by accelerations induced by stopping and starting the lifting, lowering, and transporting functions to ensure that the maximum allowable stress of any component in the load path is not exceeded. This may be accomplished with devices to limit the speed of lifting, lowering, or transporting the BOP stack, and/or mitigating acceleration and decelerations with step-down transformers, ramping software controls, fluid cushions, surge accumulators, springs, elastomer bumpers, orifice...
valves, etc. The inherent regenerative controlled braking means of a squirrel cage motor may be used if the holding brake is designed to meet the additional requirement of retarding a descending load upon the loss of power.

9.16.3.20 Load Transfer Between One Load Path and Another
For systems where the load is transferred from one load path to another, the design shall incorporate functionality such that the transfer is made reliably and seamlessly while under full control.

9.16.3.21 Fail-safe Load Holding Devices
9.12.3.21.1 At least one brake and/or mechanical device that is capable of stopping and holding the maximum rated load of the system shall be fail-safe in design, such that whenever power is lost or when the controls for raising, lowering, and transporting the load are let go by the operator and return to neutral, or when the fail-safe load limiting device specified in 9.16.3.22 is activated, the brake and/or device provided shall engage automatically. Such device shall be located in the load path in such a way as to isolate the transmission and prime-mover from the load when the brake or device is activated. Brake release hydraulic or compressed air piping, valves, and appurtenances shall not be configured in a manner such that hydraulic or pneumatic pressure is trapped to prevent or inhibit the setting of the brake. If chain hoists are utilized in a BOP handling system, they must be fitted with a fail-safe load holding device as defined in this standard. The following types of system designs and/or features are exempted from the fail-safe load holding device requirement as detailed below.

9.16.3.21.2 Fluid power cylinders incorporated in the primary load path shall have a maximum allowable working pressure that is at least 10% above the pressure created when the system is a full rated load. Devices designed to hold the load, such as counter-balance valves, check valves, etc., shall be provided to activate automatically to stop uncontrolled movement of the cylinder at loads up to, and including the design load if the hydraulic pumps that provide hydraulic pressure to such cylinders should fail or power is lost. To account for loads induced into the system that exceed the rated load that could cause an increase in cylinder pressure beyond the maximum allowable working pressure, a pressure-relieving device shall be fitted between each cylinder and the counterbalance valves or check valves employed to hold the load. The pressure-relief devices shall be set to relieve pressure at a point that is no more than 5% below the maximum allowable working pressure of the cylinder(s). Fluid emitted from such pressure-relieving devices shall be piped back to the system fluid reservoir. Flexible hoses shall not be installed between the cylinder(s) and the counter-balance or load holding valves and pressure-relieving devices described above.

9.16.3.21.3 When rack and pinion drives are incorporated in the primary load path such that sufficient redundancy in the form of multiple rack and pinion drives is not provided to support the load if one pinion drive should fail, then mechanical devices incorporating a separate load path shall be provided that will activate automatically to stop and hold the load at the rated load of the system.
9.16.3.22 Fail-safe Load Limiting Devices
Load limiting, fail-safe devices such as circuit breakers, relief valves, pressure regulating valves, etc., shall be provided such that the load on the system shall not exceed 110% of the design load of the system. Anti-tampering devices shall be employed to mitigate the manual detention of such load limiting and fail-safe devices, except for the purpose of load testing when the loads intended to be applied to the primary load path exceed 110% of the design load of the system.

9.16.3.23 Load Monitoring Devices
Load indicating systems shall be made available as an optional feature by the manufacturer. When specified in the purchase agreement, such load indicating systems shall at a minimum, display the amount of the load being handled by the system. Additional options may include a data logger to record operational and/or load information, audio/visual alarms to indicate when a certain percentage of the load has been reached, or automatic shut-downs activated by the load monitoring system when certain load values are reached to prevent system overloading in addition to that which is required by this standard.

9.16.4 Determination of Design or Rated Load
9.16.4.1 The design or rated load as defined in Section 3 shall be determined by multiplying the static load times the dynamic factor that is determined with information provided by the purchaser. If such information is not available from the purchaser, the default dynamic factors specified in Table 23 shall be used.

<table>
<thead>
<tr>
<th>BOP Handling System Mounted On Default Dynamic Factors</th>
<th>Fixed structure 1.33</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tension leg platform (TLP) or spar 1.33 + 0.003 × Hsig &gt; 1.4 (for Hsig in feet)</td>
<td></td>
</tr>
<tr>
<td>1.33 + 0.00984 × Hsig &gt; 1.4 (for Hsig in meters)</td>
<td></td>
</tr>
<tr>
<td>Semisubmersible MODU 1.33 + 0.007 × Hsig &gt; 1.4 (for Hsig in feet)</td>
<td></td>
</tr>
<tr>
<td>1.33 + 0.02297 × Hsig &gt; 1.4 (for Hsig in meters)</td>
<td></td>
</tr>
<tr>
<td>Drillship MODU or floating production storage and offloading (FPSO)</td>
<td></td>
</tr>
<tr>
<td>1.33 + 0.012 × Hsig &gt; 1.4 (for Hsig in feet)</td>
<td></td>
</tr>
<tr>
<td>1.33 + 0.03937 × Hsig &gt; 1.4 (for Hsig in meters)</td>
<td></td>
</tr>
</tbody>
</table>

NOTE 1 Hsig is the significant wave height expressed in either feet or meters as provided above.
NOTE 2 The design shall be based on a minimum wind velocity of 97 km/h (60 mph) or greater, depending on maximum operating conditions anticipated or as specified in the purchase agreement.

9.16.4.3 Apply an additional design factor to accommodate side loading as specified in 9.16.3.18 if it is in addition to the dynamic factors specified in Table 23, depending on the specific application.

9.16.4.4 Apply an additional design factor to accommodate dynamic forces induced by system operation as specified in 9.16.3.19 if it is in addition to the dynamic factors specified in Table 23, depending on the specific application.

9.16.4.5 Apply an additional design factor to accommodate loss of material due to wear or corrosion as specified in 9.16.3.17.
9.16.4.6 Apply additional design factors to accommodate other ambient or operating conditions that are either specified by the purchaser or could reasonably be anticipated that are not covered by the factors in Table 23 that would increase the stress in any part of the BOP handling system beyond the maximum allowable stress.

9.16.5 Required Minimum Design Safety Factor (DSF)
A minimum DSF of 2.5 shall be applied except for the following:

a) for systems incorporating multiple load paths, if any one primary load paths should fail while the system is in operation at the rated load, the stress in the weakest component in any of the remaining primary load paths shall not exceed 80 % of the yield strength of the material;

b) for structural components, the minimum DSF specified above shall be derived by applying a scaling factor of 1.5 to the design loads and designing to the allowable stresses specified in AISC 360-05.

9.16.6 Production Testing Requirements

9.16.6.1 A proof-load test load shall be carried out per 8.6, except the test load used shall be 1.25 times the rated load of the system for systems rated less than 50 metric tons, and 1.10 times the rated load of the system for those rated 50 metric tons or greater.

9.16.6.2 A specific test of the fail-safe load-holding device specified in 9.16.3.21 shall be performed during production testing at the full rated load prior to delivery of the system.

9.16.6.3 Function testing of the fail-safe load limiting device specified in 9.16.3.22 shall be performed prior to delivery of the system.

9.16.6.4 NDE and MPI as described in 8.6, item e & f is not applicable for BOP Handling Systems.

9.16.7 Requirements for Failure Modes and Effects Analysis (FMEA), and Hazard and Operability Studies (HAZOP) Analysis
The manufacturer shall conduct FMEA, HAZOP, or other recognized analyzes techniques of each system design family to determine single point failure modes, including both catastrophic as well as fatigue failure modes. Such analyzes shall also be used to determine control system functionality, displays, detents, interlocks, defaults, overrides, fail-safe shutdown triggers, and other similar types of features.

9.16.8 Fatigue Life
The life expectancy of the system shall be in accordance with 4.2.7, or as determined and specified by the manufacturer, based on normal and expected service conditions, notwithstanding unanticipated overload conditions that exceed 110 % of the design load. However, the fatigue analysis shall include loading from field proof-load testing above 110 % of the design load that may be prescribed or reasonably anticipated by the manufacturer to fulfill applicable regulatory requirements specified by the purchaser at the time the purchase order agreement is exercised.

9.16.9 BOP Handling System Marking
Marking of BOP handling systems shall comply with the requirements of Section 10 of this standard on one or more conspicuous locations on the system. The rated load of the system, expressed in USC or SI units shall also
be marked in accordance with 10.2.

9.16.10 Third-party Certification
When specified by the purchaser in the purchase agreement, the manufacturer shall ensure that a third party is employed to provide third-party certification to ensure that the system delivered under the purchase agreement complies with the requirements of this standard as well as other applicable regulatory or classification rules specified by the purchaser in the purchase agreement.

9.16.11 BOP Handling System Manual
The manufacturer of the BOP handling system shall provide a system manual upon delivery of the system to the purchaser in accordance with 11.3. In addition to the requirements of 11.3, all of the purchaser-defined requirements specified in 9.16.2 shall be included, as well as all other information specified in this standard.

9.17 Pressure-relieving Devices for High-pressure Drilling Fluid Circulating Systems

9.17.1 Scope
This specification covers pressure-relieving devices for drilling fluid circulating systems with an operating pressure above 3 MPa (500 psi).

9.17.2 Definition
Primary load path parts are those intended to control or regulate the movement of pressurized fluids (pressure controlling) and/or those whose failure to function as intended would result in the release of retained fluid to the atmosphere (pressure containing).

9.17.3 Design

9.17.3.1 General
Valves shall be the manual reset type, part replacement type or automatic reset type. The rated operating pressure of the device shall be the lesser of the inlet pressure rating and the outlet pressure rating. The operating pressure shall be determined by the methods described in ASME BPVC, Section VIII, Division 2, and/or API 6A.

9.17.3.2 Static Loading
The allowable stress for pressure containing components shall be in accordance with the applicable sections of ASME BPVC, Section VIII, Division 2, and/or API 6A. The allowable static stress for primary load path parts shall be 2/3 times the yield strength of the material at rated working pressure. Components designed to deform or fail during the operation of the device shall be designed in accordance with a recognized code and/or the manufacturer’s specification.

9.17.3.3 Dynamic Loading
The allowable stress for pressure containing or primary load path parts that experience increased stress due to acceleration during valve opening or closing shall be 0.90 times the yield strength of the material provided the static loading stress does not exceed the allowable required by 9.17.3.2.

9.17.3.4 Primary Design Function
The valve shall contain and/or control the pressure and flow of the drilling fluid during all phases of its operation.

9.17.3.5 Inlet and Outlet Connections
The following shall apply to inlet and outlet connections:

a) Line pipe thread connections shall not be used for connection size greater than 50 mm (2 in.) or pressure

Comment [CRP15]: SWL-marking should be sufficient. Information on rated load is available through the Usermanual.
9.17.3.6 Operation
Each relief device shall provide means to determine the open or closed condition of the device. A device with moving parts critical to proper operation shall provide means to determine that the parts are free to move. A relief device designed for operation by the use of a rupture disc or collapsing post need not provide means to determine the open or closed condition of the device.

9.17.3.7 Set Pressure
All relief devices shall contain a provision to set the relief pressure. Provision to seal the set pressure shall be available if the set pressure can be manually adjusted; however the use of the sealing provision is not a requirement of this specification. The repeatability of a relief device at any particular pressure setting shall be no more than ±10 % of the predetermined setting. The predetermined setting of a lot of shear pins, rupture discs, or collapsing posts may be determined by statistical sampling in accordance with a recognized code or practice.

9.17.4 Rated Flow
The rated flow capability of a relief device shall be the volume of water that will pass through the device with a pressure drop between the inlet and the outlet connections equal to 110 % of the maximum pressure rating of the device. Upon request, the manufacturer shall supply the purchaser with flow capacities at reduced pressure drops across the valve.

9.17.5 Prototype Testing
9.17.5.1 The relief shall be subjected to the production tests.
9.17.5.2 Following successful completion of the hydrostatic closure sealing test, the device will be subjected to a repeated opening and closing test. One cycle shall consist of reducing the pressure to 0, closing the device and raising the pressure at a rate designed to open the device in not more than 10 seconds or less than 3 seconds until the valve opens. This cycle shall be repeated 50 times except valves designed to operate by the failure of a specified component shall be cycled five times. The valve shall move from full closed to full open position smoothly and quickly without weeping or pausing during the opening process. The opening process shall initiate at no less than 90 % of the rated pressure of the valve and complete at no more than 110 % of the rated pressure of the valve. Repair and adjustment of the valve is not allowed during the test except valves designed to operate by the failure of a specified component may replace the specified component.

9.17.5.3 The flow capacity of the valve with clear water shall be measured and recorded for pressure drop across the open valve equal to 80 % and 90 % of the rated pressure. The measured flow capacity and the calculated flow capacity shall agree within 5 % under these conditions.

9.17.6 Production Test
9.17.6.1 All pressure containing sections of the valve shall be hydrostatically pressure tested at 150 % of the rating greater than 34.5 MPa (5000 psi) or when the connection is subject to vibration or bending;

b) threaded connections shall be made in accordance with API 5B;
c) flanged connections shall be made in accordance with API 6A or API 16A;
d) other connections shall be made in accordance with API 6A.
rated pressure for the section being tested.

9.17.6.2 A hydrostatic closure sealing test shall be performed on each valve. Valves with a mechanical or pilot pressure operating system shall be tested at 95% of rated pressure. Valves designed to operate by the failure of a specified component shall be tested at 90% of rated pressure. No leakage is permitted during the test. The test period is a period necessary to determine that no leakage is occurring but in no case less than three minutes after the pressure has stabilized.

9.17.7 Marking
Pressure-relief devices shall include a corrosion resistant nameplate or plates. Rupture discs shall include an identifying inscription. Shear pins and collapsing posts shall be marked with a manufacturer’s identification mark relating to known capabilities. The nameplate information shall include:

a) manufacturer’s name;
b) model designation;
c) serial number, if applicable;
d) maximum pressure rating;
e) marking related to intermediate pressure settings, i.e. spring settings, location and/or marking of rupture discs, shear pins or collapsing posts.

9.17.8 Records
In addition to the records required by this specification the manufacturer shall maintain the following records.

a) Prototype pressure and flow testing records.
b) Calculations for the determination of flow rate for water and liquids at differing fluid viscosities. The manufacturer shall supply a calculated rated flow capability to the purchaser upon request.

9.18 Snub-lines for Manual and Power Tongs

9.18.1 General
These requirements apply only to snub-lines that are used to support the reaction of a tong under normal operating conditions. These requirements do not apply to “safety” lines that are applied to power tongs equipped with integral backups.

9.18.2 Product Marking
Snub-lines furnished in conformance with this specification shall be marked with the manufacturer’s name or mark, unique serial or identification number, and the rated load. The snub-line shall be uniquely identified so that it is not confused with a conventional wire rope lifting sling. i.e. the snub-line shall be tagged and clearly marked “For Use as a Tong Snub-line ONLY.”

9.18.3 Style
Snub-lines furnished in conformance with this specification shall be made from wire rope manufactured in accordance with API 9A.

9.18.4 Length
The snub-line shall have a length as specified on the purchase order.

9.18.5 Fabrication
The snub-line shall have a mechanically spliced Flemish or turn back eye, as required by local regulatory standards, at one end, with eye size as specified on the purchase order. The field end eye may be formed with forged alloy steel or stainless steel wire rope clips for temporary installations. Snub-lines for permanent
installations may be fabricated with mechanically spliced Flemish or turn back eyes at both ends as specified on the purchase order.

9.18.6 Design Factor
The design factor for snub-lines shall be equal to or greater than 3.0.

9.18.7 Rated Load
The rated load is calculated by the following equation:

\[
\text{RL} = \frac{\text{MBF} \times \text{Eff} \times \text{DF}}{\text{DF}}
\]

where

- \( \text{RL} \) is the rated load;
- \( \text{MBF} \) is the minimum breaking force of rope used;
- \( \text{DF} \) is the design factor (equal to or greater than 3.0);
- \( \text{Eff} \) is the end fitting efficiency.

The lowest efficiency of the two end fittings/eyes shall be used. The assumed value for Flemish or turn back eyes on IWRC rope 7 mm through 25 mm (1/4 in. through 1 in.) is 95 % and for Flemish or turn back eyes in IWRC ropes over 25 mm (1 in.) through 51 mm (2 in.) is 92.5 %. The values for eyes formed using properly installed wire rope clips are 80 % for 7 mm through 22 mm (1/4 in. through 7/8 in.) and 90 % for sizes 23 mm through 89 mm (> 7/8 in. through 3 1/2 in.) diameter.

9.18.8 Proof Load Test
When manufactured, the snub-line permanent eye ends shall be proof tested to 1.33 times the rated load.

Proof testing of wire rope assemblies is intended to verify the soundness of the fittings and workmanship of the assembly. It is not a suitable means of verifying the fitness for purpose of wire rope that has been in service.

NOTE Since repeated loadings above the rating may result in cumulative damage to the wire rope, proof testing is only performed when the snub-line is first manufactured.

9.18.9 Requirements
The requirements of Sections 4, 5, 6, 7 and 8.4.1, 8.4.2, 8.4.3, 8.4.4, 8.4.6, 8.4.7, 8.4.8, 8.4.9, 8.7, and 8.8 shall not apply.

9.19 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. Antifriction bearings shall be exempt from the requirements of Section 4 through Section 8 of this specification.

10 Marking

10.1 Product Marking
Each item of equipment shall be marked with the number of this specification (API 7K) and the manufacturer’s name or mark. Additional markings shall be applied in accordance with Section 9. Equipment for which supplementary requirements apply shall be marked with the relevant "SR" numbers.

10.2 Marking Method
Marking shall be applied using low-stress, hard-die stamps, or shall be cast into components. It shall be clearly visible, clearly legible and at least 9.5 mm (3/8 in.) high where the physical dimensions of the component will permit.
11 Documentation

11.1 Record Retention

Full records of any documentation required in this specification shall be kept by the manufacturer for a period of 10 years after the equipment has been manufactured and sold. Documentation shall be clear, legible, reproducible, retrievable, and protected from damage, deterioration, or loss. All quality control records required by this specification shall be signed and dated. Computer-sorted records shall contain the originator’s personal code.

When requested by a purchaser of the equipment, authorities or certifying agencies, the manufacturer shall make available all records and documentation for examination to demonstrate compliance 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 4.9).

b) Design verification documentation (see Section 5).

c) Written specifications (see Section 6 through Section 8).

d) Qualification records, such as:
   - weld PQRs,
   - welder qualification records,
   - NDE personnel qualification records,
   - measuring and test equipment calibration records.

e) Inspection and test records traceable to the equipment or components, including:
   - material test reports covering the following tests, as applicable: chemical analysis, tensile tests, impact tests, and hardness tests;
   - NDE records covering the surface and/or volumetric NDE requirements of Section 8;
   - performance test records, including proof load-testing records, hydrostatic pressure-testing records, and functional-testing records;
   - special process records.

Special process records include actual heat-treatment time/temperature charts and weld-repair records as described in Section 7. 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. In the latter case, the requirements of 11.1 shall equally apply to the subcontractor.

11.3 Documentation to be Delivered with the Equipment

The following documentation shall be delivered with the equipment.

a) The manufacturer’s statement of compliance attesting to full compliance with the requirements of this specification and any other requirements stipulated by the purchase order. The statement 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:
   - assembly drawings,
   - list of components,
   - nominal capacities and ratings,
   - operating procedures,
   - wear limits,
   - recommended frequency of field inspection and preventive maintenance, methods and acceptance criteria,
Annex A
(normative)

Supplementary Requirements

A.1 Introduction
If specified in the purchase order, one or more of the following supplementary requirements shall apply.

A.2 SR1—Proof Load Testing
The equipment shall be proof load-tested and subsequently examined in accordance with the requirements of 8.6.

Marking “SR1” is not required on equipment for which proof load testing is normally required under Clause 8 or Clause 9.

A.3 SR2—Low-temperature Testing
The maximum impact-test temperature, for materials used in primary load-carrying components of covered equipment with a required minimum operating temperature below that specified in 4.1, shall be specified by the purchaser.

Impact testing shall be performed in accordance with the requirements of 6.3.1 and ISO 148 (V-notch Charpy) or ASTM A370 (V-notch Charpy). Except for manual tong hinge pins of wrought material, 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). For manual tong hinge pins of wrought material, the minimum average impact energy of three full-size Charpy impact test pieces, tested at the specified (or lower) temperature, shall be 15 J (11 ft-lb) with no individual value less than 12 J (8.5 ft-lb).

Each primary load-bearing component shall be marked “SR2” to indicate that low-temperature testing has been performed. Each primary load-bearing component shall also be marked to indicate the actual design and test temperature in degrees Celsius.

A.4 SR2A—Additional Low-temperature Testing
Impact testing shall also be applicable to materials used in the primary load-carrying components of equipment normally exempted from impact testing. The components to which impact testing shall apply shall be determined by mutual agreement of the purchaser and the manufacturer.

Impact testing shall be performed in accordance with the requirements of 6.3.1 and ISO 148 or ASTM A370. The maximum impact test temperature and the minimum average and individual values shall be as agreed upon by the purchaser and the manufacturer.

Each covered primary load-carrying component shall be marked “SR2A” to indicate that additional low-temperature testing has been performed. The component shall also be marked with the temperature in degrees Celsius to indicate the actual design and test temperature.
A.5 SR3—Data Book
When requested by the purchaser, records shall be prepared, gathered, and properly collated in a data book by the manufacturer. The data book shall include for each unit at least the following information:

- Statement of compliance;
- Equipment designation/serial number;
- Assembly and critical area drawings;
- Wear limits and nominal capacities and ratings;
- List of components;
- Traceability codes and systems (marking on parts/records on file);
- Steel grades;
- Heat-treatment records;
- Material test reports;
- NDE records;
- Performance test records, including functional hydrostatic and load test certificates (when applicable);
- Certificates for supplementary requirements, as required;
- Welding procedure specifications (WPSs) and qualification records.

A.6 SR4—Additional Volumetric Examination of Castings
The requirements for SR4 shall be identical to the requirements for 8.4.8, except that all critical areas of each primary load-carrying casting shall be examined.

A.7 SR5—Volumetric Examination of Wrought Material
The entire volume of primary load-carrying wrought components shall be examined by the ultrasonic method. When 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 E428. Straight-beam calibration shall be performed using a distance vs. amplitude curve based on a flat-bottomed hole with a diameter of 3.2 mm (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 vs. amplitude curve and located within 13 mm (1/2 in.) of one another, are not allowed.

Annex B
(informative)
Guidance for Qualification of Heat-treatment Equipment
B.1 Temperature Tolerance
The temperature at any point in the working zone shall not vary by more than ±14 °C from the furnace set-point temperature after the furnace working zone has been brought up to temperature. Furnaces used for tempering, ageing and/or PWHT shall not vary by more than ±14 °C 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 treating of production parts shall be performed with heat-treating 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 2 years.

B.2.3 Batch-type Furnace Methods
Batch-type furnace 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 volume greater than 0.29 m³ (10 ft³). For rectangular furnaces, place one thermocouple in 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.

c) For each 3.54 m³ (125 ft³) of furnace working zone volume surveyed, at least one thermocouple test location shall be used, up to a maximum of 60 thermocouples. These additional thermocouples shall be distributed within the working zone of the furnace.

d) For furnaces having a working zone volume 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 3 minutes to determine when the temperature of the furnace working zone approaches the bottom of the temperature range being surveyed.

f) Once the furnace has reached the set-point temperature, the temperature of all test locations shall be recorded at maximum intervals of 2 minutes, for at least 10 minutes. Then, readings shall be taken at maximum intervals of 5 minutes 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 setpoint temperature by more than 14 °C.

h) After the furnace control set-point temperature is reached, no temperature readings shall exceed the limits specified. Each furnace shall be surveyed within 1 year prior to heat treatment.

i) If a furnace is repaired or rebuilt, a new survey shall be performed before heat treatment.

Figure B.1—Thermocouple Locations in Cylindrical Furnaces

B.2.4 Continuous-type Furnace Method
Continuous heat-treating furnaces shall be calibrated in accordance with procedures specified in MIL-H-6875F, Section 3.

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.

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 at least once every 3 months. Equipment used to calibrate the production equipment shall possess an accuracy of ±0.25 % of full scale.

Annex C
(informative)
Recommended Piston Mud-pump Nomenclature and Maintenance

C.1 Piston Mud-pump Nomenclature
The intent of this annex is to standardize nomenclature for principal parts of mud pumps, excluding a relatively small number of associated parts. This will provide a common language for the industry, particularly valuable for communication.

C.2 Old Designs
This language is to be used for old pumps as well as newly designed pumps, even though the manufacturer’s literature might not be consistent with this specification. Manufacturers are expected to comply with this specification on newly designed pumps. For old designs, their literature should be made to comply when it is opportune to do so. In communications between user and manufacturer, the part number should be used as positive identification where nomenclature inconsistencies occur.

C.3 Types
This nomenclature is applicable to duplex and triplex power-piston mud pumps.

C.4 Designation
Power end (see Table C.1, Figure C.1, Figure C.2 and Figure C.3) and fluid end parts (see Table C.2, Figure C.4).
Table C.3 and Figure C.5) are grouped in separate categories. Right- and left-hand parts for all groups are determined by the same rule. The rule is: when standing at the power end and looking over the power end toward the fluid end, those parts to the right of the centerline are designated as right-hand when needed to differentiate from other like parts; and, similarly, those to the left are designated as left-hand. For triplex pumps, those parts on the centerline needing differentiation from like parts are designated center.

Table C.1—Power-end Parts, Duplex and Triplex Pumps

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>101</td>
<td>Frame</td>
</tr>
<tr>
<td>102</td>
<td>Crankshaft</td>
</tr>
<tr>
<td>103</td>
<td>Main gear</td>
</tr>
<tr>
<td>104</td>
<td>Pinion</td>
</tr>
<tr>
<td>105</td>
<td>Pinion shaft</td>
</tr>
<tr>
<td>106</td>
<td>Connecting rod a</td>
</tr>
<tr>
<td>107</td>
<td>Crosshead a</td>
</tr>
<tr>
<td>108</td>
<td>Crosshead pin a</td>
</tr>
<tr>
<td>109</td>
<td>Connecting rod bearing a</td>
</tr>
<tr>
<td>110</td>
<td>Crankshaft bearing (main) a</td>
</tr>
</tbody>
</table>
Table C.2—Fluid-end Parts, Duplex Pumps
Part Number Description
201 Fluid end—when fluid end is sectionalized, refer to right or left
202 a Cylinder head
203 a Cylinder head cover
204 b Valve cover
205 Valve guide
206 Valve spring
207 Valve seat
208 a Liner
209 a Liner packing
210 a Piston
211 a Piston rod
212 a Stuffing box
213 a Junk ring
214 a Stuffing box packing
215 a Gland
216 a Gland nut
NOTE For further detailed nomenclature see IADC Drilling Manual [12].

Table C.3—Fluid End Parts, Triplex Pumps
Part Number Description
301 Fluid end—when fluid end is sectionalized, refer to right, left or center
302 a Valve cover
303 a Valve guide
304 a Valve spring
305 a Valve seat
306 b Liner
307 b Liner packing
308 b Piston
309 b Piston rod
310 b Liner spray
NOTE For further detailed nomenclature see IADC Drilling Manual [12].

Annex D
(informative)
Use of the API Monogram by Licensees
D.1 Scope
The API Monogram Program allows an API licensee to apply the API Monogram to products. The API Monogram Program delivers significant value to the international oil and gas industry by linking the verification of an organization’s quality management system with the demonstrated ability to meet specific product specification requirements. The use of the Monogram on products constitutes a representation and warranty by the licensee to purchasers of the products that, on the date indicated, the products were produced in accordance with a verified quality management system and in accordance with an API product specification. When used in conjunction with the requirements of the API License Agreement, API Q1, in its entirety, defines the requirements for those organizations who wish to voluntarily obtain an API license to provide API monogrammed products in accordance with an API product specification.

API Monogram Program licenses are issued only after an on-site audit has verified that the licensee conforms to the requirements described in API Q1 in total, and the requirements of an API product specification. Customers/users are requested to report to API all problems with API monogrammed products. The effectiveness of the API Monogram Program can be strengthened by customers/users reporting problems encountered with API monogrammed products. A nonconformance may be reported using the API Nonconformance Reporting System available at https://ncr.api.org. API solicits information on new product that is found to be nonconforming with API-specified requirements, as well as field failures (or malfunctions), which are judged to be caused by either specification deficiencies or nonconformities with API-specified requirements.

This annex sets forth the API Monogram Program requirements necessary for a supplier to consistently produce products in accordance with API-specified requirements. For information on becoming an API Monogram licensee, please contact API, Certification Programs, 1220 L Street, N. W., Washington, D.C. 20005 or call 202-962-4791 or by email at certification@api.org.

**D.2 References**

In addition to the referenced standards listed earlier in this document, this annex references the following standard:

API Specification Q1.

For licensees under the Monogram Program, the latest version of this document shall be used. The requirements identified therein are mandatory.

**D.3 API Monogram Program: Licensee Responsibilities**

**D.3.1 Maintaining a License to Use the API Monogram**

For all organizations desiring to acquire and maintain a license to use the API Monogram, conformance with the following shall be required at all times:

a) the quality management system requirements of API Q1;

b) the API Monogram Program requirements of API Q1, Annex A;

c) the requirements contained in the API product specification(s) for which the organization desires to be licensed;

d) the requirements contained in the API Monogram Program License Agreement.

**D.3.2 Monogrammed Product Conformance with API Q1**
When an API-licensed organization is providing an API monogrammed product, conformance with API-specified requirements, described in API Q1, including Annex A, is required.

D.3.3 Application of the API Monogram
Each licensee shall control the application of the API Monogram in accordance with the following.

a) Each licensee shall develop and maintain an API Monogram marking procedure that documents the marking/monogramming requirements specified by the API product specification to be used for application of the API Monogram by the licensee. The marking procedure shall define the location(s) where the licensee shall apply the API Monogram and require that the licensee's license number and date of manufacture be marked on monogrammed products in conjunction with the API Monogram. At a minimum, the date of manufacture shall be two digits representing the month and two digits representing the year (e.g. 05-07 for May 2007) unless otherwise stipulated in the applicable API product specification. Where there are no API product specification marking requirements, the licensee shall define the location(s) where this information is applied.

b) The API Monogram may be applied at any time appropriate during the production process but shall be removed in accordance with the licensee’s API Monogram marking procedure if the product is subsequently found to be nonconforming with API-specified requirements. Products that do not conform to API-specified requirements shall not bear the API Monogram.

c) Only an API licensee may apply the API Monogram and its license number to API monogrammable products. For certain manufacturing processes or types of products, alternative API Monogram marking procedures may be acceptable. The current API requirements for Monogram marking are detailed in the API Policy Document, Monogram Marking Requirements, available on the API Monogram Program website at http://www.api.org/certifications/monogram/.

d) The API Monogram shall be applied at the licensed facility.

e) The authority responsible for applying and removing the API Monogram shall be defined in the licensee’s API Monogram marking procedure.

D.3.4 Records
Records required by API product specifications shall be retained for a minimum of five years or for the period of time specified within the product specification if greater than five years. Records specified to demonstrate achievement of the effective operation of the quality system shall be maintained for a minimum of five years.

D.3.5 Quality Program Changes
Any proposed change to the licensee’s quality program to a degree requiring changes to the quality manual shall be submitted to API for acceptance prior to incorporation into the licensee’s quality program.

D.3.6 Use of the API Monogram in Advertising
Licensee shall not use the API Monogram on letterheads or in any advertising (including company-sponsored web sites) without an express statement of fact describing the scope of licensee’s authorization (license number). The licensee should contact API for guidance on the use of the API Monogram other than on products.
D.4.1 General
These marking requirements apply only to those API licensees wishing to mark their products with the API Monogram.

D.4.2 Product Specification Identification
Manufacturers shall mark equipment with the information identified in Section 10, as a minimum, including “API Spec 7K.”

D.4.3 Units
As a minimum, equipment should be marked with U.S. customary (USC) units. Use of dual units [metric (SI) units and USC units] is acceptable.

D.4.4 License Number
The API Monogram license number shall not be used unless it is marked in conjunction with the API Monogram.

D.4.5 API Monogram Program: API Responsibilities
The API shall maintain records of reported problems encountered with API monogrammed products. Documented cases of nonconformity with API-specified requirements may be reason for an audit of the licensee involved, (also known as audit for “cause”). Documented cases of specification deficiencies shall be reported, without reference to licensees, customers or users, to API Subcommittee 18 (Quality) and to the applicable API Standards Subcommittee for corrective actions.

Bibliography
[7] API Recommended Practice 17B, Recommended Practice for Flexible Pipe
[12] DOD MIL-STD-120 17, Gauge Inspection
[13] FEM 18, Rules for the design of hoisting appliances
[16] SAE AS 1260 20, Equivalent Sections of Certain Shapes to Round Bars
Invoice To (Check here if same as "Ship To")

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Company:
Department:
Address:
City: State/Province: Zip/Postal Code: Country:
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API Standards
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Steel wire rope safety factor for running application or forming part of sling and for mast stays, pendants and similar standing applications shall be the greater of:

\[
\text{Not less than the greater of } 3 \text{ and } \frac{10^4}{0.885 \cdot \text{SWL} + 1910} \]

but need not exceed 5.

\[SF = 2.3 \psi\]
\[\psi = \text{design dynamic coefficient for the crane}\]
\[\text{SWL} = \text{Safe Working Load (kN)}\]

The above is with reference to DNV Standard 2-22 Lifting appliances.