Drilling and Well Servicing Equipment

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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;

a) rotary bushings;

b) high-pressure mud and cement hoses;

c) piston mud-pump components;

d) drawworks components;

e) manual tongs;

f) safety clamps not used as hoisting devices;

g) blowout preventer (BOP) handling systems;

h) pressure-relieving devices for high-pressure drilling fluid circulating systems;

i) snub lines for manual and power tongs;

j) rotary slips, both manual and powered;

k) slip bowls; and

l) spiders, both manual and powered.

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 9A, *Specification for Wire Rope*

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

API Specification 16A, *Specification for Drill-through Equipment*

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*

ASNT SNT-TC-1A [4], *Recommended Practice for Personnel Qualification and Certification in Nondestructive Testing*

ASTM A370 [5], *Standard Test Methods and Definitions for Mechanical Testing of Steel Products*

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

ASTM A751, *Standard Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products*

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

ASTM E4, *Standard Practices for Force Verification of Testing Machines*

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

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

ASTM E186, *Standard Reference Radiographs for Heavy-Walled (2 to 4 $^1/_2$-in. (51 to 114-mm)) Steel Castings*

ASTM E280, *Standard Reference Radiographs for Heavy-Walled (4 $^1/_2$ to 12-in. (114 to 305-mm)) Steel Castings*

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

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

ASTM E709, *Standard Guide for Magnetic Particle Examination*

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[1] American Gear Manufacturers Association, 500 Montgomery Street, Suite 350, Alexandria, Virginia 22314, www.agma.org.
[2] American Institute of Steel Construction, One East Wacker Drive, Suite 700, Chicago, Illinois 60601, www.aisc.org.
[3] ASME International, 3 Park Avenue, New York, New York 10016-5990, www.asme.org.
[4] American Society for Nondestructive Testing, 1711 Arlingate Lane, P.O. Box 28518, Columbus, Ohio 43228, www.asnt.org.
[5] ASTM International, 100 Barr Harbor Drive, West Conshohocken, Pennsylvania 19428, www.astm.org.

AWS D1.1 [6], *Structural Welding Code-Steel*

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

CI-1500 [7], *Test Methods for Fiber Rope*

DNV [8], *Rules for the Certification of Lifting Appliances*

EN 287 (all parts) [9], *Qualification Test of Welders—Fusion Welding—Steels*

ISO 148 [10], *Steel—Charpy Impact Test (V-notch)*

ISO 6892, *Metallic Materials—Tensile Testing*

ISO 7500-1, *Metallic Materials—Verification of Static Uniaxial Testing Machines—Part 1: Tension/compression Testing Machines—Verification and Calibration of the Force-measuring System*

ISO 9712, *Non-destructive Testing—Qualification and Certification of NDT Personnel*

MSS SP-53 [11], *Quality Standard for Steel Castings and Forgings for Valves, Flanges and Fittings and Other Piping Components—Magnetic Particle Examination Method*

MSS SP-55, *Quality Standard for Steel Castings for Valves, Flanges and Fittings and Other Piping Components—Visual Method for Evaluation of Surface Irregularities*

NFPA T2.12.10 R1 [12], *Recommended Practice—Hydraulic Fluid Power—Systems and Products—Testing General Measurement Principles and Techniques*

SAE J517, *Hydraulic Hose*

3 Terms, Definitions, and Acronyms

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

3.1 Terms and Definitions

3.1.1
anistropic material
A material for which properties vary with changes in test direction relative to an initial datum.

3.1.2
average limit load
The numerical average of primary load which causes the limiting component to release the primary load in load limiting designs (reference Annex E).

[6]American Welding Society, 550 N.W. LeJeune Road, Miami, Florida 33126, www.aws.org.
[7]Cordage Institute, 994 Old Eagle School Road, Suite 1019, Wayne, Pennsylvania 19087, http://www.ropecord.com
[8]Det Norske Veritas, Veritasveien 1, 1322, Hovik, Oslo, Norway, www.dnv.com.
[9]European Committee for Standardization, Avenue Marnix 17, B-1000, Brussels, Belgium, www.cen.eu.
[10]International Organization for Standardization, 1, ch. de la Voie-Creuse, Case postale 56, CH-1211, Geneva 20, Switzerland, www.iso.org.
[11]Manufacturers Standard Society of the Valve and Fittings Industry, Inc., 127 Park Street, N.E., Vienna, Virginia 22180-4602, www.mss-hq.com.
[12]National Fire Protection Association, 1 Batterymarch Park, Quincy, Massachusetts 02169-7471, www.nfpa.org

3.1.3
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.

3.1.4
BOP stack
BOPs assembled as a unit, including all attachments.

3.1.5
buffered components
All primary load carrying components with the exception of the limiting component in load limiting designs (reference Annex E).

3.1.6
buffered load
The minimum load capacity of all primary load-carrying components except for the limiting component in load-limiting designs (reference Annex E).

3.1.7
creep
The time-dependent increase in deformation of a component when subjected to a constant stress.

3.1.8
critical area
Highly stressed regions on a primary load-carrying component.

3.1.9
design load
Sum of the static and dynamic loads that would induce the maximum allowable stress in the equipment.

3.1.10
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.

3.1.11
design verification test
Test undertaken to validate the integrity of the design calculations used.

3.1.12
drilling liquids
Liquid solutions and suspensions (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 gases of any kind.

3.1.13
dynamic load
Load applied to the equipment due to acceleration effects.

3.1.14
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.

3.1.15
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.

3.1.16
glass transition temperature
The temperature below which elastomers exhibit brittle, glass-like behavior.

3.1.17
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.

3.1.18
high pressure
Working pressure values ranging from 10.3 MPa to 103.4 MPa (1500 psi to 15,000 psi).

NOTE See Table 10.

3.1.19
high-pressure cement hose
A hose used strictly for the conveyance of cement slurries at high pressure.

3.1.20
high-pressure mud hose
A rotary hose, vibrator hose, or jumper hose.

3.1.21
hose assembly
Consists of hose body and hose coupling.

NOTE See Figure 11.

3.1.22
hose body
Plain end hose with no hose couplings or end connectors attached.

3.1.23
hose coupling
Fitting attached to the ends of the hose body.

3.1.24
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.

3.1.25
identical design concept
Property of a family of units whereby all units of the family have similar geometry in the primary load-carrying areas.

3.1.26
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.

3.1.27
kelly bushing
An adapter that is fitted in the master bushing and by either square, pin, or other method, transmits torque from the rotary table to the kelly; simultaneously, it allows vertical movement of the kelly when it works down.

3.1.28
load-limiting component
A component, material, or mechanism that will release or limit the primary load in the event of an overload in load-limiting designs (reference Annex E).

3.1.29
linear indication
An indication, revealed by NDE, having a length at least three times its width.

3.1.30
load variance
γ
A measure of how widely values are dispersed from the average value in load limiting designs (reference Annex E).

3.1.31
loose gear
Off-the-shelf equipment including, but not limited to, shackles, chain, hooks, connecting links, turnbuckles, binders, sheave blocks, and swivels used in an assembly to suspend, secure, or lift a load.

3.1.32
maximum allowable stress
Specified minimum yield strength divided by the design safety factor.

3.1.33
maximum working temperature
The upper limit of the temperature range specified in 9.7.3.

3.1.34
minimum bend radius
MBR
The minimum hose bending radius dimension measured from the centerline of the hose specified in Table 10.

NOTE See Figure 11.

3.1.35
moon pool 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.

3.1.36
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.

3.1.37
primary load
Load that arises within the equipment when the equipment is performing its primary design function.

3.1.38
primary load-carrying component
Component of the equipment through which the primary load is carried.

3.1.39
proof load test
Production load test undertaken to validate the structural soundness of the equipment.

3.1.40
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.

3.1.41
rated speed
Rate of rotation, motion, or velocity as specified by the manufacturer.

3.1.42
rated working pressure
The maximum internal pressure equipment is designed to contain and/or control.

3.1.43
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.

3.1.44
rotary hose
A flexible hose assembly used to convey high-pressure drilling liquids between the top of the mud standpipe and the rotary swivel.

3.1.45
rotary slip system
The combination of rotary slips and their accompanying slip bowls.

3.1.46
rotary slips
A device for the purpose of suspending tubular goods of any type from the rotary table, not capable of being used as elevators, that have some element on the internal diameter to grip the outer diameter surface of the pipe body of various tubular goods, and a tapered outside diameter to fit inside slip bowls that are operated manually or by spring(s) and/or pneumatic or hydraulic power that are installed above, on, in, or partly in the master bushing.

3.1.47
rounded indication
Indication, revealed by NDE, with a circular or elliptical shape and having a length less than three times its width.

3.1.48
safe working load
Design load reduced by the dynamic load.

3.1.49
size class
Designation of the dimensional interchangeability of equipment specified herein.

3.1.50
size range
Range of tubular diameters to which an assembly is applicable.

3.1.51
sling
An assembly typically manufactured from wire rope, chain, or synthetic material used for lifting when connected between a load and a lifting mechanism.

3.1.52
slip bowls
A cylindrical body with a tapered inner surface, either one piece or segmented, that supports the slips.

3.1.53
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.

3.1.54
special process
Operation that may change or affect the mechanical properties, including toughness, of the materials used in the equipment.

3.1.55
spiders
A device for the purpose of suspending tubular goods of any type from the drilling structure, not capable of being used as elevators, that have some element on the internal diameter to grip the outer diameter surface of the pipe body of various tubular goods, that are operated manually or by spring(s) and/or pneumatic or hydraulic power or other assist device or method.

3.1.56
static load
The load exerted on the BOP handling system by the static weight of the BOP stack.

3.1.57
stress relaxation
The time-dependent reduction in stress of a component when subjected to a constant strain (see creep).

3.1.58
test unit
Prototype unit upon which a design verification test is conducted.

3.1.59
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.

3.1.60
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 3.1.10.

3.1.61
working load limit
A load value assigned to loose gear by the manufacturer that is a fraction of the breaking load value that 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
PTFE	polytetrafluoroethylene
PWHT	post-weld heat treatment
SMYS	specified minimum yield stress
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 A.3 and A.4), the design and minimum operating temperature for rotary tables and drawworks is 0 °C (32 °F). The design and minimum operating temperature for safety clamps, spiders, rotary slips, slip bowls, rotary bushings, rotary adapters, rotary slip systems, and manual tongs is -20 °C (-4 °F), unless changed by a supplementary requirement. See Annex A for supplementary requirements that apply only when specified.

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 A.3 and A.4).

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 that, 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 σ_{allow} as calculated by Equation (1).

$$\sigma_{\text{allow}} = \frac{S_{Y\,\text{min}}}{F_{\text{DS}}} \tag{1}$$

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 σ_{allow} as calculated by Equation (2).

$$\sigma_{allow} = \frac{S_{ULTmin}}{F_{DS}} \tag{2}$$

where

S_{ULTmin} is the specified minimum ultimate tensile strength;

F_{DS} 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, rotary slips, slip bowls, rotary slip systems, rotary bushings (other than Kelly bushings), rotary adapters, master bushings, and manual 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 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 unless specified otherwise in Section 9;

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 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 DSF for spiders, rotary slips, and rotary slip systems shall be established as specified in Table 1.

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

4.6.4 The minimum DSF for manual tongs and jaws shall be established as specified in Table 2.

Table 1—Minimum Design Safety Factors for Spiders and Rotary Slips

Load Rating R	**Design Safety Factor** F_{DS}
< 1334 kN (150 short tons)	3.00
1334 kN to 4448 kN (150 short tons to 500 short tons) inclusive	$3.00 - 0.75\,(R - 1334)/3114$ [a] $3.00 - 0.75\,(R - 150)/350$ [b]
> 4448 kN (500 short tons)	2.25

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

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

Table 2—Minimum Design Safety Factors for Manual Tongs

Torque Rating R	**Design Safety Factor** F_{DS}
≤ 41 kN m (30 × 10^3 ft-lb)	3.00
> 41 kN m (30 × 10^3 ft-lb) to 136 kN m (100 × 10^3 ft-lb)	$3.00 - 0.75\,(R - 41)/95$ [a] $3.00 - 0.75\,(R - 30 \times 10^3)/(70 \times 10^3)$ [b]
≥ 136 kN m (100 × 10^3 ft-lb)	2.25

[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.

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.

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:

a) function testing,

b) pressure testing,

c) 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 three 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 in accordance with Table 3.

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 T_R shall be computed for each component in the assembly. The smallest of these ratios shall be used in the equations.

b) Each component may be load tested separately if the holding fixtures duplicate the loading conditions applicable. In this case, the ratio, T_R, used for each test shall be that computed for the specific component tested.

$$R = L_b \times \frac{T_R}{F_{\mathrm{DS}}} \tag{3}$$

$$T_R = \frac{S_{Y\mathrm{min}}}{S_{\mathrm{ULT}a}} \tag{4}$$

where

L_b is the breaking load;

$S_{Y\mathrm{min}}$ is the specified minimum yield strength;

S_{ULTa} is the actual tensile strength;

F_{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.

Table 3—Determination of Test Loads

Load Rating R	**Design Verification Test Load**
≤ 11,120 kN (1250 short tons), and all torque ratings	$0.8 \times R \times F_{\mathrm{DS}}$, but not less than $2R$
> 11,120 kN ≤ 14,678 kN (> 1250 short tons ≤ 1650 short tons)	$C \times R$
> 14,678 kN (1650 short tons)	$1.5 \times R$

in SI units

$$C = 2 - 0.5 \times \left(\frac{R - (11{,}120)}{3558}\right)$$, in kilonewtons[a]

or, in USC units

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

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 3.1.10 and 4.6.

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

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

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

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 results 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 Metallic Materials

6.3.1 Mechanical Properties

6.3.1.1 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 4. 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.

6.3.1.2 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 %.

Table 4—Adjustment Factors for Subsize Impact Specimens

Specimen Dimensions mm × mm	Adjustment Factor
10.0 × 7.5	0.833
10.0 × 5.0	0.667

6.3.2 Material Qualification

6.3.2.1 General

The mechanical tests required by this specification shall be performed on qualification test coupons representing the heat and heat-treatment lot used in the manufacture of the component. Tests shall be performed in accordance with the requirements of ISO 6892, 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.

6.3.2.2 Equivalent Rounds

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.

6.3.2.3 Material Test Coupons

6.3.2.3.1 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.

6.3.2.3.2 Test specimens shall be removed from integral or separate qualification test coupons so that their longitudinal centerline axis is entirely within the center core $^1/_4$-thickness ($^1/_4T$) 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 $^1/_4T$ from the ends of the test coupon.

6.3.2.3.3 Test specimens taken from sacrificed production parts shall be removed from the center core $^1/_4T$ envelope location of the thickest section of the part.

6.3.2.3.4 For components to be machined entirely from wrought material that has been fully heat treated as a solid or tubular bar, whereby the standard $^1/_4T$ 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

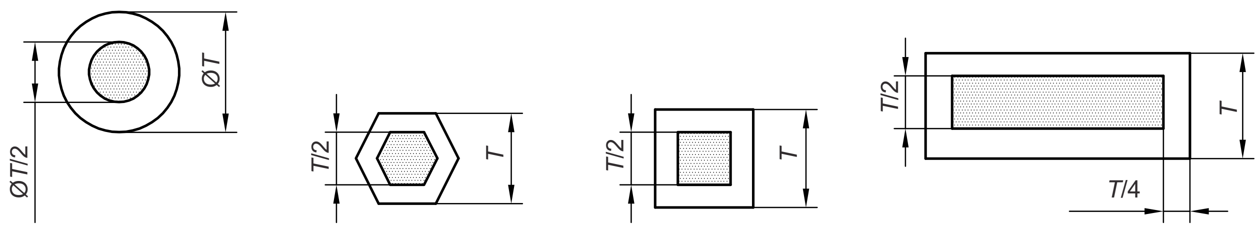
6 in. OD 4340 mod bar, normalized, quenched and tempered (NQT);

part final dimensions have maximum OD of 5.5 in., minimum ID of 2.5 in.;

T = (5.5 – 2.5)/2 = 1.5 in. $^1/_3T$ = 0.5 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; (the $^1/_3T$ outer envelope and the finished ID of the component).



$ER = T$ a) Round

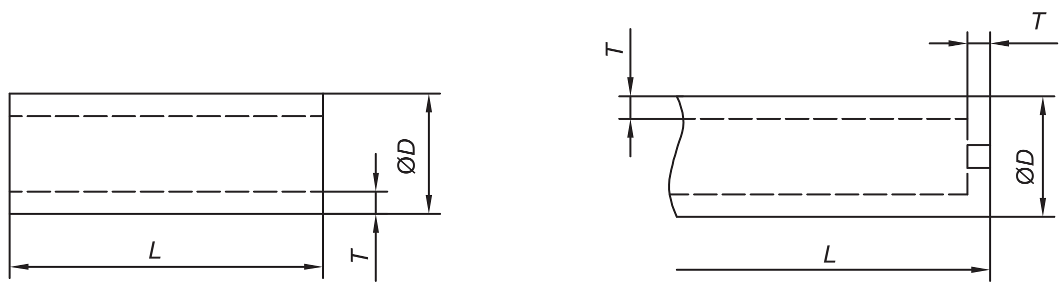
$ER = 1.1T$ b) Hexagon

$ER = 1.25T$ c) Square

$ER = 1.5T$ d) Rectangle or Plate

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

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



a) Open Both Ends [a]

$ER = 2T$

b) Restricted or Closed at One or Both Ends [b]

$ER = 2.5T$ when D is $\leq$ 63.5 mm (2.5 in.).

$ER = 3.5T$ when D is > 63.5 mm (2.5 in.).

[a] When L is < D, consider as a plate of thickness T. When L is < T, consider as a plate of L thickness.
[b] Use maximum thickness, T, in the calculation.

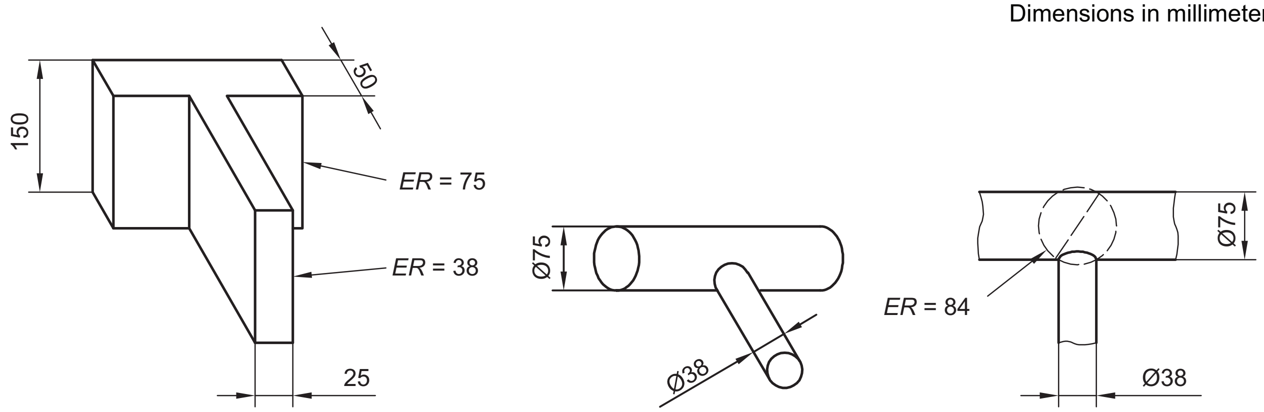
Figure 2—Equivalent Round (ER) Models—Tube (Any Section)

6.3.3 Manufacture

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

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

Dimensions in millimeters



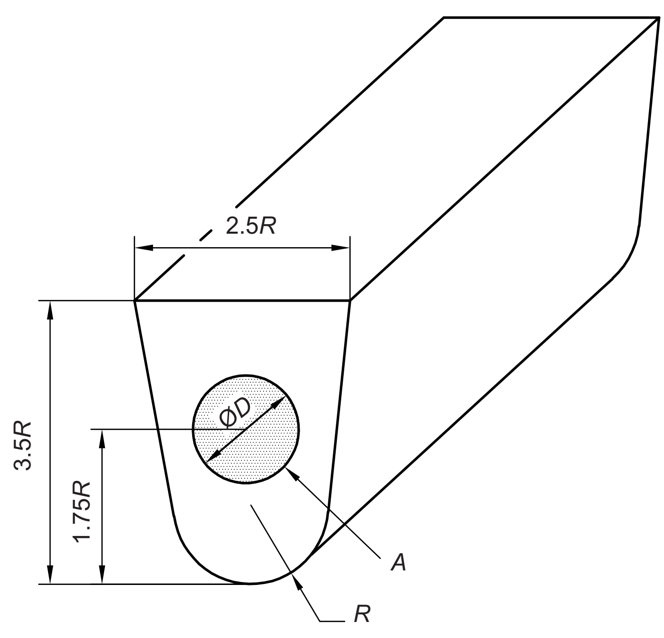
a) Reduce to Simple Sections b) *ER* Values c) *ER* Intersectional Value

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

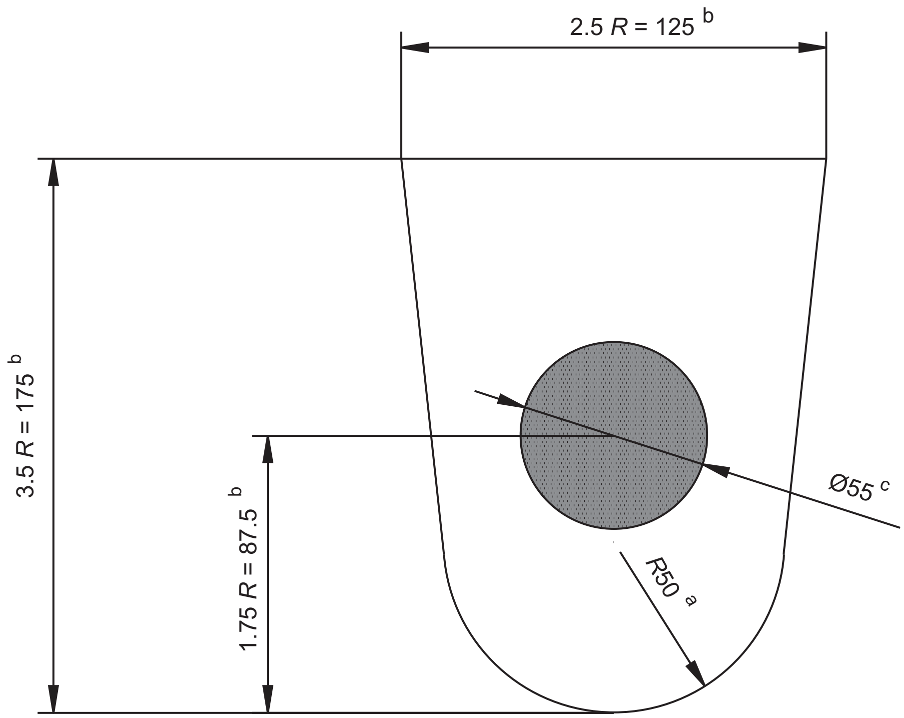


$R = ER/2.3$
$D = 1.1R$

NOTE Shaded area *A* indicates $^{1}/_{4}T$ envelope for test specimen removal.

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

Dimensions in millimeters



To develop a keel block for *ER* = 115 mm:
a) note that *R* = *ER*/2.3 = 50 mm and *D* = 1.1*R*,
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

6.3.3.3 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.

6.3.4 Chemical Composition

The material composition of each heat shall be analyzed in accordance with the requirements of ASTM A751 (see ISO TR 9769 for further information), or equivalent national standard, for all elements specified in the manufacturer's written material specification.

6.4 Non-metallic and Composite Materials

6.4.1 General

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

6.4.2 Mechanical Properties

6.4.2.1 General

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

6.4.2.2 Test Temperature

The material properties shall be qualified at a minimum temperature of –4 °F (–20 °C) unless otherwise specified in Section 9, and at a specified maximum temperature corresponding to the maximum recommended operating temperature. A lower minimum test temperature is required if SR2B is specified (see Annex A.5).

6.4.2.3 Test Specimen Orientation

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

6.4.2.4 Creep, Stress Relaxation, and Rate Effects

Materials susceptible to creep and/or stress relaxation shall be tested for resistance to these effects under the most severe conditions encountered in service, including, but not limited to, time, temperature, stress, and strain. The presence of creep and/or stress relaxation shall not cause loss of function for the component under operating conditions.

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

6.4.2.5 Equivalent Yield Strength

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

6.4.3 Environmental Factors

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

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

6.4.4 Material Qualification

6.4.4.1 General

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

6.4.4.2 Material Test Coupons

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

6.4.4.3 Manufacture

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

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

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

6.4.5 Documentation

The manufacturer shall provide specific procedures for the inspection of all non-metallic materials (including frequency, methods, equipment, and acceptance and rejection criteria) to the user/owner in an inspection and maintenance manual upon delivery of the equipment under a purchase agreement. These procedures shall also include recommendations for maximum intervals for replacement due to aging and shelf life of replacement components. The manufacturer shall also provide instructions and information regarding the material's resistance to chemical attack, along with a list of what types of chemicals will affect the serviceability of the equipment or its ability to be used at its designated rated load. In addition, the manufacturer shall provide the minimum and maximum temperatures that the equipment can be used at its designated rated load, plus any other ambient conditions that could adversely affect the ability of the equipment to be operated at its designated rated load.

6.4.6 Additional Requirements

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

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

6.4.6.3 Aramid Fiber Cordage with Unbonded Elastomeric Coating Loaded in Simple Tension—The material shall be qualified and controlled for conformance to the manufacturer's written specification. The material specification shall contain, as a minimum with appropriate limits, the uncoated cordage diameter, the denier of the cordage, the coated cord diameter, the twist density, and the tensile strength. The tensile strength shall be tested in accordance with CI-1500. All mechanical testing is to be performed on no less than a single fully encapsulated cord.

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

7 Welding Requirements

7.1 General

This section describes requirements for the fabrication and repair welding 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 and 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 or ISO 9712.

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 [12]), 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

$$\geq \frac{0.75 S_{Y\mathrm{min}}}{F_{\mathrm{DS}}} \tag{5}$$

where

$S_{Y\text{min}}$ is the specified minimum yield strength;

F_{DS} 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

$$\leq \frac{0.1 S_{Y\text{min}}}{F_{\text{DS}}} \tag{6}$$

where

$S_{Y\text{min}}$ is the specified minimum yield strength;

F_{DS} 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 for metallic materials shall be in accordance with 6.3.4.

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. Nonconducting 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 5.

Table 5—Castings Indication Acceptance Criteria

Type	Discontinuity Descriptions	Maximum Permitted Degree	
		Critical Areas	Non-critical Areas
I	Hot tears, cracks	None	Degree 1
II	Shrinkage	Degree 2	Degree 2
III	Inclusions	Degree 2	Degree 2
IV	Internal chills, chaplets	Degree 1	Degree 1
V	Porosity	Degree 1	Degree 2

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 cm^2 (6 $in.^2$) area;

— no more than 3 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.

8.4.7.5 Non-metallic Components

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

The methods for detection and measurement of the expected discontinuity shall be specified and proven effective in detecting discontinuities as small as 75 % of the maximum allowable size or severity. All primary load carrying components are to be examined in both critical and non-critical areas.

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 10 castings, 1 out of every 10 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 (6)] 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.

The following acceptance criteria shall apply:

— no relevant linear indications (see 3.1.29);

— no rounded indications (see 3.1.47) 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 five 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 testing 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 three 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.

8.9 Processes Requiring Validation

8.9.1 General

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

— NDE,

— welding,

— heat treating.

8.9.2 Heat Treating

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

8.9.3 Bolt Pretensioning

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

9 Equipment

9.1 General

The requirements of Section 4 through Section 8 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 6.3.1, 6.3.2, 6.3.3, 6.4.4, 8.4, and 8.6.

9.2 Rotary Tables

9.2.1 General

The requirements of 4.2.7, 5.4, 5.5, 5.6, 6.3.1.1, 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 9.15.

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

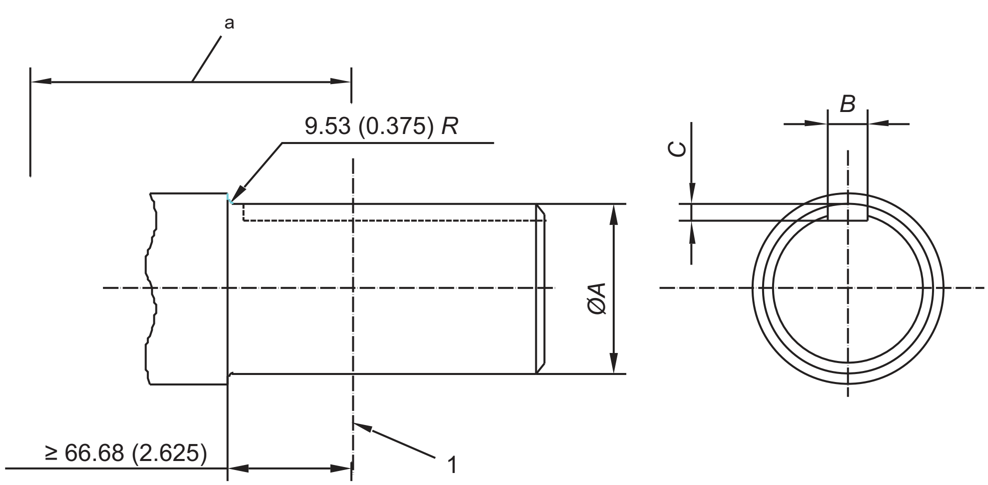
Rotary tables, with straight pinion-shaft extensions, shall be furnished in the sizes shown in Table 6 and shall conform to the dimensions and tolerances shown in Table 6 and Figure 6. This section does not preclude alternative drive input configurations (e.g. other straight or tapered pinion-shaft extensions,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

Table 6—Rotary Table Pinion-straight Shaft Extension
Dimensions in Millimeters (Inches)

Size No.	Diameter of Extension *A*		Keyway Width *B*		Keyway Depth *C*	
	$^{0}_{-0.025}$	$\left(^{0}_{-0.001}\right)$	$^{+0.025}_{0}$	$\left(^{+0.001}_{0}\right)$	$^{+1.52}_{0}$	$\left(^{+0.060}_{0}\right)$
1	82.55	(3.250)	19.05	(0.750)	6.35	($^{1}/_{4}$)
2	100.03	(3.938)	25.40	(1.000)	9.52	($^{3}/_{8}$)
3	107.95	(4.250)	25.40	(1.000)	9.52	($^{3}/_{8}$)
4	114.30	(4.500)	25.40	(1.000)	9.52	($^{3}/_{8}$)
5	125.43	(4.938)	31.75	(1.250)	11.11	($^{7}/_{16}$)

NOTE See Figure 6 for illustration of dimension symbols.

Dimensions in millimeters (inches)



Key
1 centerline of first row of teeth

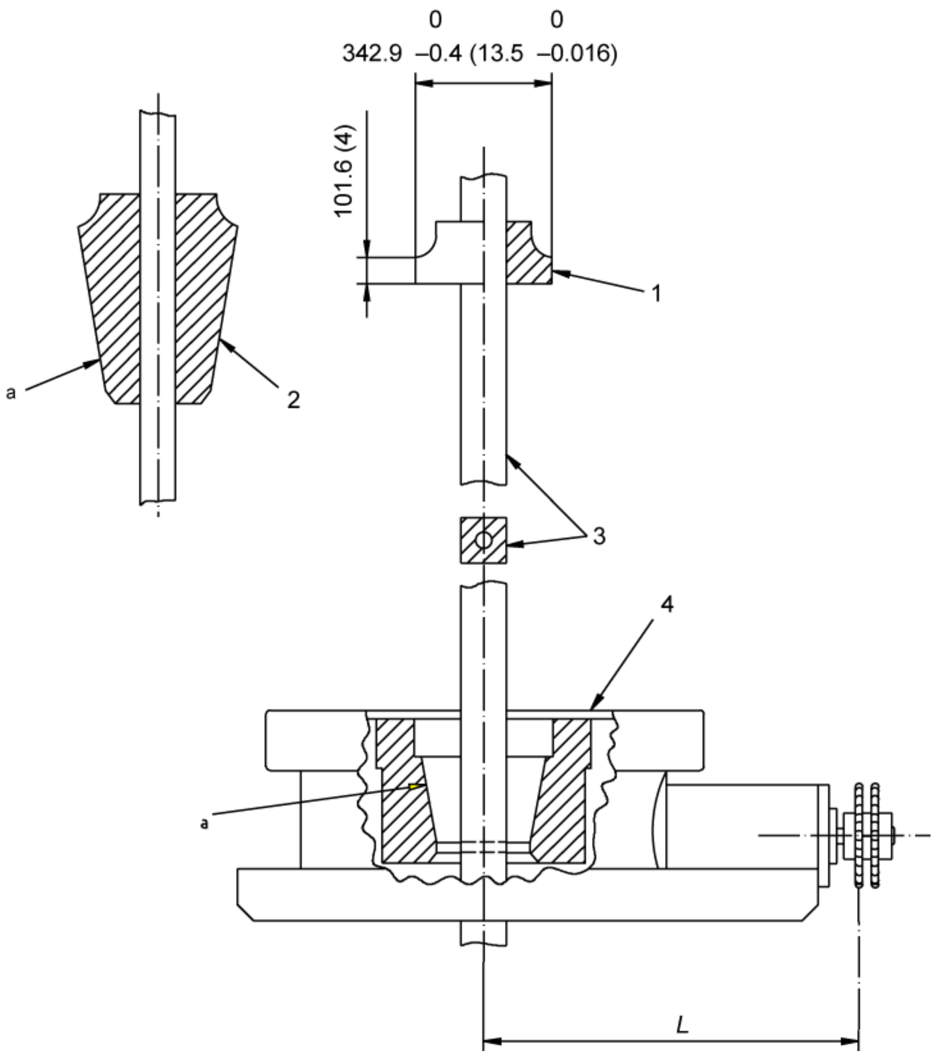
NOTE See Table 6 for dimensions.

[a] See Figure 7 and 9.2.6.

Figure 6—Rotary Table Pinion-straight Shaft Extension

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, less than a nominal 1257 mm (49 $^1/_2$ in.), 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.



1 square-drive bushing removed from rotary table
2 rotary slips
3 kelly
4 cut-away showing master bushing

NOTE See 9.2.6 and 9.3.2 for description

[a] (333.3 ± 1.5) mm/m [(4 ± 0.018) in./ft] taper on diameter.

Figure 7—Rotary Table with Square-drive Bushings

9.2.7 Rotary Table Openings

Rotary tables for use with square-drive master bushings shall conform to the requirements of Table 7 and Figure 8. Rotary tables for use with the four-pin-drive master bushings shall conform to the requirements in Table 8 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 9 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 shall include kelly bushings, master bushings, and bushing adapters as defined in 9.3.2 and 9.3.3.

9.3.2 Kelly Bushings

Square-drive kelly bushing dimensions shall comply with those shown in Figure 7.

Four-pin-drive kelly bushing dimensions shall comply with those shown in Figure 9 and Table 8.

Kelly bushings shall be exempt from load rating.

9.3.3 Master Bushing and Bushing Adapters

The dimensions of square-drive master bushings and rotary table square-drive master bushings shall conform to the requirements of Table 7 and Figure 8. Dimensions for four-pin-drive master bushings shall conform to the requirements in Table 8 and Figure 9. Master bushings are used to fit inside rotary tables or bushing adapters as applicable to provide a means by which to transfer loads from the rotary slips to the rotary table that are created when a drill string is suspended by the rotary table with rotary slips.

The requirements of 8.6 shall not apply to master bushings and bushing adapters loaded in compression only.

9.3.4 Marking

Master bushings shall be marked in accordance with the requirements of Section 10 and the following:

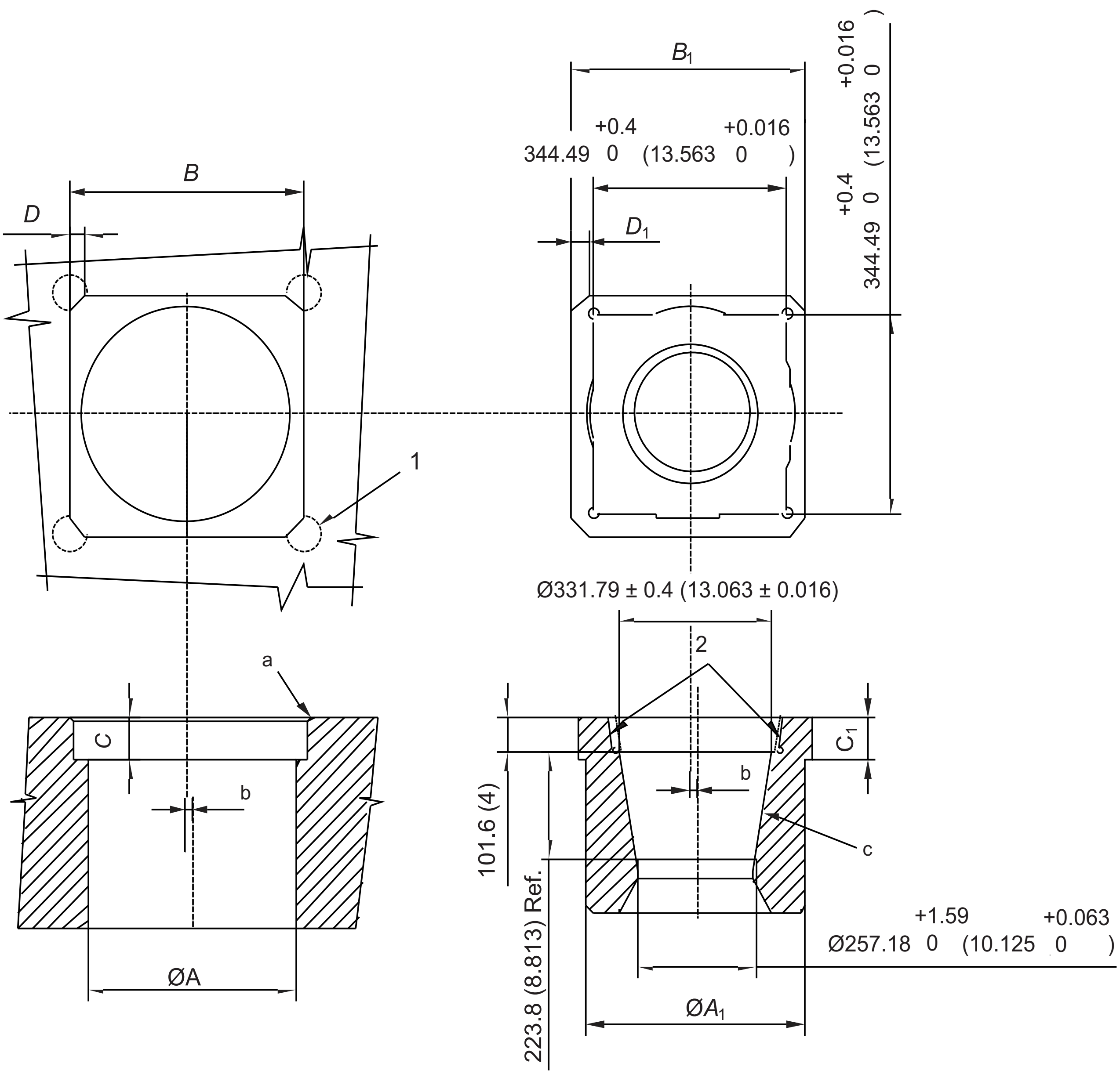
a) load rating;

b) taper, delineated as inches of diametrical change per foot with two decimal precision; and

c) unique serial number that provides traceability in accordance with requirements specified in 8.4.5.

EXAMPLE A taper of 4 in./ft will be marked as 4.00.

Dimensions in millimeters (inches)

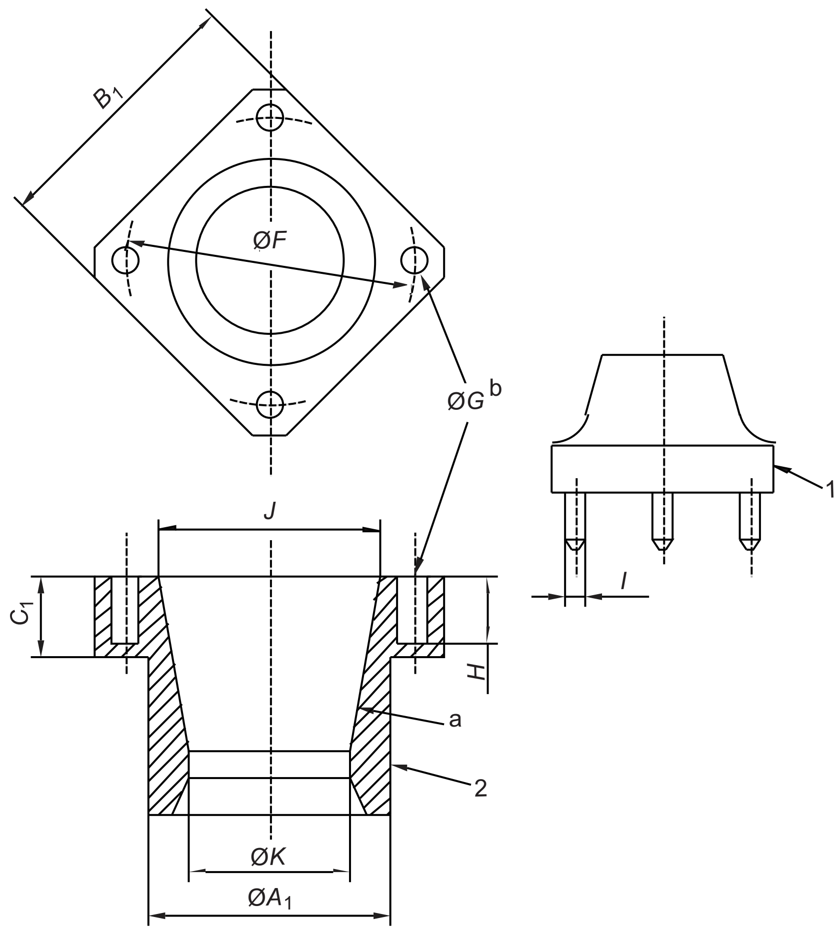


Key
1 optional relief
2 relief

NOTE 1 See 9.2.7, 9.3.3, and Table 7 for dimensions
NOTE 2 ID dimensions shown and “c” taper are those used for equipment of 4 in./ft design. For tapers other than 4 in./ft, these dimensions are to be defined by agreement between the purchaser and manufacturer.

[a] Chamfer ≥ 6.35 mm (0.250 in.) × 45°.
[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



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

NOTE See 9.2.7, 9.3.2, 9.3.3, Table 7, and Table 8 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

9.4 Slip Bowls

9.4.1 General

9.4.1.1 Slip bowls are used between rotary slips and master bushings to provide a means by which to transfer loads from the rotary slips to the master bushing that are created when tubulars are suspended from the rotary table with rotary slips.

9.4.1.2 For the analysis and rating of slip bowls per Section 4 and Section 5, the coefficient of friction between the mating surface on the outside of the slips and the inner surface of the bowl shall not exceed 0.08. The manufacturer may specify a certain type of lubricant to be used between the rotary slips and slip bowls or other like equipment during design verification testing. If the same lubricant is required to be used in order to maintain the load rating of the equipment, such lubricants shall be specified in the manufacturer's product operating and maintenance manual.

Table 7—Rotary Table Opening and Square-drive Master Bushing
Dimensions in millimeters (inches)

Nominal Table Size		Rotary Table Opening								Square-drive Master Bushing								Concentricity TIR	
		A		B		C		D		A_1		B_1		C_1		D_1			
		$^{+0.38}_{0}$	$\left(^{+0.015}_{0}\right)$	$^{+0.76}_{0}$	$\left(^{+0.030}_{0}\right)$			max.	max.	$^{0}_{-0.38}$	$\left(^{0}_{-0.015}\right)$	$^{0}_{-0.76}$	$\left(^{0}_{-0.030}\right)$			$^{+6.35}_{0}$	$\left(^{+0.250}_{0}\right)$		
(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	(1/32)
(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	(1/32)
(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	(1/32)
(37 1/2)	952.5	952.50	(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 1 See Figure 8 and Figure 9 for illustration of symbols.

NOTE 2 All dimensions in this table imply use of 4" per foot taper. A, A1, B, B1, C, C1, D, D1, F, G, H, and I remain fixed irrespective of the taper and for tapers other than 4 in./ft, other dimensions will result from the design and must be clearly communicated by the manufacturer.

Table 8—Four-pin-drive Master Bushing and Kelly Bushing
Dimensions in millimeters (inches)

Nominal Table Size		F		G		H		I		J		K	
		±1.59	(±1/16)	±0.13	(±0.005)			±0.13	(±0.005)	$^{+1.59}_{0}$	$\left(^{+1/16}_{0}\right)$	$^{+1.59}_{0}$	$\left(^{+1/16}_{0}\right)$
(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 1/8)
(20 1/2)	520.7	584.20	(23)	65.15	(2.565)	107.95	(4 1/4)	62.79	(2.472)	365.13	(14 3/8)	257.18	(10 1/8)
(27 1/2)	698.5	654.05	(25 3/4)	86.23	(3.395)	107.95	(4 1/4)	82.93	(3.265)	365.13	(14 3/8)	257.18	(10 1/8)
(37 1/2)	952.5	654.05	(25 3/4)	86.23	(3.395)	107.95	(4 1/4)	82.93	(3.265)	365.13	(14 3/8)	257.18	(10 1/8)
(49 1/2)	1257.3	—	—	—	—	—	—	—	—	365.13	(14 3/8)	257.18	(10 1/8)
(60 1/2)	1536.7	—	—	—	—	—	—	—	—	365.13	(14 3/8)	257.18	(10 1/8)

NOTE 1 See Figure 9 for illustration of symbols.

NOTE 2 All dimensions in this table imply use of 4" per foot taper. A, A1, B, B1, C, C1, D, D1, F, G, H, and I remain fixed irrespective of the taper and for tapers other than 4 in./ft, other dimensions will result from the design and must be clearly communicated by the manufacturer.

Table 9—Demountable Rotary Sprocket Data

Sprocket Type	Number of Teeth on Sprocket min.	Sprocket Groove Diameter max. *A*		Sprocket Thickness at Groove min. *B*	
		mm	(in.)	mm	(in.)
1 3/4 P single	23	—		—	
2 P single	21	—		—	
2 1/2 P single	17	—		—	
1 3/4 P double	25	306.39	(12 1/16)	10.32	(13/32)
2 P double	22	301.63	(11 7/8)	7.94	(5/16)
2 1/2 P double	19	315.91	(12 7/16)	15.08	(19/32)

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

9.4.1.3 The requirements of 8.6 shall not apply to tapered slip bowls loaded in compression only.

9.4.1.4 The requirements of 5.4 or 5.6 shall apply.

9.4.2 Marking

Slip bowls shall be marked in accordance with the requirements of Section 10 and the following:

a) load rating;

b) taper, delineated as inches of diametrical change per foot with two decimal precision; and

c) unique serial number that provides traceability in accordance with requirements specified in 8.4.5.

EXAMPLE A taper of 4 in./ft will be marked as 4.00.

9.4.3 Toughness Testing

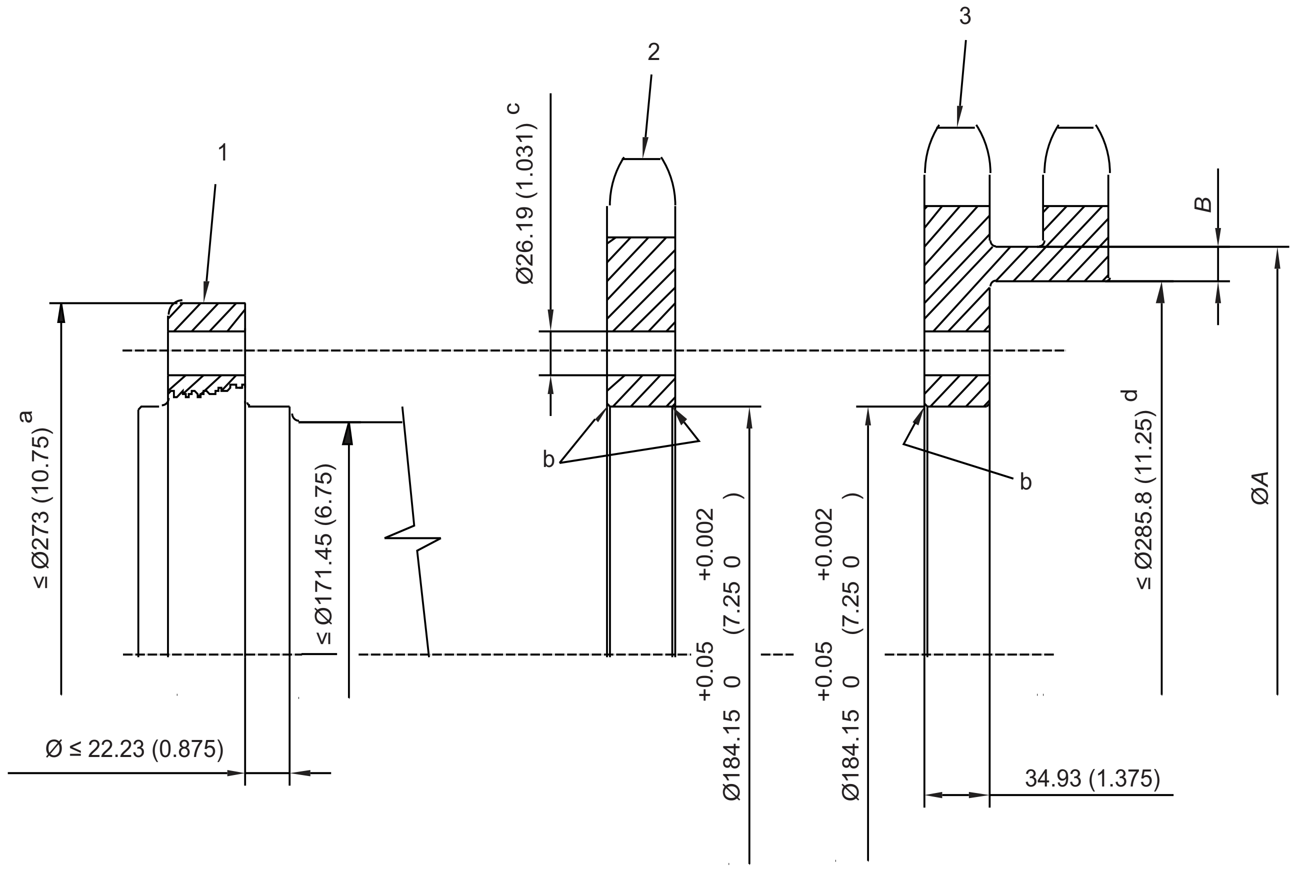
The minimum Charpy V-notch impact value shall be no less than 26 J (19 ft-lbs) with an average value of no less than 33 J (25 ft-lbs) at –20 °C (–4 °F). This is notwithstanding any additional requirements available to the purchaser by referencing different values for temperatures below –20 °C (–4 °F) per SR2 or other temperature and impact values that may be invoked by the purchaser in accordance with SR2A.

9.5 Rotary Slips

9.5.1 General

For the analysis and rating of rotary slips in accordance with 5.5 or 5.6, the coefficients of friction (1) between the mating surface on the outside of the slips and the inner surface of the bowl and (2) between the dies and rotary slip segments shall not exceed 0.08. The manufacturer may specify a certain type of lubricant to be used between the rotary slips and drilling bowls during design verification testing. If the same lubricant is required to be used in order to maintain the load rating of the equipment, such lubricants shall be specified in the manufacturer's product operating and maintenance manual.

Dimensions in millimeters (inches)



Key
1 hub
2 single sprocket
3 double sprocket

NOTE See 9.2.8 and Table 9 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

9.5.2 Load Ratings

All slips shall be tested to verify the load rating of the slip as detailed below. The manufacturer will complete these tests using a pipe or mandrel that the manufacturer determines will create the highest stresses in the slip segments.

Segments or carriers rated according to the number of segments used shall not have a combined load rating above 500 tons unless the particular group of segments used has been proof load tested as a group and remain together as an inseparable group. These segments may be disassembled for inspection or other service needs but shall be reassembled as a group using the same pieces that were tested together as a group.

For all slips load rated higher than 500 tons, the segments or group of carriers shall be load rated as an assembly wherein that assembly must be kept together as an inseparable entity for all service events. These segments may be disassembled for inspection or other service needs but shall be reassembled as a group using the same pieces that were tested together as a group.

9.5.3 Design Verification Test Description

9.5.3.1 General

9.5.3.1.1 A design verification test shall be conducted in accordance with 5.4 or 5.6.

9.5.3.1.2 For rotary slips with a load rating that exceeds 500 tons, two design verification tests shall be carried out as follows.

a) One shall be performed with a mandrel as described in 9.5.3.2 and in accordance with the loads calculated in 5.4. This test shall include strain gauging and monitoring the stress in the drilling bowls, master bushings or slip frames, spiders, or whatever other interfaces are required to either absorb or transmit the load to the master bushing in which the particular slip system is designed to operate.

b) A fit-for-purpose test shall also be performed with a tubular mandrel constructed in accordance with 9.5.3.2 at the rated load.

9.5.3.2 Test Mandrels

Test mandrels representing the tubular used during design verification testing of rotary slips shall be solid; the design of which shall be determined by the rotary slip manufacturer. However, a tubular mandrel may be used in place of the solid mandrel if it is demonstrated via full scale testing with strain gauges that the maximum stress in the tubular shall not exceed 80 % of the minimum yield stress of the tubular mandrel when the mandrel is loaded with slips to twice the rated load of the slips being tested.

The test mandrel for the fit-for-purpose test shall be constructed of a steel tubular with an outside diameter equivalent to the largest OD tubular for which the slip was designed. The designed cross sectional area in the test section will be defined such that the average calculated uniaxial tensile stress is 827 MPa (120 ksi) or greater for pipe OD up to and including 178 mm (7 in.), and 758 MPa (110 ksi) or greater for OD greater than 178 mm (7 in.) up to 508 mm (20 in.). Pipe larger than 508 mm (20 in.) OD shall have an average calculated uniaxial stress of at least 80 % of the specified minimum yield stress (SMYS) of the pipe being used for this test mandrel at full load. The minimum acceptable SMYS for pipe larger than 508 mm (20 in.) OD is 345 MPa (50 ksi). The test section shall be the length of engagement of the slips plus $3 \times \sqrt{D/T}$ (where D is the nominal outside diameter of the tubular and T is the wall thickness) on either side of the slip engagement prior to any change of cross section.

9.5.4 Proof Load Testing

Proof load testing shall be required for all rotary slips that have a designated load rating greater than 500 tons. The User may require proof load testing at their option for rotary slips that have a designated load rating that is less than or equal to 500 tons by specifying the requirements in SR1 in the purchase agreement. This applies to all original primary load-carrying components and any replacement primary load-carrying components used during the entire life of the equipment.

9.5.5 Toughness Testing

The minimum Charpy V-notch impact value shall be no less than 26 J (19 ft-lbs) with an average value of no less than 33 J (25 ft-lbs) at –20 °C (–4 °F). This is notwithstanding any additional requirements available to the purchaser by referencing different values for temperatures below –20 °C (–4 °F) in accordance with SR2 or other temperature and impact values that may be invoked by the purchaser per SR2A.

9.5.6 Critical Areas

Critical areas shall be defined by the manufacturer in accordance with 8.4.1.

9.5.7 User Information on Rotary Slips

Instructions for the use, care, inspection, and maintenance of rotary slips shall be published by the manufacturer in the operations and maintenance manuals that shall include, but not be limited to, the following:

a) the specific markings utilized by the manufacturer to comply with the marking requirements in 9.5.8;

b) inspection requirements and measurable acceptance and rejection criteria;

c) considerations that the User should take into account when determining the safe working load, such as wear limits, dynamic factors, the coefficient of friction, and other factors that can affect the load capacity of used rotary slips;

d) for slips that are intended to be installed below the rotary table out of sight of the driller or other operator, instructions and/or means shall be provided to allow the operator of the equipment to confirm that the slips are engaged properly on to the tubulars without having to cease rig floor operations.

9.5.8 Marking

Each rotary slip segment or carrier shall be marked in accordance with the requirements of Section 10 and the following:

a) load rating;

b) taper, delineated as inches of diametrical change per foot with two decimal precision; and

c) a unique serial number that provides traceability in accordance with requirements specified in 8.4.5.

EXAMPLE A taper of 4 in./ft will be marked as 4.00.

Segments or carriers load-rated according to the number of segments used shall have a dual marking consisting of the per-piece load rating and the combined total load rating of any combination of segments used in an assembly.

The taper and rating shall be visible when the slips are engaged on a tubular. However, for casing slips or other slips with limited visible marking area, the manufacturer's mark, model number, and serial number may be marked on the side of individual sections or another area where the markings will not wear off due to regular usage.

9.6 Spiders

9.6.1 Marking

Spiders shall be marked in accordance with the requirements of Section 10 and the following:

a) load rating;

b) for spiders without integral slips, taper, delineated as inches of diametrical change per foot with two decimal precision; and

c) a unique serial number that provides traceability in accordance with requirements specified in 8.4.5.

EXAMPLE A taper of 4 in./ft will be marked as 4.00.

The gripping elements, primary load-carrying elements, and the body shall all be marked with the same model number or other unique identifying mark.

9.6.2 Impact Toughness

The following impact toughness values apply to primary load carrying components of spiders.

Components shall be made from materials possessing a minimum impact toughness of 33 J (25 ft-lbs) 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-lbs).

9.6.3 Design Verification Test

The design verification load test, as described in Section 5 shall apply to all spiders.

9.6.4 Proof Load Test

Proof load testing, as described in 8.6, shall apply. Production proof load testing shall be carried out for all spiders. This testing may be carried out using a tapered mandrel in place of the slips/inserts to simulate the actual loading condition. This applies to all original primary load-carrying components and any replacement primary load-carrying components used during the entire life of the equipment. Replacement hinge pins or latch pins shall meet or exceed the original manufacturer's specification. Replacement hinge pins and latch pins manufactured from wrought material are exempt from proof load testing.

9.7 High-pressure Mud and Cement Hoses

9.7.1 General

This specification applies to high-pressure flexible mud and cement hose assemblies as defined in 9.7.2.1 and listed in Table 10. 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, jumper hose, and rotary hose covered by this specification.

9.7.2 Exceptions to Requirements Specified in Section 1 through Section 8

9.7.2.1 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 rated working pressure of the hose assembly specified in Table 10;

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.

Table 10—Rotary Drilling and Vibrator Hoses, Cement Hoses, and Mud Delivery Hoses Dimensions and Pressures

Inside Diameter mm (in.)	**API Grade**	**Rated Working Pressure** MPa (psi)	**Test Pressure** MPa (psi)	**Safety Factor**	**Minimal Burst Pressure** Mpa (psi)	**MBR Operational** [a] m (in.)	**Remark**
50.8 (2.0)	A	10.3 (1500)	15.5 (2250)	2.50	25.8 (3750)	0.9 (36)	
	B	13.8 (2000)	20.7 (3000)	2.50	34.5 (5000)	0.9 (36)	
	C	27.6 (4000)	41.4 (6000)	2.50	69.0 (10,000)	0.9 (36)	
	D	34.5 (5000)	51.7 (7500)	2.50	86.3 (12,500)	0.9 (36)	
		69.0(10,000)	103.4 (15,000)	2.25	155.3 (22,500)	1.2 (48)	Cement
		103.4 (15,000)	155.1 (22,500)	2.25	232.7 (33,750)	1.4 (55)	Cement
63.5 (2.5)	A	10.3 (1500)	15.5 (2250)	2.50	25.8 (3750)	0.9 (36)	
	B	13.8 (2000)	20.7 (3000)	2.50	34.5 (5000)	0.9 (36)	
	C	27.6 (4000)	41.4 (6000)	2.50	69.0 (10,000)	0.9 (36)	
	D	34.5 (5000)	51.7 (7500)	2.50	86.3 (12,500)	0.9 (36)	
	E	51.7 (7500)	77.6 (11,250)	2.50	129.3 (18,750)	1.2 (48)	
		69.0 (10,000)	103.4 (15,000)	2.25	155.3 (22,500)	1.2 (48)	Cement
		103.4 (15,000)	155.1 (22,500)	2.25	232.7 (33,750)	1.5 (60)	Cement
76.2 (3.0)	C	27.6 (4000)	41.4 (6000)	2.50	69.0 (10,000)	1.2 (48)	
	D	34.5 (5000)	51.7 (7500)	2.50	86.3 (12,500)	1.2 (48)	
	E	51.7 (7500)	77.6 (11,250)	2.50	129.3 (18,750)	1.2 (48)	
		69.0 (10,000)	103.4 (15,000)	2.25	155.3 (22,500)	1.5 (60)	Cement
		103.4 (15,000)	155.1 (22,500)	2.25	232.7 (33,750)	1.6 (64)	Cement
88.9 (3.5)	C	27.6 (4000)	41.4 (6000)	2.50	69.0 (10,000)	1.4 (54)	
	D	34.5 (5000)	51.7 (7500)	2.50	86.3 (12,500)	1.4 (54)	
	E	51.7 (7500)	77.6 (11,250)	2.50	129.3 (18,750)	1.4 (54)	
101.6 (4.0)	C	27.6 (4000)	41.4 (6000)	2.50	69.0 (10,000)	1.4 (54)	
	D	34.5 (5000)	51.7 (7500)	2.50	86.3 (12,500)	1.4 (54)	
	E	51.7 (7500)	77.6 (11,250)	2.50	129.3 (18,750)	1.5 (60)	
		69.0 (10,000)	103.4 (15,000)	2.25	155.3 (22,500)	1.8 (72)	Cement
127.0 (5.0)	C	27.6 (4000)	41.4 (6000)	2.50	69.0 (10,000)	1.5 (60)	
	D	34.5 (5000)	51.7 (7500)	2.50	86.3 (12,500)	1.5 (60)	
	E	51.7 (7500)	77.6 (11,250)	2.50	129.3 (18,750)	1.8 (72)	
152.4 (6.0)	D	34.5 (5000)	51.7 (7500)	2.50	86.3 (12,500)	1.8 (72)	
	E	51.7 (7500)	77.6 (11,250)	2.50	129.3 (18,750)	1.8 (72)	

NOTE See Figure 11 for illustration of symbols.

[a] MBR is taken to the centerline of each hose.

9.7.2.2 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 –20 °C (–4 °F).

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 9.7.3. In addition, when supplementary requirements SR2 and SR2A are specified in the purchase agreement, they shall only apply to the hose coupling.

9.7.2.3 Strength Analysis

The requirements specified in 4.2.7 shall not apply.

9.7.2.4 Size Class Designation

Size class designation shall be in accordance with the hose assembly diameters and corresponding rated working pressures specified in Table 10.

9.7.2.5 Rating

The rating of hose assemblies covered by this specification shall be in accordance with the rated working pressure specified in Table 10, and the temperature range and FSL level specified in 9.7.3.

9.7.2.6 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.

9.7.2.7 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 9.7.7.2 and the rated working pressure of the hose assembly specified in Table 10.

9.7.2.8 Design Verification

The design verification requirements are specified in 9.7.10; Section 5 shall not apply.

9.7.2.9 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.

9.7.2.10 Proof Load Testing

Proof load testing required by 8.6 shall not apply.

9.7.2.11 Hydrostatic Testing

Hydrostatic testing requirements specified in 8.7.2 shall not apply. Hydrostatic testing shall be in accordance with 9.7.7.

9.7.3 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.

9.7.3.1 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).

9.7.3.2 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 9.7.10.

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 9.7.10, excluding the pulsating pressure tests in 9.7.10.4 and 9.7.10.5.

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 9.7.10, excluding the high-frequency pulsating pressure test in 9.7.10.5.

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 9.7.10, excluding the low-frequency pulsation test specified in 9.7.10.4.

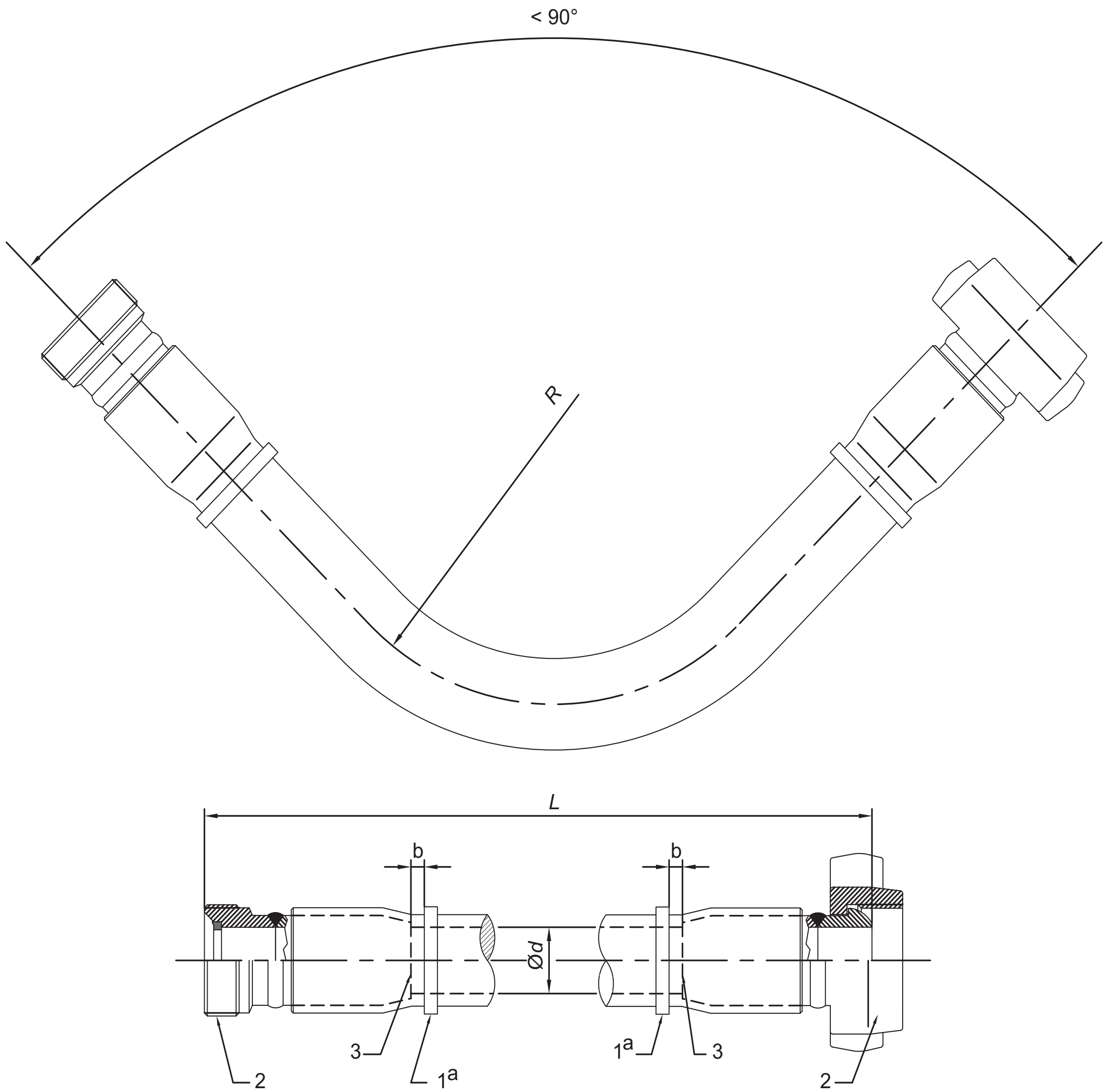
9.7.4 Sizes and Lengths

All hose assemblies shall comply with the sizes specified in Table 10. The length of each hose assembly shall comply with the dimension specified in the purchase agreement within the tolerances specified in 9.7.5. 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 9.7.5 when specifying the overall length of the hose assemblies in the purchase agreement.

9.7.5 Dimensions and Tolerances

9.7.5.1 Dimensions of the hose assemblies shall conform to the requirements of Table 10 and Figure 11.

9.7.5.2 For hose assembly lengths up to 6 m (20 ft), the finished unpressurized 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 rated working pressure shall not be different by more than 65 mm (2 $^{1}/_{2}$ in.) + 0.01*L* (*L* is the length of the hose assembly, see Figure 11).



Key
1 safety clamp
2 end connector
3 inboard end of the coupling
d inside diameter
L nominal length
R bending radius

NOTE See Table 10 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

9.7.5.3 For hose assembly lengths exceeding 6 m (20 ft), the finished unpressurized 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 rated working pressure shall not change by more than ±2 %.

9.7.5.4 The manufacturer shall specify the MBR if it is less than the values listed in Table 10.

9.7.6 Hose Couplings and End Connectors

9.7.6.1 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 re-qualify the hose assembly.

9.7.6.2 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 rated working pressures exceeding 34.5 MPa (5000 psi). For hose assemblies with rated 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).

9.7.7 Test Pressure and Burst Pressure

9.7.7.1 Test Pressure

9.7.7.1.1 Each high-pressure mud and cement hose assembly shall be hydrostatically tested to 1.5 times the rated working pressure (see Table 10). Test pressure shall be held for a minimum of 15 minutes. The test medium shall be water.

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

9.7.7.2 Burst Pressure

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

9.7.8 Rated Working Pressure

The maximum rated working pressure of the hose assembly is specified in Table 10. Maximum surge pressures encountered in the hose shall be included in the rated working pressure. The rated working pressure is identical to design pressure.

9.7.9 Marking

9.7.9.1 Hose assemblies shall be marked in accordance with the requirements of Section 10 and the following:

a) month and year of manufacture,

b) the rated working pressure,

c) the test pressure,

d) the working temperature range, and

e) FSL level.

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.

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

9.7.9.3 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 10:

a) Grade A—1,

b) Grade B—2,

c) Grade C—3,

d) Grade D—4,

e) Grade E—5.

9.7.10 Design Verification Testing

9.7.10.1 General

9.7.10.1.1 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 9.7.3.2. High-temperature pulsating pressure tests specified in 9.7.10.4 and 9.7.10.5 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.

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

9.7.10.1.3 Successful completion of verification testing shall qualify the same size and smaller sizes of the design family for the same or lower-rated working pressure for the full temperature range specified in 9.7.3 that was used for the tests.

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

9.7.10.1.5 The tests in 9.7.10.2 through 9.7.10.7 shall be performed on the same hose assembly in accordance with the FSL requirements specified in 9.7.3.2. The sequence of tests shall follow the order specified below.

9.7.10.1.6 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 9.7.10.5, 9.7.10.6, and 9.7.10.7. Three temperature ranges are specified in 9.7.3.1. 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 9.7.10.3.2. 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 9.7.10.4 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 9.7.10.5 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.

9.7.10.1.7 If the minimum operating temperature specified by the manufacturer is lower than –20 °C (–4 °F), the low-temperature bending test 9.7.10.3.2 shall be carried out at the minimum operating temperature specified by the manufacturer.

9.7.10.2 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 10 for at least 15 minutes;

c) the pressure shall be lowered to the rated working pressure of the assembly as specified in Table 10, 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 %.

9.7.10.3 Bending Test

9.7.10.3.1 Ambient Temperature Bending Test

Bend the hose assembly to its MBR 100 times with the hose at rated 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.

9.7.10.3.2 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.

9.7.10.4 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 9.7.3.1. The upper pressure limit of the pulsating pressure test shall not be less than the rated working pressure, and the amplitude of the pressure pulsation shall be at least 90 % of the rated working pressure. One pressure cycle of raising and lowering the pressure shall not last longer than five minutes.

The acceptance criterion is no visible leakage.

9.7.10.5 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 9.7.3.1. The upper pressure limit of the pulsating pressure test shall not be less than the rated working pressure, and the amplitude of the pressure pulsations shall be at least 90 % of the rated 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.

9.7.10.6 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 10, and shall be held for a period not less than four 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 four-hour period. The test medium shall be water.

9.7.10.7 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 10 for the hose assembly tested.

9.8 Piston Mud-pump Components

9.8.1 General

9.8.1.1 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, 6.3.1.1, 8.4.4, 8.4.5, 8.4.7, and 8.4.8 shall not apply. For antifriction bearing design and manufacturing requirements, see 9.15.

9.8.1.2 Pressure-rated items, as defined in 9.8.1.1, shall be pressure-tested in production to 1.5 times the working pressure. Hydrostatic testing shall be performed in accordance with 8.7.

9.8.1.3 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 9.8.1.2.

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

9.8.2.1 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 11, 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 12 and Figure 14.

9.8.2.2 Threads

Threads on rod ends and in retainer nuts shall conform to the dimensions given in Table 11 and Table 12 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.

9.8.2.3 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.

9.8.2.4 Marking

Marking shall be in accordance with Section 10 and the following:

a) Pistons, double-acting, with a taper shall be marked with 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 shall be marked with the connection number.

c) Piston rods, double-acting shall be marked with the taper number. The crosshead extension end of the piston rod shall be marked with the taper thread number or the straight thread number from Table 13 or Table 14.

d) Piston rods, single-acting shall be marked with the connection number. If the crosshead extension end of the piston rod conforms to 9.8.3.1 or 9.8.3.2, this end shall be marked with the taper thread number or the straight thread number from Table 13 or Table 14.

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

Dimensions in millimeters (inches)

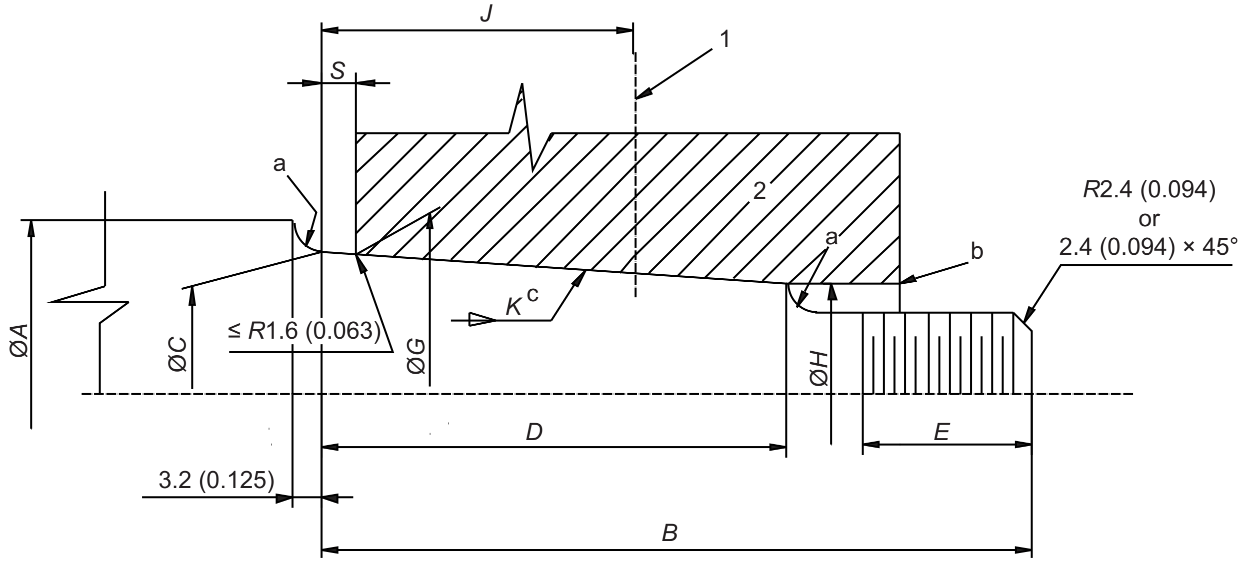
Piston and Rod Taper No.	Rod Diameter Range [a]	Piston Rod: Length of Rod End ±1.6 (±1/16)	Piston Rod: Major Diam. Rod Taper ±0.03 (±0.001)	Piston Rod: Length of Taper ±1.6 (±1/16)	Piston Rod: Length of Perfect Thread ±3.2 (±1/8)	Piston: Diam. of Thread Boss $^{0}_{-1.6}$ ($^{0}_{-1/16}$)	Piston: Gauge Point Piston Diameter ±0.05 (±0.002)	Piston: Diameter of Cylindrical Bore ±0.40 (±1/64)	Piston: Center of Piston	Piston and Rod Taper mm/m on Diameter ±0.05 (±0.002)	Standoff S min.	Standoff S max.	Thread Designation
	A	B	C	D	E	F	G [c]	H	J	K			
1	25.4 to 31.0 (1 to 1 7/32)	98.4 (3 7/8)	25.40 (1.000)	38.1 (1 1/2)	44.5 (1 3/4)	—	24.87 (0.979)	23.0 (29/32)	34.9 (1 3/8)	83.33 (1.000)	6.4 (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)	47.6 (1 7/8)	83.33 (1.000)	6.4 (1/4)	—	1-8UNC-2A
3	38.1 to 46.8 (1 1/4 to 1 27/32)	181.0 (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 23/32)	219.1 (8 5/8)	57.15 (2.250)	101.6 (4)	104.8 (4 1/8	—	56.62 (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 (1.000)	1.04 (0.041)	2.87 (0.113)	1 7/8-8UN-2A
6HP	76.2 to 88.9 (3 to 3 1/2)	231.8 (9 1/8)	69.22 (2.275)	108.0 (4 1/4)	111.1 (4 1/8)	52.4 (2 1/16)	69.32 (2.279)	60.3 (2 3/8)	68.3 (2 11/16)	83.33 (1.000)	1.04 (0.041)	2.87 (0.118)	2 1/4-8UN-2A

NOTE See Figure 12 and Figure 13 for illustration of dimension symbols.

[a] Selected diameter tolerances for ISO/API rod numbers 1 and 2: $^{+0.25}_{-0.13}$ mm ($^{+0.010}_{-0.005}$ in.). For rod number 3 and larger: $^{+0.25}_{0}$ mm ($^{+0.010}_{0}$ in.).

[b] Recommended as a substitute for ISO/API 6HP piston for reduced liner sizes only.

[c] Dimension G relates to dimension S min. only (standoff).



Key

1 centerline of piston (hand-tight position)

2 piston

NOTE See Table 11 for dimensions.

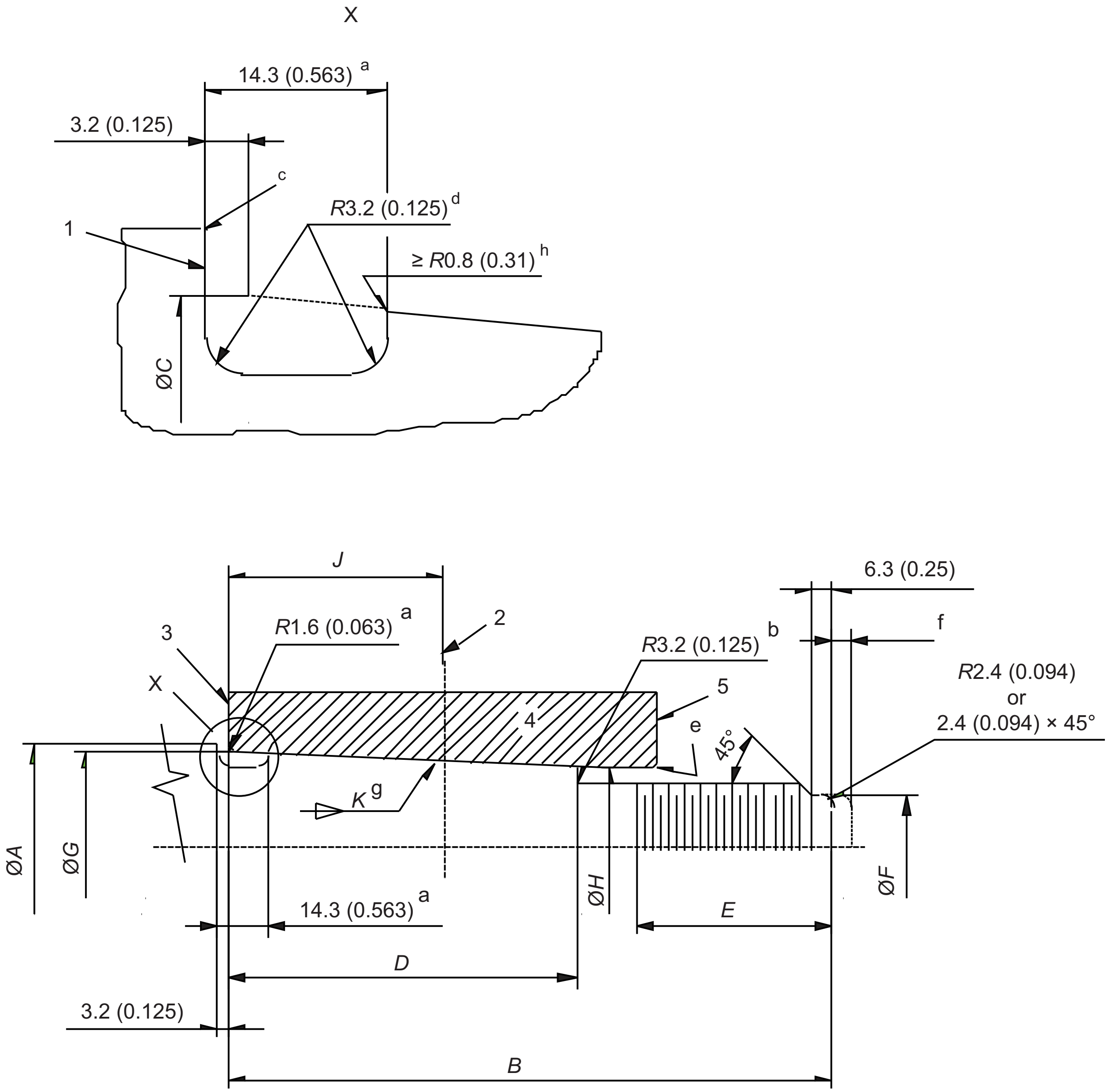
a 3.2 mm (0.125 in.) *R* at each shoulder.

b Break corner.

c Taper.

Figure 12—Tapers 1 Through 6

Dimensions in millimeters (inches)



Key

1 shoulder M, rod shoulder
2 centerline of piston (hand-tight position)
3 shoulder N, piston shoulder, rod end
4 piston
5 shoulder P, piston shoulder, thread end

NOTE See Table 11 for dimensions.

[a] Maximum dimension.
[b] Minimum dimension.
[c] Break ≤ 0.4 mm (0.016 in.).
[d] Fillets and undercut diameter to be prestressed by coldworking.
[e] Break corner.
[f] Maximum optional end extension 3.2 mm (0.125 in.).
[g] Taper.
[h] Radius or break corner.

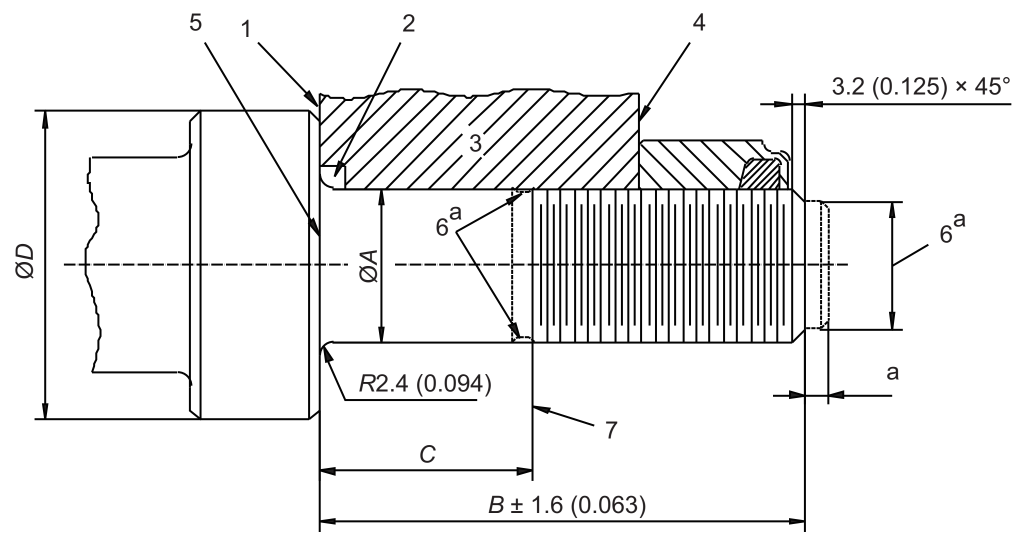
Figure 13—Tapers 5 HP and 6 HP

Table 12—Fluid End of Single-acting Mud-pump Piston Rods and Piston Body Bores
Dimensions in millimeters (inches)

Piston and Rod Connection Number	Connection Diameter Nominal mm (in.)	Piston Rod						Piston Bore
		Rod Diameter mm (in.) *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		
SA-2	25.4 (1)	25.32 to 25.38 (0.997 to 0.999)	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)	38.02 to 38.07 (1.497 to 1.499)	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.

Dimensions in millimeters (inches)



Key
1 shoulder N, piston shoulder, rod end
2 seal required, dimensions are the option of the manufacturer
3 piston
4 shoulder P, piston shoulder, thread end
5 shoulder M, rod shoulder
6 thread relief feature, details at the option of manufacturer
7 last full thread

NOTE See Table 12 for dimensions

[a] Optional feature

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

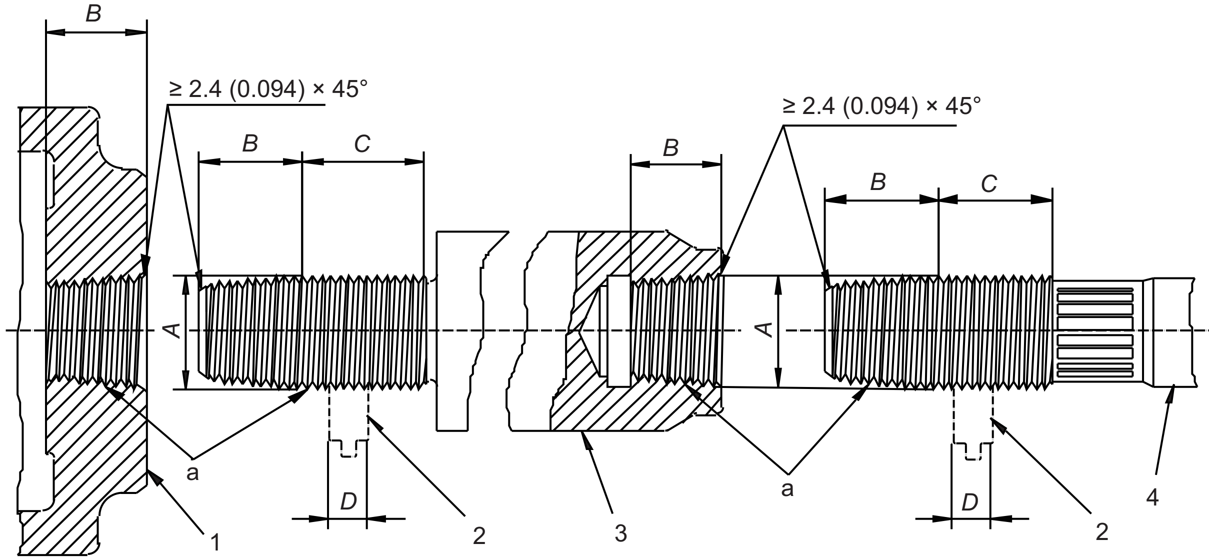
Table 13—Crosshead, Crosshead Extension, and Piston Rod Connections-Tapered Thread Type
Dimensions in millimeters (inches)

Taper Thread Number	Nominal Size *A* [a]		Taper Thread *B*		Length of Straight Thread *C*		Locknut Thickness *D*	
T1	25.4	(1)	31.8	(1 1/4)	25.4	(1)	19.1	(3/4)
T2	28.6	(1 1/8)	35.7	(1 13/32)	25.4	(1)	19.1	(3/4)
T3	31.8	(1 1/4)	39.7	(1 9/16)	25.4	(1)	22.2	(7/8)
T4	34.9	(1 3/8)	43.7	(1 23/32)	25.4	(1)	22.2	(7/8)
T5	38.1	(1 1/2)	47.6	(1 7/8)	31.8	(1 1/4)	25.4	(1)
T6	41.3	(1 5/8)	51.6	(2 1/32)	31.8	(1 1/4)	25.4	(1)
T7	44.5	(1 3/4)	55.6	(2 3/16)	31.8	(1 1/4)	28.6	(1 1/8)
T8	47.6	(1 7/8)	59.5	(2 11/32)	31.8	(1 1/4)	28.6	(1 1/8)
T9	50.8	(2)	63.5	(2 1/2)	38.1	(1 1/2)	31.8	(1 1/4)
T10	57.2	(2 1/4)	71.4	(2 13/16)	38.1	(1 1/2)	34.9	(1 3/8)
T11	63.5	(2 1/2)	79.4	(3 1/8)	44.5	(1 3/4)	38.1	(1 1/2)
T12	69.9	(2 3/4)	87.3	(3 7/16)	44.5	(1 3/4)	41.3	(1 5/8)
T13	76.2	(3)	95.3	(3 3/4)	50.8	(2)	44.5	(1 3/4)
T14	82.6	(3 1/4)	103.2	(4 1/16)	50.8	(2)	47.6	(1 7/8)
T15	88.9	(3 1/2)	111.1	(4 3/8)	57.2	(2 1/4)	50.8	(2)
T16	101.6	(4)	127.0	(5)	57.2	(2 1/4)	50.8	(2)
T17	114.3	(4 1/2)	142.9	(5 3/8)	57.2	(2 1/4)	50.8	(2)
T18	127.0	(5)	158.8	(6 1/4)	57.2	(2 1/4)	50.8	(2)
T19	139.7	(5 1/2)	174.6	(6 7/8)	57.2	(2 1/4)	50.8	(2)
T20	152.4	(6)	190.5	(7 1/2)	57.2	(2 1/4)	50.8	(2)

NOTE See Figure 15 for illustration of dimension symbols.

[a] All threads are 8 TPI, Series UN, Class 2A-2B modified.

Dimensions in millimeters (inches)



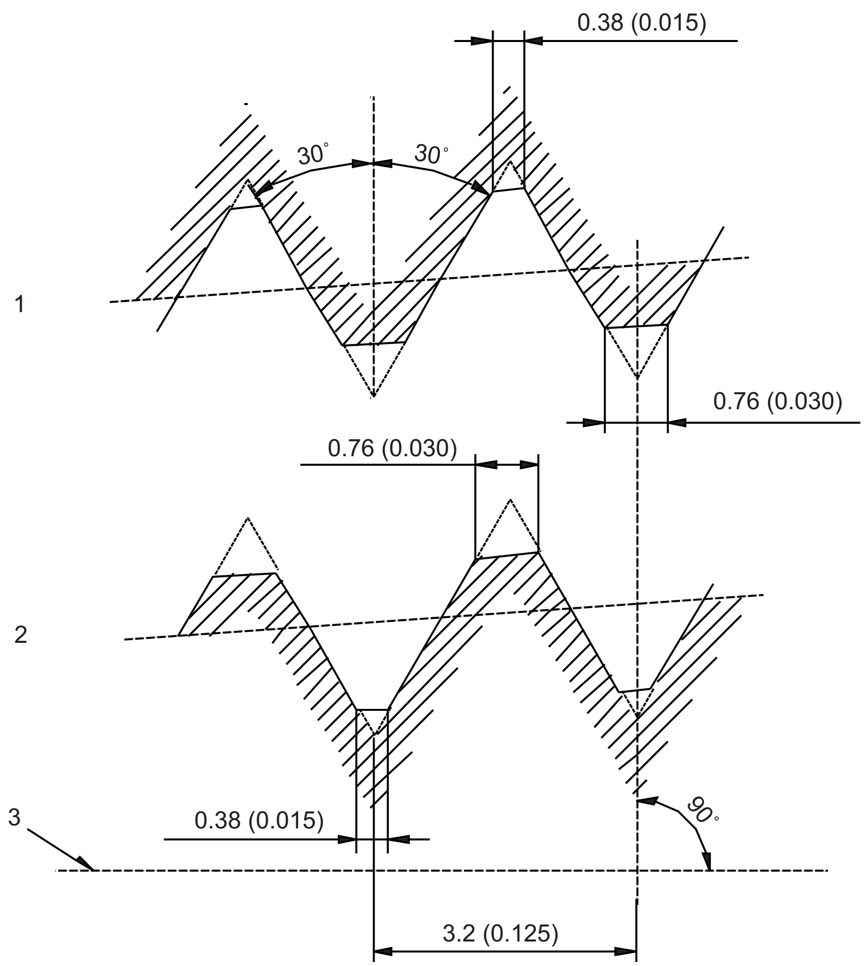
Key
1 crosshead
2 locknut
3 crosshead extension
4 piston rod

NOTE See Table 13 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

Dimensions in millimeters (inches)



Key
1 internal thread
2 external thread
3 thread axis

NOTE See 9.8.3.2 for description.

Figure 16—Tapered Thread Form

Table 14—Crosshead, Crosshead Extension, and Piston Rod Connections-Straight Thread Type Dimensions in millimeters (inches)

Straight Thread Number	Nominal Size *A* [a]		Length of Internal Thread *B*		Length of External Thread *C*		Locknut Thickness Minimum *D*	
S1	25.4	(1)	31.8	(1 1/4)	57.2	(2 1/4)	19.1	(3/4)
S2	28.6	(1 1/8)	35.7	(1 13/32)	61.1	(2 13/32)	19.1	(3/4)
S3	31.8	(1 1/4)	39.7	(1 9/16)	65.1	(2 9/16)	22.2	(7/8)
S4	34.9	(1 3/8)	43.7	(1 23/32)	69.1	(2 23/32)	22.2	(7/8)
S5	38.1	(1 1/2)	47.6	(1 7/8)	79.4	(3 1/8)	25.4	(1)
S6	41.3	(1 5/8)	51.6	(2 1/32)	83.3	(3 9/32)	25.4	(1)
S7	44.5	(1 3/4)	55.6	(2 13/16)	87.3	(3 7/16)	28.6	(1 1/8)
S8	47.6	(1 7/8)	59.5	(2 11/32)	91.3	(3 19/32)	28.6	(1 1/8)
S9	50.8	(2)	63.5	(2 1/2)	101.6	(4)	31.8	(1 1/4)
S10	57.2	(2 1/4)	71.4	(2 13/16)	109.5	(4 5/6)	34.9	(1 3/8)
S11	63.5	(2 1/2)	79.4	(3 1/8)	123.8	(4 7/8)	38.1	(1 1/2)
S12	69.9	(2 3/4)	87.3	(3 7/16)	131.8	(5 3/16)	41.3	(1 5/8)
S13	76.2	(3)	95.3	(3 3/4)	146.1	(5 3/4)	44.5	(1 3/4)
S14	82.6	(3 1/4)	103.2	(4 1/16)	154.0	(6 1/16)	47.6	(1 7/8)
S15	88.9	(3 1/2)	111.1	(4 3/8)	168.3	(6 5/8)	50.8	(2)
S16	101.6	(4)	127.0	(5)	184.2	(7 1/4)	50.8	(2)
S17	114.3	(4 1/2)	142.9	(5 5/8)	200.0	(7 7/8)	50.8	(2)
S18	127.0	(5)	158.8	(6 1/4)	215.9	(8 1/2)	50.8	(2)
S19	139.7	(5 1/2)	174.6	(6 7/8)	231.8	(9 1/8)	50.8	(2)
S20	152.4	(6)	190.5	(7 1/2)	247.7	(9 3/4)	50.8	(2)

NOTE See Figure 20 for illustration of dimension symbols.

[a] All threads are 8 TPI, Series UN, Class 2A-2B modified.

9.8.3 Duplex Mud-pump Crosshead, Crosshead Extension, and Piston Rod Connections—Tapered Thread Type

9.8.3.1 Sizes

Tapered thread type connections between crossheads, crosshead extensions, and piston rods shall be eight threads per inch (TPI), Series UN, Class 2A-2B modified, in the sizes given in Table 13. Requirements for gauges and gauging practice are given in 9.8.3 and 9.8.4.

9.8.3.2 Thread Dimensions and Tolerances

Tapered thread type connections shall conform to dimensions given in Table 13, 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 $\binom{0}{-0.51}$ mm $\left[\binom{0}{-0.020}\text{in}\right]$ for internal threads and $\binom{+0.51}{0}$ mm $\left[\binom{+0.020}{0}\text{in}\right]$ 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:

$$L_{\text{ET}} = B + C \tag{7}$$

$$B = 1.25 \times A \tag{8}$$

where

L_{ET} 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.

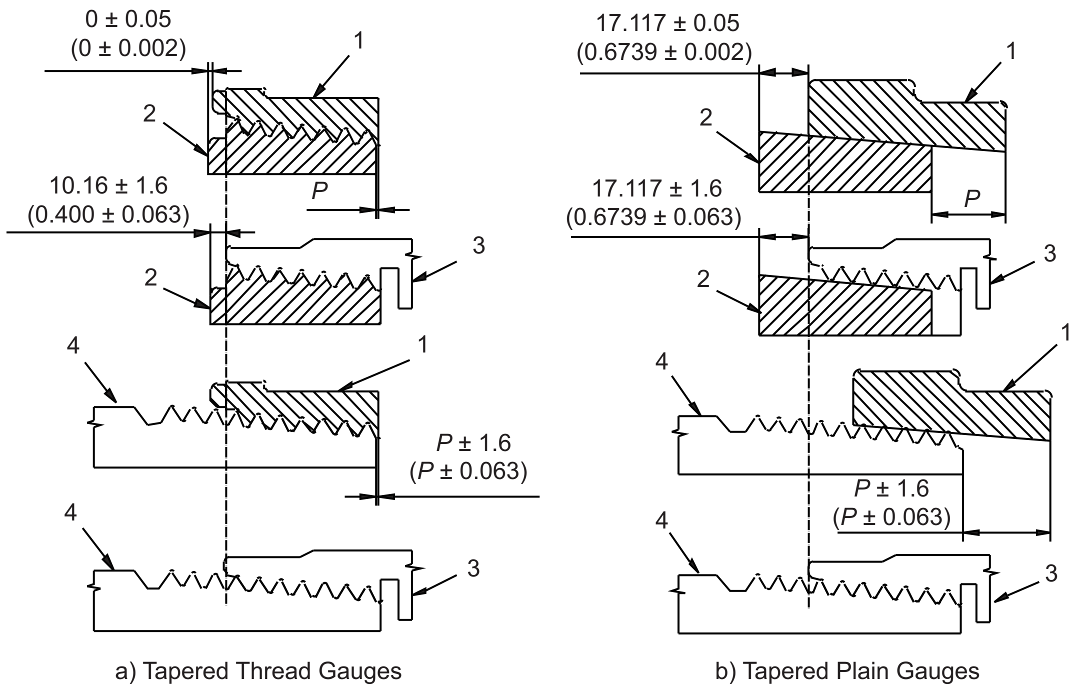
i) Standoff: In gauging tapered threads, standoff of product from plain and threaded plug and ring gauges shall be maintained within a tolerance of ±1.6 mm (±$^{1}/_{16}$ in.) (see Figure 17).

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

9.8.3.3 Locknuts

Crosshead extension and piston rod locknuts shall be furnished in accordance with 9.8.3.2 and Figure 18.

Dimensions in millimeters (inches)

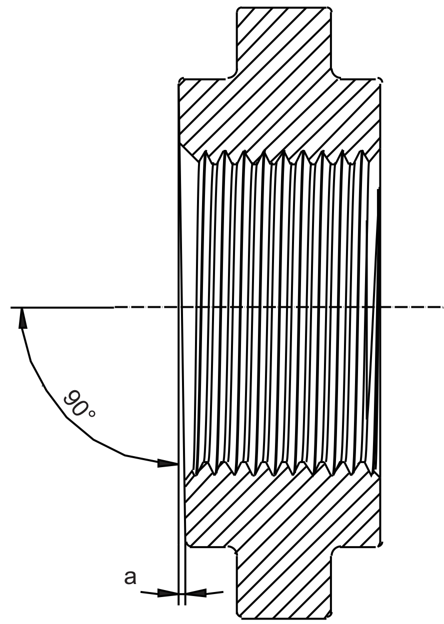


Key
1 ring gauge
2 plug gauge
3 product box
4 product pin

P extension of ring beyond end of product pin/plug gauge at full engagement

NOTE See 9.8.9.2 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

9.8.4 Duplex Mud-pump Crosshead, Crosshead Extension, and Piston Rod Connections—Straight Thread Type

9.8.4.1 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 14.

9.8.4.2 Thread Dimensions and Tolerances

Straight-thread type connections shall conform to the dimensions and tolerances given in Table 14, 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 14):

internal: $B = 1.25 \times A$; (9)

external: $C = B + D + 6.4$ mm. (10)

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

9.8.4.3 Locknuts

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

9.8.4.4 Taper Threads

Locknut threads for the taper type connection shall conform to the requirements of 9.8.3.2.

9.8.4.5 Threads

Locknut threads for the straight type connection shall conform to the requirements of 9.8.4.2.

9.8.5 Mud-pump Valve Pots

9.8.5.1 Sizes and Dimensions

Mud-pump valve pots shall be furnished in the sizes and dimensions given in Table 15 and Figure 21, or as specified on the purchase order. API valve pots for caged valves shall provide a minimum G dimension. See Table 15 for cage clearance.

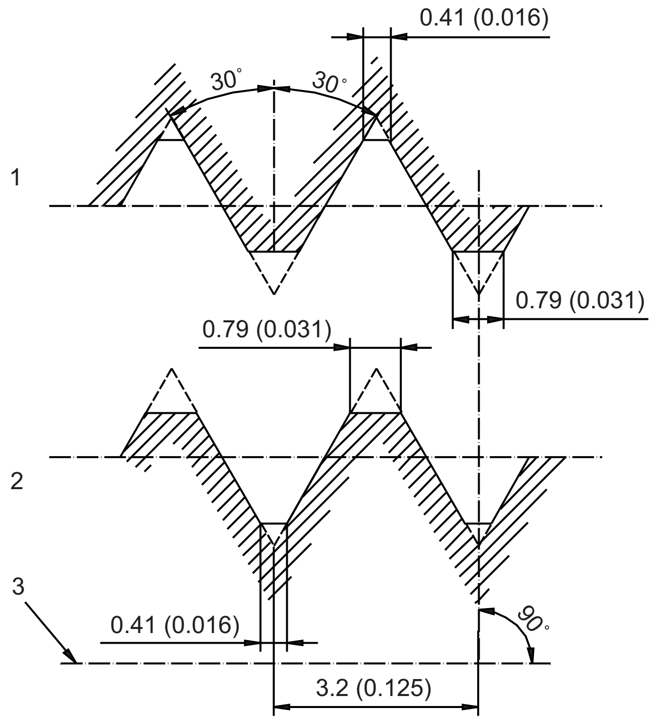
9.8.5.2 Spring Mounting Dimensions

Valve-pot spring mounting dimensions shall conform to dimensions L, M, and N in Figure 21 and Table 15.

9.8.5.3 Marking

Mud-pump valve pots shall be marked in accordance with the requirements of Section 10 and with 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.

Dimensions in millimeters (inches)

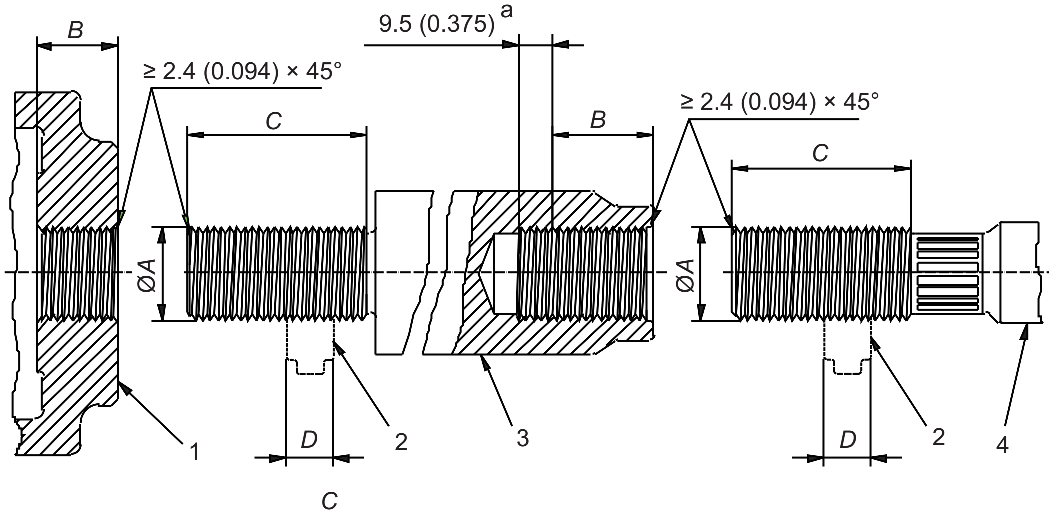


Key
1 internal thread
2 external thread
3 thread axis

NOTE See 9.8.4.2 for description.

Figure 19—Straight Thread Form

Dimensions in millimeters (inches)



Key

1 crosshead
2 locknut
3 crosshead extension
4 piston rod

NOTE See Table 14 for dimensions

[a] Imperfect thread

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

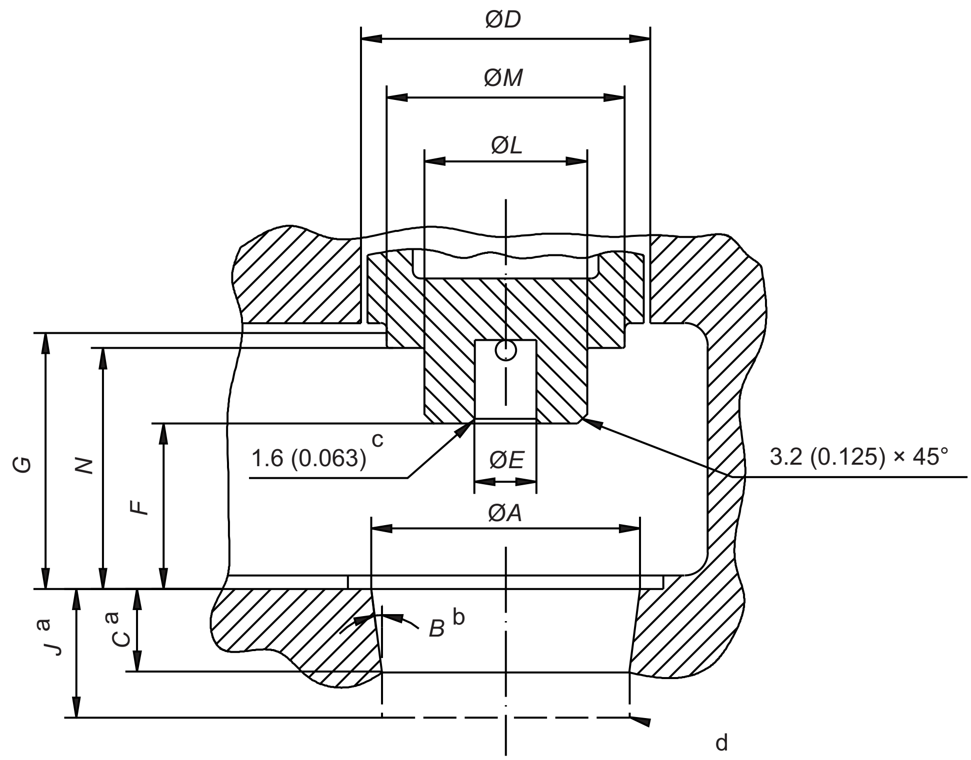
Table 15—Mud-pump Valve Pots

Dimensions in millimeters (inches)

Pot Size	Valve Pot Dimensions								Spring Mounting Dimensions		
	A	*B*/m (*B*/ft)	*C*	*D*	*E*	*F*	*G*	*J*	*L*	*M*	*N*
1	73.0 (2 7/8)	166.7 (2)	25.4 (1)	82.6 (3 1/4)	Solid	44.5 (1 3/4)	Solid	57.2 (2 1/4)	25.4 (1)	63.5 (2 1/2)	63.5 (2 1/2)
2	85.7 (3 3/8)	166.7 (2)	28.6 (1 1/8)	95.3 (3 3/4)	20.6 (13/16)	57.2 (2 1/4)	85.7 (3 3/8)	63.5 (2 1/2)	44.5 (1 3/4)	76.2 (3)	82.6 (3 1/4)
3	98.4 (3 7/8)	166.7 (2)	31.8 (1 1/4)	108.0 (4 1/4)	20.6 (13/16)	63.5 (2 1/4)	95.3 (3 3/4)	66.7 (2 5/8)	44.5 (1 3/4)	76.2 (3)	88.9 (3 1/2)
4	111.1 (4 3/8)	166.7 (2)	34.9 (1 3/8)	120.7 (4 3/4)	20.6 (13/16)	69.9 (2 3/4)	104.8 (4 1/8)	69.9 (2 3/4)	50.8 (2)	76.2 (3)	95.3 (3 3/4)
5	127.0 (5)	166.7 (2)	38.1 (1 1/2)	136.5 (5 3/8)	33.3 (1 5/16)	76.2 (3)	123.8 (4 7/8)	79.4 (3 1/8)	69.9 (2 3/4)	95.3 (3 3/4)	108.0 (4 1/4)
5.5	136.5 (5 3/8)	166.7 (2)	41.3 (1 5/8)	146.1 (5 3/8)	33.3 (1 5/16)	82.6 (3 1/4)	133.4 (5 1/4)	85.7 (3 3/8)	69.9 (2 3/4)	95.3 (3 3/4)	114.3 (4 1/2)
6	142.9 (5 5/8)	166.7 (2)	44.5 (1 3/4)	152.4 (6)	33.3 (1 5/16)	82.6 (3 1/4)	133.4 (5 1/4)	85.7 (3 3/8)	69.9 (2 3/4)	95.3 (3 3/4)	114.3 (4 1/2)
7	158.8 (6 1/4)	166.7 (2)	50.8 (2)	168.3 (6 5/8)	33.3 (1 5/16)	88.9 (3 1/2)	142.9 (5 5/8)	95.3 (3 3/4)	69.9 (2 3/4)	95.3 (3 3/4)	120.7 (4 3/4)
8	177.8 (7)	166.7 (2)	57.2 (2 1/4)	187.3 (7 3/8)	33.3 (1 5/16)	95.3 (3 3/4)	152.4 (6)	98.4 (3 7/8)	69.9 (2 3/4)	95.3 (3 3/4)	127.0 (5)
9	196.9 (7 3/4)	166.7 (2)	63.5 (2 1/2)	206.4 (8 1/8)	33.3 (1 5/16)	101.6 (4)	161.9 (6 3/8)	104.8 (4 1/8)	69.9 (2 3/4)	95.3 (3 3/4)	133.4 (5 1/4)
10	215.9 (8 1/2)	166.7 (2)	73.0 (2 7/8)	225.4 (8 7/8)	33.3 (1 5/16)	108.0 (4 1/4)	171.5 (6 3/4)	123.8 (4 7/8)	69.9 (2 3/4)	95.3 (3 3/4)	139.7 (5 1/2)
11	241.3 (9 1/2)	166.7 (2)	82.6 (3 1/4)	250.8 (9 7/8)	33.3 (1 5/16)	114.3 (4 1/2)	181.0 (7 1/8)	136.5 (5 3/8)	69.9 (2 3/4)	95.3 (3 3/4)	146.1 (5 3/4)

NOTE See Figure 21 for illustration of dimension symbols.

Dimensions in millimeters (inches)



NOTE See Table 15 for dimensions

a Minimum dimension.
b Taper, mm/m (in./ft) on diameter.
c Maximum chamfer.
d Minimum clearance.

Figure 21—Mud-pump Valve Pot

9.8.6 Mud-pump Pistons

9.8.6.1 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 11. Piston outside diameters shall be suitable for use in liners or cylinders having increments of diameter change as noted in 9.8.7.1 and Figure 22.

9.8.6.2 Marking

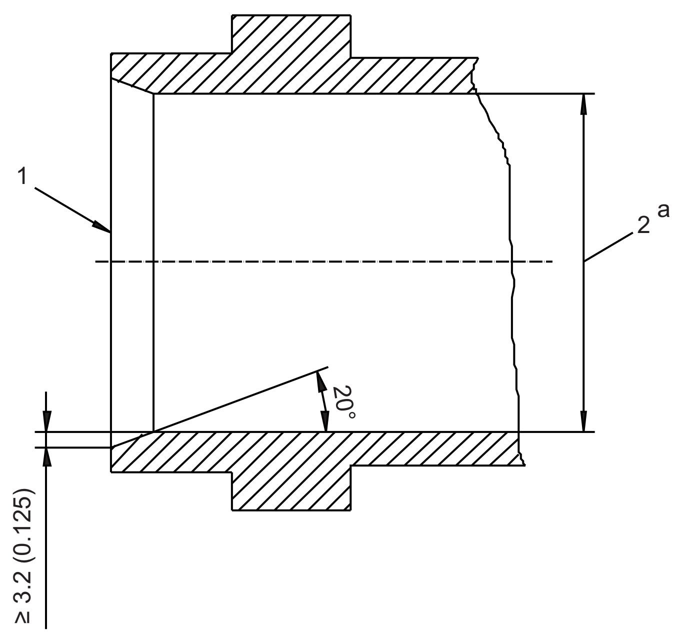
Pistons shall be marked in accordance with the requirements of Section 10 and the following:

a) the corresponding API rod number; and

b) the 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.

Dimensions in millimeters (inches)



Key
1 piston entering end
2 liner bore

a Nominal diameter tolerance: $^{+0.130}_{0}$ mm ($^{+0.005}_{0}$ in.).

Figure 22—Mud-pump Liner

9.8.7 Mud-pump Liners

9.8.7.1 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.

9.8.7.2 Chamfer

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

9.8.7.3 Marking

Mud-pump liners shall be marked in accordance with the requirements of Section 10 and with 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.

9.8.8 Mud-pump Gear Ratings

9.8.8.1 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.

9.8.8.2 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.

9.8.8.3 Nameplate Rating

The nameplate (power) rating of a mud pump shall not exceed the (power) rating of the gears.

9.8.9 Gauges and Gauging Practice for Mud-pump Components

9.8.9.1 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.

9.8.9.2 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 API 7-2, Annex D, 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.

9.8.9.3 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 16 except that, in the case of setting plugs, the tolerance applies to a length of thread equal to that in the mating ring gauge.

Table 16—Tolerances on Gauge Dimensions

Dimensions in millimeters (inches) at 20 °C (67 °F), except as otherwise indicated

<table>
<tr><th colspan="8">Tapered Gauges (Threaded and Plain)</th></tr>
<tr><th colspan="4">Plug Gauge</th><th colspan="4">Ring Gauge</th></tr>
<tr><td colspan="3">Pitch diameter at gauge point</td><td>±0.010
(±0.0004)</td><td colspan="3">Minor diameter at gauge point</td><td>±0.051
(±0.002)</td></tr>
<tr><td colspan="3">Major diameter at gauge point</td><td>±0.051
(±0.002)</td><td colspan="3">Outside diameter, D_R</td><td>±0.381
(±0.015)</td></tr>
<tr><td colspan="3">Diameter of plain plug at large end, D_{FP}</td><td>±0.010
(±0.0004)</td><td colspan="3">Diameter of counterbore, D_R</td><td>±0.381
(±0.015)</td></tr>
<tr><td colspan="3">Diameter of fitting plate, D_P</td><td>±0.381
(±0.015)</td><td colspan="3">Diameter of fitting plate, D_P</td><td>±0.381
(±0.015)</td></tr>
<tr><th rowspan="2">Taper Thread Number</th><th colspan="2">Taper [a]</th><th rowspan="2">Lead</th><th rowspan="2">Taper Thread Number</th><th colspan="2">Taper [a]</th><th rowspan="2">Lead</th></tr>
<tr><th>Threaded Plug</th><th>Plain Plug</th><th>Threaded Ring</th><th>Plain Ring</th></tr>
<tr><td>T1 to T15</td><td>+0.010
(+0.0004)</td><td>±0.005
(±0.0002)</td><td>±0.010
(±0.0004)</td><td rowspan="2">T1 to T15</td><td>–0.010
(–0.0004)</td><td>±0.005
(±0.0002)</td><td>±0.010
(±0.0004)</td></tr>
<tr><td>T16 to T18</td><td>+0.013
(+0.0005)</td><td>±0.008
(±0.0003)</td><td>±0.013
(±0.0005)</td><td>–0.030
(–0.0012)</td><td></td><td></td></tr>
<tr><td>T19 and T20</td><td>+0.018
+0.0007</td><td>±0.010
(±0.0004)</td><td>±0.018
(±0.0007)</td><td rowspan="2">T16 to T18</td><td>–0.013
(–0.0005)</td><td>±0.008
(±0.0003)</td><td>±0.020
(±0.0008)</td></tr>
<tr><td colspan="3">Half-angle of thread</td><td>±7 min</td><td>–0.038
(–0.0015)</td><td></td><td></td></tr>
<tr><td colspan="3">Length, L_{PT} and L_{PP}</td><td>±0.051
(±0.002)</td><td rowspan="2">T19 and T20</td><td>–0.018
(–0.0007)</td><td>±0.010
(±0.0004)</td><td>±0.025
(±0.0010)</td></tr>
<tr><td colspan="4" rowspan="4"></td><td>–0.053
(–0.0021)</td><td></td><td></td></tr>
<tr><td colspan="3">Half-angle of thread</td><td>±15 min</td></tr>
<tr><td colspan="3">Length, L_{RT} and L_{RP}</td><td>±0.051
(±0.002)</td></tr>
<tr><td colspan="3">Mating standoff</td><td>±0.051
(±0.002)</td></tr>
<tr><th colspan="8">Straight Thread Gauges</th></tr>
<tr><td colspan="8">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.</td></tr>
<tr><td colspan="8">The ends of plug and ring gauges shall be square with the thread axis within a tolerance of 0.025 mm (0.001 in.).</td></tr>
<tr><td colspan="8">[a] Tolerances for taper apply to the full gauge length.</td></tr>
</table>

9.8.9.4 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 LRT (see Table 17) shall conform to the basic taper within the tolerances specified in Table 16. 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 LRP (see Table 17 and Table 18) shall conform to the basic taper within the tolerance specified in Table 16. The taper of straight-thread setting plugs shall not exceed 0.0038 mm (0.00015 in.) over the length LTS (see Table 19, Table 20, 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.

9.8.9.5 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.

9.8.9.6 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 23. 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.

9.8.9.7 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 16, Table 17, Table 18, Table 19, Table 20, Figure 24, Figure 25, and Figure 26 for dimensional tolerances.

9.8.9.8 Pitch Diameter

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

9.8.9.9 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.).

9.8.9.10 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 with a thin film of white, high-purity mineral oil 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:

1) for gauges T1 to T9, use a 0.45 kg (1 lb) weight;

2) for gauges T10 to T13, use a 0.91 kg (2 lb) weight;

3) for gauges T14 to T17, use a 1.36 kg (3 lb) weight;

4) 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.

9.8.9.11 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.).

9.8.10 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.

Table 17—Tapered Thread and Plain Gauges [a]
Dimensions in millimeters at 20 °C

Taper Thread Number	Nom. Size	Outside Diam. of Ring D_R	Tapered Thread Gauges [b]: Pitch Diam. at Gauge Point	Major Diam. at Gauge Point	Minor Diam. at Gauge Point	Diam. of Fitting Plate D_P	Length of Plug and Ring L_{PT} and L_{RT}	Diam. of Counter -bore D_C	Tapered Plain Gauges: Diam. of Plug at Large End D_{EP}	Diam. of Ring at Large End D_{ER}	Length of Plug and Ring L_{PP} and L_{RP}
T1	1	60.3	21.9304	23.3568	20.5039	17.27	41.910	29.11	24.6268	21.7739	31.750
T2	1 1/8	63.5	25.1016	26.5280	23.6751	20.45	45.878	32.28	27.7980	24.9451	35.718
T3	1 1/4	66.7	28.2753	29.7017	26.8488	23.62	49.848	35.46	30.9718	28.1188	39.688
T4	1 3/8	69.9	31.4452	32.8717	30.0187	26.80	53.818	38.63	34.1417	31.2887	43.658
T5	1 1/2	73.0	34.6189	36.0454	33.1925	29.97	57.785	41.81	37.3154	34.4625	47.625
T6	1 5/8	76.2	37.7927	39.2191	36.3593	33.15	61.752	44.98	40.4891	37.6362	51.593
T7	1 3/4	79.4	40.9638	42.3903	39.5374	36.32	65.723	48.16	43.6603	40.8074	55.563
T8	1 7/8	82.6	44.1363	45.5628	42.7098	39.50	69.693	51.33	46.8328	43.9800	59.533
T9	2	85.7	47.3100	48.7365	45.8836	42.67	73.660	54.51	50.0065	47.1536	63.500
T10	2 1/4	92.1	53.6550	55.0814	52.2285	49.00	81.598	60.83	56.3514	53.4985	71.438
T11	2 1/2	98.4	60.0024	61.4289	58.5760	55.35	89.535	67.18	62.6989	59.8460	79.375
T12	2 3/4	117.5	66.3485	67.7751	64.9221	61.70	97.473	73.53	69.0451	66.1921	87.313
T13	3	123.8	72.6935	74.1200	71.2671	68.05	105.410	79.88	75.3899	72.5371	92.250
T14	3 1/4	130.2	79.0410	80.4675	77.6145	74.40	113.348	86.23	81.7375	78.8845	103.188
T15	3 1/2	136.5	85.3897	86.8162	83.9633	80.75	121.285	92.58	88.0862	85.2333	111.125
T16	4	149.2	98.0834	99.5098	96.6569	93.45	137.160	105.28	100.7798	97.9270	127.000
T17	4 1/2	161.9	110.777	112.2035	109.3506	106.12	153.035	117.96	113.4735	110.6206	142.875
T18	5	174.6	123.471	124.8971	122.0442	118.82	168.910	130.65	126.1671	123.3142	158.750
T19	5 1/2	187.3	136.166	137.5921	134.7391	131.52	184.785	143.36	138.8620	136.0091	174.625
T20	6	200.0	148.862	150.2882	147.4353	144.22	200.660	156.06	151.5582	148.7053	190.500

NOTE See Figure 23 for illustration of dimension symbols.

[a] Taper for all sizes is 166.67 mm/m on diameter.

[b] All threads are 8 TPI, pitch = 3.175 mm.

Table 18—Tapered Thread and Plain Gauges [a]
Dimensions in inches at 68 °F

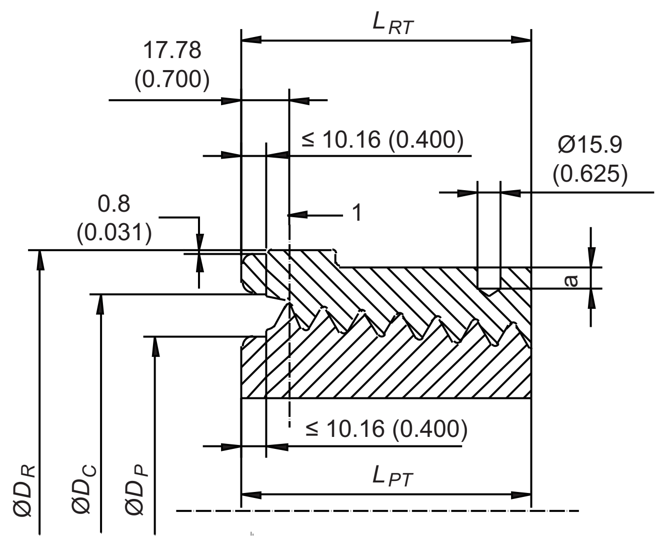
Taper Thread Number	Nom. Size	Outside Diam. of Ring D_R	Tapered Thread Gauges b: Pitch Diam. at Gauge Point	Major Diam. at Gauge Point	Minor Diam. at Gauge Point	Diam. of Fitting Plate D_P	Length of Plug and Ring L_{PT} and L_{RT}	Diam. of Counter -bore D_C	Tapered Plain Gauges: Diam. of Plug at Large End D_{EP}	Diam. of Ring at Large End D_{ER}	Length of Plug and Ring L_{PP} and L_{RP}
T1	1	2 3/8	0.86340	0.91956	0.80724	0.680	1.6500	1.146	0.96956	0.85724	1.2500
T2	1 1/8	2 1/2	0.98825	1.04441	0.93209	0.805	1.8062	1.271	1.09441	0.98209	1.4062
T3	1 1/4	2 5/8	1.11320	1.16936	1.05704	0.930	1.9625	1.396	1.21936	1.10704	1.5625
T4	1 3/8	2 3/4	1.23800	1.29416	1.18184	1.055	2.1188	1.521	1.34416	1.23184	1.7188
T5	1 1/2	2 7/8	1.36295	1.41911	1.30679	1.180	2.2750	1.646	1.46911	1.35679	1.8750
T6	1 5/8	3	1.48790	1.54406	1.43147	1.305	2.4312	1.771	1.59406	1.48174	2.0312
T7	1 3/4	3 1/8	1.61275	1.66891	1.55659	1.430	2.5875	1.896	1.71891	1.60659	2.1875
T8	1 7/8	3 1/4	1.73765	1.79381	1.68149	1.555	2.7438	2.021	1.84381	1.73149	2.3438
T9	2	3 3/8	1.86260	1.91876	1.80644	1.680	2.9000	2.146	1.96876	1.85644	2.5000
T10	2 1/4	3 5/8	2.11240	2.16856	2.05624	1.929	3.2125	2.395	2.21856	2.10624	2.8125
T11	2 1/2	3 7/8	2.36230	2.41846	2.30614	2.179	3.5250	2.645	2.46846	2.35614	3.1250
T12	2 3/4	4 5/8	2.61215	2.66831	2.55599	2.429	3.8375	2.895	2.71831	2.60599	3.4375
T13	3	4 7/8	2.86195	2.91811	2.80579	2.679	4.1500	3.145	2.96811	2.85579	3.7500
T14	3 1/2	5 1/8	3.11185	3.16801	3.05569	2.929	4.4625	3.395	3.21801	3.10569	4.0625
T15	3 1/2	5 3/8	3.36180	3.41796	3.30564	3.179	4.7750	3.645	3.46796	3.35564	4.3750
T16	4	5 7/8	3.86155	3.91771	3.80539	3.679	5.4000	4.145	3.96771	3.85539	5.0000
T17	4 1/2	6 3/8	4.36130	4.41746	4.30514	4.178	6.0250	4.644	4.46746	4.35514	5.6250
T18	5	6 7/8	4.86105	4.91721	4.80489	4.678	6.6500	5.144	4.96721	4.85489	6.2500
T19	5 1/2	7 3/8	5.36085	5.41701	5.30469	5.178	7.2750	5.644	5.46701	5.35469	6.8750
T20	6	7 7/8	5.86070	5.91686	5.80454	5.678	7.9000	6.144	5.96686	5.85454	7.5000

NOTE See Figure 23 for illustration of dimension symbols.

[a] Taper for all sizes is 2.0000 in./ft on diameter.

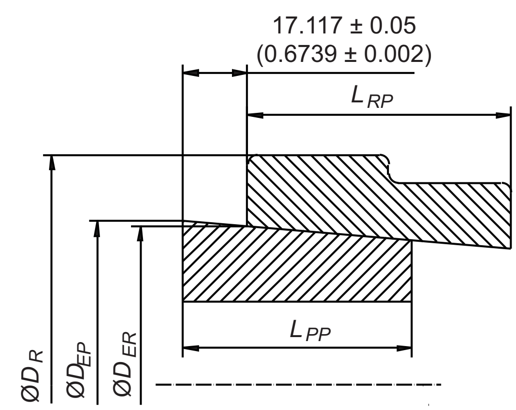
[b] All threads are 8 TPI, pitch = 0.1250 in.

Dimensions in millimeters (inches)



a) Tapered Thread Gauge

Dimensions in millimeters (inches)



b) Tapered Plain Gauge

Key

1 plane of gauge point

NOTE See Table 17 and Table 18 for dimensions.

[a] 9.5 mm to 19.1 mm (0.375 in. to 0.75 in.). Dimension varies with gauge size.

Figure 23—Tapered-thread and Plain Gauges

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

Dimensions in millimeters at 20 °C

Taper Thread Number	Nom. Size	Full Form Major Diam.	Go Gauges					No-go Gauges				
			Truncated Major Diam.	Pitch Diam.	Thread Length	Ring Length	Ring Minor Diam.	Truncated Major Diam.	Pitch Diam.	Thread Length	Ring Length	Ring Minor Diam.
		B_S	B_{ST}	E_S	L_{TS}	L_N	K_N	B_{ST}	E_S	L_{TS}	L_N	K_N
T1	1	24.717	24.282	23.287	53.975	23.8	21.857	23.828	23.114	38.1	17.5	22.400
T2	1 1/8	27.889	27.455	26.459	53.975	23.8	25.029	26.998	26.284	38.1	17.5	25.570
T3	1 1/4	31.064	30.630	29.634	60.325	28.6	28.204	30.170	29.456	41.3	19.1	28.743
T4	1 3/8	34.237	33.802	32.807	60.325	28.6	31.377	33.338	32.624	41.3	19.1	31.910
T5	1 1/2	37.411	36.977	35.982	60.325	28.6	34.552	36.510	35.796	41.3	19.1	35.082
T6	1 5/8	40.587	40.152	39.157	73.025	31.8	37.727	39.682	38.969	47.6	20.6	38.255
T7	1 3/4	43.759	43.325	42.329	73.025	31.8	40.900	42.852	42.139	47.6	20.6	41.425
T8	1 7/8	46.934	46.500	45.504	73.025	31.8	44.074	46.022	45.309	47.6	20.6	44.595
T9	2	50.109	49.675	48.679	73.025	31.8	47.249	49.195	48.481	47.6	20.6	47.767
T10	2 1/4	56.457	56.022	55.027	76.200	34.9	53.597	55.537	54.823	50.8	22.2	54.110
T11	2 1/2	62.807	62.372	61.377	82.550	38.1	59.947	61.882	61.168	50.8	22.2	60.455
T12	2 3/4	69.154	68.720	67.724	88.900	41.3	66.294	68.227	67.513	50.8	22.2	66.799
T13	3	75.502	75.067	74.071	95.250	44.5	72.641	74.569	73.856	50.8	22.2	73.142
T14	3 1/4	81.852	81.417	80.421	101.600	47.6	78.991	80.914	80.201	50.8	23.8	79.487
T15	3 1/2	88.202	87.767	86.771	107.950	50.8	85.341	87.262	86.548	50.8	23.8	85.834
T16	4	100.899	100.465	99.469	107.950	50.8	98.039	99.952	99.238	50.8	23.8	98.524
T17	4 1/2	113.596	113.162	112.166	107.950	50.8	110.736	112.641	111.928	54.0	25.4	111.214
T18	5	126.294	125.860	124.864	107.950	50.8	123.434	125.331	124.617	54.0	25.4	123.904
T19	5 1/2	138.991	138.557	137.561	107.950	50.8	136.131	138.024	137.310	54.0	25.4	136.596
T20	6	151.691	151.257	150.261	107.950	50.8	148.831	150.716	150.002	54.0	25.4	149.289

NOTE See Figure 24 for illustration of dimension symbols.

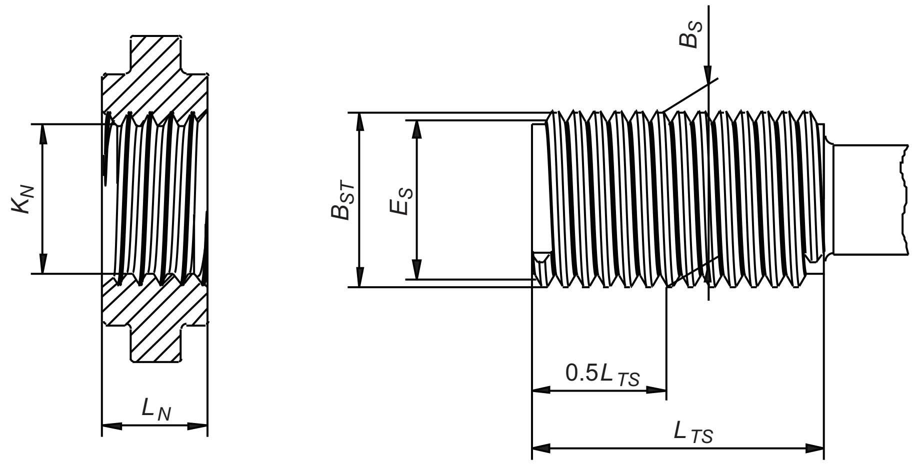
[a] All threads are 8 TPI, pitch = 3.175 mm.

Table 20—Pin Go and No-go Gauges [a] (for Straight-threaded Portion of Tapered-thread Connection)
Dimensions in inches at 68 °F

Taper Thread Number	Nom. Size	Full Form Major Diam.	Go Gauges				Ring Minor Diam.	No-go Gauges				
			Truncated Major Diam.	Pitch Diam.	Thread Length	Ring Length		Truncated Major Diam.	Pitch Diam.	Thread Length	Ring Length	Ring Minor Diam.
		B_S	B_{ST}	E_S	L_{TS}	L_N	K_N	B_{ST}	L_S	L_{TS}	L_N	K_N
T1	1	0.9731	0.9560	0.9168	2 1/8	15/16	0.8605	0.9381	0.9100	1 1/2	11/16	0.8819
T2	1 1/8	1.0980	1.0809	1.0417	2 1/8	15/16	0.9854	1.0629	1.0348	1 1/2	11/16	1.0067
T3	1 1/4	1.2230	1.2059	1.1667	2 3/8	1 1/8	1.1104	1.1878	1.1597	1 5/8	3/4	1.1316
T4	1 3/8	1.3479	1.3308	1.2916	2 3/8	1 1/8	1.2353	1.3125	1.2844	1 5/8	3/4	1.2563
T5	1 1/2	1.4729	1.4558	1.4166	2 3/8	1 1/8	1.3603	1.4374	1.4093	1 5/8	3/4	1.3812
T6	1 5/8	1.5979	1.5808	1.5416	2 7/8	1 1/4	1.4853	1.5623	1.5342	1 7/8	13/16	1.5061
T7	1 3/4	1.7228	1.7057	1.6665	2 7/8	1 1/4	1.6102	1.6871	1.6590	1 7/8	1 13/16	1.6309
T8	1 7/8	1.8478	1.8307	1.7915	2 7/8	1 1/4	1.7352	1.8119	1.7838	1 7/8	13/16	1.7557
T9	2	1.9728	1.9557	1.9165	2 7/8	1 1/4	1.8602	1.9368	1.9087	1 7/8	13/16	1.8806
T10	2 1/4	2.2227	2.2056	2.1664	3	1 3/8	2.1101	2.1865	2.1584	2	7/8	2.1303
T11	2 1/2	2.4727	2.4556	2.4164	3 1/4	1 1/2	2.3601	2.4363	2.4082	2	7/8	2.3801
T12	2 3/4	2.7226	2.7055	2.6663	3 1/2	1 5/8	2.6100	2.6861	2.6580	2	7/8	2.6299
T13	3	2.9725	2.9554	2.9162	3 3/4	1 3/4	2.8599	2.9358	2.9077	2	7/8	2.8796
T14	3 1/4	3.2225	3.2054	3.1662	4	1 7/8	3.1099	3.1856	3.1575	2	15/16	3.1294
T15	3 1/2	3.4725	3.4554	3.4162	4 1/4	2	3.3599	3.4355	3.4074	2	15/16	3.3793
T16	4	3.9724	3.9553	3.9161	4 1/4	2	3.8598	3.9351	3.9070	2	15/16	3.8789
T17	4 1/2	4.4723	4.4552	4.4160	4 1/4	2	4.3597	4.4347	4.4066	2 1/8	1	4.3785
T18	5	4.9722	4.9551	4.9159	4 1/4	2	4.8596	4.9343	4.9062	2 1/8	1	4.8781
T19	5 1/2	5.4721	5.4550	5.4158	4 1/4	2	5.3595	5.4340	5.4059	2 1/8	1	5.3778
T20	6	5.9721	5.9550	5.9158	4 1/4	2	5.8595	5.9337	5.9056	2 1/8	1	5.8775

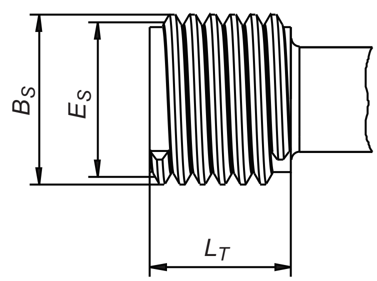
NOTE See Figure 24 for illustration of dimension symbols.

[a] All threads are 8 TPI, pitch = 0.1250 in.



NOTE See Table 19 and Table 20 for dimensions.

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



NOTE See Table 21 and Table 22 for dimensions.

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

Table 21—Box Go and No-go Gauges [a] (for Locknut)
Dimensions in millimeters at 20 °C

Taper Thread Number	Nominal Size	Go Gauges			No-go Gauges		
		Major Diameter B_S	Pitch Diameter E_S	Thread Length L_T	Major Diameter B_S	Pitch Diameter E_S	Thread Length L_T
T1	1	24.768	23.338	25.4	24.275	23.561	15.9
T2	1 1/8	27.943	26.513	25.4	27.455	26.741	15.9
T3	1 1/4	31.118	29.688	31.8	30.635	29.921	19.1
T4	1 3/8	34.293	32.863	31.8	33.813	33.099	19.1
T5	1 1/2	37.468	36.038	31.8	36.993	36.279	19.1
T6	1 5/8	40.643	39.213	31.8	40.173	39.459	22.2
T7	1 3/4	43.818	42.388	31.8	43.350	42.636	22.2
T8	1 7/8	46.993	45.563	31.8	46.530	45.817	22.2
T9	2	50.168	48.738	31.8	49.708	48.994	22.2
T10	2 1/4	56.518	55.088	34.9	56.065	55.352	22.2
T11	2 1/2	62.868	61.438	50.8	62.421	61.707	22.2
T12	2 3/4	69.218	67.788	54.0	68.776	68.062	25.4
T13	3	75.568	74.138	54.0	75.133	74.420	25.4
T14	3 1/4	81.918	80.488	57.2	81.488	80.775	25.4
T15	3 1/2	88.268	86.838	57.2	87.843	87.130	25.4
T16	4	100.968	99.538	57.2	100.554	99.840	25.4
T17	4 1/2	113.668	112.238	57.2	113.261	112.547	25.4
T18	5	126.368	124.938	57.2	125.971	125.258	25.4
T19	5 1/2	139.068	137.638	57.2	138.679	137.965	25.4
T20	6	151.768	150.338	57.2	151.387	150.673	25.4

NOTE See Figure 25 for illustration of dimension symbols.

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

Table 22—-Box Go and No-go Gauges [a] (for Locknut)
Dimensions in inches at 68 °F

Tapered Thread Length	Nominal Size	Go Gauges			No-go Gauges		
		Major Diameter	Pitch Diameter	Thread Length	Major Diameter	Pitch Diameter	Thread Length
		B_S	E_S	L_T	B_S	E_S	L_T
T1	1	0.9751	0.9188	1	0.9557	0.9276	5/8
T2	1 1/8	1.1001	1.0438	1	1.0809	1.0528	5/8
T3	1 1/4	1.2251	1.1688	1 1/4	1.2061	1.1780	3/4
T4	1 3/8	1.3501	1.2938	1 1/4	1.3312	1.3031	3/4
T5	1 1/2	1.4751	1.4188	1 1/4	1.4564	1.4283	3/4
T6	1 5/8	1.6001	1.5438	1 1/4	1.5816	1.5535	7/8
T7	1 3/4	1.7251	1.6688	1 1/4	1.7067	1.6786	7/8
T8	1 7/8	1.8501	1.7938	1 1/4	1.8319	1.8038	7/8
T9	2	1.9751	1.9188	1 1/4	1.9570	1.9289	7/8
T10	2 1/4	2.2251	2.1688	1 3/8	2.2073	2.1792	7/8
T11	2 1/2	2.4751	2.4188	2	2.4575	2.4294	7/8
T12	2 3/4	2.7251	2.6688	2 1/8	2.7077	2.6796	1
T13	3	2.9751	2.9188	2 1/8	2.9580	2.9299	1
T14	3 1/4	3.2251	3.1688	2 1/4	3.2082	3.1801	1
T15	3 1/2	3.4751	3.4188	2 1/4	3.4584	3.4303	1
T16	4	3.9751	3.9188	2 1/4	3.9588	3.9307	1
T17	4 1/2	4.4751	4.4188	2 1/4	4.4591	4.4310	1
T18	5	4.9751	4.9188	2 1/4	4.9595	4.9314	1
T19	5 1/2	5.4751	5.4188	2 1/4	5.4598	5.4317	1
T20	6	5.9751	5.9188	2 1/4	5.9601	5.9320	1

NOTE See Figure 25 for illustration of dimension symbols.

[a] All threads are 8 TPI, pitch = 0.125 0 in.

Table 23—Gauge Thread Height Dimensions
Dimensions in millimeters (inches) at 20 °C (68 °F

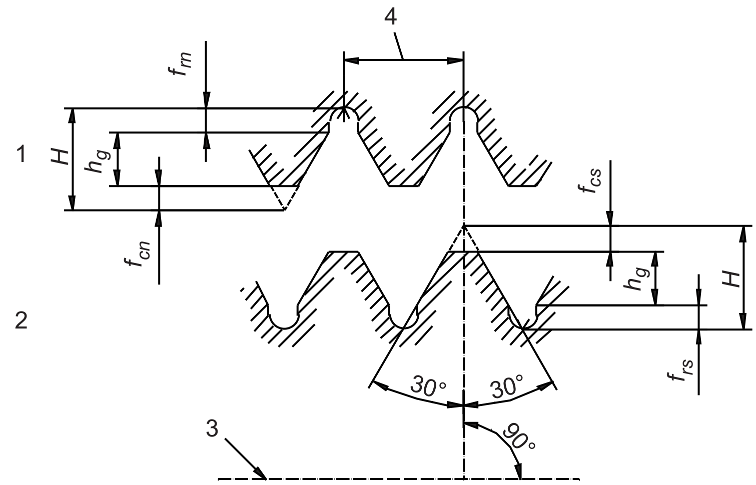
Thread Element	Tapered [a b] Thread Gauges	Straight [c] Thread Gauges
$F_{rn}, f_{cn}, f_{rs}, f_{cs}$	0.658 4 (0.02592)	0.659 9 (0.02598)
h_g	1.426 5 (0.05616)	1.429 8 (0.05629)
H	2.743 2 (0.10800)	2.749 6 (0.10825)

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.).

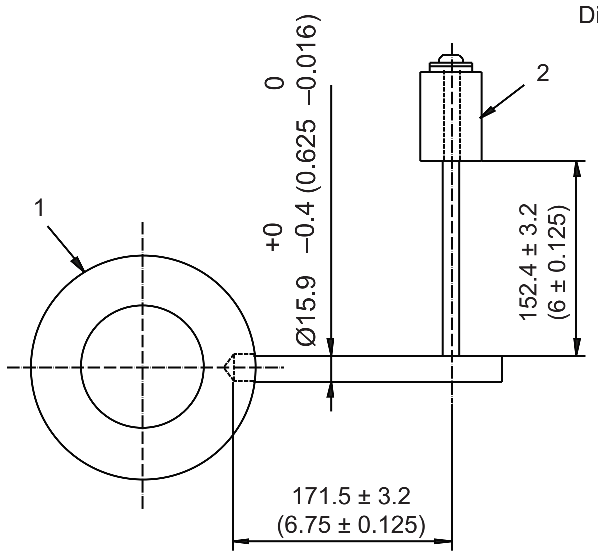


Key
1 internal thread
2 external thread
3 thread axis
4 pitch

NOTE See Table 23 for dimensions.

Figure 26—Gauge Thread Form

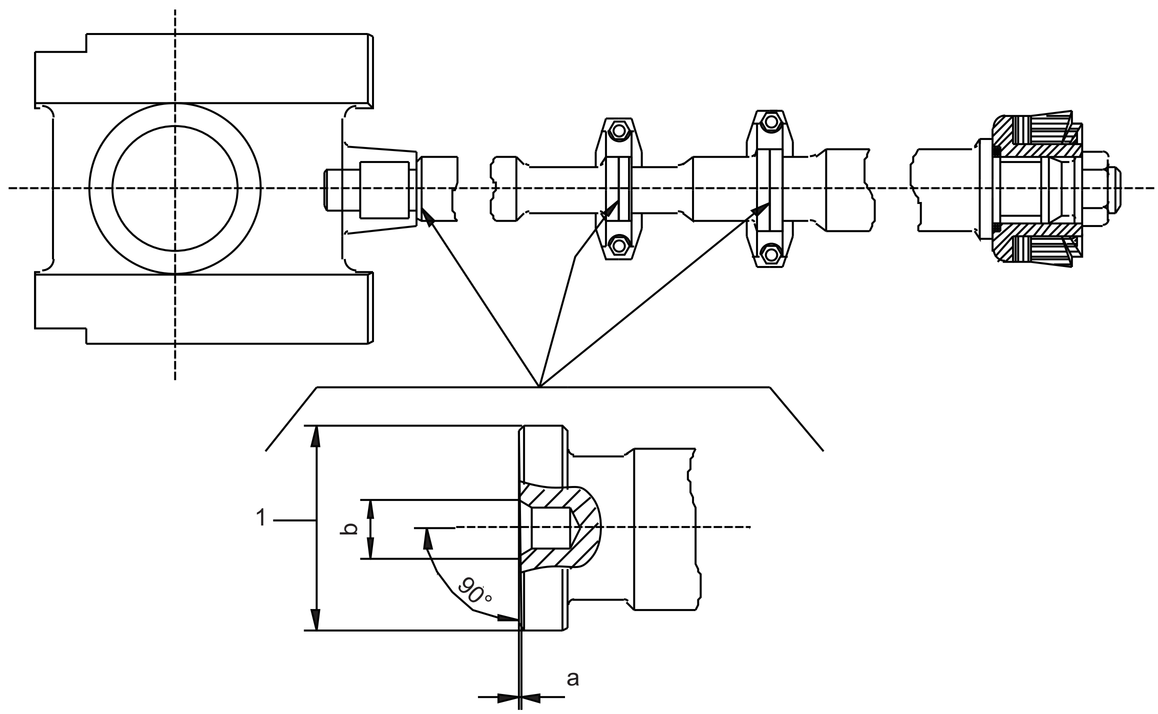
Dimensions in millimeters (inches)



Key
1 gauge
2 weight

Figure 27—Torque Hammer

Dimensions in millimeters (inches)



Key
1 face diameter

[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

9.9 Drawworks Components

9.9.1 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.

9.9.2 Requirements

The requirements of 4.2.7, 5.4, 5.5, 5.6, 6.3.1.1, 8.4.4, 8.4.5, 8.4.7, 8.4.8, and 8.6 shall not apply, except as noted below. For antifriction bearing design and manufacturing requirements, see 9.15.

9.9.3 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.

9.9.4 Brake Bands for Main Drum

9.9.4.1 General

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

9.9.4.2 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.

9.9.4.3 Weldments

9.9.4.3.1 The design load capacity of the weldment shall not be less than the minimum design load capacity of the band only.

9.9.4.3.2 Weldments shall be reviewed for the effect of weld stress concentration as it affects fatigue life of the weldments.

9.9.4.4 Quality Control

9.9.4.4.1 All castings and welds shall be inspected in accordance with 8.4.7.

9.9.4.4.2 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.

9.9.4.4.3 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.

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

9.10 Manual Tongs

9.10.1 Marking

Manual tongs shall be marked in accordance with the requirements of Section 10 and with the rated load.

9.10.2 Size Class Designation

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

9.10.3 Impact Toughness

9.10.3.1 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).

9.10.3.2 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).

9.10.4 Component Traceability

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

9.10.5 Design Verification Load Tests

The design verification load test, as described in Section 5, shall apply except for load-limiting manual tongs, which shall comply with the requirements of Annex E.

9.10.6 Proof Load Testing

Proof load testing, as described in 8.6, shall apply except for load limiting manual tongs. Load-limiting manual tongs shall be proof tested in accordance with Annex E.4. Jaw hinge pins of wrought material shall be exempt from this requirement.

9.10.7 Load-limiting Manual Tongs

Load-limiting manual tongs shall be designed and design verification load tested in accordance with Annex E.

9.11 Safety Clamps Not Used as Hoisting Devices

9.11.1 Load rating of safety clamps is not required.

9.11.2 The requirements of 6.3.1.1, 8.4.4, 8.4.5, 8.4.8, and 8.4.9 shall not apply.

9.11.3 The requirements of 8.4.7 apply to safety clamps except that the method and acceptance criteria of MSS SP-53 shall apply.

9.12 BOP Handling Systems and Equipment

9.12.1 Applicability of the Requirements in Section 1 Through Section 8

9.12.1.1 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 9.12.3, 9.12.4, and 9.12.5.

9.12.1.2 Section 4.2.7 regarding fatigue life shall apply to this equipment, or as specified by the manufacturer in accordance with 9.12.8.

9.12.1.3 Section 4.4.1 covering rotary tables, spiders, and manual tongs shall not apply to this equipment.

9.12.1.4 Section 4.4.3 covering torque ratings for manual tongs shall not apply to this equipment.

9.12.1.5 Production proof load testing as required in 8.6, and as further specified in 9.12.6, shall be required unless it is waived by the purchaser in the purchase agreement.

9.12.2 Requirements for Purchaser-defined Information and Specifications in Purchase Agreements for BOP Handling Systems

9.12.2.1 General

The requirements in 9.12.2.2 and 9.12.2.3 shall be specified by the purchaser in purchase agreements issued for BOP handling systems covered by this standard.

9.12.2.2 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 power (e.g. electrical, pneumatic, and hydraulic) is restored after interruption. The controls shall be designed to prevent unexpected movement regardless of whether one source or multiple sources of power are interrupted and subsequently restored.

9.12.2.3 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.

9.12.2.4 Other Systems Interface Requirements

9.12.2.4.1 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.

9.12.2.4.2 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.

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

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

9.12.2.4.5 The purchaser shall specify whether a production proof load test in accordance with 8.6 and 9.12.6 shall be performed by the manufacturer prior to delivery.

9.12.2.5 Loading Conditions

9.12.2.5.1 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.

9.12.2.5.2 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.

9.12.3 Subsystem Design Requirements

9.12.3.1 General

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

9.12.3.2 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. Hydraulic 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.

9.12.3.3 Wire Rope

For wire rope components other than slings covered by 9.12.3.4, the working load limit shall be based on a wire rope design factor of five. 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 published manufacturer's data. For any type of termination, the equation for determining the working load limit is:

$$WLL = \frac{MBF \times Eff}{DF} \tag{11}$$

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 %.

9.12.3.4 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.

9.12.3.5 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.

9.12.3.6 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.

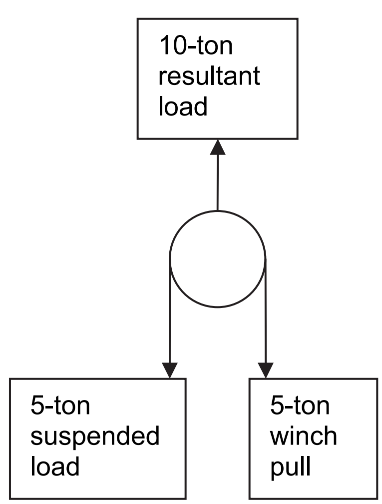


Figure 29—Illustration of the Resultant Load on a Single Sheave Block

9.12.3.7 Hydraulic Hoses

9.12.3.7.1 The use of hydraulic hoses shall be kept to an absolute minimum required to compensate for vibration, thermal expansion and contraction, misalignment, or relative movement required between the hydraulic hose end terminations.

9.12.3.7.2 Hydraulic hoses shall meet the requirements of SAE J 517, and shall have a working pressure equal to or exceeding the piping system into which they are installed. The minimum burst pressure of hydraulic hoses shall be a minimum of four times the working pressure of the hose, as specified by the hydraulic hose manufacturer.

9.12.3.7.3 Only hydraulically crimped type hydraulic hose end fittings shall be used. Swivel-type end fittings that are widely available are recommended to be installed at each end of the hydraulic hose to prevent hose twisting during installation and removal. No galvanized end fittings shall be used and no PTFE tape shall be applied to any pressure sealing threaded connections, such as national pipe thread (NPT) threads.

9.12.3.7.4 Raw hose body material used to fabricate hydraulic hose assemblies shall not be older than five years from the date of manufacture and shall be suitable and compatible with the media being conveyed.

9.12.3.7.5 The outer cover of the hydraulic hose body of all hydraulic hose assemblies shall not be painted.

9.12.3.7.6 All hydraulic hose assemblies shall be internally cleaned after pressure testing to ensure that any contamination inside the hydraulic hose assembly will not adversely affect system operation. Hydraulic hose assemblies shall be capped and sealed after pressure testing and cleaning.

9.12.3.7.7 When installing hydraulic hose assemblies, they shall be routed and secured in such a manner that will avoid kinking or bends in the hydraulic hose body that are less than the published minimum bending radius. Additional protection shall be provided to the outer cover of the hydraulic hose in way of contact with surfaces subject to vibration.

9.12.3.7.8 Each hydraulic hose assembly shall be pressure tested to a minimum of 1.5 times the working pressure of the hydraulic hose body prior to cleaning. Water should be used as the pressure testing media.

9.12.3.7.9 A list of all hydraulic hose assemblies utilized in the system shall be provided in an attachment to the system parts manual, which shall specify as a minimum, the hydraulic hose manufacturer and part number, type, size, and part number of the end fittings, overall length, and the working pressure of the hydraulic hose assembly.

9.12.3.8 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 9.12.4 to determine the design load. A DSF shall then be applied in accordance with 9.12.5.

9.12.3.9 Attachments to Rig Structure

The manufacturer shall provide maximum load values, load/force vectors, and load concentrations for each 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.

9.12.3.10 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.

9.12.3.11 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 9.12.4 and the application of a DSF in accordance with the requirements of 9.12.5.

9.12.3.12 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 that 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.

9.12.3.13 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.

9.12.3.14 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.

9.12.3.15 Wire Rope Hoist Features

Wire rope hoists shall incorporate a brake and/or load holding device as described in 9.12.3.21. Level-wind devices shall be considered when fleet angles exceed those specified in the DNV *Rules for Certification of Lifting Appliances*.

9.12.3.16 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.

9.12.3.17 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 9.12.8. 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.

9.12.3.18 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.

9.12.3.19 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.

9.12.3.20 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.

9.12.3.21 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 9.12.3.22 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.

9.12.3.21.2 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 counter-balance 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. Hydraulic hoses shall not be installed between the cylinder(s) and the counter-balance or load-holding valves and pressure-relieving devices described above.

9.12.3.21.3 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.

9.12.3.22 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.

9.12.3.23 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.

9.12.4 Determination of Design or Rated Load

9.12.4.1 The design or rated load as defined in Section 3 shall be determined by multiplying the static load by the dynamic factor, which is determined with information provided by the purchaser. If such information is not available from the purchaser, the default dynamic factors specified in Table 24 shall be used.

9.12.4.2 In the case where the manufacturer elects to design and manufacture one or more systems on speculation without purchaser-provided information specified in 9.12.2, the default dynamic factors specified in Table 24 shall apply. This requirement shall also apply whenever the information provided by the purchaser for a specific application is inadequate to determine applicable and appropriate dynamic factors.

Table 24—Default Dynamic Factors

BOP Handling System Mounted On	Default Dynamic Factors
Fixed structure	1.33
Tension leg platform (TLP) or spar	$1.33 + 0.003 \times H_{sig} > 1.4$ (for H_{sig} in feet) $1.33 + 0.00984 \times H_{sig} > 1.4$ (for H_{sig} in meters)
Semisubmersible MODU	$1.33 + 0.007 \times H_{sig} > 1.4$ (for H_{sig} in feet) $1.33 + 0.02297 \times H_{sig} > 1.4$ (for H_{sig} in meters)
Drillship MODU or floating production storage and offloading (FPSO)	$1.33 + 0.012 \times H_{sig} > 1.4$ (for H_{sig} in feet) $1.33 + 0.03937 \times H_{sig} > 1.4$ (for H_{sig} in meters)
NOTE 1 H_{sig} 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.	

9.12.4.3 Apply an additional design factor to accommodate side loading as specified in 9.12.3.18 if it is in addition to the dynamic factors specified in Table 24, depending on the specific application.

9.12.4.4 Apply an additional design factor to accommodate dynamic forces induced by system operation as specified in 9.12.3.19 if it is in addition to the dynamic factors specified in Table 24, depending on the specific application.

9.12.4.5 Apply an additional design factor to accommodate loss of material due to wear or corrosion as specified in 9.12.3.17.

9.12.4.6 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 24 that would increase the stress in any part of the BOP handling system beyond the maximum allowable stress.

9.12.5 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.

9.12.6 Production Testing Requirements

9.12.6.1 A production 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.

9.12.6.2 A specific test of the fail-safe load-holding device specified in 9.12.3.21 shall be performed during production testing at the full rated load prior to delivery of the system.

9.12.6.3 Function testing of the fail-safe load-limiting device specified in 9.12.3.22 shall be performed prior to delivery of the system.

9.12.7 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 and fatigue failure modes. Such analyses shall also be used to determine control system functionality, displays, detents, interlocks, defaults, overrides, fail-safe shutdown triggers, and other similar types of features.

9.12.8 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.

9.12.9 Marking

BOP handling systems shall be marked in accordance with the requirements of Section 10 and with the rated load of the system, expressed in USC or SI units, on one or more conspicuous locations on the system.

9.12.10 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.

9.12.11 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 9.12.2 shall be included, as well as all other information specified in this standard.

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

9.13.1 Scope

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

9.13.2 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).

9.13.3 Design

9.13.3.1 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. Maximum operating pressure shall be determined by the methods described in ASME *BPVC*, Section VIII, Division 2, and/or API 6A.

9.13.3.2 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.

9.13.3.3 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 9.13.3.2.

9.13.3.4 Primary Design Function

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

9.13.3.5 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 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.

9.13.3.6 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.

9.13.3.7 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.

9.13.4 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.

9.13.5 Prototype Testing

9.13.5.1 The relief shall be subjected to the production tests.

9.13.5.2 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 5 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.

9.13.5.3 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.

9.13.6 Production Test

9.13.6.1 All pressure containing sections of the valve shall be hydrostatically pressure tested at 150 % of the rated pressure for the section being tested.

9.13.6.2 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.

9.13.7 Marking

Pressure-relief devices shall be marked in accordance with the requirements of Section 10 and the following on a corrosion resistant nameplate or plates:

a) model designation;

b) serial number, if applicable;

c) maximum pressure rating; and

d) marking related to intermediate pressure settings, i.e. spring settings; location; and/or marking of rupture discs, shear pins, or collapsing posts.

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.

9.13.8 Records

In addition to the records required by this specification the manufacturer shall maintain the following records:

a) prototype pressure and flow testing records; and

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.

9.14 Snub Lines for Manual and Power Tongs

9.14.1 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.

9.14.2 Marking

Snub lines shall be marked in accordance with the requirements of Section 10 and the following:

a) unique serial or identification number; and

b) the rated load.

The snub line shall be tagged and clearly marked “For Use as a Tong Snub Line ONLY.”

9.14.3 Style

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

9.14.4 Length

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

9.14.5 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.

9.14.6 Design Factor

The design factor for snub lines shall be equal to or greater than 3.0.

9.14.7 Rated Load

The rated load is calculated by the following equation:

$$RL = \frac{MBF \times Eff}{DF} \tag{12}$$

where

RL is the rated load;

MBF is the minimum breaking force of rope used;

DF is the design factor (equal to or greater than 3.0);

Eff_{min} 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.

9.14.8 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.

9.14.9 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.

9.15 Antifriction Bearings

Antifriction bearings used as primary load path components shall be designed and manufactured in accordance with a recognized bearing industry code or standard. 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:

   1) weld PQRs,

   2) welder qualification records,

3) NDE personnel qualification records,

4) measuring and test equipment calibration records.

e) Inspection and test records traceable to the equipment or components, including:

1) material test reports covering the following tests, as applicable: chemical analysis, tensile tests, impact tests, and hardness tests;

2) NDE records covering the surface and/or volumetric NDE requirements of Section 8;

3) performance test records, including proof load testing records, hydrostatic pressure testing records, and functional testing records;

4) 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:

1) assembly drawings;

2) list of components;

3) nominal capacities and ratings;

4) operating procedures;

5) wear limits;

6) recommended frequency of field inspection and preventive maintenance, methods, and acceptance criteria;

7) itemized spare parts (not applicable to single component equipment) and recommended stock levels.

A comprehensive data book can be specified by the purchaser by calling out supplementary requirement SR3 (see Annex A) in the purchase order.

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.

The equipment shall be marked “SR1” by means of low-stress hard-die stamping near the load rating identification.

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 (Metallic Components Only)

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 6.3.1.1 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 (Metallic Components Only)

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 6.3.1.1 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 SR2B—Additional Low-temperature Testing (Non-metallic Components Only)

The maximum 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. Testing shall be performed in accordance with the test requirements of 6.4.6.

Each covered primary load-carrying component shall be marked “SR2B” 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.6 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:

a) statement of compliance;

b) equipment designation/serial number;

c) assembly and critical area drawings;

d) wear limits and nominal capacities and ratings;

e) list of components;

f) traceability codes and systems (marking on parts/records on file);

g) steel grades;

h) heat-treatment records;

i) material test reports;

j) NDE records;

k) performance test records, including functional hydrostatic and load test certificates (when applicable);

l) certificates for supplementary requirements, as required;

m) welding procedure specifications (WPSs) and qualification records.

A.7 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.8 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 that 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 (±25 °F) from the furnace set-point temperature after the furnace working zone has been brought up to temperature. Furnaces used for tempering, aging, and/or PWHT shall not vary by more than ±14 °C (±25 °F) from the furnace set-point temperature after the furnace working zone has been brought up to temperature.

B.2 Furnace Calibration

B.2.1 General

Heat 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 two 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 m^3 (10 ft^3). 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 m^3 (125 ft^3) 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 m^3 (10 ft^3), the temperature survey may be made with a minimum of three thermocouples located at the front, center, and rear or at the top, center, and bottom of the furnace working zone.

e) After insertion of the temperature-sensing devices, readings shall be taken at least once every three minutes to determine when the temperature of the furnace working zone approaches the bottom of the temperature range being surveyed.

f) Once the furnace 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 set-point temperature by more than 14 °C (25 °F).

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

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

B.2.4 Continuous-type Furnace Method

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

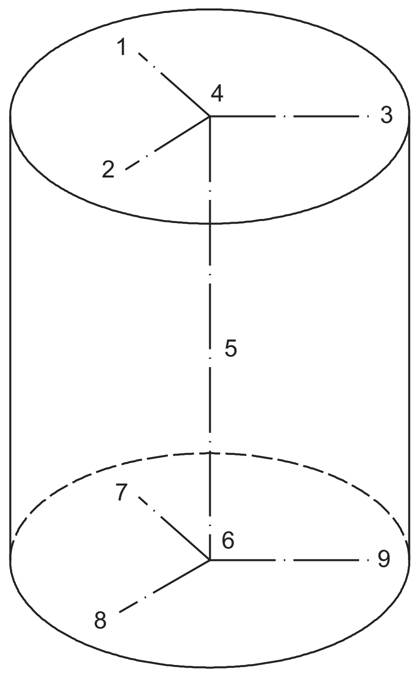


Figure B.1—Thermocouple Location in Cylindrical Furnaces

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 temperature-recording instruments shall be calibrated at least once every three 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; 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

Part Number	Description
101	Frame
102	Crankshaft
103	Main gear
104	Pinion
105	Pinion shaft
106	Connecting rod [a]
107	Crosshead [a]
108	Crosshead pin [a]
109	Connecting rod bearing [a]
110	Crankshaft bearing (main) [a]
111	Crankshaft bearing housing [a]
112	Pinion shaft bearing [a]
113	Crosshead pin bearing [a]
114	Crosshead extension rod (pony) [a]
115	Crosshead extension rod wiper [a]

[a] Exact location of these parts designated as right or left and center if triplex pump.

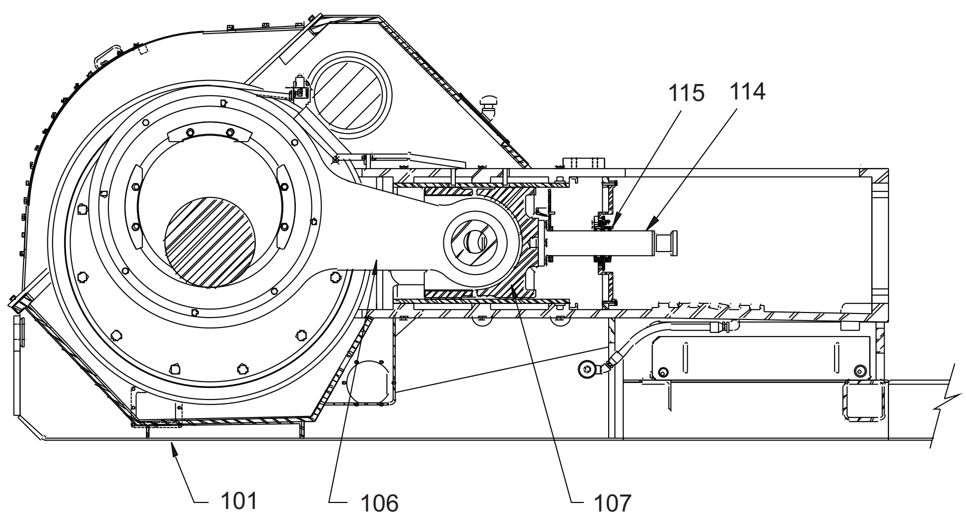


Figure C.1—Section Through Power End (See Table C.1 for Nomenclature)

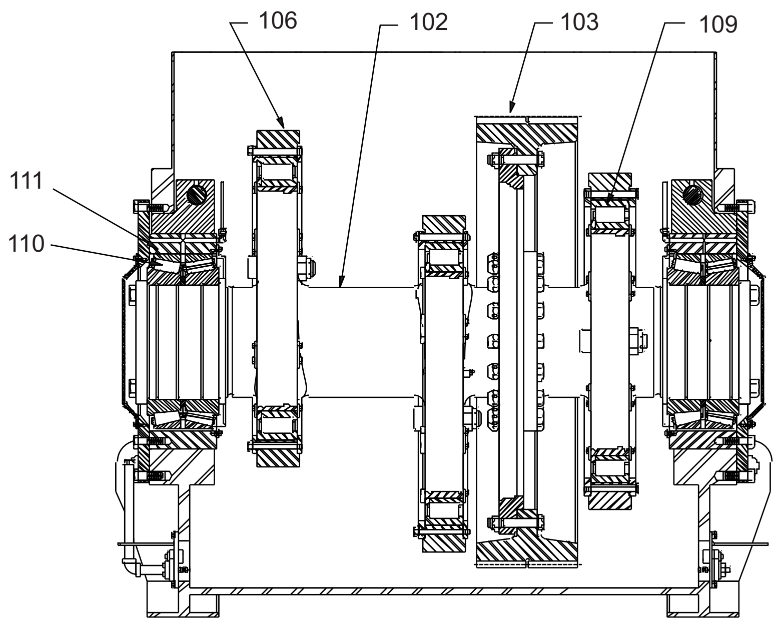


Figure C.2—Section Through Crankshaft (See Table C.1 for Nomenclature)

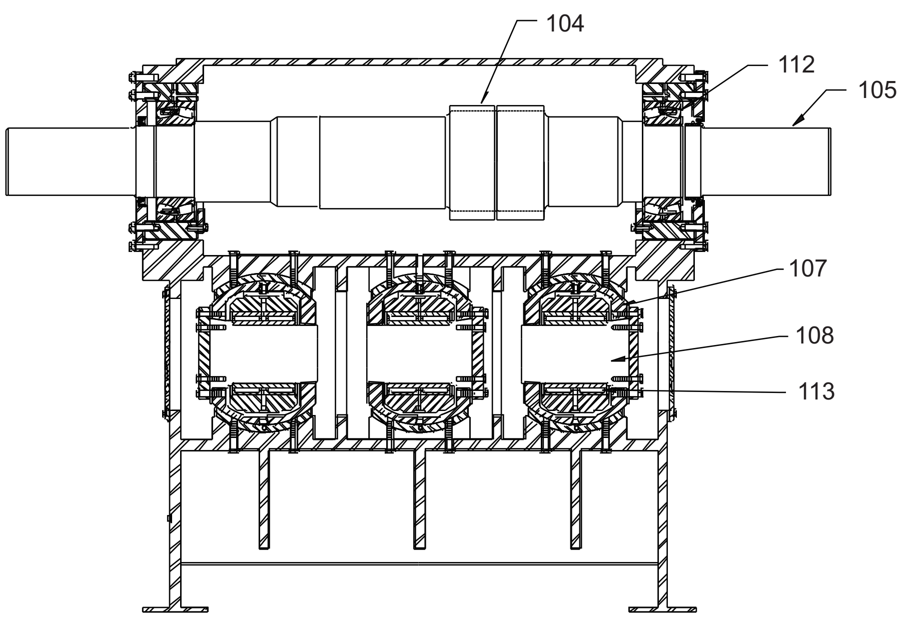


Figure C.3—Section Through Pinion Shaft and Crosshead (See Table C.1 for Nomenclature)

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].

[a] Exact location of these parts designated right or left.

[b] Exact location of these parts designated right or left, or when more convenient, the IADC Drilling Manual numerals may be used.

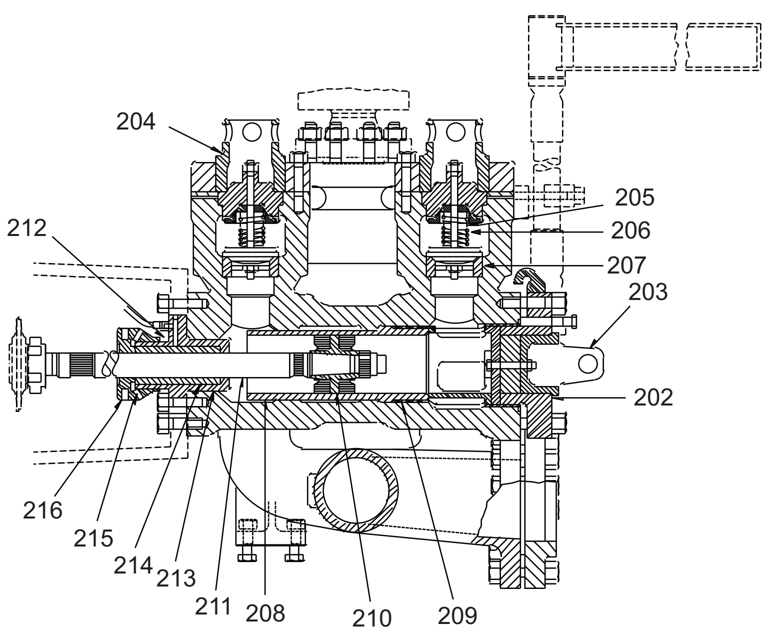


Figure C.4—Fluid End of Duplex Double-acting Mud Pump (See Table C.2 for Nomenclature)

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].

[a] Exact location of these parts designated right or left.

[b] Exact location of these parts designated right or left; or when more convenient, the IADC Drilling Manual numerals may be used.

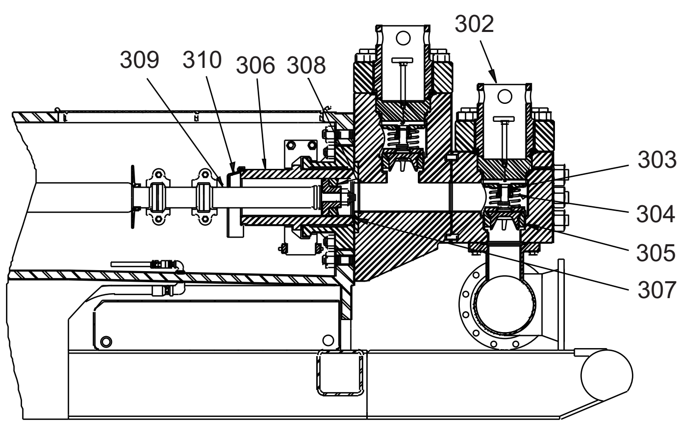


Figure C.5—Fluid End of Triplex Single-acting Mud Pump (See Table D.3 for Nomenclature)

Annex D
(informative)

Use of the API Monogram by Licensees

D.1 Scope

The API Monogram® is a registered certification mark owned by the American Petroleum Institute (API) and authorized for licensing by the API Board of Directors. Through the API Monogram Program, API licenses product manufacturers to apply the API Monogram to new products which comply with product specifications and have been manufactured under a quality management system that meets the requirements of API Q1. API maintains a complete, searchable list of all Monogram licensees on the API Composite List website (www.api.org/compositelist).

The application of the API Monogram and license number on products constitutes a representation and warranty by the licensee to API and to purchasers of the products that, as of the date indicated, the products were manufactured under a quality management system conforming to the requirements of API Q1 and that the product conforms in every detail with the applicable standard(s) or product specification(s). API Monogram program licenses are issued only after an on-site audit has verified that an organization has implemented and continually maintained a quality management system that meets the requirements of API Q1 and that the resulting products satisfy the requirements of the applicable API product specification(s) and/or standard(s). Although any manufacturer may claim that its products meet API product requirements without monogramming them, only manufacturers with a license from API can apply the API Monogram to their products.

Together with the requirements of the API Monogram license agreement, this annex establishes the requirements for those organizations who wish to voluntarily obtain an API license to provide API monogrammed products that satisfy the requirements of the applicable API product specification(s) and/or standard(s) and API Monogram Program requirements.

For information on becoming an API Monogram Licensee, please contact API, Certification Programs, 1220 L Street, NW, Washington, DC 20005 or call 202-682-8145 or by email at certification@api.org.

D.2 Normative References

API Specification Q1, *Specification for Quality Management System Requirements for Product Manufacturing for the Petroleum and Natural Gas Industry*

D.3 Terms and Definitions

For purposes of this annex, the following terms and definitions apply:

D.3.1
API monogrammable product
Product that has been newly manufactured by an API licensee utilizing a fully implemented API Q1 compliant quality management system and that meets all the API specified requirements of the applicable API product specification(s) and/or standard(s).

D.3.2
API specified requirements
Requirements, including performance and licensee-specified requirements, set forth in API Q1 and the applicable API product specification(s) and or standard(s).

NOTE Licensee-specified requirements include those activities necessary to satisfy API specified requirements.

D.3.3
API product specification
Prescribed set of rules, conditions, or requirements attributed to a specified product that address the definition of terms; classification of components; delineation of procedures; specified dimensions; manufacturing criteria; material requirements, performance testing, design of activities; and the measurement of quality and quantity with respect to materials, products, processes, services, and/or practices.

D.3.4
licensee
Organization that has successfully completed the application and audit process and has been issued a license by API.

D.3.5
design package
Records and documents required to provide evidence that the applicable product has been designed in accordance with API Q1 and the requirements of the applicable product specification(s) and/or standard(s).

D.4 Quality Management System Requirements

An organization applying the API Monogram to products shall develop, maintain, and operate at all times a quality management system conforming to API Q1.

D.5 Control of the Application and Removal of the API Monogram

Each licensee shall control the application and removal of the API Monogram in accordance with the following.

a) Products that do not conform to API specified requirements shall not bear the API Monogram.

b) Each licensee shall develop and maintain an API Monogram marking procedure that documents the marking/monogramming requirements specified by this annex and any applicable API product specification(s) and/or standard(s). The marking procedure shall:

   1) define the authority responsible for application and removal of the API Monogram;

   2) define the method(s) used to apply the Monogram;

   3) identify the location on the product where the API Monogram is to be applied;

   4) require the application of the licensee's license number and date of manufacture of the product in conjunction with the use of the API Monogram;

   5) require that the date of manufacture, at a minimum, be two digits representing the month and two digits representing the year (e.g. 05-12 for May 2012) unless otherwise stipulated in the applicable API product specification(s) or standard(s); and

   6) require application of the additional API product specification(s) and/or standard(s) marking requirements.

c) Only an API licensee may apply the API Monogram and its designated license number to API monogrammable products.

d) The API Monogram license, when issued, is site-specific and subsequently the API Monogram shall only be applied at that site specific licensed facility location.

e) 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 out of conformance with any of the requirements of the applicable API product specification(s) and/or standard(s) and API Monogram Program.

For certain manufacturing processes or types of products, alternative API Monogram marking procedures may be acceptable. Requirements for alternative API Monogram marking are detailed in the API Policy, API Monogram Program Alternative Marking of Products License Agreement, available on the API Monogram Program website at http://www.api.org/alternative-marking.

D.6 Design Package Requirements

Each licensee and/or applicant for licensing must maintain a current design package for all of the applicable products that fall under the scope of each Monogram license. The design package information must provide objective evidence that the product design meets the requirements of the applicable and most current API product specification(s). The design package(s) must be made available during API audits of the facility.

In specific instances, the exclusion of design activities is allowed under the Monogram Program, as detailed in Advisory #6, available on API Monogram Program website at http://www.api.org/advisories.

D.7 Manufacturing Capability

The API Monogram Program is designed to identify facilities that have demonstrated the ability to manufacture equipment that conforms to API specifications and/or standards. API may refuse initial licensing or suspend current licensing based on a facility's level of manufacturing capability. If API determines that additional review is warranted, API may perform additional audits (at the organization's expense) of any subcontractors to ensure their compliance with the requirements of the applicable API product specification(s) and/or standard(s).

D.8 API Monogram Program: Nonconformance Reporting

API solicits information on products that are 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. Customers are requested to report to API all problems with API monogrammed products. A nonconformance may be reported using the API Nonconformance Reporting System available at http://compositelist.api.org/ncr.asp.

Annex E
(normative)

Load-limiting Design of Manual Tongs

E.1 Purpose

E.1.1 General

The purpose of this annex is to provide standards for certifying a design as load limiting. A load-limiting design is one that in the event of an overload, the primary load will be either prevented from increasing or released in a controlled manner without unlatching and with no fragments expelled. Clauses 4.2.4, 4.2.5, 4.6, 5.4, 5.5, and 5.6 regarding the design and design verification testing of manual tongs does not apply to load-limiting manual tongs designed, qualified, and tested in accordance with this annex.

Load-limiting designs may be accomplished by the use of materials, components, or mechanisms to release or limit the primary load in an overload condition. The limiting component shall be an integral part of the equipment, impossible to be removed, bypassed, or adjusted in the field.

E.1.2 Equipment Covered

This annex applies to the design, manufacture, and testing of load-limiting manual tongs.

E.2 Design

E.2.1 Average Limit Load

The average limit load shall be determined by testing the limiting component. A minimum sample size of 50 tests of the same size and type of component shall be used. The primary load to the equipment required to cause a limit of the load shall be measured or calculated using the mechanical relationship of the measured load to the primary load. The average limit load shall be documented in terms of the output.

Testing shall be performed at the worst case(s) of temperature and rate of loading that may be encountered in service. The worst case being one that increases the limit load or that decreases the buffered strength.

Testing of reduced sized specimens is permitted provided that a minimum of two full-size tests are conducted to verify the relationship between the two sizes of test specimens.

E.2.2 Load Variance

The load variance (γ) of the limit load shall be calculated from the test data used to determine the average limit load. The load variance shall be the greater of the standard deviation (determined from the equation below) or one-seventh ($^1/_7$) of the average limit load:

$$D = \sqrt{\frac{1}{(n-1)}\sum_{i=1}^{n}(L_i - \bar{L})^2}$$

where

L is the load corresponding to each sample in measuring the average limit load;

n is the number of samples

$\bar{L}$ is the average limit load.

E.2.3 Rated Load

The rated load shall be a maximum of the average limit load minus two times the load variance. The rated load is given by the equation:

$$R = \bar{L} - 2\gamma$$

E.2.4 Buffered Load

The buffered load shall be a minimum of the average limit load plus three times the load variance. The buffered load is given by the equation:

$$S = \bar{L} + 3\gamma$$

E.2.5 Design of Buffered Components

All buffered components shall be designed such that the minimum specified material yield strength is equal to or greater than the stresses created by the buffered load.

E.3 Design Verification Load Test

The test procedure is as follows.

An assembled production 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's parts shall not be impaired by this loading.

The equipment shall be mounted in a test fixture capable of loading the equipment in a similar manner as found in typical field use. This may include, but is not limited to, the use of springs to simulate the compliance of the expected field loading equipment.

Strain gauges shall be applied to the unit at all places where high stresses are anticipated in all buffered components, 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.

The design verification test load shall be applied to the unit at a rate expected in field use or, such that the limiting load shall be obtained in a maximum of 10 seconds, whichever is the greater rate of loading.

The unit shall be loaded at the rate determined above until an indication that the load is being limited. The application of the load is then to be stopped manually and held in position for a minimum of five minutes. With the application of the load stopped, the measured load on the test unit may decrease in value indicating a release of stored energy. The test unit shall not unlatch and no components or portions of components shall become separated from the test unit assembly. This test shall be video recorded.

The peak load and the peak stresses computed from the strain gauges shall be recorded. The peak stresses computed shall not be greater than the equivalent stress from the following equation:

$$\sigma_e = \frac{S_y \times F_t}{S}$$

where

S_y is the specified minimum yield strength for the component;

F_t is the peak load recorded in testing;

S is the buffered load from clause E.2.4.

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 of the test unit to meet the above requirements or failure in a buffered component shall be cause for complete reassessment of the design, followed by additional testing of an identical number of production units as originally required, including a unit of the same load rating as the one that failed.

Upon completion of the design verification load test, the test unit shall be disassembled and the dimensions of all buffered load-carrying components shall be checked for evidence of permanent deformation. Evidence of permanent deformation shall be compared to expected results in the design analysis. Any permanent deformation shall not affect the serviceability of the components.

E.4 Proof Load Testing

The test procedure is as follows.

Each production unit or primary load-carrying component shall be load tested in accordance with the requirements of this section.

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 unless design verification testing indicates that the contact area is not the location of maximum stress and that the stresses produced by the alternate loading are not less than the maximum stresses expected from the design analysis and the design verification testing.

A test load equal to 1.5 times rated load shall be applied to all buffered components and held for a period of not less than five minutes. Production load-limiting components are to be tested at a load equal to the rated load and held for a period of not less than five minutes.

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

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

All critical areas of the primary load-bearing parts shall be subjected to magnetic particle examination in conformance with 8.4.7.1 with the exception of bearings and nonmetallic components. Nonmetallic components shall be visually inspected for cracks, delamination, or other physical damage.

E.5 Quality Control of Limiting Components

Limiting components are to be controlled for a load equal to the average limit load plus one or minus two standard deviations.

NOTE Nonconformance of the limiting component to control within the minimum and maximum loads will necessitate corrective action so that loss of load limiting and an undesirable failure mode will not occur.

E.6 Product Marking

Load-limiting manual tongs shall be marked with the manufacturer's name or mark, rated load, and API 7K-LL.

Annex F
(informative)

Information with Inquiry or Order

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

a) API Monogram required (Yes or No);

b) reference to this international standard;

c) reference to any requirement for third-party certification, name of the third-party agency, and, if applicable, the level of certification;

d) reference to Annex A for optional supplemental requirements (SR) for proof load testing, low-temperature impact testing, data book requirements, and additional volumetric examinations.

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

a) Rotary Table:

   1) rotary opening size;

   2) configuration of the pinion shaft extension. The dimensions may be chosen from Table 6 and Figure 6, or in accordance with another configuration;

   3) nominal distance between the center of the rotary table and the center of the first row of sprocket teeth (see Figure 7);

   4) model number (if available);

   5) load rating;

   6) torque requirement;

   7) horsepower of input drive;

   8) if applicable, specify type of drive for the kelly bushing (see Figures 8 and 9);

   9) minimum operating temperature if that temperature is below 32 °F (0 °C).

b) Master Bushing and Bushing Adapters:

   1) internal taper of the bushings and the sizes to achieve the final desired size;

   2) make, model, and size of the rotary table in which the master bushing or bushing adapter will be used;

   3) interface requirements for OD and ID;

   4) type of bushing (hinged, split, or solid).

c) Rotary Slips:

1) taper and style/model of the slips;

2) load rating, if applicable;

3) size(s) and configuration(s) of the tubular to be handled.

d) Rotary Hose—High-pressure Mud and Cement Hoses:

1) type (cement hose, rotary hose, jumper hose or vibrator hose);

NOTE If application is unusual or different from the listed ones, then give details. For vibrator and jumper hoses, a configuration analysis is recommended in order to avoid over bending or over stressing a hose in its application or layout.

2) internal diameter and working pressure rating;

3) length of the hose assembly. The length of vibrator or jumper hoses assemblies should account for the change in length when pressurized (see 9.7.5). Rotary hose assembly lengths should be calculated according to API 7L, Annex A, Section A.1;

4) minimum bend radius required;

5) mud type and flow rate (oil based, high aniline, abrasive);

6) minimum operating temperature if that temperature is below –4 °F (–20 °C);

7) operating temperature range (I, II, III) described in 9.7.3.1;

8) Flexible Specification Level: FSL 0 (cement hoses only), FSL 1 (rotary, vibrator and jumper hoses only), FSL 2 (rotary, vibrator and jumper hoses only) described in 9.7.3.2;

9) End connectors for the hose:

— type (hub, flange, hammer union female sub, hammer union male sub/nut, API LPT);

— nominal size;

— working pressure;

— seal ring number, if applicable;

— groove: standard or stainless steel overlay (for sour service).

10) Safety clamp requirement (none, chain type, or cable);

11) safety clamp sling length, if required;

12) special lifting equipment, if required;

13) define type of external protection or armoring, if required.

e) Piston Mud-pump Components:

1) make and model of mud pump (include serial number, if applicable);

2) pressure rating.

f) Pressure-relieving Devices for Mud-pumps:

1) rated working pressure of relief device assembly;

2) maximum required relief pressure;

3) minimum required relief pressure (if applicable);

4) nominal size of inlet and outlet connections;

5) type of inlet and outlet connection:

— line pipe threaded per API 5B (not for use with pressures greater than 5000 psi or sizes larger than 2 in.);

— flanged or studded in accordance with API 6A;

— clamp hub connectors in accordance with API 16A;

— other end connector in accordance with API 6A.

6) type: manual reset type, part replacement type or automatic reset type;

7) flow capabilities at reduced pressure drops across valve to be furnished (only if specified by purchaser).

g) Drawworks Components:

— make and model of drawworks (include serial number, if applicable).

h) Spiders, Both Manual and Powered:

1) load rating;

2) size(s) and configuration(s) of tubular to be handled;

3) internal taper of the spider, bushings, and the sizes to achieve the final desired size;

4) actuation: hydraulic, air, or manual;

5) rotary table interface (for flush-mounted spiders).

i) BOP Handling Systems and Equipment:

1) optional waiver of production proof load testing;

2) Requirements from 9.12.2;

3) dynamic factor appropriate to the system installation;

4) requirements for use in hazardous areas or zones to apply to electrical power and control system components;

5) model number (if available);

6) load rating;

7) system type.

j) Manual Tongs:

1) torque rating;

2) diameter size or range of sizes.

k) Snub Lines:

1) eye size and type for mechanically spliced Flemish or turn-back eye end(s) (as required by local regulatory standards);

2) plain end, mechanically spliced Flemish, or turn-back eye on one end of the snub line;

3) length of the snub line.

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[16] Department of Defense, 1400 Defense Pentagon, Washington DC 20301-1400, www.defenselink.mil.
[17] Fédération Européenne de la Manutention, 39-41, rue Louis Blanc, 92400 Courbevoie, 92038 Paris, La Défense Cedex, France, www.fem-eur.com.
[18] International Association of Drilling Contractors, P.O. Box 4287, Houston, Texas 77210, www.iadc.org.
[19] Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, Pennsylvania 15096-0001, www.sae.org.

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