Rotary Drill Stem Elements

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Rotary Drill Stem Elements

1 Scope

This standard specifies the technical delivery conditions for rotary drill stem elements: upper and lower kelly valves, square and hexagonal kellys, drill stem subs, drill collars (steel and non-magnetic, round, and spiral), heavy-weight drill pipe (HWDP), drilling and coring bit connections, and stabilizers.

This standard is not applicable to drill pipe and tool joints, rotary shouldered connection designs, thread gauging practices, or grand master, reference master and working gauges, and does not include or identify performance properties. A typical drill stem assembly applicable to this standard is provided (see 4.1, Figure 1).

2 Normative References

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

API Recommended Practice 7G, *Drill Stem Design and Operating Limits*

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

ASME *Boiler and Pressure Vessel Code (BPVC), Section IX, Welding, Brazing, and Fusing Qualifications*

ASNT SNT-TC-1A, *Personnel Qualification and Certification in Non-Destructive Testing*

ASTM A262, *Standard Practices for Detecting Susceptibility to Intergranular Attack in Austenitic Stainless Steels*

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

ASTM A434, *Standard Specification for Steel Bars, Alloy, Hot-Wrought or Cold-Finished, Quenched and Tempered*

ASTM E10, *Standard Test Method for Brinell Hardness of Metallic Materials*

ASTM E18, *Standard Test Methods for Rockwell Hardness of Metallic Materials*

ASTM E23, *Standard Test Methods for Notched Bar Impact Testing of Metallic Materials*

ASTM E213, *Standard Practice for Ultrasonic Examination of Metal Pipe and Tubing*

ASTM E309, *Standard Practice for Eddy-Current Examination of Steel Tubular Products Using Magnetic Saturation*

ASTM E1209, *Standard Test Method for Fluorescent Liquid Penetrant Examination Using the Water-Washable Process*

ASTM E1219, *Standard Test Method for Fluorescent Liquid Penetrant Examination Using the Solvent-Removable Process*

ASTM E1220, *Standard Test Method for Visible Penetrant Examination Using the Solvent-Removable Process*

ASTM E1418, *Standard Test Method for Visible Penetrant Examination Using the Water-Washable Process*

ASTM E3024, *Standard Practice for Magnetic Particle Testing for General Industry*

ISO 6892, *Metallic materials — Tensile testing*

ISO 10893-5, *Non-destructive testing of steel tubes — Part 5: Magnetic particle inspection of seamless and welded ferromagnetic steel tubes for the detection of surface imperfections*

ISO 11484, *Steel tubes for pressure purposes — Qualification and certification of non-destructive (NDT) personnel*

NACE MR0175/*ISO 15156, Petroleum and natural gas industries—Materials for use in* H_2S*-containing environments in oil and gas production*

SAE AMS H-6875, *Heat Treatment of Steel Raw Materials*

3 Terms, Definitions, Abbreviations, and Symbols

3.1 Terms and Definitions

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

3.1.1
A-scan display
The ultrasonic instrument display in which the received signal is displayed as a vertical height or "pip" from the horizontal-sweep time trace, while the horizontal distance between two signals represents the material distance for time of travel between the two conditions causing the signals.

3.1.2
amplitude
The vertical height of the A-scan received signal, measured from base to peak or peak to peak.

3.1.3
back reflection
The signal received from the back surface of a surface test object.

3.1.4
bending strength ratio
BSR
The ratio of the section modulus of a rotary shouldered box at the point in the box where the pin ends, when made up, to the section modulus of the rotary shouldered pin at the last engaged thread.

3.1.5
bevel diameter
The outer diameter of the sealing shoulder of a rotary shouldered connection.

3.1.6
bit sub
A sub, usually with two box connections, that is used to connect the bit to the drill stem.

3.1.7
blade
An enlarged region of stabilizer intended to contact the walls of the borehole.

3.1.8
box connection
A threaded connection on oilfield country tubular goods (OCTG) that has internal (female) threads.

3.1.9
calibration system
The documented system of gauge calibration and control.

3.1.10
cold working
The plastic deformation of the thread roots of a rotary shouldered connection, of radii, and of cylindrical sections at a temperature low enough to ensure or cause permanent strain of the metal.

3.1.11
core
The continuous member of a welded-blade stabilizer.

3.1.12
crown length
The axial extent of full-blade diameter except when blades have water-melon profile.

3.1.13
decarburization
The loss of carbon from the surface of a ferrous alloy as a result of heating in a medium that reacts with the carbon at the surface.

3.1.14
defect
An imperfection of sufficient magnitude to warrant rejection of the product based on criteria defined in this standard.

3.1.15
depth prove-up
The act of grinding a narrow notch across a surface-breaking indication until the bottom of the indication is located and then measuring the depth of the indication with a depth gauge for comparison to acceptance criteria.

3.1.16
drift
A gauge used to check minimum internal diameter of drill stem components.

3.1.17
drill collar
Thick-walled pipe used to provide stiffness and concentration of mass at or near the bit.

3.1.18
drill pipe
A length of tube, usually steel, to which special threaded connections called tool joints are attached.

3.1.19
forge (verb)
To make or shape a metal by heating and then hammering it into desired shaped by use of compressive force.

NOTE Dies may be used to attain the final desired shape.

3.1.20
forging (noun)
The “product” shaped metal part formed by the forging method.

3.1.21
full-depth thread
The thread in which the thread root lies on the minor cone of an external thread or on the major cone of an internal thread.

3.1.22
gas-tight
A capable of holding gas without leaking under the specified pressure for the specified length of time.

3.1.23
gauge point
The plane perpendicular to the thread axis in API rotary shouldered connections.

NOTE The gauge point is located 15.9 mm (0.625 in.) from the shoulder of the product pin.

3.1.24
gouge
An elongated groove or cavity caused by mechanical removal of metal.

3.1.25
H_2S-trim
All components, except external valve body, meeting the H_2S service requirements of NACE MR0175/ISO 15156.

3.1.26
hard-banding
(hard-facing)
Metalworking process where harder material is applied to a base metal to reduce external wear.

3.1.27
hardness number
The result from a single hardness impression.

3.1.28
heat
(heat of steel)
The metal produced by a single cycle of a batch-melting process.

3.1.29
heat analysis
A chemical analysis representative of a heat as reported by the metal producer.

3.1.30
imperfection
A discontinuity in the product wall or on the product surface that can be detected by an NDE method included in this standard.

3.1.31
indication
Evidence of a discontinuity that requires interpretation to determine its significance.

3.1.32
inspection
The process of measuring, examining, testing, gauging, or otherwise comparing the product with the applicable requirements.

3.1.33
integral-blade stabilizer
A stabilizer manufactured from single piece of material.

3.1.34
kelly
A square or hexagonally shaped steel pipe connecting the swivel to the drill pipe that moves through the rotary table and transmits torque to the drill stem.

3.1.35
kelly saver sub
A short rotary sub that is made up onto the bottom of the kelly to protect the pin end of the kelly from wear during make-up and break-out operations.

3.1.36
label
A dimensionless designation for the size and style of a rotary shouldered connection.

3.1.37
length of box thread
LBT
The length of threads in the box measured from the make-up shoulder to the intersection of the non-pressure flank and crest of the last thread with full thread depth.

3.1.38
linear imperfection
An imperfection that includes, but is not limited to seams, laps, cracks, plug scores, cuts, gouges, and elephant hide (see API 5T1).

3.1.39
lot
A definite quantity of product manufactured under conditions that are considered uniform for the attribute being inspected.

3.1.40
lot size
The number of units in a lot.

3.1.41
lower kelly valve
(kelly cock)
A full-opening style valve installed immediately below the kelly, with outside diameter equal to the tool joint outside diameter, that can be closed to remove the kelly under pressure and can be stripped in the hole for snubbing operations.

3.1.42
low stress steel stamps
Steel stamps that do not contain any sharp protrusions on the marking face.

3.1.43
make-up shoulder
The sealing shoulder on a rotary shouldered connection.

3.1.44
mean hardness number
The result of averaging the hardness numbers for the single specimen or location being evaluated.

3.1.45
neck
The region at upper and lower end of stabilizer that contains connections.

3.1.46
non-essential variable
A variable parameter in which a change may be made in the WPS without re-qualification.

3.1.47
nonlinear imperfection
An imperfection that includes, but is not limited to, pits (see API 5T1).

3.1.48
non-pressure flank [box]
The thread flank farthest from the make-up shoulder where no axial load is induced from make-up of the connection or from tensile load on the drill stem member.

3.1.49
non-pressure flank [pin]
The thread flank closest to the make-up shoulder where no axial load is induced from make-up of the connection or from tensile load on the drill stem member.

3.1.50
out-of-roundness
The difference between the maximum and minimum diameters of the bar or tube, measured in the same cross-section.

NOTE Does not include the surface finish tolerances outlined in 8.1.4.

3.1.51
pin end
The external (male) threads of a threaded connection.

3.1.52
procedure qualification record
PQR
Written documentation stating an assessment that a specific WPS produces welds in accordance with the requirements of this standard.

3.1.53
process of quenching
The hardening of a ferrous alloy by austenitizing and then cooling rapidly enough so that some or all of the austenite transforms to martensite.

3.1.54
process of tempering
Reheating a quench hardened or normalized ferrous alloy to a temperature below the transformation range and then cooling to soften and remove stress.

3.1.55
purchaser
The party responsible for both the definition of requirements for a product order and for payment for that order.

3.1.56
quench crack
crack in steel resulting from stresses produced during the transformation from austenite to martensite.

NOTE This transformation is accompanied by an increase in volume.

3.1.57
reference dimension
The dimension that is a result of two or more other dimensions.

3.1.58
rotary shouldered connection
A connection used on drill stem elements which has tapered threads and sealing shoulders.

3.1.59
sample
One or more units of product selected from a lot to represent that lot.

3.1.60
seamless pipe
The wrought steel tubular product made without a weld seam.

NOTE It is manufactured by hot working and, if necessary, by subsequently cold-working or heat-treating, or a combination of these operations to produce the desired shape, dimensions, and properties.

3.1.61
stabilizer blade diameter
The diameter at largest cross section.

3.1.62
stress-relief features
The modification performed on rotary shouldered connections by removing the unengaged threads on the pin or box to make the joint more flexible and to reduce the likelihood of fatigue cracking in highly stressed areas.

3.1.63
sub
The short drill stem members with different rotary shouldered connections at each end for the purposes of joining unlike members of the drill stem.

3.1.64
swivel
A device at the top of the drill stem that permits simultaneous circulation and rotation.

3.1.65
tensile strength
The maximum tensile stress that a material is capable of sustaining that is calculated from the maximum load during a tensile test carried to rupture and the original cross-sectional area of the specimen.

3.1.66
tensile test
The mechanical test used to determine the mechanical response of material under tension load.

3.1.67
test pressure
The pressure above working pressure used to demonstrate structural integrity of a pressure vessel.

3.1.68
thread form
The thread profile in an axial plane for a length of one pitch.

3.1.69
Tolerance
The amount of variation permitted.

3.1.70
tool joint
A heavy coupling element for drill pipe having coarse, tapered threads, and sealing shoulders.

3.1.71
upper kelly valve
(kelly cock)
The valve immediately above the kelly that can be closed to confine pressures inside the drill stem.

3.1.72
welded-blade stabilizer
A stabilizer manufactured by welding blades to a core.

3.1.73
working pressure
The pressure to which a particular piece of equipment is subjected during normal operation.

3.1.74
working temperature
The temperature to which a particular piece of equipment is subjected during normal operation.

3.1.75
wrap angle
The total angular extent of full blade diameter summed across all blades.

3.2 Abbreviations and Symbols

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

A_{m}	cross-sectional area of the tensile specimen, expressed in square millimeters (square inches)
AMMT	American macaroni tubing style of thread design
AMT	alternate abbreviation for AMMT
BSR	bending strength ratio
C	standard Charpy impact energy, expressed in foot-pounds
C_{m}	standard Charpy impact energy, expressed in Joules
D	outside diameter
D_{PB}	diameter baffle plate recess
D_{C}	distance across corners, forged kellys
D_{CC}	distance across corners, machined kellys
D_{F}	bevel diameter (pin and box)
D_{FL}	distance across flats on kellys
D_{FR}	diameter float valve recess
D_{L}	outside diameter, lift shoulder

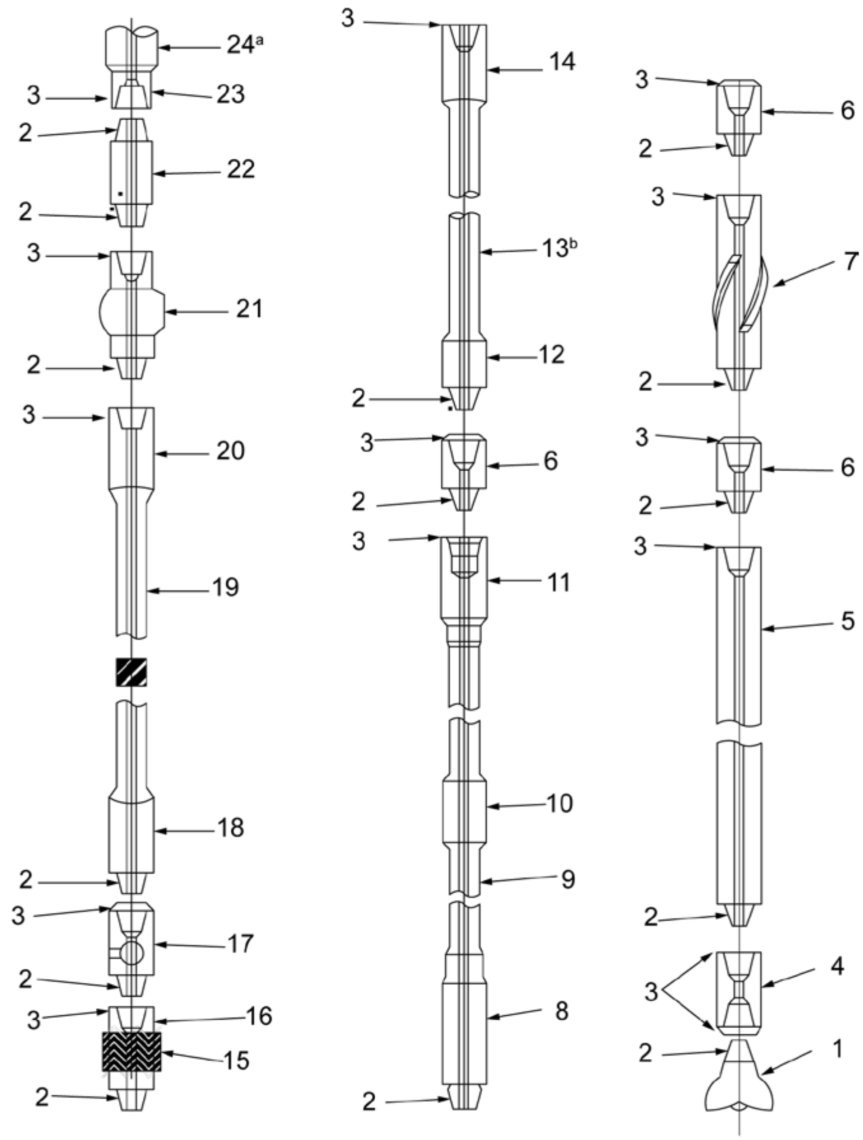
D_{LR}	outside diameter, kelly lower upset
D_R	outside diameter, reduced section
D_S	diameter slip groove
D_U	outside diameter, upper kelly upper upset
d	inside diameter
d_B	decibel
d_b	inside bevel
e	minimum extension in a gauge length of 50.8 mm (2.0 in.)
e_m	minimum elongation
F_h	API full-hole style of thread design
G	gauge length
HBW	Brinell hardness
L	overall length
L_D	length kelly drive section
L_{FV}	length float valve assembly
L_G	minimum length kelly sleeve gauge
LH	left hand
L_L	lower upset length, kellys
L_R	depth of float valve recess
L_U	upper upset length, kellys
I_S	slip recess groove depth
MT	magnetic particle testing
M.T.	macaroni tubing style of thread design
N	fraction or number with a fraction
NC	API number style of thread design
NPC	non-preferred connections
PT	liquid penetrant testing
R	radius
R_c	corner radius, forged kelly
R_{cc}	corner radius, machined kelly
REG	API regular style of thread design
RH	right hand
R_H	maximum fillet radius, hexagonal kelly sleeve gauge
R_S	maximum fillet radius, square kelly sleeve gauge
RSC	rotary shouldered connection
THD	thread

T_S tensile strength

t minimum wall thickness

4 Conformance

4.1 General Illustration of Typical Drill Stem Elements



Key

1	bit	9	HW drill pipe	17	lower kelly valve
2	rotary pin connection	10	HW center upset	18	lower kelly upset
3	rotary box connection	11	HW box tool joint	19	kelly drive section
4	bit sub	12	pin tool joint	20	upper kelly upset
5	drill collar - spiral or round	13	drill pipe	21	upper kelly valve
6	crossover sub	14	box tool joint	22	swivel sub
7	stabilizer	15	protector rubber	23	swivel stem
8	HW pin tool joint	16	kelly saver sub	24	swivel

[a] Requirements on the swivel can be found in API 8A and API 8C.
[b] Requirements on drill pipe with weld-on tool joints can be found in API 5DP.

Note 1 All connections between lower kelly upset and the bit are RH.
Note 2 All connections between upper kelly upset and the swivel are LH.

Figure 1—Typical Drill-stem Assembly

4.2 References to Annexes

For additional information regarding inspections by the purchaser, as referred, see Annex A.

For additional requirements or information concerning the manufacturing of rotary drill stem elements, as referenced, see the following.

— material requirements, see Annex B (normative);

— product tables in SI units, see Annex C (normative);

— product tables in USC units, see Annex D (normative);

— conversion procedures for USC to SI units, see Annex E (informative).

4.3 Dual Citing of References

In the interest of worldwide application of this technical report, the API Subcommittee on Tubular Goods (SC5) has decided, after detailed technical analysis, that certain documents listed in Section 2 and prepared by API SC5 or other technical committees are interchangeable in the context of the relevant requirement with the relevant document prepared by the International Organization for Standardization (ISO) or the American Society for Testing and Materials (ASTM). These latter documents are cited in the running text following the API reference and preceded by "or" for example, "API XXXX or ISO YYYY" or "ISO YYYY or ASTM ZZZZ". Application of an alternative document cited in this manner may lead to technical results different from the use of the preceding API reference. However, both results are acceptable, and these documents are thus considered interchangeable in practice.

4.4 Units of Measurement

In this standard, data are expressed in both the International System (SI) of units and the United States Customary (USC) system of units. For a specific order item, it is intended that only one system of units be used without combining data expressed in the other system.

Products manufactured to specifications expressed in either of these unit systems shall be accepted as equivalent and totally interchangeable. Consequently, compliance with the requirements of this standard as expressed in one system provides compliance with requirements expressed in the other system.

In the text, data in SI units are followed by data in USC units in brackets.

4.5 Marking of Threaded-only Rotary Shouldered Connections (RSC)

When specified, for threaded-only RSCs used on products in accordance with this standard, the following shall be identified by stamping or stenciling the product adjacent to the connection with the following:

a) threader's name or mark (optional),

b) "API 7-2",

c) THD,

d) date of threading, and

e) size and style of connection.

EXAMPLE—An NC46 connection would be marked: AB Co. (or mark), API 7-2, THD Mo [xx]-Yr [yy], NC46.

NOTE The connection marking may be applied to products, which are not covered by API standards if the threading and gauging stipulations in API 7-2 are met.

5 Upper and Lower Kelly Valves

5.1 General

This standard specifies the minimum design, material, inspection, and testing requirements for upper and lower kelly valves. This standard also applies to drill stem safety valves used with overhead drilling systems. It applies to valves of all sizes and shall be furnished with rated working pressures of 34.5 MPa, 68.9 MPa or 103.5 MPa (5000 psi, 10,000 psi or 15,000 psi) used in normal service conditions (H_2S service conditions are addressed as a supplementary requirement, see 5.8). Rated working temperatures are –20 °C (–4 °F) and above for valve bodies. Sealing system components may have other temperature limitations.

5.2 Design Criteria

5.2.1 General

The manufacturer shall document the design criteria and analysis for each type of valve produced under this standard. This documentation shall include loading conditions that will initiate material yield for the valve body with minimum material properties and tolerances under combined loading, including tension, internal pressure, and torsion. Body material yield loading conditions shall be documented in either tabular or graphical form. The minimum design yield safety factor shall be 1.0 at the shell test pressure found in Table C.1 (Table D.1).

For the valve to have a useful fatigue life, loading conditions should be monitored to ensure they remain well below manufacturer supplied valve body material yield conditions. Endurance load conditions, below which fatigue does not accumulate, will depend on the service conditions that are primarily determined by the temperature and corrosive nature of the fluids in contact with the valve.

5.2.2 Material Requirements

Where material requirements are not otherwise specified, material for equipment supplied to this standard may vary depending on the application but shall comply with the manufacturer's written specifications. Manufacturer specifications shall define the following:

a) chemical composition limits;

b) heat treatment conditions;

c) limits for the following mechanical properties:

    1) tensile strength;

    2) yield strength;

    3) elongation; and

    4) hardness.

Minimum values for mechanical properties shall conform to material requirements for drill collars as specified in Section 8.

5.2.3 Impact Strength

5.2.3.1 Test Specimen

Three longitudinal impact test specimens per heat per heat treatment lot shall be tested in accordance with ASTM A370 or ASTM E23. Qualification test coupons may be integral with or separate from the components they represent, or as a sacrificial production part. In all cases, test coupons shall be from the same heat as the components which they qualify and shall be heat-treated with the components.

Test specimens shall be removed from integral or separate qualification test coupons such that their longitudinal centerline axis is wholly within the center $^1/_4$-thickness envelope for a solid test coupon or within 3 mm (1/8 in.) of the mid-thickness of the thickest section of a hollow test coupon.

Test specimens taken from sacrificial production parts shall be removed from the center $^1/_4$-thickness envelope location of the thickest section of the part.

If the test coupon is obtained from a trepanned core or other portion removed from a production part, the test coupon shall only qualify production parts that are identical in size and shape to the production part from which it was removed.

5.2.3.2 Requirements

The average impact value of the three specimens shall not be less than 42 J (31 ft-lbs), with no single value below 32 J (24 ft-lbs). Testing shall be at –20 °C (–4 °F) or less.

5.2.3.3 Sub-size Specimens

If it is necessary for sub-size impact test specimens to be used, the acceptance criteria shall be multiplied by the appropriate adjustment factor listed in Table C.2 (Table D.2). Sub-size test specimens of width less than 5 mm (0.197 in.) shall not be permitted.

5.2.4 Service-class Pressure Sealing Performance Requirements

Kelly valve and other drill stem safety valves (regardless of closure mechanism) shall be designed for either surface only or for both surface and downhole service. Upper kelly valves shall be classified as class 1 or class 2 depending on which design performance requirements the valve meets. Lower kelly valves and lower safety valves used with overhead drilling systems shall be designed for down-hole service and shall meet the design performance requirements for class 2-service. The design performance requirements for pressure sealing for each service class are shown in Table C.3 (Table D.3).

5.2.5 Basic Design Performance Requirements

Kelly valves and other drill stem safety valves (regardless of closure mechanism) shall be designed to meet the following basic performance requirements:

a) operation in drilling mud;

b) closing to shut off a mud flow from the drill stem; and

c) sealing over the design range of temperature and tension load conditions.

5.3 Hydrostatic Testing

5.3.1 General

The manufacturer shall have or have access to a facility certified for high pressure testing. Pressure testing of the end connections on the valve is not required. See Table C.1 (Table D.1).

Hydrostatic testing shall be conducted to the pressures as shown in Table C.1 (Table D.1). Testing shall be conducted at ambient temperature with a non-corrosive, low viscosity, low compressibility fluid. During the pressure-holding period, timing shall start when pressure stabilization is achieved. During the test period, no visually detectable leakage is permitted, and pressure drop shall be within manufacturer's tolerance for a zero leak rate.

5.3.2 Hydrostatic Shell Testing

Hydrostatic shell testing shall be conducted with the valve in the half-closed position. If there is a stem seal in the valve body, a low pressure test to 1.7 MPa (250 psi) shall also be conducted. Each new valve body shall be tested to the hydrostatic shell test pressure by the method outlined below, where both the low pressure and the high pressure tests shall be conducted in three parts:

a) initial pressure-holding period of 3 min;

b) reduction of pressure to zero; and

c) re-build pressure to required final value and end test with valve body holding pressure for a period of not less than 10 min.

5.3.3 Tests at Working Pressure

5.3.3.1 General

Each valve shall be tested to the working pressure to which it is rated, depending on its class of service as defined in Table C.3 (Table D.3). This testing shall apply to all new valves and shall be conducted as specified in 5.3.3.2 and 5.3.3.3.

Working pressure test period shall be for a minimum of 5 min.

5.3.3.2 Tests at Pressure from Below

This testing applies to both class 1-type and class 2-type valves.

Pressure shall be applied to the functional lower end of the valve (normally the pin end) with the valve in the closed position.

Low and high pressure tests shall be conducted. The low pressure test shall be at 1.7 MPa (250 psi) and the high pressure test shall be at the maximum working pressure rating. Open and close the valve after the high pressure test to release any trapped pressure in cavities of valve.

5.3.3.3 Tests at Pressure from Above

CAUTION—After working pressure tests are completed, check to ensure that the alignment of the ball or flapper when in the indicated "open position" is still within manufacturing tolerances, as misalignment can cause fluid erosion problems in field applications.

This testing applies to class 2-type valves only.

This testing applies to valves with ball-type closure mechanisms only.

Pressure shall be applied to the functional upper end of the valve (normally the box end) with the valve in the closed position. Low and high pressure tests shall be conducted. The low pressure test shall be at 1.7 MPa (250 psi) and the high pressure test shall be at the maximum working pressure rating. Open and close the valve after the high pressure test to release any trapped pressure in cavities of the valve, and then repeat the low pressure test.

5.3.4 Design Verification Test for Stem Seal External Pressure

Each class 2-service valve design shall have appropriate stem seal external pressure testing as outlined below:

a) The test period shall be for a minimum of 5 min.

b) The stem-seal external pressure test applies to class 2-type valves only and is only required for design verification purposes.

   1) Pressure shall be applied to the outside of the valve (e.g. through a high pressure sleeve mounted over the stem seal area) with the valve in the half-open position.

   2) Low and high pressure stem-seal tests shall be conducted.

   3) The low pressure test shall be at 1.7 MPa (250 psi) and the high pressure test shall be a minimum of 13.8 MPa (2000 psi) but may be higher (up to the rated working pressure) at the manufacturer's discretion.

5.3.5 Design Verification Test for Sealing Temperature Range

This applies to class 2-type valves only and is only required for design verification purposes.

Non-metallic seal systems are available for operation over a temperature range of –10 °C (14 °F) to 90 °C (194 °F), so design verification testing shall be conducted with the valve and the test fluid at these temperature extremes, unless the purchaser specifies otherwise. Pressure testing shall be performed in accordance with 5.3.3 and 5.3.4 at both low and high temperatures, using suitable testing fluids for extreme temperature conditions.

5.4 Connections

5.4.1 General

All valves covered by this standard shall be furnished by the manufacturer with end connections.

5.4.2 Preferred Connections

5.4.2.1 General—Size and Style

The preferred end connections on all valves shall be of the size and style indicated in 5.4.2.2 for the valve type.

5.4.2.2 Upper Kelly Valves

Preferred connections on upper kelly valves shall be of the size and style shown in Section 6, and column 3 of Table C.5 (Table D.5) and Table C.7 (Table D.7) of this standard.

5.4.2.3 Lower Kelly Valves

5.4.2.3.1 Upper Connection on Lower Kelly Valves

Preferred upper connections on lower kelly valves shall be of the size and style shown in Section 6, and column 7 of Table C.5 (Table D.5) and Table C.7 (Table D.7) of this standard.

5.4.2.3.2 Lower Connection on Lower Kelly Valves

Preferred lower connections on lower kelly valves shall be of the size and style of any connection shown in Table C.5 (Table D.5), Table C.7 (Table D.7), Table C.14 (Table D.14), and Table C.27 (Table D.27) of this standard. The NC40 and 6-$^{5}/_{8}$ FH connections are also acceptable.

5.4.2.4 Connections on Other Drill Stem Safety Valves

Preferred connections on other drill stem safety valves shall be of the size and style of any connection shown in Table C.5 (Table D.5), Table C.7 (Table D.7), Table C.14 (Table D.14), and Table C.27 (Table D.27) of this standard. The NC40 and 6-$^{5}/_{8}$ FH connections are also acceptable.

5.4.3 Non-preferred Connection

Connections stated on the purchase order that are not listed in the tables of this standard for each valve type shall be identified as non-preferred (NPC) for these applications.

Non-preferred connections are not a part of this standard.

5.4.4 Bevel Diameters

When connections are machined, the corresponding bevel diameters specified for the connection on the joining product shall be used.

5.4.5 Surface Treatment of Threads and Sealing Shoulders for Galling

To help with galling problems that could occur during usage, a treatment of zinc or manganese or zinc-and-manganese phosphate shall be applied to the threads and the sealing shoulders for all end connections of kelly valves and on other drill stem safety valves manufactured from standard steels. Application of the treatment shall be after completion of all gauging. The treatment type shall be at the discretion of the manufacturer.

Surface treatments to lessen the effect of galling are not readily available for non-magnetic materials, therefore not required.

5.4.6 Cold Working of Thread Roots

Cold working of threads is optional. However, any necessary cold working of thread should be performed after thread gauging. See 8.1.7.3 for further details.

5.5 Non-destructive Examination of Connections

5.5.1 Coverage

End connections and any service connections shall be subjected to non-destructive examination for both transverse and longitudinal defects.

5.5.2 Connections from Standard Steel

Connections manufactured from standard steel shall be examined by the wet magnetic particle method. The examination shall be performed according to a written procedure developed by the manufacturer. The procedure shall be in accordance with ASTM E3024 and shall be made available to the purchaser on request.

5.5.3 Connections from Non-magnetic Steel

Connections manufactured from non-magnetic steel shall be examined by liquid penetrant, using the visible or fluorescent solvent-removable or water-washable method. The examination shall be performed according to a written procedure developed by the manufacturer. The procedure shall be in accordance with either ASTM E1209, ASTM E1219, ASTM E1220, or ASTM E1418, and shall be made available to the purchaser on request.

5.6 Documentation and Retention of Records

The manufacturer shall maintain, and provide on request to the purchaser, documentation of inspection (dimensional, visual, and non-destructive), and hydrostatic testing for each valve supplied. The manufacturer shall maintain documentation of performance verification testing for a period not less than seven years after the last model is sold.

5.7 Marking

5.7.1 General

Kelly valves and other drill stem safety valves manufactured in accordance with this standard shall be imprinted using low stress steel stamps or a low stress milling process.

5.7.2 All Valves with Only Preferred End Connections

Valves furnished by the valve manufacturer with all connections listed in the tables referenced in 5.4.2, 5.4.3, 5.4.4, and 5.4.5 shall be marked with the following information:

a) the manufacturer's name or mark;

b) "API 7-1";

c) date of manufacture (month [xx]/year[yy]);

d) class of service;

e) unique serial number;

f) maximum rated working pressure, to be applied in milled recess;

g) the connection size and style applied on the OD surface within 127 mm (5 in.) of the connection, but no marking shall be applied to the sealing face or the face bevel;

h) place on the OD surface, within 76 mm (3 in.) of each valve's operating mechanism, an indication of the rotation direction required to turn the flow shutoff mechanism to the closed position; and

i) on class 1-type valves, indication of normal mud flow direction marked with an arrow (→) and the word "Flow".

5.7.3 All Valves with at Least One Non-preferred Connection

End connections that are not listed in Table C.5 (Table D.5), Table C.7 (Table D.7), Table C.14 (Table D.14), and Table C.27 (Table D.27), or the NC40 and 6-$^{5}/_{8}$ FH, shall be identified as non-preferred. Non-preferred connections are not a part of this standard.

On upper and lower kelly valves and other drill stem safety valves with one or more non-preferred connections (NPC), only the valve body, valve operating mechanism, and the preferred connection specified in Table C.5 (Table D.5), Table C.7 (Table D.7), Table C.14 (Table D.14), and Table C.27 (Table D.27), or the NC40 and 6-$^{5}/_{8}$ FH, are covered by this standard.

Marking the valves as stated below certifies that only the valve body, valve operating mechanism and the preferred connections listed in the tables above meet all the requirements of this standard.

Valves furnished by the valve manufacturer with one or more non-preferred connections shall be marked with the following information:

a) the manufacturer's name or mark;

b) "API 7-1";

c) the letters “NPC”;

d) class of service;

e) unique serial number;

f) date of manufacture (month/year);

g) maximum rated working pressure, to be applied in milled recess;

h) the connection size and style applied on the OD surface within 127 mm (5 in.) of the connection, but no marking shall be applied to the sealing face or the face bevel;

i) place on the OD surface, within 76 mm (3 in.) of each valve’s operating mechanism, an indication of the rotation direction required to turn the flow shutoff mechanism to the closed position; and

j) on class 1-type valves, an indication of normal mud flow direction marked with an arrow (→) and the word “Flow”.

5.7.4 All Valves with No Preferred End Connections

End connections that are not listed in Table C.5 (Table D.5), Table C.7 (Table D.7), Table C.14 (Table D.14), and Table C.27 (Table D.27), or the NC40 and 6–5/8 FH, shall be identified as non-preferred. Non-preferred connections are not a part of this standard.

On upper and lower kelly valves and other drill stem safety valves with no preferred connections, only the valve and the valve operating mechanism are covered this standard.

Marking the valves as stated below certifies that only the valve body and valve operating mechanism meet all the requirements of this standard.

Valves furnished by the manufacturer with no preferred connections shall be marked with the following information:

a) the manufacturer’s name or mark;

b) “API 7-1”;

c) the letters “NPC” “NPC” (mark twice);

d) class of service;

e) unique serial number;

f) date of manufacture (month/year);

g) the maximum working pressure, to be applied in milled recess;

h) the connection size and style applied on the OD surface within 127 mm (5 in.) of the connection, but no marking shall be applied to the sealing face or the face bevel;

i) place on the OD surface, within 76 mm (3 in.) of each valve’s operating mechanism, an indication of the rotation direction required to turn the flow shutoff mechanism to the closed position; and

j) on class 1-type valves, an indication of normal mud flow direction, marked with an arrow (→) and the word “Flow”.

5.8 Supplementary Requirements

5.8.1 General

The following supplementary requirements for kelly valves and other types of drill stem safety valves shall apply by agreement between the purchaser and the manufacturer and when specified on the purchase order.

5.8.2 Performance Verification Testing of Gas-tight Sealing

Supplementary performance verification testing of drill-stem safety valves designed and manufactured in accordance with this standard shall be performed or certified, or both by a quality organization independent of the design function. Since leak testing at high pressure is potentially more hazardous with gas than with fluids of low compressibility, gas testing at high pressure shall be restricted to performance verification testing. It is recommended that Nitrogen or another non-flammable gas be used at ambient-temperature conditions. Otherwise, testing at low and high pressures shall be conducted in accordance with 5.3.3. No gas bubbles shall be observed in a 5-minute test period.

For each valve manufactured to the same specifications as a valve that has been designed and verified as being capable of gas-tight sealing, a gas test at a low pressure to 0.62 MPa (90 psi), and at ambient-temperature, shall be performed in accordance with in 5.3.3. No gas bubbles shall be observed in a 5-minute test period.

5.8.3 Supplementary Requirements for H_2S-trim

If valve trim materials conform to the requirements of NACE MR0175/ISO 15156 for H_2S service at conditions specified by the manufacturer, the valve shall be designated "H_2S-trim". H_2S-trim may be requested as a supplementary requirement by the purchaser.

H_2S-trim valves shall not be deemed suitable for use in a sour environment, as defined in NACE MR0175/ISO 15156 since the material used in the body of H_2S-trim valves is not suitable for sour service.

5.8.4 Supplementary Marking

Supplementary performance verification testing information shall be applied in a separate milled recess. Designations shall be used to indicate verified performance as follows:

a) successful gas-tight sealing supplemental testing: "Gas-tight"; and

b) H_2S-trim supplemental requirement: "H_2S-trim".

6 Square and Hexagonal Kellys

6.1 Size, Type, and Dimensions

Kellys shall be either square or hexagonal and conform to the sizes and dimensions in Table C.4 (Table D.4), Table C.5 (Table D.5), and Figure 2 for square kellys; or Table C.6 (Table D.6), Table C.7 (Table D.7), and Figure 3 for hexagonal kellys.

6.2 Dimensional Gauging

6.2.1 Drive Section

The drive section of all kellys shall be gauged for dimensional accuracy by using a sleeve gauge conforming to Table C.8 (Table D.8) and Figure 4.

6.2.2 Bore

All kelly bores shall be gauged with a drift mandrel 3.05 m (10 ft) long minimum. The drift mandrel shall have a minimum diameter equal to the specified bore of the kelly (standard or optional) minus [–] 3.2 mm ($^1/_8$ in.).

For 133.4 mm (5-$^1/_4$ in.) hexagonal kellys, a standard or optional inside diameter (bore) may be specified. See Table C.7 (Table D.7) for the optional bore.

6.3 Connections

Kellys shall be furnished with box and pin connections in the sizes and styles stipulated in Table C.5 (Table D.5) or Table C.7 (Table D.7) and shall conform to the requirements of API 7-2.

For the lower end of 108 mm (4-$^1/_4$ in.) and 133.4 mm (5-$^1/_4$ in.) square kellys and for the lower end of 133.4 mm (5-$^1/_4$ in.) and 152.4 mm (6 in.) hexagonal kellys, two sizes and styles of connections are standard.

A treatment of zinc or manganese or zinc-and-manganese phosphate shall be applied to the threads and the sealing shoulders of both the upper and lower connections of kellys. Application of the treatment shall be after completion of all gauging. The treatment type shall be at the discretion of the manufacturer (see 5.4.5).

6.4 Square Forged Kellys

Square forged kellys shall be manufactured such that the decarburized surface layer is removed in the zones defined by the radiuses joining the drive section to the upper and lower upsets and extending a minimum of 3.2 mm ($^1/_8$ in.) beyond the tangency points of the radiuses.

6.5 Mechanical Properties

6.5.1 General

The mechanical properties of kellys, as manufactured, shall comply with the requirements of Table C.9 (Table D.9).

6.5.2 Tensile Requirements

Tensile properties shall be verified by performing a tensile test on one specimen per heat per heat treatment lot.

Tensile properties shall be determined by tests on cylindrical specimens conforming to the requirements of ASTM A370, 0.2 % Offset Method. Specimens of diameter 12.7 mm (0.500 in.) shall be used except where there is insufficient material; in which case the next smaller standard sub-size specimen obtainable shall be used. The next standard sub-size specimens are of diameters 8.9 mm (0.350 in.) and 6.4 mm (0.250 in.).

Tensile specimens shall be taken from the lower upset of the kelly in a longitudinal direction, having the centerline of the tensile specimen 25.4 mm (1 in.) from the outside surface or mid-wall (whichever is less).

Tensile testing is not necessary or practical on the upper upset.

A minimum Brinell hardness number of 285 shall be prima facie evidence of satisfactory mechanical properties in the upper upset.

The hardness test shall be made on the OD of the upper upset in accordance with ASTM A370 and ASTM E10 for Brinell hardness tests, and ASTM A370 and ASTM E18 for Rockwell C hardness tests.

If the Rockwell C method is used the results shall be converted to Brinell for comparison to the requirement of 285 HBN stated above.

6.5.3 Impact Strength Requirements

6.5.3.1 General

Charpy V-notch impact tests shall be conducted on specimens conforming to the requirements of ASTM A370 and ASTM E23 shall be conducted at a temperature of 21 °C ± 3 °C (70 °F ± 5 °F). Tests conducted at lower temperatures that meet the requirements stated in 6.5.3.4 are acceptable.

6.5.3.2 Specimens

One set of three specimens per heat per heat-treatment lot shall be tested.

Specimens shall be taken from the lower upset at 25.4 mm (1 in.) below the surface or at mid-wall, whichever is closer to the outer surface.

The specimens shall be longitudinally oriented and radially notched.

6.5.3.3 Specimen Size

Full size specimens of 10 mm × 10 mm (0.394 in. × 0.394 in.) shall be used except where there is insufficient material, in which case the next smaller standard sub-size specimen obtainable shall be used.

If it is necessary to use sub-size test specimens, the acceptance criteria shall be multiplied by the appropriate adjustment factor listed in Table C.2 (Table D.2). Sub-size test specimens of less than 5 mm (0.197 in.) are not permitted.

6.5.3.4 Acceptance Criteria

The average of the three specimens shall be 54 J (40 ft-lbs) or greater, with no single value less than 47 J (35 ft-lbs).

6.6 Non-destructive Examination

Each bar or tube used to manufacture kellys shall be examined for both surface and internal defects in accordance with Section 12.

6.7 Marking

Kellys manufactured in conformance with this standard shall be die-stamped on the OD of the upper upset with the following information:

a) manufacturer's name or identifying mark;

b) "API 7-1"; and

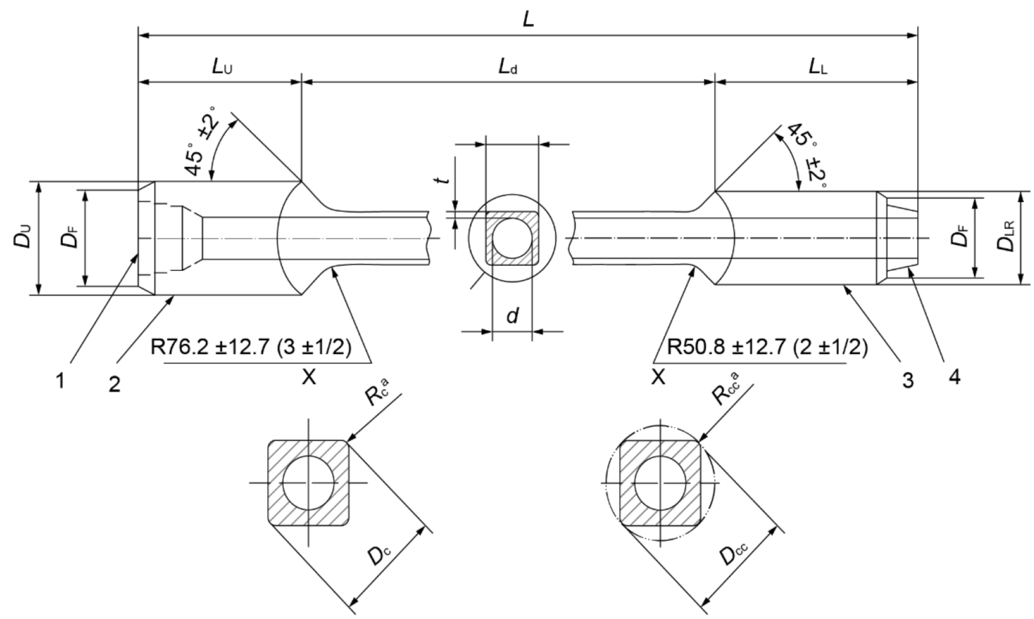
c) the size and style of the upper connection.

The lower upset shall be die-stamped on the OD with the size and style of the lower connection.

EXAMPLE—A 108 mm (4-$^{1}/_{4}$ in.) square kelly with a 6-$^{5}/_{8}$ regular left-hand upper box connection, manufactured by AB Company, is marked:

— On upper upset: AB Co. (or mark) API 7-1, 6-$^{5}/_{8}$ REG LH

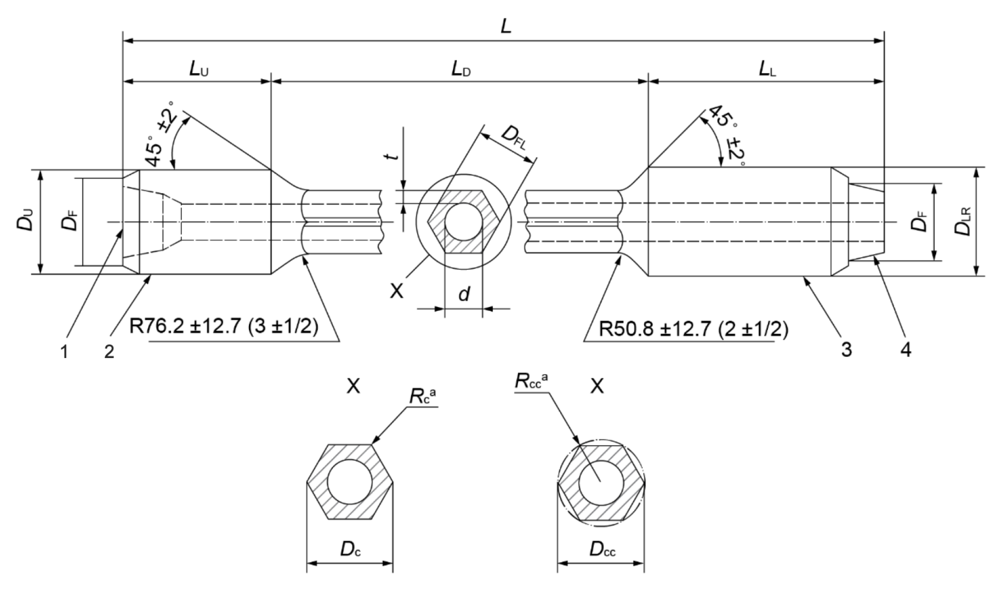
— On lower upset: NC50



Key
1 LH rotary box connection
2 upper upset
3 lower upset
4 RH rotary pin connection

a Corner configuration Rc or Rcc shall be at the manufacturer's option.

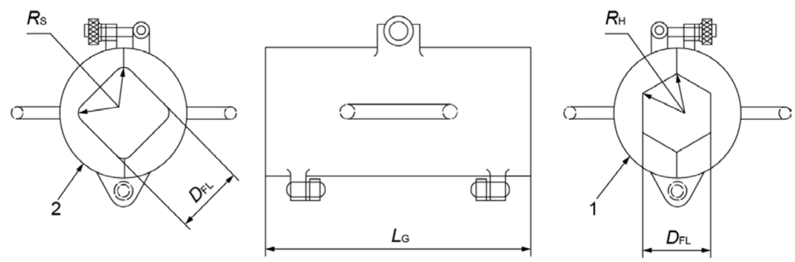
Figure 2—Square Kelly



Key
1 LH rotary box connection
2 upper upset
3 lower upset
4 RH rotary pin connection

a Corner configuration Rc or Rcc shall be at the manufacturer's option.

Figure 3—Hexagonal Kelly



Key
1 hexagonal sleeve gauge
2 square sleeve gauge

Figure 4—Sleeve Gauge for Kellys (see Table C.8 or Table D.8)

7 Drill Stem Subs

7.1 Class and Type

Drill stem subs shall be furnished in the classes and types shown in Table C.10 (Table D.10), Figure 5 and Figure 6.

7.2 Dimensions for Type A and Type B

7.2.1 Connections, Bevel, and Outside Diameters

The connections shall conform to the dimensional and gauging requirements of API 7-2.

The connection sizes and styles shall conform to the applicable sizes and styles, and the bevel diameter dimensions and outside diameters shall conform to the applicable dimensions and tolerances, as follows:

a) Table C.5 (Table D.5) and Table C.7 (Table D.7) when connecting to kellys;

b) Table C.14 (Table D.14) and Table C.20 (Table D.20) when connecting to drill collars;

c) Table C.27 (Table D.27) when connecting to heavy-weight drill pipe;

d) Table C.28 (Table D.28), Table C.29 (Table D.29), and Table C.31 (Table D.31) when connecting to bits.

See API 5DP when connecting to drill pipe tool joints.

7.2.2 Inside Diameters

The inside diameters of the two connecting members shall be determined. The inside diameter (and applicable tolerances) of the Type A or Type B sub shall be equal to the smaller of the two inside diameters of these members.

7.2.3 Inside Bevel Diameter

The inside bevel diameter of the pin shall be equal to 3.2 mm $^{+1.6}/_{0}$ mm ($^{1}/_{8}$ in. $^{+1/16}/_{0}$ [$^{+0.06}/_{0}$] in.) larger than the inside diameter specified for the corresponding connecting member.

7.2.4 Length

Lengths and tolerances for Type A and Type B drill stem subs shall be as shown in Figure 5.

7.2.5 Float Valve Recess for Bit Subs

Float valve recesses are optional. If float valve recesses are specified, bit subs shall be bored to the dimensions shown in Table C.13 (Table D.13) and Figure 7 for the applicable assembly.

7.3 Dimensions for Type C (Swivel Subs)

7.3.1 Connections, Bevel, and Outside Diameters

The connections shall conform to the dimensional and gauging requirements of API 7-2. The connections on the swivel sub shall be pin-up and pin-down (both left-hand).

The lower pin connection size and style shall conform to the applicable sizes and styles, and the bevel diameter dimensions for the pin-down connection shall conform to the applicable dimensions and tolerances, specified in Table C.5 (Table D.5) or Table C.7 (Table D.7) for the upper kelly box connection. The upper connection shall be the same size and style as the swivel stem box connection, and the bevel diameter for the upper pin connection shall match the bevel diameter of the swivel stem box connection (i.e. 4-$^{1}/_{2}$, 6-$^{5}/_{8}$, or 7-$^{5}/_{8}$ API Reg).

The outside diameter and tolerances of the sub shall conform to the larger of either the kelly upper box connection or the swivel stem box connection outside diameter.

7.3.2 Inside Diameter

The maximum inside diameter shall be the largest diameter allowed for the upper kelly connection specified in Table C.5 (Table D.5) or Table C.7 (Table D.7). In the case of step-bored subs where the upper pin bore is larger than the lower pin bore, the upper pin bore shall not be too large to cause the upper pin to have either lower tensile or torsional strength than the lower pin as calculated in accordance with the strength and design equations of API 7G.

7.3.3 Inside Bevel Diameter

The inside bevel diameter shall be 6 mm $^{+2}/_{-1}$ mm ($^{1}/_{4}$ in. $^{+1/25.4}/_{-1/12.7}$ [$^{+0.08}/_{-0.04}$] in.) larger than the inside diameter.

7.3.4 Length

The minimum tong space allowable shall be 200 mm (8 in.).

7.4 Dimensions for Type D (Lift Subs)

7.4.1 Diameter of both Lift Recess and Lift Shoulder

The diameters of the lift recess and lift shoulder shall conform as applicable to Table C.12 (Table D.12).

7.4.2 Connections, Bevel, and Outside Diameters

The connection sizes and styles shall conform as applicable to Table C.14 (Table D.14).

The bevel and outside diameters shall conform as applicable to Table C.14 (Table D.14).

The connections shall conform to the dimensional and gauging requirements of API 7-2.

7.4.3 Inside Diameter

The maximum inside diameter shall be the largest diameter allowed for the applicable size and style of connection specified in Table C.14 (Table D.14) and Table C.21 (Table D.21).

7.4.4 Length

Lengths and tolerances for Type D drill stem subs shall be as shown in Figure 6.

7.5 Mechanical Properties

7.5.1 Tensile Requirements

The tensile properties of Type A and Type C subs and the larger-diameter section of Type B and Type D subs shall conform to the tensile requirements of drill collars as specified in 8.2.

On Type B subs with turned-OD's, the original test results may not be indicative of the tensile properties of the reduced-section. On Type B subs, destructive determination of tensile properties by testing is not necessary on the reduced-diameter section.

7.5.2 Hardness Requirements

A Brinell hardness reading as specified in Table C.11 (Table D.11) shall be prima facie evidence of satisfactory mechanical properties in the section of reduced-diameter. The surface hardness of the as-manufactured reduced-diameter section of Type B and Type D subs shall be measured in accordance with ASTM A370 and ASTM E10.

7.5.3 Impact Strength Requirements

7.5.3.1 General

Charpy V-notch impact tests shall be conducted on specimens conforming to the requirements of ASTM A370 and ASTM E23 and shall be conducted at a temperature of 21 °C ± 3 °C (70 °F ± 5 °F). Tests conducted at lower temperatures that meet the requirements stated in 7.5.3.4 are acceptable.

7.5.3.2 Specimens

One set of three specimens per heat per heat treatment lot shall be tested.

Specimens shall be taken from the lower upset at 25.4 mm (1 in.) below the outside surface or at a depth equal to the distance from the outside surface to the mid-wall radius, whichever is closer to the outside surface.

The mid-wall radius shall be located at a depth below the outside surface defined by the following:

a) For tubes, the depth from the outside surface to the mid-wall radius = (OD-ID)/4,

b) For solid bars, the depth from the outside surface to the mid-wall radius = OD/4.

The tolerances on the depths of testing shall be $^{+6.35}/_{0}$ mm ($^{+0.250}/_{0}$ in.).

The specimens shall be longitudinally-oriented and radially-notched.

7.5.3.3 Specimen Size

Specimens of full-size 10 mm × 10 mm (0.394in. × 0.394 in.) shall be used except where there is insufficient material; in which case the next smaller standard sub-size specimen obtainable shall be used.

If it is necessary to use sub-size test specimens, the acceptance criteria shall be multiplied by the appropriate adjustment factor in Table C.2 (Table D.2). Sub-size test specimens of less than [<] 5 mm (0.197 in.) are not permitted.

7.5.3.4 Acceptance Criteria

The average impact strength of the three specimens shall be 54 J (40 ft-lbs) or greater, with no single value less than [<] 47 J (35 ft-lbs).

7.6 Non-destructive Examination

All bars or tubes used to manufacture drill stem subs shall be examined for both surface and internal defects in accordance with Section 12. Materials containing defects shall not be used to manufacture drill stem subs.

7.7 Connection Stress-relief Features

Stress-relief features are optional on Type A and B subs and mandatory on Type C subs which are 4-$^{1}/_{2}$ API Reg and larger. Stress-relief features on Type D subs is not recommended.

The dimensions and tolerances of the stress-relief features for connections on Type A, B, and C subs shown in Table C.10 (Table D.10) shall conform to the dimensions and tolerances in API 7.2.

7.8 Cold Working of Thread Roots

Cold working of thread roots is optional on Type A, B, and C subs. Cold working of thread roots on Type D subs is not recommended. See 8.1.7.3 for details.

7.9 Surface Treatment of Threads and Sealing Shoulders for Galling

A treatment of zinc or manganese or zinc-and-manganese phosphate shall be applied to the threads and the sealing shoulders of both the upper and lower connections of drill stem subs. The treatment type shall be at the discretion of the manufacturer.

Application of the treatment shall be after completion of all gauging.

7.10 Marking

Subs manufactured in conformance with this standard shall be marked with the following information:

a) the manufacturer's name or identification mark;

b) "API 7-1";

c) the inside diameter; and

d) the size and style of the connection at each end.

The marking shall be die-stamped on a marking recess located on the outside diameter of the sub. The marking identifying the size and style of the connection shall be placed on that end of the recess closest to the connection to which it applies. The marking recess location is shown in Figure 5.

EXAMPLE 1—A sub with 4-$^{1}/_{2}$ Reg LH box connection on each end and with a 57.2 mm (2-$^{1}/_{4}$ in.) inside diameter, manufactured by AB Company, is marked as follows:

— AB Co. (or mark), API 7-1;

— 4-$^{1}/_{2}$ REG LH 57.2 4-$^{1}/_{2}$ REG LH; or

— AB Co. (or mark), API 7-1;

— 4-$^{1}/_{2}$ REG LH 2-$^{1}/_{4}$, 4-$^{1}/_{2}$ REG LH.

EXAMPLE 2—A sub with NC31 pin connection on one end and NC46 box connection on the other end and with a 50.8 mm (2 in.) inside diameter, manufactured by AB Company, is marked as follows:

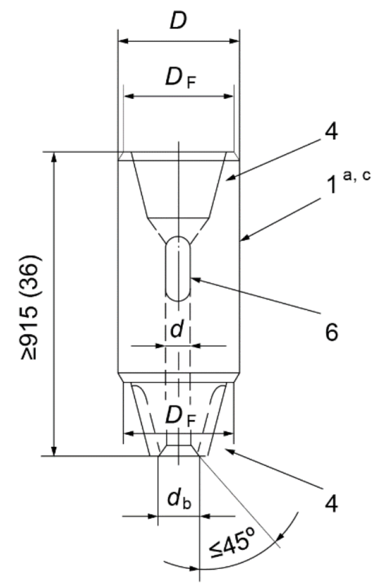
— AB Co. (or mark) API 7-1;

— NC31 50.8, NC46; or

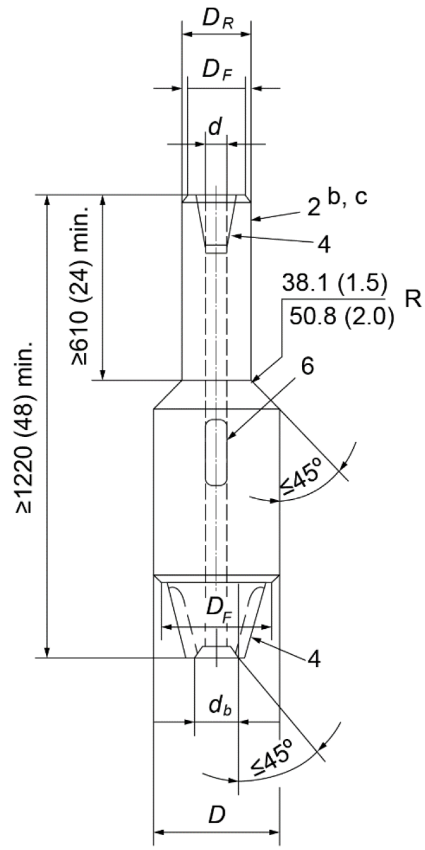
— AB Co. (or mark) API 7-1;

— NC31 2, NC46.

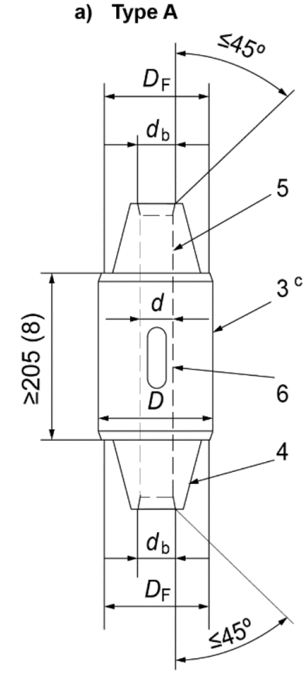
Dimensions in millimeters (inches)



a) Type A



b) Type B



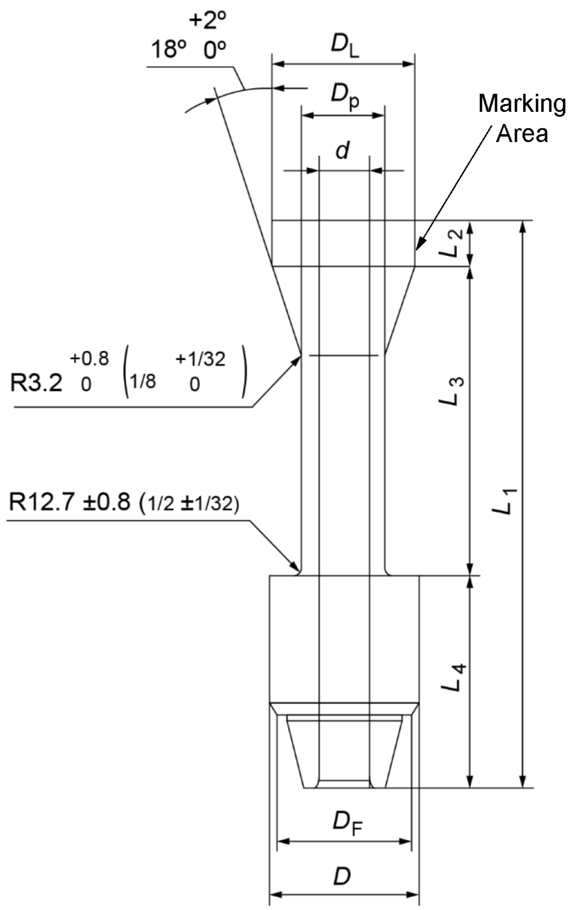
c) Type C

Key

1 type A rotary sub
2 type B rotary sub
3 type C rotary sub
4 rotary pin or box connection
5 LH pin connection
6 marking recess location

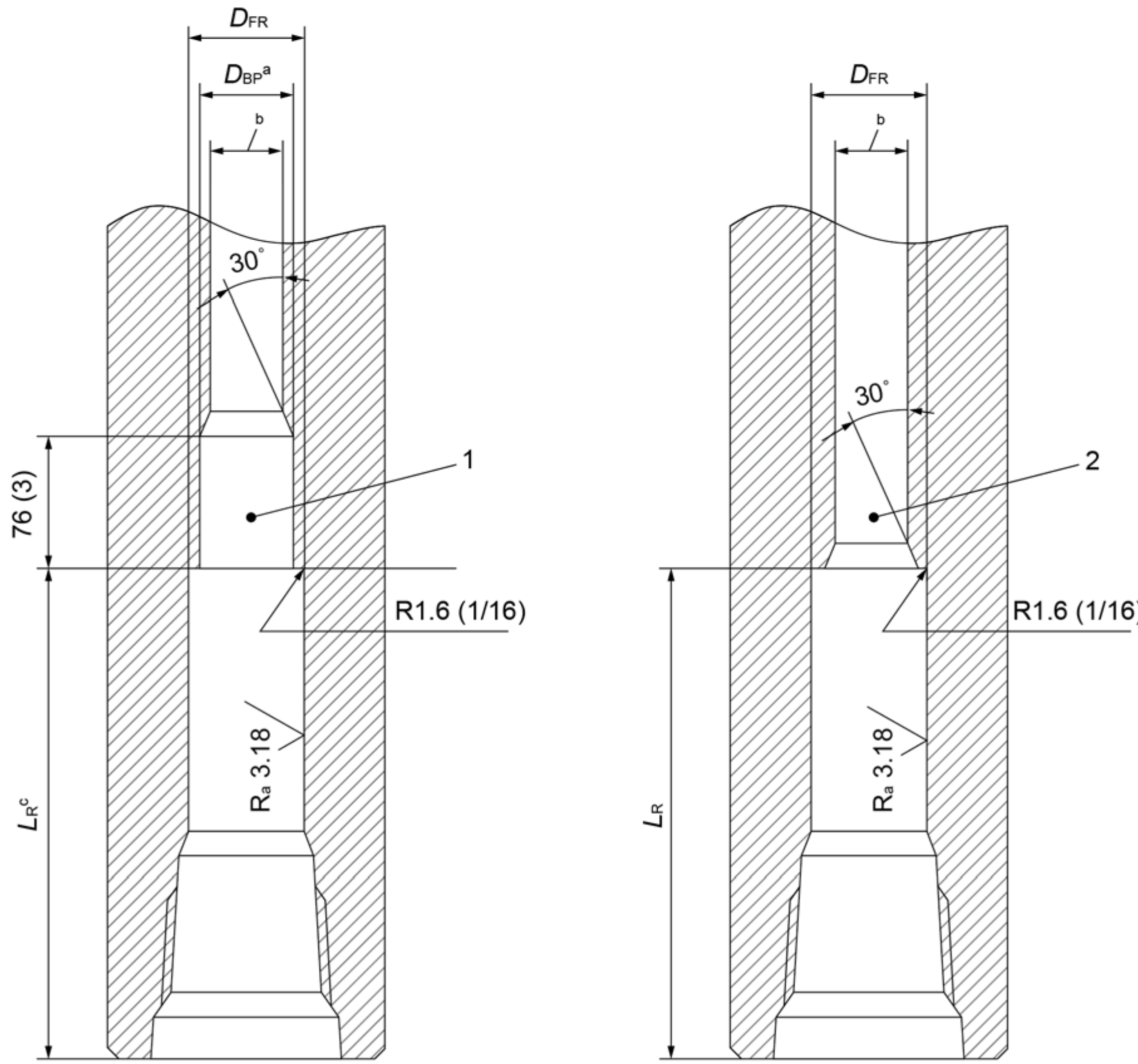
a If type A is a double-box or double-pin sub, the overall length shall be 915 mm (36 in.) minimum.
b If type B is a double-box or double-pin sub, the overall length shall be 1220 mm (48 in.) minimum.
c See Table 10 for function of sub.

Figure 5—Drill Stem Subs (Types A, B, and C)



NOTE See Table C.12 (Table D.12) for dimensions.

Figure 6—Lift Subs (Type D)



a) Sub with baffle plate

b) Sub without baffle plate

Dimensions in millimeters (inches)

Key

1 with baffle plate recess
2 without baffle plate recess

[a] If diameter D_{BP} is the same as or smaller than bore, then disregard.
[b] The ID of drill collar or sub and the ID of the bit pin shall be small enough to hold valve assembly.
[c] $L_R = L_{FV}$ + length of rotary shouldered pin + 6.4 mm (+ 1/4 in.).

NOTE See Table C.13 (Table D.13) for dimensions.

Figure 7—Float Valve Recess in Bit Subs

8 Drill Collars

8.1 General

8.1.1 Size

Standard steel drill collars shall be furnished in the sizes and dimensions shown in Table C.14 (Table D.14) and illustrated in Figure 8.

Non-magnetic drill collars shall be furnished in the sizes and dimensions shown in Table C.14 (Table D.14) or Table C.21 (Table D.21), with the exceptions noted in 8.3.1.

8.1.2 Outside Diameter Tolerances

The outside diameter shall comply with the tolerances of Table C.15 (Table D.15).

8.1.3 Bores

All drill collar bores shall be gauged with a drift mandrel 3.05 m (10 ft) long minimum. The drift mandrel shall have a minimum diameter equal to the bore diameter (d), see Table C.14 or Table D.14, minus 3.2 mm ($^{1}/_{8}$ in.).

8.1.4 Surface Finish

8.1.4.1 Standard Steel

The minimum external surface finish shall be hot-rolled and mill-finished. Workmanship shall comply with ASTM A434. Surface imperfection removal shall comply with Table C.16 (Table D.16).

8.1.4.2 Non-magnetic

Non-magnetic bars and tubes shall have the outside surface machine-turned or ground to 100 % clean-up. Surface imperfection removal shall comply with Table C.16 (Table D.16).

8.1.5 Straightness

The external surface of drill collars shall not deviate from a straight line extending from end to end of the drill collar, when the straight line is placed adjacent to the surface, by more than 0.5 mm/m ($^{1}/_{160}$ in./ft) of drill collar length.

EXAMPLE—On a drill collar of length 9.14 m (30 ft), the maximum permitted deviation from a straight line is: 9.14 × 0.5 = 4.6 mm (30 × $^{1}/_{160}$ = $^{3}/_{16}$ in.).

8.1.6 Non-destructive Examination

Each bar or tube used to manufacture drill collars shall be examined for both surface and internal defects in accordance with Section 12.

8.1.7 Connections

8.1.7.1 Size and Type

8.1.7.1.1 Standard Steel Drill Collars

Standard steel drill collars shall be furnished with box-up and pin-down connections in the sizes and styles stipulated for the OD and ID combinations listed in Table C.14 (Table D.14). The connections shall conform to the dimensional and gauging requirements of API 7-2.

8.1.7.1.2 Non-magnetic Drill Collars

Non-magnetic drill collars shall be permitted for use as drill-stem-type collars or as bottom-hole-type collars.

Drill-stem-type non-magnetic drill collars shall be furnished with box-up and pin-down connections in the sizes and styles stipulated for the OD and ID combinations listed in Table C.14 (Table D.14) or Table C.21 (Table D.21). The connections shall conform to the dimensional and gauging requirements of API 7-2.

Bottom-hole non-magnetic drill collars shall be furnished with upper box connections in the sizes and styles stipulated for the OD and ID combinations listed in Table C.14 (Table D.14) or Table C.21 (Table D.21) and with lower box connections as listed in Table C.20 (Table D.20). Both the upper and lower connections shall conform to the dimensional and gauging requirements of API 7-2.

8.1.7.2 Connection Stress-Relief Features

Stress-relief features, when specified, shall conform to API 7-2.

The surfaces of stress-relief features shall be free of sharp-bottomed tool marks, pitting and steel stencil impressions.

NOTE 1 Where fatigue failures at points of high stress are a problem, stress-relief features may be provided.

The stress-relief feature for box connections shall be the boreback design or the box relief groove design.

NOTE 2 Stress-relief features cause a reduction in the tensile strength of the pin and the section modulus of the connection; under most conditions this reduction in cross-sectional area is more than offset by the reduction in fatigue failures.

8.1.7.3 Cold Working

8.1.7.3.1 Gauging

When cold working is performed, the method of cold working shall be in accordance with the manufacturer's written specification.

If threads are cold worked, they shall be gauged to API 7-2 requirements before cold working since gauge standoff changes after cold working of threads and can result in connections that do not fall within the specified API gauge standoff if gauged after cold working.

NOTE Cold working of thread roots is optional; where fatigue failures at points of high stress are a problem, cold working may be provided.

8.1.7.3.2 Marking

Connections shall also be stamped with a circle enclosing "CW" to indicate cold working after gauging. The mark shall be located on the connection as follows:

a) pin connection—at the small end of the pin,

b) box connection—in the box counterbore.

NOTE Changes to gauge standoff do not affect the interchangeability of connections and improves connection performance; a connection may be marked as conforming to the requirements of API 7-2 if it meets the standoff requirements before cold working.

8.1.7.4 Low Torque

If the 8-$^5/_8$ Reg connection is machined on drill collars with OD larger than 266.7 mm (10-$^1/_2$ in.), the faces and box counterbores shall conform to the dimensions for low torque feature as specified in API 7-2.

8.1.8 Slip Grooves

When specified, slip grooves shall conform to the dimensions shown in Table C.22 (Table D.22) and Figure 9.

8.1.9 Surface Treatment of Threads and Sealing Shoulders

A treatment of zinc or manganese or zinc-and-manganese phosphate shall be applied to the threads and the sealing shoulders of both the upper and lower connections of magnetic drill collars. The treatment type shall be in accordance with the manufacturer's written specification.

Application of the treatment shall be after completion of all gauging.

NOTE Surface treatments of zinc or manganese or zinc-and-manganese phosphate on non-magnetic drill collars are not required.

8.2 Standard Steel Drill Collars

8.2.1 Mechanical Properties

8.2.1.1 Tensile Requirements

The tensile properties of standard steel drill collars, as manufactured, shall comply with the requirements of Table C.17 (Table D.17).

These properties shall be verified by performing a tensile test on one specimen per heat per heat treatment lot.

Tensile properties shall be determined by tests on cylindrical specimens conforming to the requirements ASTM A370, 0.2 % Offset Method.

The tensile specimen may be taken from either end of the bar or tube. The specimen shall be machined so that the center point of the gauge area is located a minimum of 101.6 mm (4 in.) from the end of the bar or tube. The tensile specimen shall be oriented in the longitudinal direction, with the centerline of the specimen located 25.4 mm (1 in.) from the outside surface or at the mid-wall radius, whichever is closer to the outside surface.

For the location of the mid-wall radius, see 7.5.3.2.

8.2.1.2 Hardness Requirements

In addition, a hardness test shall be performed on each drill collar as prima facie evidence of conformation. The hardness test shall be made on the OD of the drill collar (Brinell hardness in accordance with ASTM A370 is preferred although Rockwell C hardness is an acceptable alternative). The hardness number shall conform to the requirements of Table C.17 (Table D.17).

8.2.1.3 Impact Strength Requirements

8.2.1.3.1 General

Charpy V-notch impact tests shall be conducted on specimens conforming to the requirements of ASTM A370 and ASTM E23 and shall be conducted at a temperature of 21 °C ± 3 °C (70 °F ± 5 °F). Tests conducted at lower temperatures that meet the requirements stated in 8.2.1.3.4 are acceptable.

8.2.1.3.2 Specimens

One set of three specimens per heat per heat-treatment lot shall be tested.

Specimens shall be taken at 25.4 mm (1 in.) below the surface or at the mid-wall radius (see 7.5.3.2 for the location of the mid-wall radius), whichever is closer to the as-heat-treated outer surface.

The specimens shall be longitudinally oriented and radially notched.

8.2.1.3.3 Specimen Size

Full size specimens of 10 mm × 10 mm (0.394 in × 0.394 in.) shall be used except where there is insufficient material, in which case the next smaller standard sub-size specimen obtainable shall be used.

If it is necessary to use sub-size test specimens, the acceptance criteria shall be multiplied by the appropriate adjustment factor listed in Table C.2. (Table D.2). Sub-size test specimens of less than 5 mm (0.197 in.) are not permitted.

8.2.1.3.4 Acceptance Criteria

The average impact strength of the three specimens shall be 54 J (40 ft-lbs) or greater, with no single value less than 47 J (35 ft-lbs).

8.2.2 Hard-banding

Hard-banding of drill collars is optional. If hard-banding is specified, it shall conform to the dimensions in Figure 10.

Hard-band may be applied either in a groove (flush to the OD) or on the OD surface (raised). The type and height of the hard-band shall be agreed between the purchaser and manufacturer.

Welding shall be performed using procedures and personnel qualified in accordance with the requirements of ASME *BPVC* Section IX (section on hard-banding), including post weld heat treatment (WPS and PQR). The procedure shall identify the essential variables and non-essential variables for the welding process and the type of hard-band being applied.

The manufacturer shall qualify the welding processes and the welding operators to a specific WPQ for each WPS.

8.2.3 Marking

Standard steel drill collars conforming to this standard shall be die-stamped on the drill collar OD with the following information:

a) the manufacturer's name or identifying mark;

b) outside diameter;

c) bore;

d) connection designation;

e) "API 7-1";

NOTE The drill collar number consists of two parts separated by a hyphen; the first part is the connection number in the NC style; the second part, consisting of two (or three) digits, indicates the drill collar outside diameter in units and tenths of inches; drill collars with 209.6 mm, 241.3 mm, and 279.4 mm outside diameters are shown with 6-$^{5}/_{8}$, 7-$^{5}/_{8}$, and 8-$^{5}/_{8}$ REG connections since there are no NC connections in the recommended range of bending-strength ratios.

EXAMPLE 1—A drill collar of diameter 158.6 mm (6 $^{1}/_{4}$ in.) with 71.4 mm (2 $^{13}/_{16}$ in.) bore and NC46 connections, manufactured by AB Company, is stamped:

AB Co. (or mark) NC46-62, 71.4, API 7-1; or

AB Co. (or mark) NC46, 6.25, 2.81 API 7-1

EXAMPLE 2—A drill collar of diameter 209.6 mm (8 $^{1}/_{4}$ in.) with 71.4 mm (2 $^{13}/_{16}$ in.) bore and 6-$^{5}/_{8}$ Reg connections, manufactured by AB Company, is stamped:

AB Co. (or mark) 209.6, 71.4, 6-$^{5}/_{8}$ REG API 7-1; or

AB Co. (or mark) 8.25, 2.81, 6-$^{5}/_{8}$ REG API 7-1

8.3 Non-magnetic Drill Collars

8.3.1 Dimensional Requirements

8.3.1.1 Length Tolerance

The length tolerance for non-magnetic drill collars shall be $^{+152.4}/_{0}$ mm ($^{+6.0}/_{0}$ in.).

8.3.1.2 Bore Eccentricity

The maximum bore eccentricity shall be 2.39 mm (0.094 in.) at the collar ends. The center eccentricity shall not exceed 6.35 mm (0.250 in.).

NOTE The purpose of the eccentricity specification in the center of a non-magnetic collar is to ensure reasonably accurate alignment of a survey instrument with the drill collar axis; eccentricity in the center does not have a significant effect on the torsional or tensile strength of the collar.

8.3.2 Mechanical Properties

8.3.2.1 Tensile Requirements

The tensile properties of non-magnetic drill collars shall comply with the requirements of Table C.18 (Table D.18).

These properties shall be verified by performing one tensile test on each full-length bar.

Tensile properties shall be determined by tests on cylindrical specimens conforming to the requirements of ASTM A370, 0.2 % Offset Method.

The tensile specimen may be taken from either end of the bar or tube. The specimen shall be machined so that the center point of the gauge area is located a minimum of 65 mm (2.6 in.) from the end of the bar or tube. The tensile specimen shall be oriented in the longitudinal direction with the centerline of the specimen located 25.4 mm (1 in.) from the outside surface or at the mid-wall radius, whichever is closer to the outside surface (see 7.5.3.2 for the location of the mid-wall radius).

8.3.2.2 Hardness Requirements

In addition, a hardness test shall be performed on each drill collar for information only. Correlation between hardness and material strength is not reliable. The hardness test shall be made on the outside diameter of the drill collar in accordance with ASTM A370 and ASTM E10 for Brinell hardness tests or ASTM A370 and ASTM E18 for Rockwell C hardness tests.

8.3.2.3 Impact Strength Requirements

8.3.2.3.1 General

Charpy V-notch impact tests shall be conducted on specimens conforming to the requirements of ASTM A370 or ASTM E23 and shall be conducted at a temperature of 21 °C ± 3 °C (70 °F ± 5 °F).

Tests conducted at lower temperatures that meet the requirements stated in Table C.19 (Table D.19) are acceptable.

8.3.2.3.2 Specimens

A minimum of one specimen per bar shall be tested, with a minimum of three specimens from each heat. Specimens shall be taken at 25.4 mm (1 in.) below the outside surface or at mid-wall, whichever is closer to the outside surface. The specimen shall be longitudinally oriented and radially notched. See 7.5.3.2 for the definition of mid-wall.

8.3.2.3.3 Specimen Size

Full size specimens of 10 mm × 10 mm (0.394 in. × 0.394 in.) shall be used unless the expected impact energy can exceed the calibrated rating of the machine. In this case, sub-size specimens down to half size 10 mm × 5 mm (0.394 in. × 0.197 in.) may be used. The absorbed energy requirement is not changed.

8.3.2.3.4 Acceptance Criteria

The required impact energy shall conform to the requirements in Table C.19 (Table D.19).

8.3.3 Magnetic Properties

8.3.3.1 Measurements of Relative Magnetic Permeability

Drill collars shall have a relative magnetic permeability less than 1.010. Each certification of relative magnetic permeability shall identify the test method. The manufacturer shall also state whether tests have been performed on individual collars or on a sample that qualifies a product lot. One lot is defined as all material from the same heat processed at one time.

8.3.3.2 Field Gradient Measurement

The magnetic field in the bore of new drill collars shall exhibit deviation from a uniform magnetic field not exceeding ± 0.05 µT. This shall be measured with a magnetoscope and differential field probe having its magnetometers oriented in the axial direction of the collar. A record showing the differential field along the entire bore of the collar shall be part of the certification of each collar.

8.3.4 Intergranular Corrosion Resistance Requirements (for Austenitic Stainless Steel Drill Collars)

8.3.4.1 Microstructure Tests and Requirements

Resistance to corrosion shall be demonstrated by testing a sample of the raw material for each non-magnetic drill collar.

a) A test sample shall be taken from a point 25.4 mm (1.0 in.) or deeper below the outside surface.

b) This test sample shall be in the same condition as the collar (i.e. not heated to increase grain boundary carbide precipitation).

c) The test sample shall be polished on a longitudinal plane and etched in accordance with ASTM A262, Practice A.

d) The microstructures “step” and “dual” shall be accepted without further corrosion testing in accordance with the ASTM A262 figures for step and dual structures, respectively.

e) A collar with “ditch” microstructure shall be further tested in accordance with ASTM A262, both the ditch structure and Practice E, and accepted only when it passes Practice E.

For Practice E, the test specimen may have at the discretion of each supplier, an axial orientation, taken 25.4 mm (1.0 in.) or deeper below the outside surface, or the test specimen may have a tangential orientation, in which case its midpoint shall be 25.4 mm (1.0 in.) or deeper below the outside surface.

8.3.4.2 Compressive Treatment

Some environmental conditions may cause stress-corrosion cracking of austenitic stainless steels, especially in regions where the manufacturing process creates tensile residual stress. Non-magnetic drill collars made from austenitic stainless steel containing over 12 % chromium shall be treated on the ID surface to generate a layer at least 1 mm (0.040 in.) deep with compressive residual stress.

8.3.5 Marking

Non-magnetic drill collars conforming to this standard shall be die-stamped with the following information:

a) the manufacturer’s name or identifying mark;

b) outside diameter;

c) bore;

d) non-magnetic identification (non-magnetic drill collar NMDC);

e) connection designation;

f) “API 7-1”.

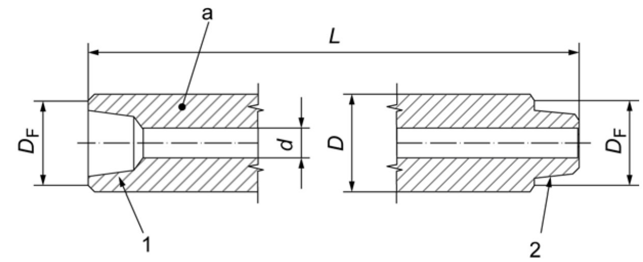
NOTE The drill collar number consists of two parts separated by a hyphen; the first part is the connection number in the NC style; the second part, consisting of two (or three) digits, indicates the drill collar outside diameter in units and tenths of inches; drill collars with 209.6 mm, 241.3 mm, and 279.4 mm outside diameters are shown with 6-$^{5}/_{8}$, 7-$^{5}/_{8}$, and 8-$^{5}/_{8}$ REG connections, since there are no NC connections in the recommended range of bending-strength ratios.

The example below illustrates these marking requirements. Location of the markings and the application of additional markings shall be specified by the manufacturer.

EXAMPLE—A 209.6 mm (8-$^{1}/_{4}$ in.) collar, with 71.4 mm (2-$^{13}/_{16}$ in.) bore, manufactured by AB Company, is stamped:

— AB Co. (or mark) 209.6, 71.4, NMDC, 6-$^{5}/_{8}$ REG, API 7-1; or

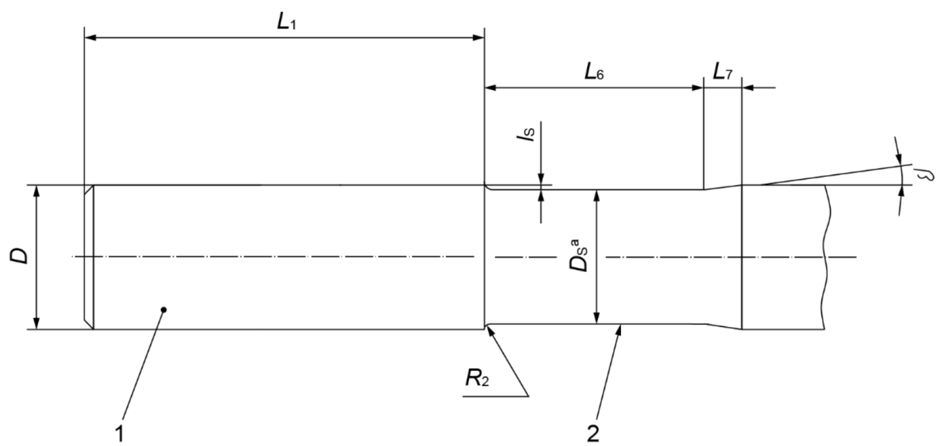
— AB Co. (or mark) 8.25, 2.81, NMDC, 6-$^{5}/_{8}$ REG, API 7-1



Key
1 rotary box connection
2 rotary pin connection

a See Table C.14 (Table D.14) and Table C.20 (Table D.20) for dimensions.

Figure 8—Drill Collars



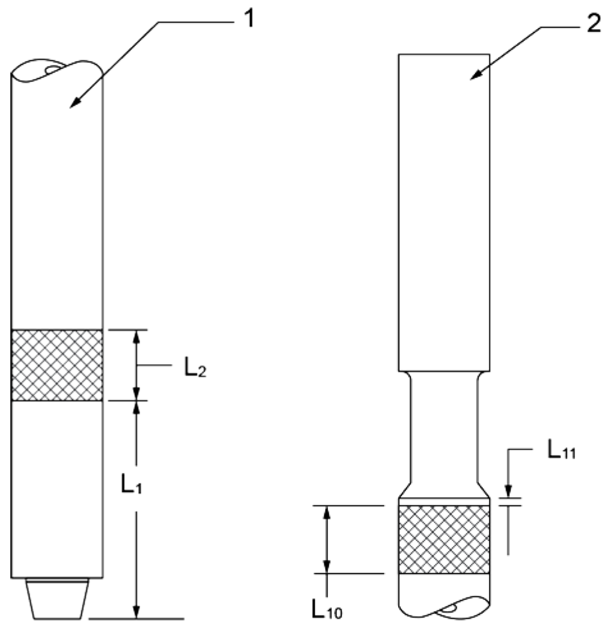
L_1	L_6	L_7	R_2
1067 Ref (42 Ref)	$457\ ^{+51}_{0}$ $(18\ ^{+2}_{0})$	76 Ref (3 Ref)	25.4 Ref (1 Ref)

Key
1 box end
2 slip groove

a $D_S = D - 2 \times l_S$

NOTE Dimensions in millimeters (inches); see Table C.22 (Table D.22) for other dimensions.

Figure 9—Drill Collar Slip Grooves



Dimensions in millimeters (inches)

L_1	L_2	L_{10}	L_{11}
762 (30)	254 (10)	254 (10)	25 (1)

Key
1 Type A - pin end
2 Type C - box end with slip recess only

Figure 10—Drill Collar Hard-band Locations

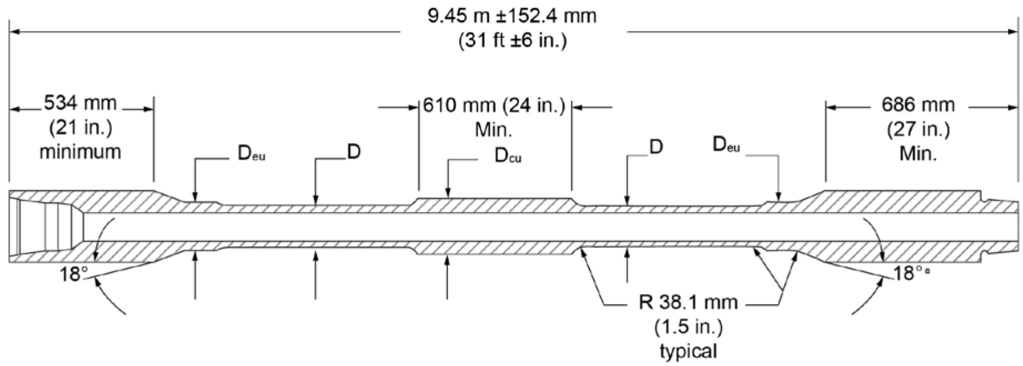
9 Heavy-weight Drill Pipe (HWDP)

9.1 General

This section covers the manufacturing specifications of heavy-weight drill pipe (HWDP). HWDP is most used in the bottom-hole assemblies. HWDP should not be confused with heavy-wall or thick-wall drill pipe manufactured to meet API 5DP; sometimes also referred to as heavy-weight drill pipe. Similarly, the tool joints in this section are different from the tool joints in API 5DP. To avoid confusion between the requirements of API 5DP and this standard, the product according to this standard shall be referred to as HWDP (the assembly of the heavy-weight drill pipe and the tool joint according to this standard).

9.2 Sizes

HWDP shall be furnished in the sizes and dimensions shown in Table C.26 (Table D.26) and as illustrated in Figure 11.



NOTE 1 All dimensions are in mm (in.) except where noted.
NOTE 2 See Table C.23 (Table D.23) for dimensions.
NOTE 3 The center upset, (or wear pad), is located approximately equal distance between box face and small end of pin.
NOTE 4 The above dimensions apply to both integral HWDP and welded HWDP.

[a] 35 degree taper on pin end at the manufacturer's option.

Figure 11—Dimensions of HWDP

9.3 Outside Diameter Tolerances

The tube and tool joint outside and inside diameter dimensions shall comply with those specified in Table C.26 (Table D.26).

9.4 Tool Joint Alignment

The maximum angular misalignment between the longitudinal axis of the tube and the longitudinal axis of the tool joint shall be 8 mm/m (0.010 in./in.) for Size 4 and smaller, and 8 mm/m (0.008 in./in.) for larger sizes. The maximum parallel misalignment between the longitudinal axis of the tube and the longitudinal axis of the tool joint shall be 3.2 mm (0.125 in.) total indicator reading. The misalignment measurements shall be taken at the approximate longitudinal mid-point of the tool joint outer diameter (also known as tong length).

9.5 Bores

All welded and integral HWDP bores shall be gauged with a drift mandrel 3.05 m (10 ft) long minimum. The minimum diameter of the drift mandrel shall not be less than the minimum drift diameter shown in Table C.23 (Table D.23). If product is drilled from each end, the match point shall be located under the center upset or wear pad.

9.6 Material Inspection Requirements

9.6.1 Integral HWDP Tube and All Tool Joints

Each bar, tool joint forging, or tube used to manufacture HWDP tool joints or integral HWDP shall be examined for both surface and internal defects in accordance with Section 12.

9.6.2 Welded HWDP Tube

Tubes shall be examined, which may occur prior to or after machining, for both surface and internal effects in accordance with Section 12.

9.6.3 Disposition of Defects

All defects discovered in drifting or inspection shall be removed, within allowable tolerances.

9.6.4 External Surface Defects

The external surface of the center upset (or wear pad) shall be hot-rolled mill finish. Hot-roll mill finish imperfections may be removed by grinding. If imperfections are removed, the depth of the removal shall comply with Table C.24 (Table D.24) and grinds shall be contoured with the surface of the upset.

External surface imperfections in machined areas of the tube OD may be blended to remove them if the depth is less than 1.59 mm ($^{1}/_{16}$ in.).

Diameter tolerances shall not be applied to localized areas of imperfection removal.

9.7 Connections

9.7.1 Size and Type

HWDP shall be furnished with box up and pin down connections listed in Table C.23 (Table D.23). The connections shall conform to the dimensional and gauging requirements of API 7-2.

Proprietary connections are not covered by this standard. when proprietary connections are specified in the purchase agreement by the user, they should be specified to conform to the mechanical properties, dimensions, marking, and gauging requirements specified by the manufacturer of the proprietary connections.

9.7.2 Connection Stress Relief Features

Connection stress relief features are optional. When specified in the purchase agreement, stress relief features complying with the dimensions specified in API 7-2 shall be provided.

The surfaces of stress relief features shall be free of stress risers such as tool marks and steel stencil impressions. Laboratory fatigue tests and tests under actual service conditions have demonstrated the beneficial effects of stress relief contours at the pin shoulder and at the base of the box thread. It is recommended that, where fatigue failures at points of high stress are a problem, stress relief features be provided.

The boreback design is the recommended relief feature for box connections. However, the box API relief groove design has been shown to also provide beneficial effects. It may be used as an alternate to the boreback design.

Stress relief features will cause a slight reduction in the tensile strength of the pin and the section modulus of the connection. However, under most conditions this reduction in cross-sectional area is more than offset by the reduction in fatigue failures. If unusually high tensile loads are expected, calculations of the effect should be made.

9.7.3 Cold Working of Thread Roots

When specified in the purchase agreement, cold working of thread roots shall be provided. Method of cold working is optional with the manufacturer.

As with stress relief features, laboratory fatigue tests and tests under actual service conditions have demonstrated the beneficial effects of cold working the thread roots of rotary shouldered connections. It is recommended that, where fatigue failures at points of high stress are a problem, cold working be provided.

If threads are cold worked, they shall be gauged to API 7-2 requirements before cold working.

Gauge stand-off will change after cold working of threads and may result in connections that do not fall within the specified gauge standoff if gauged after cold working. This will not affect the interchangeability of connections and will improve connection performance. It is therefore permissible for a connection to be marked as complying with the requirements of API 7-2 if it meets the standoff requirements before cold working. In such event, the connection shall also be stamped with a circle enclosing “CW” to indicate cold working after gauging. The mark shall be located on the connection as follows:

a) Pin connection—at the small end of the pin,

b) Box connection—in box counterbore.

9.7.4 Surface Treatment of Threads and Sealing Shoulders for Galling

Galling of rotary shouldered connections and sealing shoulders occurs frequently in field usage. Treating the shoulders and threads with a coating of zinc or manganese or zinc-and-manganese phosphate has proven to be beneficial in lessening this problem. Therefore, a treatment of zinc or manganese or zinc-and-manganese phosphate shall be applied to the threads and the sealing shoulders for all end connections of HWDP.

Application of the treatment shall be after completion of all gauging. The treatment type shall be at the discretion of the manufacturer.

9.8 Mechanical Properties

9.8.1 Tool Joints

9.8.1.1 Material

Tool joints shall be manufactured from tool joint forgings or hot-rolled steel.

9.8.1.2 Heat Treatment

Heat treatment shall be performed according to a documented procedure. The procedure shall address the permissible number of reheat treatments.

Tool joint forgings and hot-rolled steel shall be quenched and tempered for the manufacture of HWDP tool joints.

9.8.1.3 Heat-treatment Lot

When manufactured from a tool joint forging, a lot shall consist of those pin or box tool joints with the same specified dimensions that are heat treated as part of a continuous operation (or batch), and are of a single heat of steel, or from different heats that are grouped according to a documented procedure that ensures that the appropriate requirements of this standard are met.

9.8.1.4 Tensile Requirements

9.8.1.4.1 General

The tensile properties of the material used to manufacture HWDP tool joints shall comply with the requirements of Table C.25 (Table D.25).

These properties shall be verified by performing a tensile test on one specimen per heat per heat treatment lot.

Tensile properties shall be determined by tests on cylindrical specimens conforming to the requirements of ASTM A370, 0.2 % Offset Method.

Elongation shall be determined in a gauge length of 4x diameter.

9.8.1.4.2 Tensile Specimen from a Bar or Tube

The tensile specimen may be taken from either end of the bar or tube. The specimen shall be machined so that the center point of the gauge area is located a minimum of 101.6 mm (4 in.) from the end of the bar or tube. The tensile specimen shall be oriented in the longitudinal direction and the longitudinal center of the specimen shall be taken from material at or below the gauge point diameter of the connection.

9.8.1.4.3 Tensile Specimen from a Tool Joint Forging

The tensile specimen shall be removed from the pin tool joint, as in Figure 12, after final heat treatment. Specimens may be taken from semi-finished products (that is, before threading, machining, or hard-banding operations).

NOTE Compliance with the requirements for tensile properties for the tool-joint box is verified by hardness testing, as in Figure 12.

By agreement between the purchaser and manufacturer, tensile tests shall also be undertaken on box tool joints. In such cases, details of testing shall also be agreed.

The test shall be conducted using a 12.7 mm (0.500 in.) diameter round specimen.

If the pin section at the specified location is not sufficient to obtain a tensile specimen of 12.7 mm (0.500 in.) diameter, an 8.9 mm (0.350 in.) or 6.4 mm (0.250 in.) diameter specimen may be used. The largest possible diameter specimen shall be used.

If the pin section at the specified location is not sufficient to obtain a 6.4 mm (0.250 in.) diameter specimen [25 mm (1 in.) gauge length], a hardness test shall be performed on the pin tool joint in accordance with 9.8.1.5. Additionally, a tensile specimen shall be removed from the mid-wall location of the thick section of the pin tool joint, after final heat treatment. The largest possible diameter specimen shall be used.

9.8.1.4.4 Heat Control Tensile Tests for Tool Joint Forgings

When manufactured from a tool joint forging, one tensile test shall be made as a control test from each heat of steel used by the manufacturer to produce tool joint pins under this standard. A record of such tests shall be available to the purchaser.

A heat control test may also be used as a product test for the lot being tested.

9.8.1.4.5 Re-test for Bar, Tube, and Tool Joint Forging

If the initial tensile test fails to conform to the specified requirements, the manufacturer may elect to test two additional specimens from the same piece. If both additional specimens pass, the lot shall be accepted.

9.8.1.4.6 Re-test for Tool Joint Forging

If one or both additional specimens fail to conform to the requirements, the manufacturer may elect to test three additional pin tool joints from the same lot. If the specimens from all three pin tool joints conform to the requirements, the lot shall be accepted. If one or more specimens fail to conform to the requirement, the lot shall be rejected.

Rejected lots may be reheat treated and tested as new lots.

9.8.1.5 Hardness Tests for Tool-joint Box Forgings

9.8.1.5.1 Procedure

Hardness tests shall be performed at room temperature in compliance with ASTM A370 or ASTM E10 for Brinell hardness tests, and ASTM A370 or ASTM E18 for Rockwell C hardness tests.

9.8.1.5.2 Test Specimen

The specimen shall be removed from the box tool joint forging, as in Figure 12, after final heat treatment. The specimen may be taken from semi-finished products (i.e. before threading, machining, or hard-banding operations).

If the specified location for the pin tool-joint tensile test is not sufficient to obtain an acceptable tensile test specimen (see 9.8.1.4.3), a hardness test shall be performed on the pin tool joint as in Figure 12 and in conformance to 9.8.1.6.

9.8.1.5.3 Frequency of Testing

The hardness-test frequency for the tool joint shall be performed at the tensile testing frequency or 1 per 100, whichever is more frequent.

When hardness testing is required for pin tool joints due to insufficient material for tensile testing, the hardness testing of the pin tool joint shall be performed at the tensile testing frequency or 1 per 100, whichever is more frequent.

9.8.1.5.4 Heat Control Hardness Tests

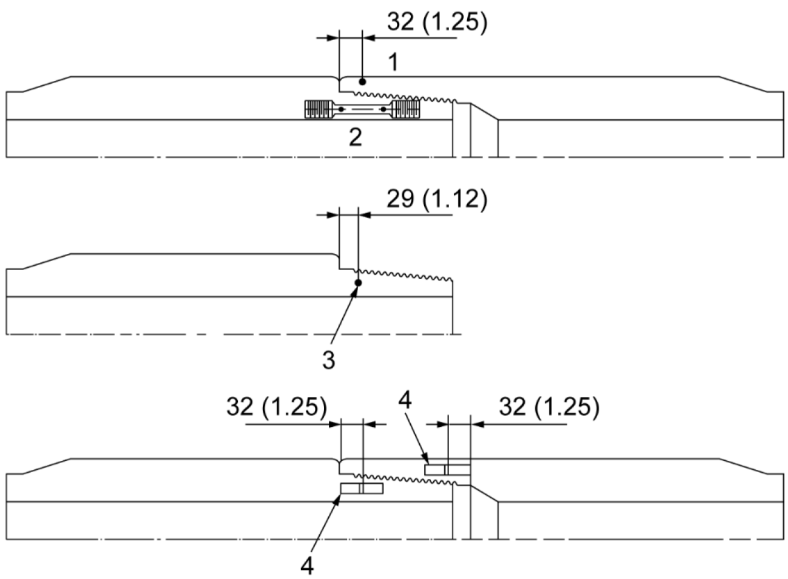
One hardness test shall be made as a control test from each heat of steel used by the manufacturer to produce tool joint boxes; and for tool joint pins if a hardness test is required for conformance in accordance with 9.8.1.4.3. A record of such tests shall be available to the purchaser.

A heat control test may also be used as a product test for the lot being tested.

9.8.1.5.5 Re-tests

Any tool joint representing a lot that fails to meet the hardness requirements may be retested. Two additional tests shall be made, one test approximately three impression diameters from one side of the original test location, and a second test approximately three impression diameters from the opposite side of the original test location. If both additional tests meet the requirements, the lot shall be accepted.

If one or both additional tests fail to conform to the requirements, the manufacturer may elect to test three additional tool joints from the same lot. If the tests on all three tool joints conform to the requirements, the lot shall be accepted. If one or more tests fail to conform to the requirement, the lot shall be rejected. Rejected lots may be reheat treated and tested as new lots.



Key
1 box hardness test location
2 pin tensile test specimen
3 pin hardness test location (when required)
4 longitudinal Charpy specimen

Figure 12—Test Specimen Location and Orientation for HWDP Tool Joints

9.8.1.6 Surface Hardness Requirements—Outer Diameter (OD)

9.8.1.6.1 General

A hardness test shall be performed on each bar, forging, or tube used to manufacture tool joints. The hardness shall conform to the requirements of Table C.25 (Table D.25). The hardness test shall be on the outside diameter of the bar, tool joint forging, or tube.

If the Rockwell C method is used the results shall be converted to Brinell for comparison to the requirement in Table C.25 (Table D.25).

9.8.1.6.2 Procedure

Hardness testing shall be performed at room temperature in compliance with ASTM A370 or ASTM E10 for Brinell hardness tests, and ASTM A370 or ASTM E18 for Rockwell C hardness tests.

9.8.1.7 Impact Strength Requirements

9.8.1.7.1 General

Charpy V-notch impact tests shall be conducted on tool joint specimens after final heat treatment, conforming to the requirements of ASTM A370 or ASTM E23 and shall be conducted at a temperature of 21 °C ± 3 °C (70 °F ± 5 °F). Tests conducted at lower temperatures that meet the requirements stated in 9.8.1.7.8 are acceptable.

9.8.1.7.2 Specimens

One set of three per heat per heat treated lot shall be tested.

The impact specimens shall be taken from material at or below the gauge point diameter of the connection. The specimen shall be longitudinally oriented and radially notched.

9.8.1.7.3 Specimen Size

Full-size specimens of 10 mm × 10 mm (0.394 in. × 0.394 in.) shall be used except where there is insufficient material; in which case the next smaller standard sub-size specimen obtainable shall be used.

If it is necessary to use sub-size test specimens, the acceptance criteria shall be multiplied by the appropriate adjustment factor listed in Table C.2 (Table D.2). Sub-size test specimens less than 5 mm (0.197 in.) are not permitted.

9.8.1.7.4 Specimens from Tool Joint Forgings

Specimens may be taken from semi-finished product (that is, before threading, machining, or hard-banding operations), and shall conform to all requirements in 9.8.1.7.

9.8.1.7.5 Heat Control Test

For tool joint forgings, one impact test shall be made as a control on each heat of steel used by the tool joint manufacturer. A record of such tests shall be available to the purchaser.

A heat control test may also be used as a product test for the lot being tested.

9.8.1.7.6 Re-test for Bar, Tube, and Tool Joint Forging

If the requirements of 9.8.1.7.8 are not met and not more than one specimen is below the minimum specimen absorbed-energy requirement, then the manufacturer may elect either to reject the lot or to retest a set of three additional specimens from the same test piece. For all three of these specimens, the absorbed energy shall be equal to or greater than the minimum average absorbed energy requirement, or the lot shall be rejected.

9.8.1.7.7 Re-test for Tool Joint Forging

If one of the additional specimens fail to conform to the requirements, the manufacturer may elect to test three additional pin tool joints from the same lot. If all the specimens from all three pin tool joints conform to the requirements, the lot shall be accepted. If one or more of the specimens from any of the three pin tool joints fails to conform to the requirement, the lot shall be rejected.

Rejected lots may be re-heat-treated and tested as new lots.

9.8.1.7.8 Acceptance Criteria

The average of the three specimens shall be 54 J (40 ft-lbs) or greater with no single value less than 47 J (35 ft-lbs).

9.8.2 Tubes

9.8.2.1 Welded HWDP Tube

Tubes shall be manufactured from normalized, normalized, and tempered or quenched and tempered seamless alloy steel, meeting the following mechanical property requirements.

a) Minimum tensile strength—655 MPa (95,000 psi)

b) Minimum yield strength—379 MPa (55,000 psi)

c) Minimum elongation—18 %

9.8.2.2 Integral HWDP Tube

The material for integral HWDP tubes shall meet the requirements of 9.8.1 of this standard.

9.9 Assembly

The design of the tool joint to tube weld shall be such that the weld is not located in the radius between the tube and tool joint taper. The design of the weld shall ensure that the strength of the weld (cross sectional area of the weld times the minimum yield strength of the weld) exceeds the strength of the tube section (minimum cross sectional area of the tube times the minimum yield strength of the tube). The welding shall be performed in accordance with a written welding procedure specification (WPS) that specifies the essential and non-essential welding variables. The welding procedure specification shall include a post-weld heat treatment to ensure that the hardness is less than 37 HRC and that the minimum weld yield strength is satisfied. The welding procedure shall be qualified by destructive testing to demonstrate that the minimum yield strength and hardness requirements of the weld are satisfied. The welding machine operators shall be qualified by documenting completion of a weld that satisfies these requirements. The manufacturer shall maintain procedure qualification records (PQR) and records of welder performance qualifications (WPQ).

Each weld zone shall be hardness tested in the heat affected zone to demonstrate the surface hardness of the weld zone is less than 37 HRC. The hardness testing method is optional with the manufacturer.

9.10 Traceability

The HWDP manufacturer shall establish and follow procedures for maintaining heat identity. The methods of maintaining identity shall be at the option of the manufacturer. These procedures shall provide means for tracing the tool joints and pipe body to the relevant heat, chemical analysis report, and specified mechanical tests results. Lot identity shall be maintained until all required lot tests are performed and conformance with specified requirements has been shown.

9.11 Marking

HWDP conforming to this standard shall be steel stencil-stamped on the taper of the pin end or on the tool joint OD or center upset or wear pad, with the manufacturer's name or mark, "API 7-1", and traceability identification. If a slot is used on the center upset or wear pad, the depth shall not be below the tube OD. Stamping shall not be done in highly stressed areas such as the radius between the tube and tool joint taper, weld line or the tube machined OD.

The example below illustrates these marking requirements.

EXAMPLE—AB Co. (or Mark) API 7-1 Traceability Identification.

9.12 Hard-banding

9.12.1 Requirements

Unless stated otherwise in the purchase agreement, hard-band may be applied on the tool joints (either flush with or raised above the OD) and center upset or wear pad (raised-type only) of HWDP; hard-banding on the 18-degree taper is optional. Figure 13 details the recommended locations and lengths of hard-band. The type of hard-banding shall be specified in the purchase agreement.

If hard-banding is applied to the tool joint, unless otherwise specified, the thickness shall be 2.4 mm $^{+0.8}/_{-0.8}$ mm (0.094 in. $^{+0.031}/_{-0.031}$ in.).

If hard-banding is applied to the center upset or wear pad, unless otherwise specified, the thickness of shall be 2.4 mm $^{+1.6}/_{-0.8}$ mm (0.094 in. $^{+0.062}/_{-0.031}$ in.).

9.12.2 Weld Qualification

Welding shall be performed using procedures and personnel qualified in accordance with the requirements of ASME *BPVC* Section IX (see section on hard-banding) that specifies the essential and non-essential welding variables. The manufacturer shall maintain procedure qualification records (PQR) and records of welder performance qualifications (WPQ).

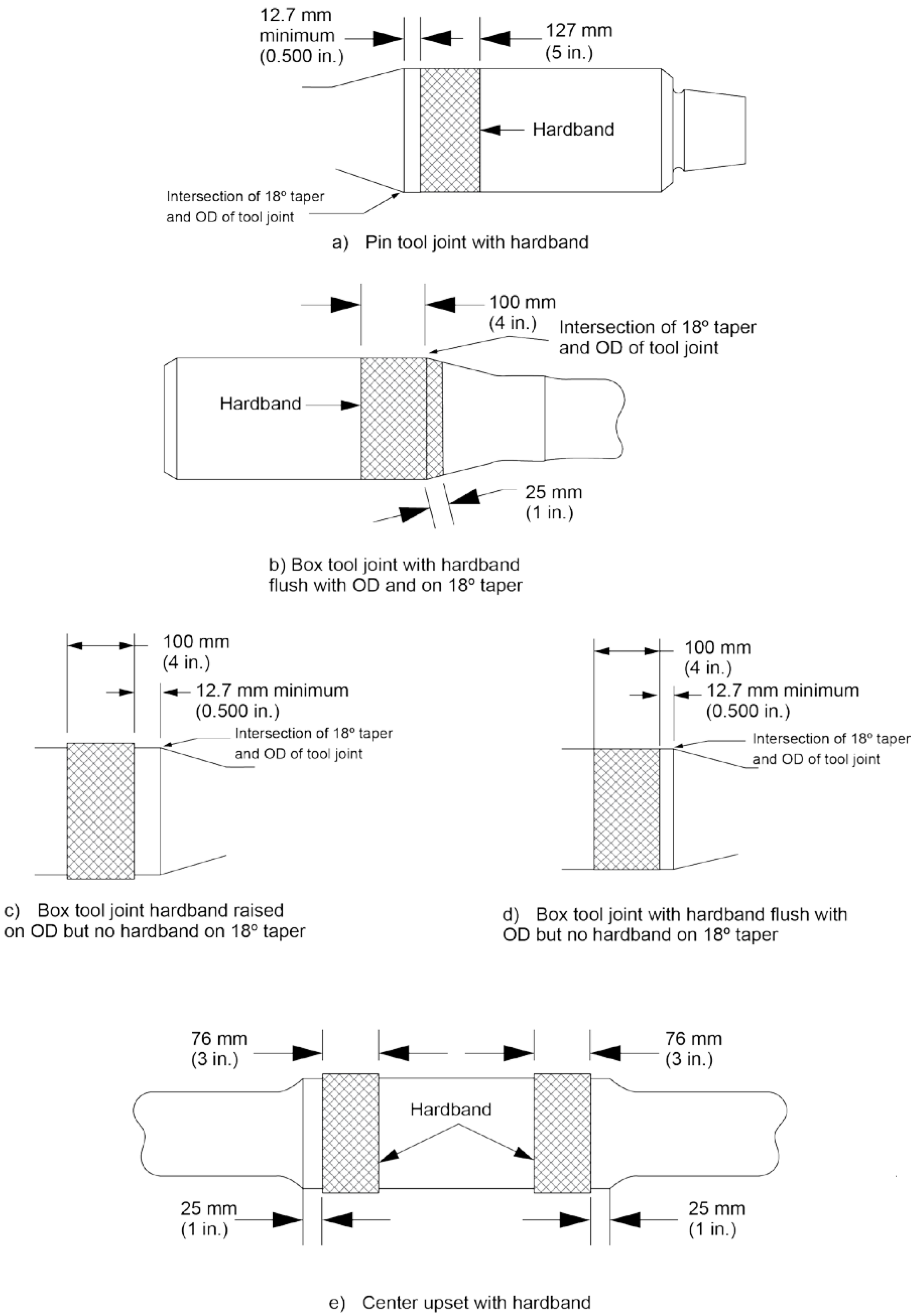


Figure 13—Recommended Hard-banding Locations on HWDP

10 Drilling and Coring Bits

10.1 Roller Bits and Blade Drag Bits

10.1.1 Size

Roller bits shall be furnished with sizes as specified on the purchase order. Blade drag bits shall be furnished in the sizes specified on the purchase order.

NOTE See API 7G for commonly used sizes for roller bits.

10.1.2 Tolerances

The gauge diameter of the cutting edge of the bit shall conform to the OD tolerances specified in Table C.26 (Table D.26).

10.1.3 Connections

Roller bits shall be furnished in the size and style of the pin connection shown in Table C.27 (Table D.27). Blade drag bits shall be furnished with the size and style of connection shown in Table C.28 (Table D.28) and shall be pin or box.

10.1.4 Marking

Bits shall be die-stamped in some location other than the make-up shoulder with the following information:

a) manufacturer's name or identification mark,

b) the bit size,

c) "API 7-1";

d) the size and style of connection.

EXAMPLE—A 200 mm (7-$^{7}/_{8}$ in.) bit with 4-$^{1}/_{2}$ REG rotary shouldered connection is stamped as follows:

— AB Co. (or mark) 200, API 7-1, 4-$^{1}/_{2}$ REG; or

— AB Co. (or mark) 7.87, API 7-1, 4-$^{1}/_{2}$ REG.

10.2 Diamond Drilling Bits, Diamond Core Bits, Polycrystalline Diamond Compact (PDC) Bits

10.2.1 Diamond Bit Tolerances

Diamond drilling bits, diamond core bits, and polycrystalline diamond compact (PDC) bits shall be subject to the OD tolerances shown in Table C.29 (Table D.29).

10.2.2 Diamond Drilling Bit and PDC Bit Connections

Diamond drilling bits and PDC bits shall be furnished with the size and style pin connection shown in Table C.30 (Table D.30). All connection threads shall be right-hand.

Because of their proprietary nature, the connections on diamond core bits are not shown.

10.2.3 Diamond Bit and PDC Bit Gauging

10.2.3.1 General

All diamond and PDC bits shall have the outer diameter inspected using the dimensional guidelines for ring gauges given in 10.2.3.2 and 10.2.3.3.

10.2.3.2 Gauge Specification

"Go" and "no-go" gauges shall be fabricated as shown in Figure 14 and as described below.

a) "Go" and "no-go" gauges shall be a ring fabricated from steel plate 25.4 mm (1 in.) thick with OD equal to the nominal bit size plus 38.1 mm ($1\text{-}^1/_2$ in.).

b) The "go" gauge ID shall equal the nominal bit size plus 0.05 mm (0.002 in.) clearance, with a tolerance of $^{+0.08}/_0$ mm ($^{+0.003}/_0$ in.).

c) The "no-go" gauge ID shall equal the minimum bit size (nominal size less maximum negative tolerance) minus 0.05 mm (0.002 in.) interference, with a tolerance of $^0/_{-0.08}$ mm ($^0/_{-0.003}$ in.).

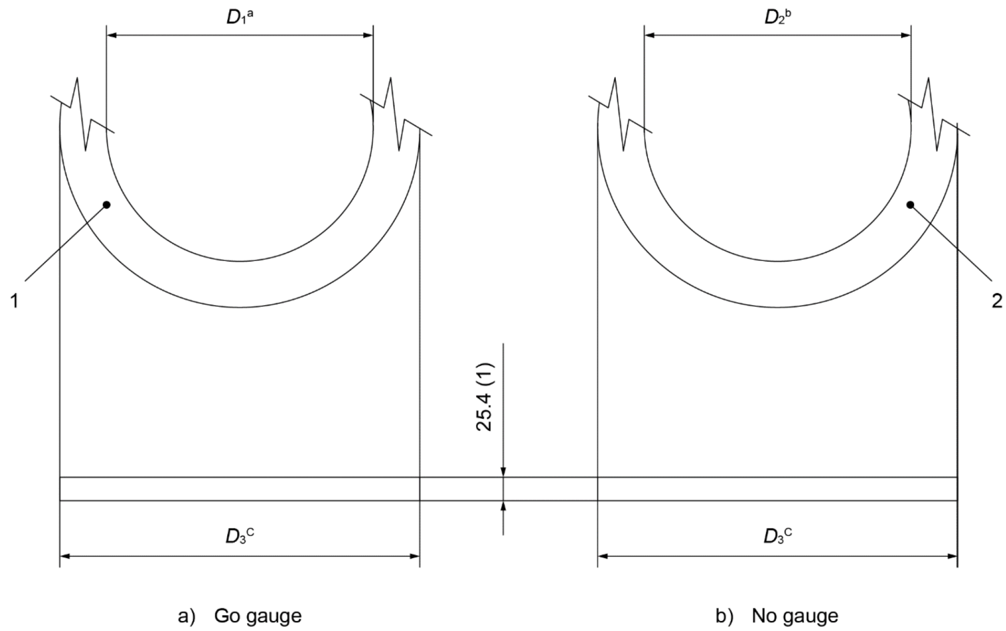
10.2.3.3 Gauging Practice

The "go" and "no-go" gauges shall be used as follows.

a) If acceptable, the product bit shall enter the "go" gauge (product not too large).

b) If acceptable, the product bit shall not enter the "no go" gauge (product not too small).

c) For accurate measurement, the temperature of both the "go" and "no-go" gauges shall be within 11 °C (20 °F) of the temperature of the bit or core-head.



Key
1 "go" gauge
2 "no-go" gauge
a D_1 = Bit size + 0.05 (+0.002). Tolerance on D_1 is +0.08 -0 (+0.003 -0).
b D_2 = Bit size – negative tolerance – 0.05 (– 0.002). Tolerance on D_2 is +0 -0.08 (+0 -0.003).
c D_3 = Nominal bit size + 38.1 (+1.5) minimum.

NOTE Dimensions shown as mm (in.).

Figure 14—Gauge Dimensions for Diamond and PDC Bits

10.2.4 Marking

Diamond drilling bits and PDC bits shall be permanently and legibly identified in some location other than the make-up shoulder with the following information:

a) the manufacturer's name or identification mark;

b) the bit size;

c) "API 7-1";

d) the size and style of connection.

EXAMPLE—A 190.5 mm (7-$^1/_2$ in.) bit with a 4-$^1/_2$ REG rotary connection is stamped as follows:

— AB Co. (or mark), 190.5, API 7-1, 4-$^1/_2$ REG; or

— AB Co. (or mark), 7.5, API 7-1, 4-$^1/_2$ REG.

Diamond core bits shall be permanently and legibly identified by die-stamping on some location other than the make-up shoulder with the manufacturer's name or identification mark and "API 7-1" as follows:

— AB Co. (or mark), API 7-1

Because of their proprietary nature, the connections on diamond core bits are not shown. The marking "API 7-1" shall indicate that the other dimensional requirements of this standard have been met.

10.3 Fixed Cutter Bits—Supplementary Requirements

10.3.1 General

This section describes supplementary requirements for fixed cutter bits that may be specified by the purchaser or agreed between purchaser and manufacturer. These requirements apply only when stated on the purchase agreement. These requirements are only applicable to polycrystalline diamond compact bits and diamond drilling bits. They do not apply to diamond core bits.

NOTE These supplemental requirements are designed to mitigate fatigue crack failures that occurred in the pin connections of small diameter (≤ 6-$^{3}/_{4}$ in. OD) fixed cutter bits; even though these requirements may be specified for any diameter bit size, they may not be as beneficial on larger diameter (> 6-$^{3}/_{4}$ in. OD) bits.

10.3.2 Supplementary Requirement 1 (SR1)—Gall-resistant Treatment of Threads and Sealing Shoulders

10.3.2.1 SR1 General Information

A gall-resistant treatment of zinc phosphate or manganese or zinc-and-manganese phosphate shall be applied to the threads and sealing shoulders of the bit's pin connection, or box connection if supplied with a box connection. Application of the treatment shall be after completion of all gauging. The treatment type shall be at the discretion of the manufacturer.

10.3.2.2 SR1 Marking

Bits treated to the requirements of SR1 shall be marked with "SR1" in addition to the marking requirements specified in 10.2.4.

10.3.3 Supplementary Requirement 2 (SR2)—Cold Rolling of Thread Roots

10.3.3.1 SR2 General Information

The thread roots shall be cold rolled. As with stress relief features, laboratory fatigue tests and tests under actual service conditions have demonstrated the beneficial effects of cold rolling the thread roots of rotary shouldered connections. Application of the cold rolling shall be after completion of connection gauging as in accordance with API 7-2.

Gauge standoff will change after cold rolling of the threads and may result in connections that do not fall within the specified gauge standoff if gauged after cold rolling. This will not affect the interchangeability of connections and will improve connection performance. It is therefore permissible for a connection to be marked as complying with the requirements of API 7-2 if it meets the standoff requirements before cold rolling. In such event, the connection shall be stamped with a circle enclosing "CW" to indicate cold rolling after gauging. The mark shall be located on the connection as follows:

a) Pin connection—at the small end of the pin,

b) Box connection—in the counterbore.

10.3.3.2 SR2 Marking

Bits treated to the requirements of SR2 shall be marked with "SR2" in addition to the marking requirements specified in 10.2.4.

10.3.4 Supplementary Requirement 3 (SR3)—Stress-relief Features

10.3.4.1 SR3 General Information

Stress-relief features shall be added to bit connections 4-$^{1}/_{2}$ REG and larger. The surfaces of stress-relief features shall be free of stress risers such as tool marks and steel stencil impressions. The stress-relief features shall conform to the dimensions specified in API 7-2.

Laboratory fatigue tests and tests under actual service conditions have demonstrated the beneficial effects of stress-relief contours at the pin shoulder and at the base of the box thread. Stress-relief features are of two basic designs: a groove on the pin and a boreback contour for boxes, or a groove on both the pins and boxes. The boreback design is the recommended relief feature for box connections. However, the box relief groove has also been shown to provide beneficial effects. It may be used as an alternative to the boreback design.

Stress-relief features cause a slight reduction in the tensile strength of the pin and the section modulus of the connection. However, under most conditions the reduction in cross-sectional area is more than offset by the reduction in fatigue failures. If unusually high tensile loads are expected, calculations of the effect should be made.

10.3.4.2 SR3 Marking

Bits treated to the requirements of SR3 shall be marked with “SR3” in addition to the marking requirements specified in 10.2.4.

10.3.5 Supplementary Requirement 4 (SR4)—Non-destructive Examination

10.3.5.1 SR4 General Information

All bit connections, after threading and any heat treating, shall be inspected via bi-directional wet fluorescent residual magnetic particle method for longitudinal and transverse imperfections/cracks both on the inside and outside surfaces in accordance with ASTM E3024. Internal surfaces of connections with ID bores 50.8 mm (2 in.) in diameter or smaller are exempt from this requirement. Inspection shall include the stress relief features. Outside inspection shall include the entire connection thread area from pin end or box end shoulder, up to and including the bit shank area. Evaluate all crack-like indications to verify that they are cracks. All bits found to have cracks shall be rejected.

10.3.5.2 SR4 Marking

Bits treated to the requirements of SR4 shall be marked with “SR4” in addition to the marking requirements specified in 10.2.4.

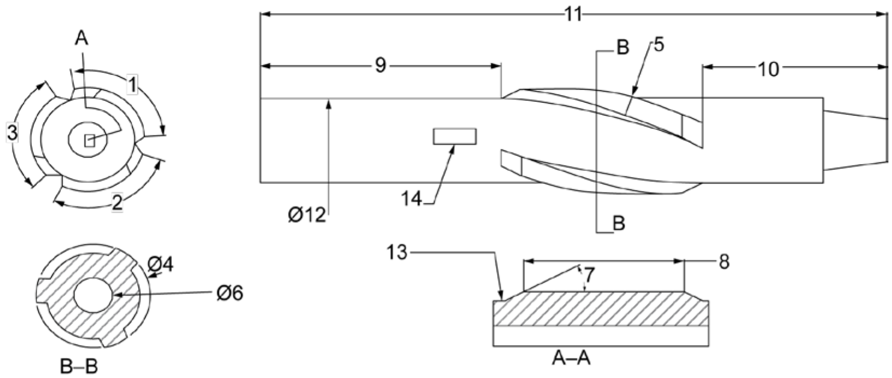
10.3.6 Supplementary Requirement 5 (SR5)—Make-up Torque

The manufacturer shall provide the recommended make-up torque for any bit manufactured to these supplementary requirements (SR1 to SR4).

11 Stabilizers

11.1 General

This section applies to drill stem stabilizers and near-bit stabilizers, with either integral-body or welded-blade construction. The important dimensions of stabilizers are defined in Figure 15.



Key
1 + 2 + 3 Wrap angle
4 Blade diameter
5 Blade width
6 Inside diameter
7 Blade taper angle
8 Crown length
9 Upper neck length
10 Lower neck length
11 Overall length
12 Neck diameter
13 Radius, 25 mm (1 in.) minimum, 2 places
14 Marking recess

Figure 15—Measurement Definitions for Stabilizers

11.2 Material Requirements

11.2.1 General

Stabilizers may be made from standard steel or non-magnetic stainless steel. Standard steel shall be used unless non-magnetic material is specified. Integral-body stabilizers or the core of welded-blade stabilizers made from standard steel shall be quenched and tempered full-length.

11.2.2 Neck Regions

11.2.2.1 Tensile Requirements

The neck regions of an integral stabilizer and the core of a welded-blade stabilizer shall have tensile properties equal to those of drill collars of the same size, as detailed in Table C.17 (Table D.17) or Table C.18 (Table D.18) of this standard.

11.2.2.2 Impact Energy Requirements

The neck regions shall also meet the impact energy requirement of 8.2.1.3 or 8.3.2.3.4 of this standard.

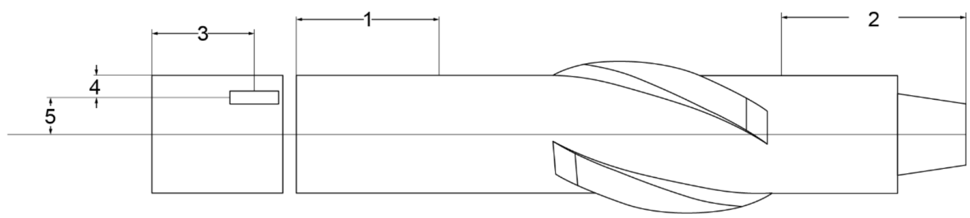
Testing of standard steel stabilizers is required on each heat per heat treatment lot.

11.2.2.3 Special Testing Requirements of Integral Stabilizers

For an integral-blade stabilizer, the tensile and impact specimens shall be taken from a prolongation of either neck, with the center of the specimen at least 101.6 mm (4 in.) from a free end and at least 25.4 mm (1 in.) below the finished surface of the neck, as shown in Figure 16. The prolongation shall be the same diameter as the neck at the time of heat treatment. The uniform region shall extend for at least 400 mm (16 in.) from each end of the finished stabilizer or to within 25.4 mm (1 in.) of the stabilizer blades, whichever is less, as shown in Figure 16. The extent of the area of controlled properties shall be verified by Brinell hardness testing of the neck outside diameter with a minimum hardness of 285 HBW.

When standard steel material is heat treated as a forging or bar, without knowledge of the final neck diameter, the sampling location shall be determined by the largest diameter of the forging or the diameter of the bar.

In all cases, the radius of the sample location shall be reported.



Key
1, 2 Zone of uniform hot working heat treatment or warm forging
3 Distance from end of forging or bar for mechanical sample
4 Depth below surface of finished neck for mechanical sampling
5 Radius of sampling for forging or raw bar
6 Prolongation

Figure 16—Sampling Locations

11.2.2.4 Traceability

The manufacturer shall establish and follow procedures for maintaining material identity. The methods of maintaining identity shall be at the option of the manufacturer. These procedures shall provide means for tracing the stabilizer body to the relevant heat, chemical analysis report, and specified mechanical test results.

11.2.3 Body Regions

An integral-blade stabilizer shall be machined from a single piece of material. The core and necks of a welded-blade stabilizer shall be machined from a single piece of material. The material shall be inspected for defects according to Section 12 and shall meet the acceptance criteria as defined therein. Mechanical testing shall only be required for the neck region as defined above.

11.3 Blade Welding

For welded-blade stabilizers, there shall be a documented welding procedure (WPS and PQR) for the welding of blades to the stabilizer core, and welders or welding machines shall have documented qualification (PQR) to this procedure. The welds shall be inspected using a documented procedure of non-destructive evaluation.

NOTE Transverse welding at the ends of blades is not recommended.

11.4 Abrasion Protection

The crown surface of the stabilizer shall be provided with protection against abrasion. The protection method is optional to the manufacturer unless specified by the purchaser and is outside the scope of this standard. However, a documented procedure for applying this protection shall exist (WPS for welded hard-facing), and welders or welding machines shall have documented qualification (PQR) to this procedure.

11.5 Dimensional Requirements

11.5.1 General

The following dimensional requirements apply to all stabilizers covered by this standard.

11.5.2 Neck Length

The length of upper and lower necks shall be as indicated in Table C.32 (Table D.32).

11.5.3 Neck Diameters

Upper and lower neck diameter shall be as described in Table C.33 (Table D.33); Figure 17 and Figure 18 are referenced by Table C.33 (Table D.33). Tolerances shall be the same as those defined for drill collars in Table C.15 (Table D.15).

11.5.4 Blade Dimensions

The blade diameter, length and number shall be as indicated in Table C.34 (Table D.34).

11.5.5 On Gauge Blade Diameter

For a gauge stabilizer, the blade diameter shall be defined using a ring gauge of the same dimensions as the bit no-go gauge of 10.2.3.1 for the given nominal diameter. Other measuring methods may be used, with the ring gauge as arbiter in case of dispute. The diametrical clearance to this gauge shall be 0 mm to 0.76 mm (0 in. to 0.03 in.).

11.5.6 Blade Spiral

The spiral shall be as defined on the purchase order and interpreted according to Table C.35 (Table D.35). Unless otherwise specified, the spiral shall be right-hand.

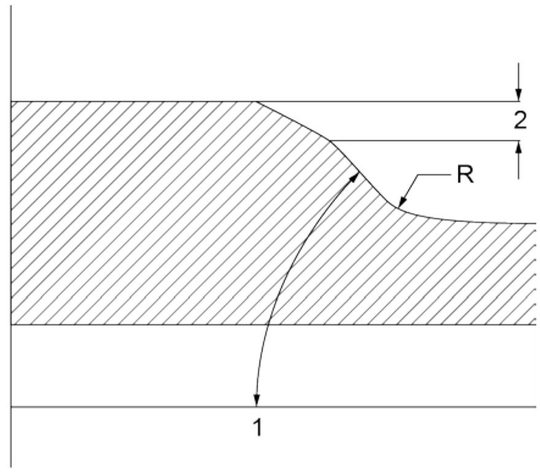
11.6 Connections and Bevel Diameters

11.6.1 Size and Type

The connections shall be as described in Table C.14 (Table D.14). The bevel diameters for the upper connection of all stabilizers and for the lower connection of drill stem stabilizers shall be the same as those defined in Table C.14 (Table D.14). The bevel diameter for the lower connection of near-bit stabilizers shall be as defined in Table C.20 (Table D.20) for a bit sub.

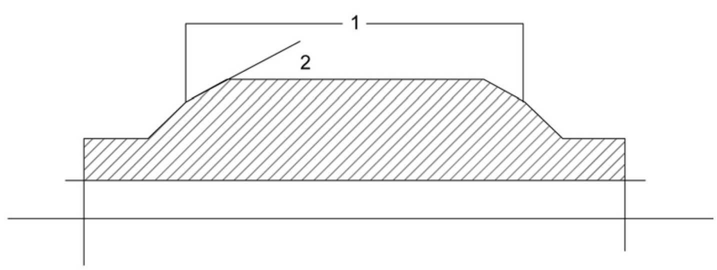
11.6.2 Gall Resistant Treatment of Threads and Sealing Shoulders

For standard steel stabilizers, a gall-resistant treatment of zinc or manganese or zinc-and-manganese phosphate shall be applied to the threads and sealing shoulders of both the upper and lower connections. Application of the treatment shall be after completion of all gauging. The treatment type shall be at the discretion of the manufacturer.



Key
1 Increased taper angle
2 Depth to start of increased taper angle

Figure 17—Blade Taper Geometry



Key
1 Crown length definition for watermelon geometry
2 Typical crown taper of watermelon geometry

Figure 18—Watermelon Geometry

11.7 Customer Information

11.7.1 Required Information from Customer

The following shall be provided by the customer:

a) stabilizer type: drill stem or near-bit,

b) integral or welded,

c) stabilizer (blade) diameter,

d) wrap: tight spiral, full spiral, open spiral or straight, and

e) neck size and connection.

11.7.2 Optional Requirements

The following may be required by the customer:

a) connection stress relief features, in accordance with API 7-2,

b) connection cold working,

c) connection surface treatment (optional for non-magnetic only),

d) non-magnetic,

e) abrasion protection type,

f) left hand spiral, and/or

g) float valve recess on near-bit stabilizer.

11.8 Marking

The following information shall be marked on a marking recess with steel stamps or milled lettering a minimum of 6 mm (0.25 in.) in height; this recess shall be located on the upper neck within 101.6 mm (4 in.) of the stabilizer blades, as shown in Figure 15.

a) Manufacturer name or mark

b) Blade diameter (add “NM” for a non-magnetic stabilizer)

c) “API 7-1”;

d) Upper Connection size and style

e) Internal diameter

f) Serial number

g) Lower Connection size and style

EXAMPLE 1—A 447.7 mm (17-5/8 in.) stabilizer, with 76 mm (3 in.) bore, manufactured by AB Company, is stamped:

— AB Co. (or mark) 447.7, API 7-1;

— 6-5/8 REG, 76, Serial No., 6-5/8 REG; or

— AB Co. (or mark), 17-5/8, API 7-1;

— 6-5/8 REG, 3, Serial No. 6-5/8 REG.

EXAMPLE 2—A 209.5 mm (8-1/4 in.) non-magnetic stabilizer, with 71.4 mm (2-13/16 in.) bore, manufactured by AB Company, is stamped:

— AB Co. (or mark), 209.5 NM, API 7-1;

— NC50, 71.4, Serial No. NC50; or

— AB Co. (or mark), 8-1/4 NM, API 7-1;

— NC50, 2-13/16, Serial No. NC50.

12 Non-destructive Examination (NDE) of Bars and Tubes

12.1 General

12.1.1 Drilling and Coring Bits

Drilling and coring bits, when manufactured without a longitudinally centralized bore (hole), shall be exempt from conformance to the requirements of this section.

12.1.2 Bars and Tubes Examination

12.1.2.1 General

All bars and tubes shall be examined for both surface-breaking and totally enclosed internal defects. Examination for surface-breaking defects for non-magnetic bars and tubes is not required if the surface has been machined.

12.1.2.2 Products Not Requiring a Machined OD Surface

BHA tools are typically manufactured from standard steel bars and tubes. Many BHA tools do not require a machined OD surface. Therefore, those products which do not require a machined OD surface may exhibit a surface condition characteristic of a “hot-rolled mill finish”. As a result, the bar surface may contain imperfections that typically prove shallow and non-injurious.

12.1.2.3 Defects

Only imperfections exceeding the limits specified in Table C.16 (Table D.16) shall be identified as defects.

12.1.3 NDE Equipment Calibration

NDE equipment calibration shall be performed in accordance with ASTM E543.

12.1.4 NDE Inspection Procedure

The NDE inspection shall be performed according to a written procedure developed by the inspection facility.

12.2 Timing of Inspection

Non-destructive examination shall take place after final heat treatment. Heat treatment is defined as where the standard wrought steel is raised to an elevated temperature above AC1 and then rapidly cooled and tempered to obtain its final microstructure and mechanical properties. In this context, the addition of metal by spot welding or application of hard-facing, stress relieving, or secondary tempering shall not be identified as a part of the heat treat process.

12.3 Retention of Records

12.3.1 Retention Period

The manufacturer of products within the scope of this specification shall maintain records for a minimum of five years, and provide upon request from the purchaser, documentation of the non-destructive examination performed.

12.3.2 Retention Responsibility

The manufacturer of products shall be responsible for ensuring that the inspection provider adheres to the requirements of this standard.

12.4 Certification and Qualification of NDE Personnel

12.4.1 Certification Program of NDE Personnel

The inspection facility used to inspect bars and tubes shall develop a program for the certification of NDE personnel. As a minimum, ASNT SNT-TC-1A or ISO 9712 shall be the basis for certification of NDE personnel.

12.4.2 Retention of NDE Training Records

The administration of the NDE personnel certification program shall be the responsibility of the inspection facility. The inspection facility shall retain records of each inspectors training and qualification for a minimum of five years after the last inspection performed, starting from the date of the inspector's first qualification at that facility.

12.4.3 Qualification and Certification of NDE Personnel

All NDE operations (except visual inspection) referred to in this standard shall be conducted by NDE personnel qualified and certified in accordance with ISO 11484, ISO 9712, ASNT ACCP, or ASNT SNT-TC-1A.

12.4.4 Demonstration of NDE Method and Procedure Capability

It shall be the responsibility of the provider of the inspection service to demonstrate that the method and procedures are capable of detecting imperfections limited in depth in accordance with Table C.16 (Table D.16).

12.5 Methods Capable of Finding Surface-breaking Imperfections

12.5.1 Ultrasonic Examination Method (UT)

Each bar or tube shall be inspected full length with 360° overlapping scans for surface-breaking imperfections. Ultrasonic examination (UT) is the preferred method for inspection of the inside surface of tubes. The straight beam method is not acceptable for finding surface-breaking defects. The examination shall be performed in accordance with ISO 10893 or ASTM E213 (longitudinal) and ASTM E213 (transverse).

12.5.2 Eddy Current Examination Method (ECT)

The eddy current examination (ECT) method may be used for inspection of the outside surface of bars and tubes. When this method is used, each bar or tube shall be inspected full-length with 360° overlapping scans for surface breaking imperfections. The examination shall be performed in accordance with ISO 10893 or ASTM E309.

12.5.3 Magnetic Particle Examination (MT)

Magnetic particle (MT) inspection of the outside surface should be limited to peeled or machined surfaces. The examination shall be performed in accordance with ISO 10893-5 or ASTM E3024.

12.5.4 Liquid Penetrant Examination (PT)

12.5.4.1 PT for Inspection of the Outside Surface of Non-magnetic Bars

If the liquid penetrant examination method (PT) is used for inspection of the outside surface of non-magnetic bars, the full-length of each bar or tube shall be inspected by either the fluorescent (Type I), or visible (Type II), water-washable (Method A), or solvent-removable (Method C), liquid penetrant method. Examination shall be performed in accordance with ASTM E165 and using one of the following: ASTM E1209 (fluorescent-water), ASTM E1219 (fluorescent-solvent), ASTM E1220 (visible-solvent), ASTM E1418 (visible-water-washable), or use ISO 3452.

12.5.4.2 Surface Condition of Product for PT Inspection

The effectiveness of liquid penetrant examination is relative to the surface condition of the product to be examined and is most effective on peeled or machined surfaces. Hot-rolled mill finished surfaces shall be cleaned to assure the dye can enter the voids.

12.5.5 Other Methods

12.5.5.1 Other Methods Demonstrated Capability

Other methods may be used by agreement between the customer and supplier providing it has been demonstrated that the system and procedures are capable of detecting indications described in Table C.16 (Table D.16).

12.5.5.2 Other Methods Requirements

Other methods shall meet the requirements of 12.4.1, 12.4.2, and 12.4.4.

12.6 Evaluation of Surface Breaking Imperfections (Prove-up)

12.6.1 Prove-up

Prove-up is required for all surface-breaking imperfections detected by MT or PT.

12.6.2 Prove-up by Grinding

12.6.2.1 General

Prove-up of an outside surface-breaking imperfection shall consist of grinding to the bottom of the imperfection, measuring the depth after grinding, and comparing the depth to the maximum allowable stock removal defined in column 2 of Table C.16 (Table D.16).

12.6.2.2 Measurement of Depth

The imperfection's depth may be measured by using a mechanical device (e.g. a depth gauge or pit gauge). The depth of removal of material by grinding or other means to facilitate measurement shall not be deeper than outlined in column 2 of Table C.16 (Table D.16).

12.6.3 Prove-up of Surface-breaking Imperfections on the Inside of Tubes

The method of prove-up of imperfections on the inside diameter of tubes is at the discretion of the manufacturer.

12.7 Acceptance Criteria for Surface-breaking Imperfections

12.7.1 Outside Surface-breaking Imperfection Acceptance Criteria—Acceptance without Stock Removal

The bar or tube shall be acceptable and used as-is if the outside surface breaking imperfection has a depth equal to or less than the depth of permissible linear imperfections max according to column 4 of Table C.16 (Table D.16).

12.7.2 Outside Surface-breaking Imperfection Acceptance Criteria—Acceptance with Stock Removal

Imperfections with depths that exceed that of 12.7.1 and that are less than or equal to the maximum allowable stock removal permitted in column 2 of Table C.16 (Table D.16) may be salvaged by completely removing the imperfection by grinding.

12.7.3 Outside Surface-breaking Imperfections—Reject Criteria

Imperfections with depths greater than the maximum allowable stock removal permitted in column 2 of Table C.16 (Table D.16) shall be rejected.

12.7.4 Remediation of Surface after Imperfection Removal by Grinding

After grinding, all abrupt changes in wall thickness caused by material removal during prove-up shall be blended to approximately restore the round appearance of the bar or tube.

Diameter tolerances shall not be applied to localized areas of imperfection removal.

12.7.5 Welding Repair of Defects

Repair welding of defects in bars and tubes is not permitted; excluding welded hard-banding.

12.7.6 Surface-breaking Blemishes Caused during the Testing and Traceability Process

Surface-breaking blemishes that are required by the manufacturing process are not to be identified as defects and shall not be cause for rejection.

This includes, but is not limited to:

a) Brinell hardness slots and the ball indentions for testing; Brinell hardness slots shall not exceed the limits in column 3 of Table C.16 (Table D.16).

b) Serial number slots for traceability and other machined features shall not be rejected.

12.8 Methods Used to Find Non-surface Breaking Imperfections

12.8.1 General

The entire volume of each bar or tube shall be volumetrically inspected full-length by ultrasonic examination method (UT) with 360-degree scan and with a minimum of 10 % overlap; and shall be prior to machining operations that limit effective interpretation of the results of the examination.

12.8.2 UT of Hot-worked Parts

Ultrasonic examination of hot-worked parts shall be performed in accordance with the procedures specified in ASTM A388/388M or equivalent.

12.8.3 UT of Non-magnetic Bars and Tubes

Inspection of non-magnetic bars and tubes shall be limited to the straight-beam (compression wave) method.

12.8.4 Acceptance Criteria for Non-surface-breaking Longitudinal Planar Imperfections

12.8.4.1 Indications Meeting or Exceeding the Reference Distance Amplitude Curve

Any single indication that meets or exceeds the reference distance amplitude curve which will not be removed by a subsequent boring process shall be identified a defect and shall be rejected.

12.8.4.2 Internal Indications Resulting in the Loss of Greater than 40 % of the Reference Standard's Back-reflection

Any internal indication that results in the loss of 40 % or more of the reference standard's back-reflection shall be rejected; unless the manufacturer establishes that the loss of back reflection is due to large grains, surface condition, or lack of parallelism between the scanning and reflecting surfaces. All internal longitudinal imperfections that will be removed by a subsequent machining (see 12.8.6) process is acceptable.

12.8.4.3 Distance Amplitude Correction Curve

Any internal longitudinal indication exceeding the distance amplitude correction curve (see ASTM E1316) or DGS (distance gain size) method (see ISO 16811), based on a 1.587 mm (0.0625 in.) diameter flat-bottom hole for under 38.1 mm (1.5 in.) cross section, 3.18 mm (0.125 in.) diameter flat-bottom hole for cross sections 38.1 mm to 152.4 mm (1.5 in. to 6 in.), and 6.35 mm (0.25 in.) diameter flat-bottom hole for cross sections over 152.4 mm (6 in.), shall be rejected. All internal longitudinal imperfections that will be removed by a subsequent machining (see 12.8.6) process are acceptable.

12.8.5 Methods Used to Find Non-surface Breaking Internal Transverse Imperfections

12.8.5.1 Inspection for Internal Transverse Imperfections

Each bar shall be inspected for internal transverse imperfections using one of the following ultrasonic examination (UT) methods:

a) The straight-beam method, (compression/longitudinal wave) with the transducer placed on the end (face) of the bar or tube, and shot from both ends of the bar or tube;

b) The shear-wave method with the sound beam oriented in the longitudinal axis of the bar to perpendicularly intersect suspected discontinuities.

12.8.5.2 Selection between Straight-beam Method and Shear-wave Method

The method used shall be the option of the manufacturer.

12.8.6 Acceptance Criteria for Non-surface Breaking Internal Transverse Imperfections

12.8.6.1 Removal of Internal Transverse Imperfections by ID Boring

All internal transverse imperfections that shall be removed by a subsequent ID boring process may be provisionally accepted.

12.8.6.2 Using Table C.14 (Table D.14) as a Reference for Bore Diameter

If the final bore diameter is not known, consult the drill collar Table C.14 (Table D.14) for bore diameters which correspond to the bar outside diameter. If there is more than one bore diameter for the bar outside diameter, select the smallest bore diameter corresponding to the bar outside diameter.

12.8.6.3 Definition of imperfection that will be removed by subsequent ID boring process, when final bore diameter is not known.

The location of an imperfection that will be removed by the subsequent ID boring process shall be defined as: an imperfection located at a diameter that is equal to or less than the smallest bore diameter for the bar outside diameter, as shown in Table C.14 (Table D.14), minus 6.35 mm (0.250 in.).

12.8.6.4 Rejection Criteria for Internal Transverse Imperfections

All internal transverse imperfections that will not be removed by the subsequent ID boring process shall be rejected.

12.9 Reference Standards

12.9.1 Reference Standards for UT and ECT

Reference standards shall be used for ultrasonic and eddy current examination methods to standardize system sensitivity levels and to demonstrate the effectiveness of the inspection equipment and procedures. Calibration shall be performed at least once each working shift and each time the nominal OD, wall thickness, or grade of the material being inspected changes.

12.9.2 Reference Standard—Requirements

12.9.2.1 General

The reference standard of convenient length shall be prepared from a length of bar or tube.

12.9.2.2 Requirements for Reference Standard for Bars

The reference standard for NDE of bars shall be of similar size (same diameter as item to be inspected ± 10 %), and the surface roughness shall be comparable to the item to be inspected and possess similar acoustical properties or magnetic permeability as the material to be examined.

The reference standard shall be free of discontinuities or other conditions producing indications that could interfere with the detection of the reference notch.

12.9.2.3 Requirements for Reference Standard for Tubes

The reference standard for NDE of tubes shall be of similar size (same diameter as item to be inspected ±3.18 mm [0.125 in.]), have a similar wall thickness (same wall thickness as item to be inspected ±3.18 mm [0.125 in.]), have a surface roughness comparable to the item to be inspected, and possess similar acoustical properties or magnetic permeability as the material to be examined.

The reference standard shall be free of discontinuities or other conditions producing indications that could interfere with the detection of the reference notch.

12.9.2.4 Reference Standards for Inspection of Solid Bars

Inspection systems for solid bars shall use reference standards containing a longitudinal (axial) reference notch on the outside surface.

12.9.2.5 Reference Standards for Inspection of Tubes

Inspection systems for tubes shall use reference standards containing both a longitudinal (axial) reference notch on the outside surface and a longitudinal (axial) reference notch on the inside surface.

12.9.2.6 Maximum Depth of Longitudinal Reference Notches

The maximum depth of the longitudinal reference notches shall be in accordance with the allowable depth *of* indication without removal as stated in Table C.16 (Table D.16) for the bar or tube size being inspected. At the manufacturer's option, shallower notch depths may be used.

12.9.2.7 Maximum Length and Width of Longitudinal Reference Notches

The longitudinal reference notches shall be of maximum length 101.6 mm (4 in.) and of a width less than or equal to 1.02 mm (0.040 in.).

12.9.3 Reference Standards with Side-drilled Holes

A side-drilled hole reference reflector may be used as an alternative to the above reference notches, per agreement between the manufacturer and the purchaser. The hole diameter shall produce a reflector which is equivalent or more sensitive than the reference notch indicated above. In either case, the reference signal amplitude as scanned by an automated scanning device shall not be used to determine the acceptance or rejection of a component. Acceptance and rejection criteria shall be determined by using specific prove-up techniques associated with the particular method(s) used, in conjunction with the requirements of this procedure.

All indications that are equal to or greater than the reject threshold shall be identified as defects. Tubes with defects shall be given a disposition in accordance with 12.8.4.

12.9.4 Flat-bottom Hole for Distance Amplitude Correction-curve

For FBH (flat-bottom hole), the distance amplitude correction-curve (see ASTM E1316) shall be based on 3.18 mm (0.125 in.) diameter flat-bottom hole for metal thicknesses through 152.4 mm (6 in.) and on 6.35 mm (0.250 in.) diameter flat-bottom hole for metal thicknesses exceeding 152.4 mm (6 in.).

12.10 NDE System Capability Records

12.10.1 General

The inspection facility shall maintain NDE system records verifying the system(s) capabilities in detecting the reference indicators used to establish the equipment test sensitivity.

12.10.2 Minimum Verification Requirements

The verification shall cover, as a minimum, the following criteria:

a) coverage calculation (i.e. scan plan);

b) repeatability;

c) transducer orientation that provides detection of defects typical of the manufacturing process;

d) documentation demonstrating that defects typical of the manufacturing process are detected using the NDE methods;

e) threshold-setting parameters.

12.10.3 Inspection Facility Documentation Requirements

In addition, the inspection facility shall maintain documentation relating to:

a) NDE system operating procedures;

b) NDE equipment description;

c) NDE personnel qualification information;

d) dynamic test data demonstrating the NDE system/operation capabilities under production test conditions.

12.11 Dynamic Standardization Test to Validate Repeatability and Accuracy of Ultrasonic Equipment

12.11.1 General

The inspection facility may use any documented procedure to establish the reject threshold for ultrasonic inspection provided the artificial reference indicators are detected dynamically at or above the reject threshold under normal operating conditions. Such detection capability shall be demonstrated dynamically. At the option of the manufacturer, this may be performed either online or offline.

12.11.2 Definition of Valid Dynamic Standardization Check

A valid dynamic standardization check is defined by two consecutive successful inspection runs of the inspection standard at production speeds with the amplitude of the notch for one run not less than 79 % of the amplitude from the other run (2 dB). Records of these runs shall be maintained for a minimum of five years from the date of the run.

12.11.3 Timing of Standardization Check

A valid standardization check shall be made at the start of the processing of a lot and at or after any significant event.

12.11.4 Composition of a Product Lot

A lot consists of product with the same nominal OD and ID and similar acoustical properties as the material to be examined.

12.11.5 Definition of Significant Event

A significant event is the end of the lot run or halting operation for more than an hour or any action that may affect the scanning device and proper inspection of the product.

12.11.6 Validity of Check-run Related to Personnel Change at Shift Change

In the case of a personnel change, the check-run by the personnel leaving the current shift and those starting the next shift may be the same.

12.11.7 Reinspection of Product When Standardization-check Is Not Valid

If a standardization-check is not valid, then all product inspected after the previous valid standardization-check shall be reinspected.

Annex A
(informative)

Purchaser Inspection

A.1 Inspection Notice

If the inspector representing the purchaser desires to inspect the product or witness a test, reasonable notice shall be given of the time at which the relevant inspection/tests are to be made.

A.2 Plant Access

All inspections should be made prior to shipment at the place of manufacture, unless otherwise specified in the purchase agreement, and shall be conducted so as not to interfere unnecessarily with the operation of the works.

A.3 Compliance

The manufacturer is responsible for complying with all the provisions of this standard. The purchaser may investigate to ensure compliance by the manufacturer and can reject any product that does not comply with this standard.

A.4 Rejection

Unless otherwise provided, material that shows defects on inspection or after acceptance at the manufacturer's works, or that proves defective when properly applied in service, may be rejected, and the manufacturer so notified. If tests that require destruction of material are made, any product which is proven not to have met the requirements of this standard shall be rejected. Disposition of rejected product shall be a matter of agreement between purchaser and manufacturer.

Annex B
(normative)

Material Requirements for Drill Stem Tools Not Directly Covered by this Standard

B.1 General

Certain tools are often used in the drill stem that are not directly covered by this international standard. To help the user ensure these tools will provide a minimum level of performance, this annex is provided to identify material requirements for certain tools not directly covered by this standard.

B.2 Large Cross Section Specialty Tools

These tools have a major diameter greater than 280 mm (11 in.) or tools with a change of 75 mm (3 in.) or more in outside diameter over the length of the tool and are not covered elsewhere in this standard.

B.3 Material Heat Treatment

B.3.1 Low Alloy Steel

Tools manufactured from low-alloy steels shall be quenched and tempered. The heat treating process may be either batch or continuous. All testing shall be performed after final heat treatment.

If the starting material is bar stock that has been heat treated full length and has been tested at a depth equal to or greater than the depth at the critical location (see B.4) and meets the required mechanical properties, the material may be used without further heat treating.

If the material does not meet the required mechanical properties at the critical location, the material shall be heat treated and tested after final heat treatment. The mechanical test specimens shall be removed from a prolongation, a sacrificial part or a qualification test coupon (QTC) as described below to verify the tensile, yield, impact and hardness properties at the critical location. Material may be rough machined prior to heat treating.

B.3.2 Non-magnetic Materials

Non-magnetic materials shall be solution annealed and cold or warm worked. All testing shall be performed after solution annealing and cold or warm working.

B.4 Critical Locations

Critical locations are areas on the part where the stresses from service loads are the highest. These locations are the most likely locations for in-service failures. The product designer shall be responsible for identifying the critical location in the product design. The manufacturer shall be responsible for verifying that the mechanical properties are met at the critical location.

B.5 Mechanical Test Specimens

B.5.1 General

For heat treated material, either batch or continuous, the mechanical test specimen shall be removed from a sacrificial production part, or from a prolongation removed from a production part, or from a quality test coupon (QTC) from the same heat.

When required, the product designer may specify that the test specimen shall come from a sacrificial production part, or from a prolongation removed from a production part, or if a quality test coupon (QTC) is to be used. If not specified by the product designer, the choice shall be at the discretion of the manufacturer.

B.5.2 Sacrificial Production Part

If a sacrificial production part is used to obtain the test specimens, it shall only be used to qualify parts that have the same dimensions at the time of heat treating and are of the same heat of material. The specimens shall be removed from the critical location identified in the part design.

B.5.3 Prolongation

If the test specimens are to be taken from a prolongation of a production part, the prolongation shall have the same dimensions as the critical location identified in the part design and shall be long enough so the test specimens are located no closer than one-half radius to a heat treated end.

B.5.4 Qualification Test Coupon (QTC)

B.5.4.1 General

A QTC is a separate test coupon from the same heat of material as the production part and shall be heat treated in the same lot as the production part. The purpose of the QTC is to provide representative mechanical properties of the part being qualified. The geometry of the QTC shall be selected so that the heat treat response of the QTC simulates the heat treat response of the critical location of the part it qualifies. This is accomplished using the ER method described in B.5.4.2. A hollow QTC shall only be used if the production part is hollow at the time of heat treatment.

Depending on the hardenability of a given material, the QTC results may not always correspond with the properties of the actual components at all locations throughout their cross-sections.

B.5.4.2 ER Method

Most available data on heat treatment refers to round sections. If the production parts are not round at the critical location, the geometry at the critical location can be visualized as simple shapes such as squares, hexagons, plates or tubes that can be equated to an equivalent round (ER). The equivalent round has essentially the same cooling rate as the simple shape and the same response to heat treatment, so a QTC based on the ER of the critical location can be used to verify the mechanical properties.

The method used to determine the diameter of the equivalent round shall be in accordance with the technique outlined in SAE AMS H-6875.

The ER of a part shall be determined using the actual dimensions of the part at the critical location and in the "as heat treated" condition.

The ER of a part has the same cross sectional area as the simple shape it replaces when the dimension "T" is the thickness of the part.

The ER of the QTC shall be equal to or greater than the dimensions of the part it qualifies.

The ER is the diameter of the equivalent round that replaced the simple shape.

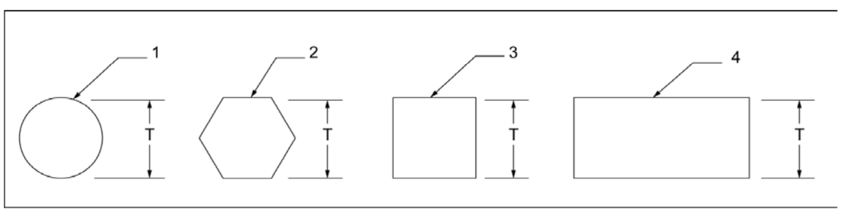
The length of the QTC shall not be less than the calculated diameter of the ER.

The QTC shall only qualify production parts whose critical sections have the same or a smaller ER.

The total hot work ratio for the QTC shall not exceed the total hot work ratio of the part(s) it qualifies. The hot work ratio is the area ratio of the cast diameter and the pre-machined finished diameter.

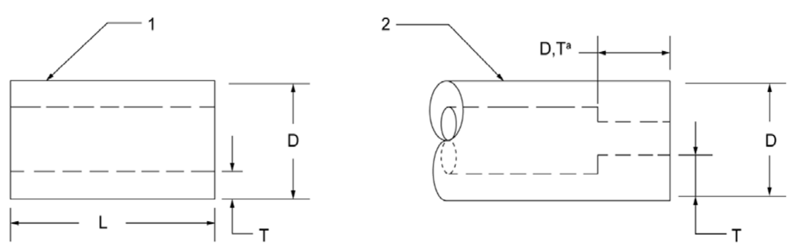
Figure B.1 illustrates the basic models for determining the ER of simple solid shapes.

Figure B.2 illustrates the basic models for determining the ER of simple hollow parts and hollow parts with more complicated shapes.



Key
1 round [a] ER = 1.0 T
2 hexagonal [a] ER = 1.1 T
3 square [a] ER = 1.25 T
4 rectangular [a] or plate ER = 1.5 T
a when "L" is less than "T", treat the section as a plate of "L" thickness
NOTE ER = equivalent round

Figure B.1—Correlation between Significant Dimensions of Simple Solid Shapes of Length "L" to the Diameters of Round Bars



Key
1 Tube open both ends [a] ER = 2 T
2 Tube restricted or closed at one or both ends
ER = 2.5 T when D is less than 63.5 mm (2.5 in.)
ER = 3.5 T when D is greater than 63.5 mm (2.5 in.)
a when "L" is less than "D", treat as a plate of "T" thickness
when "L" is less than "T", treat section as a plate of "L" thickness

Figure B.2—Correlation between the Significant Dimensions of Simple Hollow Parts and Hollow Parts with More Complicated Shapes to the Diameters of Round Bars

B.6 Mechanical Test Requirements

B.6.1 General

Tensile, hardness and impact specimens shall be removed from sacrificial parts, or prolongations or a QTC after the final heat treatment cycle. When tensile, hardness or impact tests are taken from sacrificial parts or prolongations, the tests shall be at a depth that corresponds to the critical location of the finished part. When a solid QTC is used to verify mechanical properties, the test specimen shall be removed so that the longitudinal axis of the specimens is at a depth equal to or greater than $^{1}/_{4}$ T. If a hollow QTC is used, the test specimens shall be removed so that the longitudinal axis of the specimens is located mid-wall of the QTC.

Location of the mid wall from the outside surface of the hollow QTC can be found by the following formula:

$$\text{Mid-wall} = (OD–ID)/4 \quad (B.1)$$

where

OD	the outside diameter of the QTC
ID	the inside diameter of the QTC at its thickest section

B.6.2 Tensile Testing

The standard size 12.5 mm (0.500 in.) diameter round test specimen conforming to the requirements of ISO 6892 or ASTM A370 shall be used for tensile testing unless the physical configuration prevents their use. If the standard size specimen cannot be used, the next smaller sub-sized specimens shall be used. Yield strength shall be determined by tests on cylindrical specimens conforming to the requirements of ISO 6892 or ASTM A370, 0.2 % Offset Method.

B.6.3 Hardness Testing

At least one Brinell hardness test shall be performed on the surface of each production part after the final heat treatment cycle. A Brinell hardness test is required on the surface of the QTC if a QTC is used to verify mechanical properties. A Brinell hardness test is also required at the location where the specimens are taken for the tensile and impact tests.

B.6.4 Impact Strength Testing

Charpy V-notch impact tests shall be conducted at a temperature of 21 °C ± 3 °C (70 °F ± 5 °F). Tests conducted at lower temperatures that meet the absorbed energy requirements are acceptable.

The standard size 10 mm × 10 mm (0.39 in. × 0.394 in.) test specimen conforming to the requirements of ISO 6892 or ASTM A370 shall be used for impact testing unless the physical configuration prevents their use. If the standard size specimen cannot be used, the next smaller sub-sized specimens shall be used.

If it is necessary to use sub-size impact specimens, the acceptance criteria shall be multiplied by the appropriate adjustment factor listed in Table C.2 (Table D.2). Sub-size test specimens of width less than 5 mm (0.197 in.) shall not be permitted.

One set of three specimens shall be tested.

B.6.5 Acceptance Criteria for Tensile, Yield, Elongation, Impact, and Hardness

The mechanical properties of the critical section of the part shall comply with the requirements of Table B.1.

Table B.1—Mechanical Properties and Tests for Heavy Section Tools

Yield Strength MPa (psi) Min.	Tensile Strength MPa (psi) Min.	Elongation, with Gauge Length 4× Diameter % Min.	Impact Strength [a] Joules (ft-lbs)		Brinell Hardness HBW
			Average 3 Specimens	Min. Single Specimen	
689 (100,000)	931 (135,000)	13	54 (40)	47 (35)	277 to 352

[a] The impact strength testing results shall meet $^{54}/_{47}$ J ($^{40}/_{35}$ ft-lbs) [$^{avg}/_{min}$] where the three-piece specimen set averages a minimum of 54 J (40 ft-lbs) with no individual specimen below 47 J (35 ft-lbs).

Annex C
(normative)

Tables in SI Units

Table C.1—Hydrostatic Testing Pressures

Maximum Working Pressure Rating MPa	Hydrostatic Shell Test Pressure (new valves only) MPa
34.5	68.9
68.9	103.4
103.4	155.1

Table C.2—Adjustment Factors for Impact Specimens

Specimen Dimensions mm × mm	Adjustment Factor
10 × 10	1.00
10 × 7.5	0.833
10 × 5	0.667

Table C.3—Service Class Definitions

Class No.	Service Type	Design Performance Requirements for Pressure Sealing
Class 1 [a]	Surface only	Body and any stem seal shall hold internal pressure equal to the shell test pressure [b]. Closure seal shall hold pressure from below at a low pressure of 1.7 MPa and at a high pressure equal to the maximum rated working pressure.
Class 2	Surface and downhole	Body and any stem seal shall hold internal pressure equal to the shell test pressure [b]. Stem seal shall hold external pressure at a low pressure of 1.7 MPa and at a minimum high pressure of 13.8 MPa [c]. Closure seal shall hold pressure from below at a low pressure of 1.7 MPa and at a high pressure equal to the maximum rated working pressure. Closure seal shall hold pressure from above at a low pressure of 1.7 MPa and at a high pressure equal to the maximum rated working pressure [d]. Sealing temperature range verified by testing [e].

[a] Valves manufactured to the 39th and earlier editions of API Spec 7 qualify as class 1 valves; to re-classify existing valves as class 2 shall require testing in accordance with the requirements of 5.3.3, 5.3.4, and 5.3.5.

[b] Shell test only performed once, in accordance with the values given in Table C.1, for each valve manufactured.

[c] Stem seal performance verified once for each valve design, not for each valve manufactured.

[d] Only applies to ball-type valves.

[e] Sealing temperature range verified once for each valve design, not for each valve manufactured.

Table C.4—Square Kelly Drive Section

1	2	3	4	5	6	7	8	9	10	11
Kelly Size [a]	Length Drive Section m L_D $^{+0.152}/_{-0.127}$		Length Overall m L $^{+0.152}/_{0}$		Across Flats mm D_{FL} [b]	Across Corners mm D_C [c]	Across Corners mm D_{CC} $^{0}/_{-0.4}$	Radius mm R_C ±1.6	Radius mm R_{CC} Ref. Only	Wall Thickness Eccentric Bore mm t min
	Standard	Optional	Standard	Optional						
63.5	11.28	—	12.19	—	63.5	83.3	82.55	7.9	41.3	11.43
76.2	11.28	—	12.19	—	76.2	100.0	98.42	9.5	49.2	11.43
88.9	11.28	—	12.19	—	88.9	115.1	112.70	12.7	56.4	11.43
108.0	11.28	15.54	12.19	16.46	108.0	141.3	139.70	12.7	69.8	12.06
133.4	11.28	15.54	12.19	16.46	133.3	175.4	171.45	15.9	85.7	15.88

NOTE See Figure 2 for configuration of square drive section.

[a] Size of square kellys is the same as the dimension D_{FL} across flats (distance between opposite faces) as given in column 6.

[b] Tolerances on D_{FL}, sizes 63.5 to 88.9, inclusive: $^{+2.0}/_{0}$ mm; sizes 108.0 to 133.3, inclusive: $^{+2.4}/_{0}$ mm; see 6.2 for sleeve test.

[c] Tolerances on D_C, sizes 63.5 to 88.9, inclusive: mm$^{+3.2}/_{0}$ mm; sizes 108.0 to 133.3, inclusive: $^{+4.0}/_{0}$ mm.

Table C.5—Square Kelly End Upsets and Connections

1	2	3	4	5	6	7	8	9	10	11
Kelly Size [b]	Upper Box Connection [a]					Lower Pin Connection [a]				
	Length	Label [c]	Outside Diameter D_U ±0.8	Bevel Diameter D_F ±0.4	Upset Length L_U $^{+63.5}/_{0}$	Label [c]	Outside Diameter D_{LR} ±0.8	Inside Diameter d $^{+1.6}/_{0}$	Bevel Diameter D_F ±0.4	Upset Length L_L $^{+63.5}/_{0}$
63.5	Standard	6 5/8 REG	196.8	186.1	406.4	NC26	85.7	31.8	83.0	508.0
	Optional	4 1/2 REG	146.0	134.5	406.4	NC26	85.7	31.8	83.0	508.0
76.2	Standard	6 5/8 REG	196.8	186.1	406.4	NC31	104.8	44.4	100.4	508.0
	Optional	4 1/2 REG	146.0	134.5	406.4	NC31	104.8	44.4	100.4	508.0
88.9	Standard	6 5/8 REG	196.8	186.1	406.4	NC38	120.6	57.2	116.3	508.0
	Optional	4 1/2 REG	146.0	134.5	406.4	NC38	120.6	57.2	116.3	508.0
108.0	Standard	6 5/8 REG	196.8	186.1	406.4	NC46	158.8	71.4	145.2	508.0
	Standard	6 5/8 REG	196.8	186.1	406.4	NC50	161.9	71.4	154.0	508.0
	Optional	4 1/2 REG	146.0	134.5	406.4	NC46	158.8	71.4	145.2	508.0
	Optional	4 1/2 REG	146.0	134.5	406.4	NC50	161.9	71.4	154.0	508.0
133.4	Standard	6 5/8 REG	196.8	186.1	406.4	5 1/2 FH	177.8	82.6	170.6	508.0
	Standard	6 5/8 REG	196.8	186.1	406.4	NC56	177.8	82.6	171.0	508.0

NOTE 1 Dimensions in millimeters.

NOTE 2 See Figure 2 for configuration of end upsets.

[a] See 6.3 for requirements of rotary shouldered connections.

[b] Size of square kellys is the same as dimension D_{FL} across flats (distance between opposite faces) as given in column 6 of Table C.4.

[c] Labels are for information and assistance in ordering.

Table C.6—Hexagonal Kelly Drive Section

1	2	3	4	5	6	7	8	9	10	11
Kelly Size [a]	**Length Drive Section m** L_D $^{+0.152}/_{-0.127}$		**Length Overall m** L $^{+0.152}/_{0}$		**Across Flats mm** D_{FL} [b]	**Across Corners mm** D_C [c]	**Across**	**Radius mm** R_C **±1.6**	**Radius mm** R_{CC} **Ref. Only**	**Wall**
	Standard	**Optional**		**Optional**						
76.2	11.28	—	12.19	—	76.2	85.7	85.72	6.4	42.9	12.06
88.9	11.28	—	12.19	—	88.9	100.8	100.00	6.4	50.0	13.34
108.0	11.28	15.54	12.19	16.46	108.0	122.2	121.44	7.9	60.7	15.88
133.4	11.28	15.54	12.19	16.46	133.3	151.6	149.86	9.5	75.0	15.88
152.4	11.28	15.54	12.19	16.46	152.4	173.0	173.03	9.5	86.5	15.88

NOTE See Figure 3 for configuration of hexagonal drive section.

[a] Size of hexagonal kellys is the same as the dimension D_{FL} across the flats (distance between opposite faces) as given in column 6.

Table C.7—Hexagonal Kelly End Upsets and Connections

1	2	3	4	5	6	7	8	9	10	11
Kelly Size [b]	Upper Box Connection [a]					Lower Pin Connection [a]				
	Length	Label [c]	Outside Diameter D_U ±0.8	Bevel Diameter D_F ±0.4	Upset Length L_U $^{+63.5}/_{0}$	Label [c]	Outside Diameter D_{LR} ±0.8	Inside Diameter d $^{+1.6}/_{0}$	Bevel Diameter D_F ±0.4	Upset Length L_L $^{+63.5}/_{0}$
76.2	Standard	6 $^5/_8$ Reg	196.9	186.1	406.4	NC 26	85.7	31.8	82.9	508.0
	Optional	4 $^1/_2$ Reg	146.0	134.5	406.4	NC 26	85.7	31.8	82.9	508.0
88.9	Standard	6 $^5/_8$ Reg	196.9	186.1	406.4	NC31	104.8	44.4	100.4	508.0
	Optional	4 $^1/_2$ Reg	146.0	134.5	406.4	NC31	104.8	44.4	100.4	508.0
108.0	Standard	6 $^5/_8$ Reg	196.9	186.1	406.4	NC38	120.6	57.2	116.3	508.0
	Optional	4 $^1/_2$ Reg	146.0	134.5	406.4	NC38	120.6	57.2	116.3	508.0
133.4	Standard	6 $^5/_8$ Reg	196.9	186.1	406.4	NC46	158.8	76.2 [d]	145.2	508.0
	Standard	6 $^5/_8$ Reg	196.9	186.1	406.4	NC50	161.9	82.6 [d]	154.0	508.0
152.4	Standard	6 $^5/_8$ Reg	196.9	186.1	406.4	5 $^1/_2$ FH	177.8	88.9	170.6	508.0
	Standard	6 $^5/_8$ Reg	196.9	186.1	406.4	NC56	177.8	88.9	171.0	508.0

NOTE 1 Dimensions in millimeters.

NOTE 2 See Figure 3 for configuration of end upsets.

[a] See 6.3 for requirements of rotary shouldered connections.

[b] Size of hexagonal kellys is the same as dimensions D_{FL} across flats (distance between opposite faces) given in column 6 of Table C.6.

[c] Labels are for information and assistance in ordering.

[d] For 133.3 hexagonal kellys, a bore of 71.4 mm shall be optional.

Table C.8—Kelly Sleeve Gauge

Kelly Size	Minimum Length of Gauge L_G	Distance Across Flats D_{FL} [a, b]		Maximum Fillet Radius	
		Square	Hexagonal	Square R_S	Hexagonal R_H
63.5	254	65.89	—	6	—
76.2	254	78.59	77.11	8	5
88.9	254	91.29	89.81	11	5
108.0	305	111.12	108.86	11	6
133.4	305	136.52	134.26	14	8
152.4	305	—	153.31	—	8

NOTE 1 Dimensions in millimeters.

NOTE 2 See Figure 4 for configuration of kelly sleeve gauge.

[a] Tolerances on D_{FL}, all sizes: from $^{+0.13}/_{0}$ mm.

[b] Tolerances on nominal included angles between flats: ±0.5°.

Table C.9—Mechanical Properties and Test—New Kellys (All Sizes)

Lower Upset OD mm	Lower Upset Yield Strength MPa Min.	Lower Upset Tensile Strength MPa Min.	Elongation % Min.	Brinell Hardness HBW Min.
85.7 to 174.6	758	965	13	285
177.8	689	931	13	285

Table C.10—Drill Stem Subs

Type	Class	Upper Connection to Assemble with	Lower Connection to Assemble with
A or B	Kelly sub	Kelly	Tool joint
A or B	Joint sub	Tool joint	Tool joint
A or B	Crossover sub	Tool joint	Drill collar
A or B	Drill collar sub	Drill collar	Drill collar
A or B	Bit sub	Drill collar	Bit
C	Swivel sub	Swivel stem	Kelly
D	Lift sub	Elevator	Drill collar

Table C.11—Minimum Surface Hardness of Dimension D_R of Type B Drill Stem Subs and Dimension D_P of Type D Drill Stem Subs

Large OD D mm	Surface Brinell Hardness of Reduced Diameter Section D_R HBW min
79.4 through 174.6	285
177.8 through 254.0	277

Table C.12—Dimensions for Lift Subs

Elevator Recess Diameter D_P ±0.8	Diameter of Lift Shoulder (tapered) D_L $^{+3.2}/_{0}$	Overall Length L_1 $^{+76}/^{-25}$	Top Length L_2 ±3	Elevator Recess Length L_3 (Ref.)	Bottom Length L_4 ±12	Largest Elevator [a]
60.3	88.9	915	102	457	356	2 $^7/_8$
73.0	114.3	915	102	457	356	3 $^1/_2$ or 4IU
88.9	127.0	915	102	457	356	4 $^1/_2$
101.6	152.4	915	102	457	356	5 $^1/_2$
114.3	158.8	915	102	457	356	5 $^1/_2$
127.0	165.1	915	102	457	356	5 $^1/_2$
139.7	184.2	915	102	457	356	6 $^5/_8$
168.3	203.2	915	102	457	356	6 $^5/_8$

NOTE Dimensions in millimeters.

[a] For the lift sub and elevator best fit, it is recommended to use the appropriate elevator size for the lift sub D_p value in accordance with Table 7 in API 8C, 5th Edition—where the data in this column is from.

Table C.13—Float Valve Recess in Bit Subs

Valve Assembly Diameter D (Ref.)	Float Recess Diameter D_{FR} [a] $^{+0.4}/_{0}$	Valve Assembly Length L_{FV} (Ref.)	API REG Bit Box			Other Popular Connections	
			Label [b]	L_R ±1.6	D_{BP} $^{+0.8}/_{0}$	Label [b]	L_R ±1.6
42.1	42.9	149.2	2 $^3/_8$ Reg	231.8	33.3	NC23	231.8
48.4	49.2	158.8	2 $^7/_8$ Reg	254.0	38.1	NC26	241.3
61.1	61.9	165.1	3 $^1/_2$ Reg	266.7	48.4	NC31	260.4
71.4	72.2	254.0	—	—	—	3 $^1/_2$ FH	355.6
79.4	80.2	254.0	—	—	—	NC38	362.0
88.1	88.9	211.1	4 $^1/_2$ Reg	325.4	74.6	NC44	331.8
92.9	93.7	304.8	—	—	—	NC46	425.4
98.4	99.2	247.6	5 $^1/_2$ Reg	374.6	85.7	NC50	368.3
121.4	122.2	298.4	6 $^5/_8$ Reg	431.8	108.7	5 $^1/_2$ IF	431.8
121.4	122.2	298.4	7 $^5/_8$ Reg	438.2	108.7	5 $^1/_2$ FH	431.8
121.4	122.2	298.4	8 $^5/_8$ Reg	441.3	108.7	NC61	444.5
144.5	145.2	371.5	8 $^5/_8$ Reg	514.4	131.8	6 $^5/_8$ IF	504.8

[a] Diameter D_{FR} equals D + 0.8 mm.

[b] Labels are for information and assistance in ordering.

Table C.14—Drill Collars

Drill Collar Number and Connection Label [a, b]	Outside Diameter [c] D mm	Bore d mm $^{+1.59}/_{0}$	Length L m ±152.4 mm [d]	Bevel Diameter [e] D_F mm ±0.4 mm	Reference Bending Strength Ratio [f] (BSR)
NC23-31	79.4	31.8	9.14	76.2	2.57:1
NC26-35	88.9	38.1	9.14	84.5	2.42:1
NC31-41	104.8	50.8	9.14 or 9.45	101.6	2.43:1
NC35-47	120.6	50.8	9.14 or 9.45	114.7	2.58:1
NC38-50	127.0	57.2	9.14 or 9.45	121.0	2.38:1
NC44-60	152.4	57.2	9.14 or 9.45	144.5	2.49:1
NC44-60	152.4	71.4	9.14 or 9.45	144.5	2.84:1
NC44-62	158.8	57.2	9.14 or 9.45	149.2	2.91:1
NC46-62	158.8	71.4	9.14 or 9.45	150.0	2.63:1
NC46-65	165.1	57.2	9.14 or 9.45	154.8	2.76:1
NC46-65	165.1	71.4	9.14 or 9.45	154.8	3.05:1
NC46-67	171.4	57.2	9.14 or 9.45	159.5	3.18:1
NC50-70	177.8	57.2	9.14 or 9.45	164.7	2.54:1
NC50-70	177.8	71.4	9.14 or 9.45	164.7	2.73:1
NC50-72	184.2	71.4	9.14 or 9.45	169.5	3.12:1
NC56-77	196.8	71.4	9.14 or 9.45	185.3	2.70:1
NC56-80	203.2	71.4	9.14 or 9.45	190.1	3.02:1
6 $^5/_8$ REG	209.6	71.4	9.14 or 9.45	195.6	2.93:1
NC61-90	228.6	71.4	9.14 or 9.45	212.7	3.17:1
7 $^5/_8$ REG	241.3	76.2	9.14 or 9.45	223.8	2.81:1
NC70-97	247.6	76.2	9.14 or 9.45	232.6	2.57:1
NC70-100	254.0	76.2	9.14 or 9.45	237.3	2.81:1
8 $^5/_8$ REG	279.4	76.2	9.14 or 9.45	266.7	2.84:1

NOTE See Figure 8 for configuration of drill collars.

[a] Labels are for information and assistance in ordering.

[b] The drill collar number consists of two parts separated by a hyphen; the first part is the connection number in the NC style; the second part, consisting of two (or three) digits, indicates the drill collar outside diameter in units and tenths of inches; drill collars with 209.6 mm, 241.3 mm and 279.4 mm outside diameters are shown with 6 $^5/_8$, 7 $^5/_8$ and 8 $^5/_8$ REG connections, since there are no NC connections in the recommended range of bending-strength ratios.

[c] See Table C.15 for tolerances.

[d] See 8.3.1.1 for non-magnetic drill collar tolerances.

[e] See API 7-2 for bevel diameters of drill collar ODs not shown.

[f] Stress-relief features are disregarded in the calculation of the bending-strength ratio.

Table C.15—Drill Collar OD Tolerances

Outside Diameter	Size Tolerance Inclusive		Out-of-Roundness [a]
	Max.	Min.	
Over 63.5 to 88.9, inclusive	1.2	0	0.89
Over 88.9 to 114.3, inclusive	1.6	0	1.17
Over 114.3 to 139.7, inclusive	2.0	0	1.47
Over 139.7 to 165.1, inclusive	3.2	0	1.78
Over 165.1 to 209.6, inclusive	4.0	0	2.16
Over 209.6 to 241.3, inclusive	4.8	0	2.54
Over 241.3	6.4	0	3.05

NOTE Dimensions and tolerances in millimeters.

[a] Out-of-roundness is the difference between the maximum and minimum diameters of the bar or tube, measured in the same cross-section, and does not include surface-finish tolerances outlined in 8.1.4.

Table C.16—Drill Collar Surface Imperfection Removal and Inspection Reference Standard Notch Depth

Size: Outside Diameter	Stock Removal from Surface Max.	Brinell Harness Slot Depth Max.	Allowable Depth of Indication Without Removal [b] Max.
Over 63.5 to 88.9, inclusive	1.83	1.83	0.58
Over 88.9 to 114.3, inclusive	2.29	2.29	0.76
Over 114.3 to 139.7, inclusive	2.79	2.79	0.91
Over 139.7 to 165.1, inclusive	3.18	3.18	1.09
Over 165.1 to 209.6, inclusive	3.94	3.94	1.40
Over 209.6 to 241.3, inclusive	5.16	5.16	1.60
Over 241.3	6.10 [a]	6.10 [a]	2.41

NOTE Dimensions in millimeters.

[a] Stock removal from surface is capped at 6.10 mm on drill collars over 241.3 mm as removal over this amount is not allowed.

[b] Allowable depth of indication based upon 1 % of OD of largest OD in the given range (except for sizes over 241.3 mm).

Table C.17—Mechanical Properties and Tests for New Standard Steel Drill Collars

Drill Collar OD Range mm	Yield Strength MPa min	Tensile Strength MPa min	Elongation, with Gauge Length Four-times Diameter % min	Brinell Hardness HBW min
79.4 through 174.6	758	965	13	285
177.8 through 279.4	689	931	13	285

Table C.18—Mechanical Properties for New Non-magnetic Drill Collars

Drill Collar OD Range mm	Yield Strength MPa min	Tensile Strength MPa min	Elongation Stainless Steel Collars % min	Elongation Non-ferrous Collars % min
70 through 98.4	827	896	16	13
101.6 through 174.6	758	827	18	13
177.8 through 279.4	689	758	20	13

Table C.19—Impact Energy of Non-magnetic Steels

Material Type	Yield Strength Range MPa	Minimum Impact Energy J
Non-magnetic steel	689–965	81
Non-magnetic steel	> 965–1103	68
Non-magnetic steel	> 1103	54
Non-ferrous alloys	> 689	41

Table C.20—Lower Connections for Bottom-hole Drill Collars

Outside Diameter of Drill Collar	Bottom Box Connection Label [a]	Bevel Diameter ±0.4
104.8 to 114.3, inclusive	2 $^{7}/_{8}$ REG	91.7
120.6 to 127.0, inclusive	3 $^{1}/_{2}$ REG	104.4
152.4 to 177.8, inclusive	4 $^{1}/_{2}$ REG	135.3
177.8 to 184.2, inclusive	5 $^{1}/_{2}$ REG	165.1
196.8 to 228.6, inclusive	6 $^{5}/_{8}$ REG	186.9
241.3 to 254.0, inclusive	7 $^{5}/_{8}$ REG	215.1
279.4, inclusive	8 $^{5}/_{8}$ REG	242.5

NOTE Dimensions in millimeters.

[a] Labels are for information and assistance in ordering.

Table C.21—Additional Non-magnetic Drill Collar Sizes

Drill Collar Number	Outside Diameter D [a] mm	Bore d $^{+1.6}/_{0}$ mm	Length L $^{+0.152}/_{0}$ m	Bevel Diameter D_F ±0.4 mm	Reference Bending Strength Ratio [b] (BSR)
NC 50-67	171.4	71.4	9.14 or 9.45	159.5	2.37:1

NOTE See Figure 8 for configuration of drill collar.

[a] See Table C.15 for tolerances.

[b] The NC50-67 with 71.4 ID has a bending-strength ratio of 2.37:1; this is more pin-strong than may be generally acceptable for standard steel drill collars but has proven to be acceptable for non-magnetic drill collars.

Table C.22—Drill Collar Slip Groove Dimensions

Groove Dimensions Based on Drill Collar OD		
Drill Collar OD Ranges	Slip Groove Depth l_s [a] ±0.4	Angle β [b]
101.6 to 117.5	4.8	3.5°
120.6 to 142.9	4.8	3.5°
146.0 to 168.3	6.4	5°
171.4 to 219.1	6.4	5°
222.2 and larger	6.4	5°

NOTE Dimensions in millimeters.

[a] "l_s" is from the nominal OD of the drill collar.

[b] Angle β values are reference and approximate.

Table C.23—Dimensions of Heavy-weight Drill Pipe (HWDP)

Size	Connection Label [a]	Bevel Diameter ±0.4	Tube OD $^{+1.6}/_{-0.8}$	Tool Joint OD [b] $^{+1.6}/_{-0.8}$	Maximum Elevator Upset Diameter D_{eu}	Center Upset or Wear Pad Diameter D_{cu} $^{+1.6}/_{-0.8}$	Tube [c] D	Tool Joint ID $^{+3.2}/_{0}$	Min. Drift Diameter [d]
88.9	NC 38	116.3	88.9	120.6 (123.8, 127.0)	98.4	101.6	52.4	52.4	46.0
							52.4	55.6	46.0
							57.2	57.2	50.8
							57.2	60.3	50.8
101.6	NC40	127.4	101.6	133.4	106.4	114.3	63.5	63.5	57.2
							65.1	65.1	58.7
							65.1	68.2	58.7
114.3	NC 46	145.3	114.3	158.8	119.1	127.0	68.2	68.2	61.9
							69.9	69.9	63.5
							69.9	73.0	63.5
							71.4	71.4	65.1
127.0	NC50	154.0	127.0	168.3	130.2	139.7	76.2	76.2	69.8
							76.2	77.8	69.8
139.7	5 1/2 FH	170.7	139.7	177.8 (184.2, 190.5)	144.4	152.4	82.6	82.6	76.2
							85.7	85.7	79.4
							85.7	88.9	79.4
							98.4	98.4	92.1
							101.6	101.6	95.2
149.2	5 1/2 FH	170.7	149.2	177.8	152.4	161.9	101.6	101.6	95.3
168.2	6 5/8 FH	195.7	168.2	203.2 (209.6, 215.9)	176.2	181.0	101.6	101.6	95.2
							114.3	114.3	108.0
							114.3	117.5	108.0
							127.0	127.0	120.7

NOTE Dimensions in millimeters.

[a] Labels are for information and assistance in ordering.

[b] Optional tool joint ODs are shown in parenthesis and are to be agreed upon between purchaser and manufacturer.

[c] Maximum tube ID is 3.2 mm larger than nominal; minimum tube ID is controlled by drift requirement.

[d] Drift diameter is based on ID tolerances of heavy-wall pierced tube used for the center section.

Table C.24—Allowable Surface Imperfection Removal

Center Upset Diameter D_{cu} mm	Maximum Stock Removal from Surface mm
Over 63.5 to 88.9, inclusive	1.83
Over 88.9 to 114.3, inclusive	2.29
Over 114.3 to 139.7, inclusive	2.79
Over 139.7 to 165.1, inclusive	3.18
Over 165.1	3.94

Table C.25—Mechanical Properties of HWDP Tool Joints

1	2	3	4	5
Tool Joint OD Range mm	Yield Strength MPa Min.	Tensile Strength MPa Min.	Elongation with Gauge Length 4X Diameter % Min.	Brinell Hardness HBW Min.
79.4 through 174.6	758	965	13	285
Over 174.6	689	931	13	285
NOTE Dimensions in millimeters.				

Table C.26—Roller Bit and Drag Bit Tolerances

Size of Bit mm	Tolerance mm
44.4 to 349.2, inclusive	$^{+0.8}/_{0}$
355.6 to 444.5, inclusive	$^{+1.6}/_{0}$
447.7 and larger	$^{+2.4}/_{0}$

Table C.27—Roller Bit Connections

Size of Bit OD	Label Rotary Shouldered Pin Connection [a]	Bit Sub Bevel Diameter ±0.4	Bit Bevel Diameter ±0.4
44.4 to 56.9, inclusive	1 REG [b]	37.3	38.1
57.2 to 88.6, inclusive	1 $^{1}/_{2}$ REG [c]	49.2	50.0
88.9 to 114.3, inclusive	2 $^{3}/_{8}$ REG	77.4	78.2
117.5 to 127.0, inclusive	2 $^{7}/_{8}$ REG	91.7	92.5
130.2 to 187.3, inclusive	3 $^{1}/_{2}$ REG	104.4	105.2
190.5 to 238.1, inclusive	4 $^{1}/_{2}$ REG	135.3	136.1
241.3 to 365.1, inclusive	6 $^{5}/_{8}$ REG	186.9	187.7
368.3 to 469.9, inclusive	6 $^{5}/_{8}$ REG or	186.9	187.7
	7 $^{5}/_{8}$ REG	215.1	215.9
473.1 to 660.4, inclusive	7 $^{5}/_{8}$ REG or	215.1	215.9
	8 $^{5}/_{8}$ REG	242.5	243.3
685.8 and larger	8 $^{5}/_{8}$ REG	242.5	243.3
NOTE Dimensions in millimeters.			

[a] Labels are for information and assistance in ordering.
[b] The 1 REG is interchangeable with most 1 M.T., AMT, and AMMT threads.
[c] The 1 1/2 REG is interchangeable with most 1 1/2 M.T., AMT and AMMT threads.

Table C.28—Blade Drag Bit Connections

Size of Bit OD	Label Rotary Shouldered Connection [a]	Bit Sub-bevel Diameter ±0.4	Bit Bevel Diameter ±0.4
44.4 to 56.9, inclusive	1 REG [b]	37.3	38.1
57.2 to 88.6, inclusive	1 $^{1}/_{2}$ REG [c]	49.2	50.0
88.9 to 114.3, inclusive	2 $^{3}/_{8}$ REG, pin or box	77.4	78.2
117.5 to 127.0, inclusive	2 $^{7}/_{8}$ REG, pin or box	91.7	92.5
130.2 to 187.3, inclusive	3 $^{1}/_{2}$ REG, pin or box	104.4	105.2
190.5 to 215.9, inclusive	4 $^{1}/_{2}$ REG, pin or box	135.3	136.1
219.1 to 250.8, inclusive	5 $^{1}/_{2}$ REG, pin or box	165.1	165.9
Larger than 250.8	6 $^{5}/_{8}$ REG, pin or box	186.9	187.7

NOTE Dimensions in millimeters.

[a] Labels are for information and assistance in ordering.

[b] The 1 REG is interchangeable with most 1 M.T., AMT and AMMT threads.

[c] The 1 1/2 REG is interchangeable with most 1 1/2 M.T., AMT and AMMT threads.

Table C.29—Diamond Drilling, Diamond Core and PDC Bit Tolerances

Bit Size OD	OD Tolerances [a]
171.4 and smaller	$^{0}/_{-0.38}$
172.2 to 228.6, inclusive	$^{0}/_{-0.51}$
229.4 to 349.2, inclusive	$^{0}/_{-0.76}$
350.0 to 444.5, inclusive	$^{0}/_{-1.14}$
Larger than 445.3	$^{0}/_{-1.60}$

NOTE Dimensions in millimeters.

[a] It is recognized that certain applications may warrant the manufacture of PDC bits to tolerances other than those shown in Table C.30; when manufactured, such bits are outside the scope of this standard.

Table C.30—Diamond Drilling Bit and PDC Bit Connections

Size of Bit	Label Rotary Shouldered Pin Connection [a]	Bit Sub Bevel Diameter ±0.4	Bit Bevel Diameter ±0.4
44.4 to 56.9, inclusive	1 REG [b]	38.1	38.9
57.2 to 88.6, inclusive	1 1/2 REG [c]	49.2	50.0
88.9 to 114.3, inclusive	2 3/8 REG	77.4	78.2
115.1 to 127.0, inclusive	2 7/8 REG	91.7	92.5
127.8 to 187.3, inclusive	3 1/2 REG	104.4	105.2
188.1 to 238.1, inclusive	4 1/2 REG	135.3	136.1
238.9 to 368.3, inclusive	6 5/8 REG	186.9	187.7
369.9 to 469.9, inclusive	6 5/8 REG or	186.9	187.7
	7 5/8 REG	215.1	215.9
471.5 and larger	7 5/8 REG or	215.1	215.9
	8 5/8 REG	242.5	243.3

NOTE Dimensions in millimeters.

[a] Labels are for information and assistance in ordering.
[b] The 1 REG is interchangeable with most 1 M.T., AMT and AMMT threads.
[c] The 1 1/2 REG is interchangeable with most 1 1/2 M.T., AMT and AMMT threads.

Table C.31—Sampling Requirements of Stabilizer Neck

Maximum Diameter of Forging or Bar	Radius of Samplin in Neck Region
< 188	35
189 to 245	57
248 to 508	76
> 508	89

NOTE Dimensions in millimeters.

Table C.32—Neck Lengths

Location	Minimum Lengths
Upper Neck	760
Lower Neck, Drill Stem Stabilizer	600
Lower Neck, Near-Bit Stabilizer	450

NOTE Dimensions in millimeters.

Table C.33—Neck Diameters and Connections

Neck Diameter	Connections, Drill Stem Stabilizer Box Pin	Box Connection, Near Bit Stabilizer Lower	Inside Diameter	Blade Diameter
121	NC38	3 $^{1}/_{2}$ REG	51	130 to 187
165	NC46	4 $^{1}/_{2}$ REG	71	191 to 200
171	NC50	4 $^{1}/_{2}$ REG	71	203 to 244
203	6-$^{5}/_{8}$ REG	6 $^{5}/_{8}$ REG	71	241 to 394
203	6-$^{5}/_{8}$ REG	7 $^{5}/_{8}$ REG	71	397 to 508
241	7-$^{5}/_{8}$ REG	7 $^{5}/_{8}$ REG	76	311 to 508
241	7-$^{5}/_{8}$ REG	7 $^{5}/_{8}$ REG	76	397 to 660
241 to 279	7-$^{5}/_{8}$ REG	8 $^{5}/_{8}$ REG	76	508 to 660
279	8-$^{5}/_{8}$ REG	8 $^{5}/_{8}$ REG	76	> 660

NOTE Dimensions in millimeters.

Table C.34—Blade Dimensions

Up-hole and Downhole	30 ±5 degrees (integral)					
Blade taper angles (see NOTE 2)	30 degrees to 45 degrees (welded)					
Blade diameter $^{0}/_{-0.8}$	130 to 187	191 to 244	245 to 311	318 to 394	397 to 508	> 508
Number of Blades (integral)	3	3	3	3	3	3
Number of Blades (welded)	3	3	3 or 4	3 or 4	3 or 4	4
Blade width (integral) ±6	51	64	76	89	102	102
Blade width (welded) ±6	38	51	51	64	76	76
Crown length min (see NOTE 3)	305	406	457	457	508	508

NOTE 1 Dimensions in millimeters.

NOTE 2 The taper angle requirement applies only for the first 25 mm radially from the blade surface; if the blade height exceeds 25 mm, the taper angle for the remainder of the height may be up to 45 degrees at the manufacturer's discretion (see Figure 17).

NOTE 3 The crown may be tapered at customer's option to form a "watermelon geometry" as in Figure 18; the crown length includes the length of this shallow taper.

Table C.35—Blade Spiral Definitions

Spiral Description	Wrap Angle (see Figure 15)
Straight blade	Not applicable
Open spiral	180 degrees to 280 degrees
Full spiral	300 degrees to 370 degrees
Tight spiral	500 degrees to 600 degrees

ANNEX D
(normative)

Tables in USC Units

Table D.1—Hydrostatic Testing Pressures

Maximum Working Pressure Rating psi	Hydrostatic Shell Test Pressure (new valves only) psi
5000	10,000
10,000	15,000
15,000	22,500

Table D.2—Adjustment Factors for Impact Specimens

Specimen Dimensions in. × in.	Adjustment Factor
0.394 × 0.394	1.00
0.394 × 0.295	0.833
0.394 × 0.197	0.667

Table D.3—Service class Definitions

Class No.	Service Type	Design Performance Requirements for Pressure Sealing
Class 1 [a]	Surface only	Body and any stem seal shall hold internal pressure equal to the shell test pressure [b]. Closure seal shall hold pressure from below at a low pressure of 250 psi and at a high pressure equal to the maximum rated working pressure.
Class 2	Surface and downhole	Body and any stem seal shall hold internal pressure equal to the shell test pressure [b]. Stem seal shall hold external pressure at a low pressure of 250 psi and at a minimum high pressure of 2000 psi [c]. Closure seal shall hold pressure from below at a low pressure of 250 psi and at a high pressure equal to the maximum rated working pressure. Closure seal shall hold pressure from above at a low pressure of 250 psi and at a high pressure equal to the maximum rated working pressure [d]. Sealing temperature range verified by testing [e].

[a] Valves manufactured to the 39th and earlier Editions of API Spec 7 qualify as class 1 valves; to re-classify existing valves as class 2 shall require testing in accordance with the requirements of 5.3.3, 5.3.4, and 5.3.5.

[b] Shell test only performed once, in accordance with the values given in Table D.1, for each valve manufactured.

[c] Stem seal performance verified once for each valve design, not for each valve manufactured.

[d] Only applies to ball-type valves.

[e] Sealing temperature range verified once for each valve design, not for each valve manufactured.

Table D.4—Square Kelly Drive Section

1	2	3	4	5	6	7	8	9	10	11
Kelly Size [a]	Length Drive Section ft L_D $^{+0.50}/_{-0.42}$		Length Overall ft L $^{+0.50}/_{0}$		Across Flats in. D_{FL} [b]	Across Corners in. D_C [c]	Across Corners in. D_{CC} $^{0}/_{-0.4}$	Radius in. R_C ±1.6	Radius in. R_{CC} Ref. Only	Wall Thickness Eccentric Bore in. t min
	Standard	Optional	Standard	Optional						
2 1/2	37	—	40	—	2 1/2	3 9/32	3.250	5/16	1 5/8	0.450
3	37	—	40	—	3	3 15/16	3.875	3/8	1 15/16	0.450
3 1/2	37	—	40	—	3 1/2	4 17/32	4.437	1/2	2 7/32	0.450
4 1/4	37	51	40	54	4 1/4	5 9/16	5.500	1/2	2 3/4	0.475
5 1/4	37	51	40	54	5 1/4	6 29/32	6.750	5/8	3 3/8	0.625

NOTE See Figure 2 for configuration of square drive section.

[a] Size of square kellys is the same as the dimension D_{FL} across flats (distance between opposite faces) as given in column 6.

[b] Tolerances on D_{FL}, sizes 2 1/2 to 3 1/2, inclusive: $^{+5/64}/_{0}$ in.; sizes 4 1/4 to 5 1/4, inclusive: $^{+3/32}/_{0}$ in.; see 6.2 for sleeve test.

[c] Tolerances on D_C, sizes 2 1/2 to 3 1/2, inclusive: in. $^{+1/8}/_{0}$ in.; sizes 4 1/4 to 5 1/4, inclusive: $^{+5/32}/_{0}$ in.

Table D.5—Square Kelly End Upsets and Connections

1	2	3	4	5	6	7	8	9	10	11
	Upper Box Connection [a]					Lower Pin Connection [a]				
Kelly Size [b]	**Length**	**Label** [c]	**Outside Diameter** D_U $\pm^1/_{32}$	**Bevel Diameter** D_F $\pm^1/_{64}$	**Upset Length** L_U $^{+2\ 1/2}/_0$	**Label** [c]	**Outside Diameter** D_{LR} $\pm^1/_{32}$	**Inside Diameter** d $^{+1/16}/_0$	**Bevel Diameter** D_F $\pm^1/_{64}$	**Upset Length** L_L $^{+2\ 1/2}/_0$
2 1/2	Standard	6 5/8 REG	7 3/4	7 21/64	16	NC26	3 3/8	1 1/4	3 17/64	20
	Optional	4 1/2 REG	5 3/4	5 19/64	16	NC26	3 3/8	1 1/4	3 17/64	20
3	Standard	6 5/8 REG	7 3/4	7 21/64	16	NC31	4 1/8	1 3/4	3 61/64	20
	Optional	4 1/2 REG	5 3/4	5 19/64	16	NC31	4 1/8	1 3/4	3 61/64	20
3 1/2	Standard	6 5/8 REG	7 3/4	7 21/64	16	NC38	4 3/4	2 1/4	4 37/64	20
	Optional	4 1/2 REG	5 3/4	5 19/64	16	NC38	4 3/4	2 1/4	4 37/64	20
4 1/4	Standard	6 5/8 REG	7 3/4	7 21/64	16	NC46	6 1/4	2 13/16	5 23/32	20
	Standard	6 5/8 REG	7 3/4	7 21/64	16	NC50	6 3/8	2 13/16	6 1/16	20
	Optional	4 1/2 REG	5 3/4	5 19/64	16	NC46	6 1/4	2 13/16	5 23/32	20
	Optional	4 1/2 REG	5 3/4	5 19/64	16	NC50	6 3/8	2 13/16	6 1/16	20
5 1/4	Standard	6 5/8 REG	7 3/4	7 21/64	16	5 1/2 FH	7	3 1/4	6 23/32	20
	Standard	6 5/8 REG	7 3/4	7 21/64	16	NC56	7	3 1/4	6 47/64	20

NOTE 1 Dimensions in inches.

NOTE 2 See Figure 2 for configuration of end upsets.

[a] See 6.3 for requirements of rotary shouldered connections.

[b] Size of square kellys is the same as dimension D_{FL} across flats (distance between opposite faces) as given in column 6 of Table D.4.

[c] Labels are for information and assistance in ordering.

Table D.6—Hexagonal Kelly Drive Section

1	2	3	4	5	6	7	8	9	10	11
Kelly Size [a]	Length Drive Section ft L_D $^{+0.50}/_{-0.42}$		Length Overall ft L $^{+0.50}/_{0}$		Across Flats in. D_{FL} [b]	Across Corners in. D_C [c]	Outside Diameter D_{LR} $\pm^1/_{32}$	Inside Diameter d $^{+1/16}/_0$	Bevel Diameter D_F $\pm^1/_{64}$	Upset Length L_L $^{+2\ 1/2}/_0$
	Standard	Optional	Standard	Optional						
3	37	—	40	—	3	$3\ ^3/_8$	3.375	$^1/_4$	$1\ ^{11}/_{16}$	0.475
$3\ ^1/_2$	37	—	40	—	$3\ ^1/_2$	$3\ ^{31}/_{32}$	3.937	$^1/_4$	$1\ ^{31}/_{32}$	0.525
$4\ ^1/_4$	37	51	40	54	$4\ ^1/_4$	$4\ ^{13}/_{16}$	4.781	$^5/_{16}$	$2\ ^{25}/_{64}$	0.625
$5\ ^1/_4$	37	51	40	54	$5\ ^1/_4$	$5\ ^{31}/_{32}$	5.900	$^3/_8$	$2\ ^{61}/_{64}$	0.625
6	37	51	40	54	6	$6\ ^{13}/_{16}$	6.812	$^3/_8$	$3\ ^{13}/_{32}$	0.625

NOTE See Figure 3 for configuration of hexagonal drive section.

[a] Size of hexagonal kellys is the same as the dimension D_{FL} across the flats (distance between opposite faces) as given in column 6.

Table D.7—Hexagonal Kelly End Upsets and Connections

1	2	3	4	5	6	7	8	9	10	11
Kelly Size [b]	Upper Box Connection [a]					Lower Pin Connection [a]				
	Length	Label [c]	Outside	Bevel	Upset Length L_U $^{+2\,1/2}/_{0}$	Label [c]	Outside Diameter D_{LR} $\pm^{1}/_{32}$	Inside	Bevel	Upset Length L_L $^{+2\,1/2}/_{0}$
3	Standard	6 $^{5}/_{8}$ Reg	7 $^{3}/_{4}$	7 $^{21}/_{64}$	16	NC26	3 $^{3}/_{8}$	1 $^{1}/_{4}$	3 $^{17}/_{64}$	20
	Optional	4 $^{1}/_{2}$ Reg	5 $^{3}/_{4}$	5 $^{19}/_{64}$	16	NC26	3 $^{3}/_{8}$	1 $^{1}/_{4}$	3 $^{17}/_{64}$	20
3 $^{1}/_{2}$	Standard	6 $^{5}/_{8}$ Reg	7 $^{3}/_{4}$	7 $^{21}/_{64}$	16	NC31	4 $^{1}/_{8}$	1 $^{3}/_{4}$	3 $^{61}/_{64}$	20
	Optional	4 $^{1}/_{2}$ Reg	5 $^{3}/_{4}$	5 $^{19}/_{64}$	16	NC31	4 $^{1}/_{8}$	1 $^{3}/_{4}$	3 $^{61}/_{64}$	20
4 $^{1}/_{4}$	Standard	6 $^{5}/_{8}$ Reg	7 $^{3}/_{4}$	7 $^{21}/_{64}$	16	NC38	4 $^{3}/_{4}$	2 $^{1}/_{4}$	4 $^{37}/_{64}$	20
	Optional	4 $^{1}/_{2}$ Reg	5 $^{3}/_{4}$	5 $^{19}/_{64}$	16	NC38	4 $^{3}/_{4}$	2 $^{1}/_{4}$	4 $^{37}/_{64}$	20
5 $^{1}/_{4}$	Standard	6 $^{5}/_{8}$ Reg	7 $^{3}/_{4}$	7 $^{21}/_{64}$	16	NC46	6 $^{1}/_{4}$	3 [d]	5 $^{23}/_{32}$	20
	Standard	6 $^{5}/_{8}$ Reg	7 $^{3}/_{4}$	7 $^{21}/_{64}$	16	NC50	6 $^{3}/_{8}$	3 $^{1}/_{4}$ [d]	6 $^{1}/_{16}$	20
6	Standard	6 $^{5}/_{8}$ Reg	7 $^{3}/_{4}$	7 $^{21}/_{64}$	16	5 $^{1}/_{2}$ FH	7	3 $^{1}/_{2}$	6 $^{23}/_{32}$	20
	Standard	6 $^{5}/_{8}$ Reg	7 $^{3}/_{4}$	7 $^{21}/_{64}$	16	NC56	7	3 $^{1}/_{2}$	6 $^{47}/_{64}$	20

NOTE 1 Dimensions in inches.
NOTE 2 See Figure 3 for configuration of end upsets.

[a] See 6.3 for requirements of rotary shouldered connections.
[b] Size of hexagonal kellys is the same as dimensions D_{FL} across flats (distance between opposite faces) given in column 6 of Table D.6.
[c] Labels are for information and assistance in ordering.
[d] For 5 $^{1}/_{4}$ hexagonal kellys, a bore of 2 $^{13}/_{16}$ in. shall be optional.

Table D.8—Kelly Sleeve Gauge

Kelly Size	Minimum Length of Gauge L_G	Distance Across Flats D_{FL} [a, b]		Maximum Fillet Radius	
		Square	Hexagonal	Square R_S	Hexagonal R_H
2 $^{1}/_{2}$	10	2.594	—	$^{1}/_{4}$	—
3	10	3.094	3.036	$^{5}/_{16}$	$^{3}/_{16}$
3 $^{1}/_{2}$	10	3.594	3.536	$^{7}/_{16}$	$^{3}/_{16}$
4 $^{1}/_{4}$	12	4.375	4.286	$^{7}/_{16}$	$^{1}/_{4}$
5 $^{1}/_{4}$	12	5.375	5.286	$^{9}/_{16}$	$^{5}/_{16}$
6	12	—	6.036	—	$^{5}/_{16}$

NOTE 1 Dimensions in inches.
NOTE 2 See Figure 4 for configuration of kelly sleeve gauge.

[a] Tolerances on D_{FL}, all sizes: from $^{+0.005}/_{0}$ in.
[b] Tolerances on nominal included angles between flats: ±0.5°.

Table D.9—Mechanical Properties and Test–New Kellys (All Sizes)

Lower Upset OD in.	Lower Upset Yield Strength psi Min.	Lower Upset Tensile Strength psi Min.	Elongation % Min.	Brinell Hardness HBW Min.
3 $^{3}/_{8}$ to 6 $^{7}/_{8}$	110,000	140,000	13	285
7	100,000	135,000	13	285

Table D.10—Drill Stem Subs

Type	Class	Upper Connection to Assemble with	Lower Connection to Assemble with
A or B	Kelly sub	Kelly	Tool joint
A or B	Joint sub	Tool joint	Tool joint
A or B	Crossover sub	Tool joint	Drill collar
A or B	Drill collar sub	Drill collar	Drill collar
A or B	Bit sub	Drill collar	Bit
C	Swivel sub	Swivel stem	Kelly
D	Lift sub	Elevator	Drill collar

Table D.11—Minimum Surface Hardness of Dimension D_R of Type B Drill Stem Subs and Dimension D_P of Type D Drill Stem Subs

Large OD D in.	Surface Brinell Hardness of Reduced Diameter Section D_R HBW Min.
3 $^1/_8$ through 6 $^7/_8$	285
7 through 10	277

Table D.12—Dimensions for Lift Subs

Elevator Recess Diameter D_p $\pm^1/_{32}$	Diameter of Lift Shoulder (tapered) D_L $^{+1/8}/_0$	Overall Length L_1 $^{+3}/_{-1}$	Top Length L_2 $\pm^1/_8$	Elevator Recess Length L_3 (Ref.)	Bottom Length L_4 $\pm^1/_2$	Largest Elevator [a]
2 $^3/_8$	3 $^1/_2$	36	4	18	14	2 $^7/_8$
2 $^7/_8$	4 $^1/_2$	36	4	18	14	3 $^1/_2$ or 4IU
3 $^1/_2$	5	36	4	18	14	4 $^1/_2$
4	6	36	4	18	14	5 $^1/_2$
4 $^1/_2$	6 $^1/_4$	36	4	18	14	5 $^1/_2$
5	6 $^1/_2$	36	4	18	14	5 $^1/_2$
5 $^1/_2$	7 $^1/_4$	36	4	18	14	6 $^5/_8$
6 $^5/_8$	8	36	4	18	14	6 $^5/_8$

NOTE Dimensions in inches.

[a] For the lift sub and elevator best fit, it is recommended to use the appropriate elevator size for the lift sub D_p value in accordance with Table 7 in API 8C, 5th Edition—where the data in this column is from.

Table D.13—Float Valve Recess in Bit Subs

Valve Assembly Diameter D (Ref.)	Float Recess Diameter D_{FR} [a] $^{+1/64}/_{0}$	Valve Assembly Length L_{FV} (Ref.)	API REG Bit Box			Other Popular Connections	
			Label [b]	L_R $\pm 1/16$	D_{BP} $^{+1/32}/_{0}$	Label [b]	L_R $\pm 1/16$
1 21/32	1 11/16	5 7/8	2 3/8 Reg	9 1/8	1 5/16	NC23	9 1/8
1 29/32	1 15/16	6 1/4	2 7/8 Reg	10	1 1/2	NC26	9 1/2
2 13/32	2 7/16	6 1/2	3 1/2 Reg	10 1/2	1 29/32	NC31	10 1/4
2 13/16	2 27/32	10	—	—	—	3 1/2 FH	14
3 1/8	3 5/32	10	—	—	—	NC38	14 1/4
3 15/32	3 1/2	8 5/16	4 1/2 Reg	12 13/16	2 15/16	NC44	13 1/16
3 21/32	3 11/16	12	—	—	—	NC46	16 3/4
3 7/8	3 29/32	9 3/4	5 1/2 Reg	14 3/4	3 3/8	NC50	14 1/2
4 25/32	4 13/16	11 3/4	6 5/8 Reg	17	4 9/32	5 1/2 IF	17
4 25/32	4 13/16	11 3/4	7 5/8 Reg	17 1/4	4 9/32	5 1/2 FH	17
4 25/32	4 13/16	11 3/4	8 5/8 Reg	17 5/8	4 9/32	NC61	17 1/2
5 11/16	5 23/32	14 5/8	8 5/8 Reg	20 1/4	5 3/16	6 5/8 IF	19 7/8

[a] Diameter D_{FR} equals D + 1/32 in.

[b] Labels are for information and assistance in ordering.

Table D.14—Drill Collars

Drill Collar Number and Connection Label [a, b]	Outside Diameter [c] D in.	Bore d in. $^{+1/16}/_{0}$	Length L ft ±6 in. [d]	Bevel Diameter [e] D_F in. $\pm^1/_{64}$ in.	Reference Bending Strength Ratio [f] (BSR)
NC23-31	3 1/8	1 1/4	30	3	2.57:1
NC26-35	3 1/2	1 1/2	30	3 21/64	2.42:1
NC31-41	4 1/8	2	30 or 31	4	2.43:1
NC35-47	4 3/4	2	30 or 31	4 33/64	2.58:1
NC38-50	5	2 1/4	30 or 31	4 49/64	2.38:1
NC44-60	6	2 1/4	30 or 31	5 11/16	2.49:1
NC44-60	6	2 13/16	30 or 31	5 11/16	2.84:1
NC44-62	6 1/4	2 1/4	30 or 31	5 7/8	2.91:1
NC46-62	6 1/4	2 13/16	30 or 31	5 29/32	2.63:1
NC46-65	6 1/2	2 1/4	30 or 31	6 3/32	2.76:1
NC46-65	6 1/2	2 13/16	30 or 31	6 3/32	3.05:1
NC46-67	6 3/4	2 1/4	30 or 31	6 9/32	3.18:1
NC50-70	7	2 1/4	30 or 31	6 31/64	2.54:1
NC50-70	7	2 13/16	30 or 31	6 31/64	2.73:1
NC50-72	7 1/4	2 13/16	30 or 31	6 43/64	3.12:1
NC56-77	7 3/4	2 13/16	30 or 31	7 19/64	2.70:1
NC56-80	8	2 13/16	30 or 31	7 31/64	3.02:1
6 5/8 REG	8 1/4	2 13/16	30 or 31	7 45/64	2.93:1
NC61-90	9	2 13/16	30 or 31	8 3/8	3.17:1
7 5/8 REG	9 1/2	3	30 or 31	8 13/16	2.81:1
NC70-97	9 3/4	3	30 or 31	9 5/32	2.57:1
NC70-100	10	3	30 or 31	9 11/32	2.81:1
8 5/8 REG	11	3	30 or 31	10 1/2	2.84:1

NOTE See Figure 8 for configuration of drill collars.

[a] Labels are for information and assistance in ordering.

[b] The drill collar number consists of two parts separated by a hyphen; the first part is the connection number in the NC style; the second part, consisting of two (or three) digits, indicates the drill collar outside diameter in units and tenths of inches; drill collars with 8 1/4 in., 9 1/2 in., and 11 in. outside diameters are shown with 6-5/8, 7-5/8, and 8-5/8 REG connections, since there are no NC connections in the recommended range of bending-strength ratios.

[c] See Table D.15 for tolerances.

[d] See 8.3.1.1 for non-magnetic drill collar tolerances.

[e] See API 7-2 for bevel diameters of drill collar ODs not shown.

[f] Stress-relief features are disregarded in the calculation of the bending-strength ratio.

Table D.15—Drill Collar OD Tolerances

Outside Diameter	Size Tolerance Inclusive		Out-of-Roundness [a]
	Max.	Min.	
Over 2 1/2 to 3 1/2, inclusive	3/64	0	0.035
Over 3 1/2 to 4 1/2, inclusive	1/16	0	0.046
Over 4 1/2 to 5 1/2, inclusive	5/64	0	0.058
Over 5 1/2 to 6 1/2, inclusive	1/8	0	0.070
Over 6 1/2 to 8 1/4, inclusive	5/32	0	0.085
Over 8 1/4 to 9 1/2, inclusive	3/16	0	0.100
Over 9 1/2	1/4	0	0.120

NOTE Dimensions and tolerances in inches.

[a] Out-of-roundness is the difference between the maximum and minimum diameters of the bar or tube, measured in the same cross-section, and does not include surface-finish tolerances outlined in 8.1.4.

Table D.16—Drill Collar Surface Imperfection Removal and Inspection Reference Standard Notch Depth

Size: Outside Diameter	Stock Removal from Surface Max.	Brinell Harness Slot Depth Max.	Allowable Depth of Indication Without Removal [b] Max.
Over 2 1/2 to 3 1/2, inclusive	0.072	0.072	0.035
Over 3 1/2 to 4 1/2, inclusive	0.090	0.090	0.045
Over 4 1/2 to 5 1/2, inclusive	0.110	0.110	0.055
Over 5 1/2 to 6 1/2, inclusive	0.125	0.125	0.063
Over 6 1/2 to 8 1/4, inclusive	0.155	0.155	0.083
Over 8 1/4 to 9 1/2, inclusive	0.203	0.203	0.095
Over 9 1/2	0.240 [a]	0.240 [a]	0.095

NOTE Dimensions in inches.

[a] Stock removal from surface is capped at 0.240 in. on drill collars over 9 ½ in. as removal over this amount is not allowed.

[b] Allowable depth of indication based upon 1 % of OD of largest OD in the given range (except for sizes over 9 1/2 in.).

Table D.17—Mechanical Properties and Tests for New Standard Steel Drill Collars

Drill Collar OD Range in.	Yield Strength psi Min.	Tensile Strength psi Min.	Elongation, with Gauge Length 4× Diameter % Min.	Brinell Hardness HBW Min.
3 1/8 through 6 7/8	110,000	140,000	13	285
7 through 11	100,000	135,000	13	285

Table D.18—Mechanical Properties for New Non-magnetic Drill Collars

Drill Collar OD Range in.	Yield Strength psi Min.	Tensile Strength psi Min.	Elongation Stainless Steel Collars % Min.	Elongation Non-ferrous Collars % Min.
2 $^3/_4$ through 3 $^7/_8$	120,000	130,000	16	13
4 through 6 $^7/_8$	110,000	120,000	18	13
7 through 11	100,000	110,000	20	13

Table D.19—Impact Energy of Non-magnetic Steels

Material Type	Yield Strength Range psi	Minimum Impact Energy ft-lb
Non-magnetic steel	100,000 to 140,000	60
Non-magnetic steel	> 140,000 to 160,000	50
Non-magnetic steel	> 160,000	40
Non-ferrous alloys	> 100,000	30

Table D.20—Lower Connections for Bottom-hole Drill Collars

Outside Diameter of Drill Collar	Bottom Box Connection Label [a]	Bevel Diameter $\pm^1/_{64}$
4 $^1/_8$ to 4 $^1/_2$, inclusive	2 $^7/_8$ REG	3 $^{39}/_{64}$
4 $^3/_4$ to 5, inclusive	3 $^1/_2$ REG	4 $^7/_{64}$
6 to 7, inclusive	4 $^1/_2$ REG	5 $^{21}/_{64}$
7 to 7 $^1/_4$, inclusive	5 $^1/_2$ REG	6 $^1/_2$
7 $^3/_4$ to 9, inclusive	6 $^5/_8$ REG	7 $^{23}/_{64}$
9 $^1/_2$ to 10, inclusive	7 $^5/_8$ REG	8 $^{15}/_{32}$
11, inclusive	8 $^5/_8$ REG	9 $^{35}/_{64}$

NOTE Dimensions in inches.

[a] Labels are for information and assistance in ordering.

Table D.21—Additional Non-magnetic Drill Collar Sizes

Drill Collar Number	Outside Diameter D [a] in.	Bore d $^{+1/16}/_0$ in.	Length L $^{+0.5}/_0$ ft	Bevel Diameter D_F ±1/64 in.	Reference Bending Strength Ratio [b] (BSR)
NC 50-67	6 $^3/_4$	2 $^{13}/_{16}$	30 or 31	6 $^9/_{32}$	2.37:1

NOTE See Figure 8 for configuration of drill collar.

[a] See Table D.15 for tolerances.

[b] The NC50-67 with 2 $^{13}/_{16}$ ID has a bending-strength ratio of 2.37:1; this is more pin-strong than may be generally acceptable for standard steel drill collars but has proven to be acceptable for non-magnetic drill collars.

Table D.22—Drill Collar Slip Groove Dimensions

Groove Dimensions Based on Drill Collar OD		
Drill Collar OD Ranges	**Slip Groove Depth l_s [a] $\pm^1/_{64}$**	**Angle β [b]**
4 to 4 $^5/_8$	$^3/_{16}$	3.5°
4 $^3/_4$ to 5 $^5/_8$	$^3/_{16}$	3.5°
5 $^3/_4$ to 6 $^5/_8$	$^1/_4$	5°
6 $^3/_4$ to 8 $^5/_8$	$^1/_4$	5°
8 $^3/_4$ and larger	$^1/_4$	5°
NOTE Dimensions in inches.		

[a] "l_s" is from the nominal OD of the drill collar.

[b] Angle β values are reference and approximate.

Table D.23—Dimensions of Heavy-Weight Drill Pipe (HWDP)

Size	Connection Label [a]	Bevel Dia. $\pm 1/64$	Tube OD $^{+1/16}/_{-1/32}$	Tool Joint OD [b] $^{+1/16}/_{-1/32}$	Max. Elevator Upset Dia. D_{eu}	Center Upset or Wear Pad Dia. D_{cu} $^{+1/16}/_{-1/32}$	Tube [c] ID	Tool Joint ID $^{+1/8}/_{0}$	Min. Drift Dia. [d]
3 1/2	NC 38	4 37/64	3 1/2	4 3/4 (4 7/8, 5)	3 7/8	4	2 1/16	2 1/16	1 13/16
							2 1/16	2 3/16	1 13/16
							2 1/4	2 1/4	2
							2 1/4	2 3/8	2
4	NC40	5 1/64	4	5 1/4	4 3/16	4 1/2	2 1/2	2 1/2	2 1/4
							2 9/16	2 9/16	2 5/16
							2 9/16	2 11/16	2 5/16
4 1/2	NC 46	5 23/32	4 1/2	6 1/4	4 11/16	5	2 11/16	2 11/16	2 7/16
							2 3/4	2 3/4	2 1/2
							2 3/4	2 7/8	2 1/2
							2 13/16	2 13/16	2 9/16
5	NC 50	6 1/16	5	6 5/8	5 1/8	5 1/2	3	3	2 3/4
							3	3 1/16	2 3/4
5 1/2	5 1/2 FH	6 23/32	5 1/2	7 (7 1/4 7 1/2)	5 11/16	6	3 1/4	3 1/4	3
							3 3/8	3 3/8	3 1/8
							3 3/8	3 1/2	3 1/8
							3 7/8	3 7/8	3 5/8
							4	4	3 3/4
5 7/8	5 1/2 FH	6 23/32	5 7/8	7	6	6 3/8	4	4	3 3/4
6 5/8	6 5/8 FH	7 45/64	6 5/8	8 (8 1/4, 8 1/2)	6 15/16	7 1/8	4	4	3 3/4
							4 1/2	4 1/2	4 1/4
							4 1/2	4 5/8	4 1/4
							5	5	4 3/4

Table D.23—Dimensions of Heavy-Weight Drill Pipe (HWDP) (Continued)

Size	Connection Label [a]	Bevel Dia. $\pm ^1/_{64}$	Tube OD $^{+1/16}/_{-1/32}$	Tool Joint OD [b] $^{+1/16}/_{-1/32}$	Max. Elevator Upset Dia. D_{eu}	Center Upset or Wear Pad Dia. D_{cu} $^{+1/16}/_{-1/32}$	Tube [c] ID	Tool Joint ID $^{+1/8}/_{0}$	Min. Drift Dia. [d]

NOTE Dimensions in inches.

[a] Labels are for information and assistance in ordering.

[b] Optional tool joint OD's are shown in parenthesis and are to be agreed upon between purchaser and manufacturer.

[c] Maximum tube ID is $^1/_8$ in. larger than nominal; minimum tube ID is controlled by drift requirement.

[d] Drift diameter is based on ID tolerances of heavy-wall pierced tube used for the center section.

Table D.24—Allowable Surface Imperfection Removal

Center Upset Diameter D_{cu} in.	Maximum Stock Removal from Surface in.
Over 2 $^{1}/_{2}$ to 3 $^{1}/_{2}$, inclusive	0.072
Over 3 $^{1}/_{2}$ to 4 $^{1}/_{2}$, inclusive	0.090
Over 4 $^{1}/_{2}$ to 5 $^{1}/_{2}$, inclusive	0.110
Over 5 $^{1}/_{2}$ to 6 $^{1}/_{2}$, inclusive	0.125
Over 6 $^{1}/_{2}$	0.155

Table D.25—Mechanical Properties of HWDP Tool Joints

1	2	3	4	5
Tool Joint OD Range in.	Yield Strength psi Min.	Tensile Strength psi Min.	Elongation with Gauge Length 4× Diameter % Min.	Brinell Hardness HBW Min.
3 $^{1}/_{8}$ through 6 $^{7}/_{8}$	110,000	140,000	13	285
Over 6 $^{7}/_{8}$	100,000	135,000	13	285
NOTE Dimensions in inches.				

Table D.26—Roller Bit and Drag Bit Tolerances

Size of Bit in.	Tolerance in.
1 $^{3}/_{4}$ to 13 $^{3}/_{4}$, inclusive	$^{+1/32}/_{0}$
14 to 17 $^{1}/_{2}$, inclusive	$^{+1/16}/_{0}$
17 $^{5}/_{8}$ and larger	$^{+3/32}/_{0}$

Table D.27—Roller Bit Connections

Size of Bit OD	Label Rotary Shouldered Pin Connection [a]	Bit Sub Bevel Diameter $\pm ^1/_{64}$	Bit Bevel Diameter $\pm ^1/_{64}$
1.75 to 2.24, inclusive	1 REG [b]	1 $^{15}/_{32}$	1 $^1/_2$
2.25 to 3.49, inclusive	1 $^1/_2$ REG [c]	1 $^{15}/_{16}$	1 $^{31}/_{32}$
3 $^1/_2$ to 4 $^1/_2$, inclusive	2 $^3/_8$ REG	3 $^3/_{64}$	3 $^5/_{64}$
4 $^5/_8$ to 5, inclusive	2 $^7/_8$ REG	3 $^{39}/_{64}$	3 $^{41}/_{64}$
5 $^1/_8$ to 7 $^3/_8$, inclusive	3 $^1/_2$ REG	4 $^7/_{64}$	4 $^9/_{64}$
7 $^1/_2$ to 9 $^3/_8$, inclusive	4 $^1/_2$ REG	5 $^{21}/_{64}$	5 $^{23}/_{64}$
9 $^1/_2$ to 14 $^3/_8$, inclusive	6 $^5/_8$ REG	7 $^{23}/_{64}$	7 $^{25}/_{64}$
14 $^1/_2$ to 18 $^1/_2$, inclusive	6 $^5/_8$ REG or	7 $^{23}/_{64}$	7 $^{25}/_{64}$
	7 $^5/_8$ REG	8 $^{15}/_{32}$	8 $^1/_2$
18 $^5/_8$ to 26, inclusive	7 $^5/_8$ REG or	8 $^{15}/_{32}$	8 $^1/_2$
	8 $^5/_8$ REG	9 $^{35}/_{64}$	9 $^{37}/_{64}$
27 and larger	8 $^5/_8$ REG	9 $^{35}/_{64}$	9 $^{37}/_{64}$

NOTE Dimensions in inches.

[a] Labels are for information and assistance in ordering.
[b] The 1 REG is interchangeable with most 1 M.T., AMT and AMMT threads.
[c] The 1 $^1/_2$ REG is interchangeable with most 1 $^1/_2$ M.T., AMT and AMMT threads.

Table D.28—Blade Drag Bit Connections

Size of Bit OD	Label Rotary Shouldered Connection [a]	Bit Sub Bevel Diameter $\pm ^1/_{64}$	Bit Bevel Diameter $\pm ^1/_{64}$
1.75 to 2.24, inclusive	1 REG [b]	1 $^{15}/_{32}$	1 $^1/_2$
2.25 to 3.49, inclusive	1 $^1/_2$ REG [c]	1 $^{15}/_{16}$	1 $^{31}/_{32}$
3 $^1/_2$ to 4 $^1/_2$, inclusive	2 $^3/_8$ REG, pin, or box	3 $^3/_{64}$	3 $^5/_{64}$
4 $^5/_8$ to 5, inclusive	2 $^7/_8$ REG, pin, or box	3 $^{39}/_{64}$	3 $^{41}/_{64}$
5 $^1/_8$ to 7 $^3/_8$, inclusive	3 $^1/_2$ REG, pin, or box	4 $^7/_{64}$	4 $^9/_{64}$
7 $^1/_2$ to 8 $^1/_2$, inclusive	4 $^1/_2$ REG, pin, or box	5 $^{21}/_{64}$	5 $^{23}/_{64}$
8 $^5/_8$ to 9 $^7/_8$, inclusive	5 $^1/_2$ REG, pin, or box	6 $^1/_2$	6 $^{17}/_{32}$
Larger than 9 $^7/_8$	6 $^5/_8$ REG, pin, or box	7 $^{23}/_{64}$	7 $^{25}/_{64}$

NOTE Dimensions in inches.

[a] Labels are for information and assistance in ordering.
[b] The 1 REG is interchangeable with most 1 M.T., AMT and AMMT threads.
[c] The 1 $^1/_2$ REG is interchangeable with most 1 $^1/_2$ M.T., AMT and AMMT threads.

Table D.29—Diamond Drilling, Diamond Core and PDC Bit Tolerances

Bit Size OD	OD Tolerances [a]
6 $^{3}/_{4}$ and smaller	$^{0}/_{-0.015}$
6 $^{25}/_{32}$ to 9, inclusive	$^{0}/_{-0.020}$
9 $^{1}/_{32}$ to 13 $^{3}/_{4}$, inclusive	$^{0}/_{-0.030}$
13 $^{25}/_{32}$ to 17 $^{1}/_{2}$, inclusive	$^{0}/_{-0.045}$
17 $^{17}/_{32}$ and larger	$^{0}/_{-0.063}$

NOTE Dimensions in inches.

[a] It is recognized that certain applications may warrant the manufacture of PDC bits to tolerances other than those shown in Table D.30; when manufactured, such bits are outside the scope of this standard.

Table D.30—Diamond Drilling Bit and PDC Bit Connections

Size of Bit	Label Rotary Shouldered Pin Connection [a]	Bit Sub Bevel Diameter $\pm^{1}/_{64}$	Bit Bevel Diameter $\pm^{1}/_{64}$
1.75 to 2.24, inclusive	1 REG [b]	1 $^{1}/_{2}$	1 $^{17}/_{32}$
2.25 to 3.49, inclusive	1 $^{1}/_{2}$ REG [c]	1 $^{15}/_{16}$	1 $^{31}/_{32}$
3 $^{1}/_{2}$ to 4 $^{1}/_{2}$, inclusive	2 $^{3}/_{8}$ REG	3 $^{3}/_{64}$	3 $^{5}/_{64}$
4 $^{17}/_{32}$ to 5, inclusive	2 $^{7}/_{8}$ REG	3 $^{39}/_{64}$	3 $^{41}/_{64}$
5 $^{1}/_{32}$ to 7 $^{3}/_{8}$, inclusive	3 $^{1}/_{2}$ REG	4 $^{7}/_{64}$	4 $^{9}/_{64}$
7 $^{13}/_{32}$ to 9 $^{3}/_{8}$, inclusive	4 $^{1}/_{2}$ REG	5 $^{21}/_{64}$	5 $^{23}/_{64}$
9 $^{13}/_{32}$ to 14 $^{1}/_{2}$, inclusive	6 $^{5}/_{8}$ REG	7 $^{23}/_{64}$	7 $^{25}/_{64}$
14 $^{9}/_{16}$ to 18 $^{1}/_{2}$, inclusive	6 $^{5}/_{8}$ REG or	7 $^{23}/_{64}$	7 $^{25}/_{64}$
	7 $^{5}/_{8}$ REG	8 $^{15}/_{32}$	8 $^{1}/_{2}$
18 $^{9}/_{16}$ and larger	7 $^{5}/_{8}$ REG or	8 $^{15}/_{32}$	8 $^{1}/_{2}$
	8 $^{5}/_{8}$ REG	9 $^{35}/_{64}$	9 $^{37}/_{64}$

NOTE Dimensions in inches.

[a] Labels are for information and assistance in ordering.
[b] The 1 REG is interchangeable with most 1 M.T., AMT and AMMT threads.
[c] The 1 $^{1}/_{2}$ REG is interchangeable with most 1 ½ M.T., AMT and AMMT threads.

Table D.31—Sampling Requirements of Stabilizer Neck

Maximum Diameter of Forging or Bar	Radius of Sampling in Neck Region
< 7 $^{3}/_{8}$	1 $^{3}/_{8}$
7 $^{3}/_{8}$ to 9 $^{5}/_{8}$ inclusive	2 $^{1}/_{4}$
9 $^{3}/_{4}$ to 20 inclusive	3
> 20	3 $^{1}/_{2}$

NOTE Dimensions in inches.

Table D.32—Neck Lengths

Location	Minimum Lengths
Upper Neck	30
Lower neck, drill stem stabilizer	24
Lower neck, near-bit stabilizer	18

NOTE Dimensions in inches.

Table D.33—Neck Diameters and Connections

Neck Diameter	Connections, Drill Stem Stabilizer Box X Pin	Box Connection, Near Bit Stabilizer Lower	Inside Diameter	Blade Diameter
$4\,^{3}/_{4}$	NC38	$3\text{-}^{1}/_{2}$ REG	2	$5\,^{1}/_{8}$ to $7\,^{3}/_{8}$
$6\,^{1}/_{2}$	NC46	$4\text{-}^{1}/_{2}$ REG	$2\,^{13}/_{16}$	$7\,^{1}/_{2}$ to $7\,^{7}/_{8}$
$6\,^{3}/_{4}$	NC50	$4\text{-}^{1}/_{2}$ REG	$2\,^{13}/_{16}$	8 to $9\,^{5}/_{8}$
8	$6\text{-}^{5}/_{8}$ REG	$6\text{-}^{5}/_{8}$ REG	$2\,^{13}/_{16}$	$9\,^{1}/_{2}$ to $15\,^{1}/_{2}$
8	$6\text{-}^{5}/_{8}$ REG	$7\text{-}^{5}/_{8}$ REG	$2\,^{13}/_{16}$	$15\,^{5}/_{8}$ to 20
$9\,^{1}/_{2}$	$7\text{-}^{5}/_{8}$ REG	$7\text{-}^{5}/_{8}$ REG	3	$12\,^{1}/_{4}$ to 20
$9\,^{1}/_{2}$	$7\text{-}^{5}/_{8}$ REG	$7\text{-}^{5}/_{8}$ REG	3	$15\,^{5}/_{8}$ to 26
$9\,^{1}/_{2}$ to 11	$7\text{-}^{5}/_{8}$ REG	$8\text{-}^{5}/_{8}$ REG	3	20 to 26
11	$8\text{-}^{5}/_{8}$ REG	$8\text{-}^{5}/_{8}$ REG	3	> 26

NOTE Dimensions in inches.

Table D.34—Blade Dimensions

Up-hole and downhole	30 ±5 degrees (integral)					
Blade taper angles (see NOTE 2)	30 degrees to 45 degrees (welded)					
Blade diameter $^{0}/_{-1/32}$	$5\,^{1}/_{8}$ to $7\,^{3}/_{8}$	$7\,^{1}/_{2}$ to $9\,^{1}/_{2}$	$9\,^{5}/_{8}$ to $12\,^{1}/_{4}$	$12\,^{3}/_{8}$ to $14\,^{5}/_{8}$	$14\,^{3}/_{4}$ to 20	> 20
Number of blades (integral)	3	3	3	3	3	3
Number of blades (welded)	3	3	3 or 4	3 or 4	3 or 4	4
Blade width (integral) $\pm^{1}/_{4}$	2	2.5	3	3.5	4	4
Blade width (welded) $\pm^{1}/_{4}$	1.5	2	2	2.5	3	3
Crown length min (see NOTE 3)	12	16	18	18	20	20

NOTE 1 Dimensions in inches.

NOTE 2 The taper angle requirement applies only for the first 1 in. radially from the blade surface; if the blade height exceeds 1 in., the taper angle for the remainder of the height may be up to 45 degrees at the manufacturer's discretion (see Figure 17).

NOTE 3 The crown may be tapered at customer's option to form a "watermelon geometry" as in Figure 18; the crown length includes the length of this shallow taper.

Table D.35—Blade Spiral Definitions

Spiral Description	Wrap Angle (see Figure 15)
Straight blade	Not applicable
Open spiral	180 degrees to 280 degrees
Full spiral	300 degrees to 370 degrees
Tight spiral	500 degrees to 600 degrees

Annex E
(informative)

Procedures Used to Convert Units from USC to SI

E.1 Background

The following procedures were adopted in this standard for converting units from the United States Customary (USC) system into the International System (SI).

E.2 General

E.2.1 Rounding

When the digit following the last retained digit was exactly 5 followed by all zeros, the last retained digit was unchanged if it was even or was raised if it was odd.

E.2.2 Fractions

A fraction or a number with a fraction in USC units were converted to the full decimal equivalent in USC units without rounding. The full decimal equivalent in USC units were then converted to an SI value, N_m, expressed in millimeters, using Equation (E.1):

$$N_m = 25.4 \times N \qquad \text{(E.1)}$$

where

N is the full decimal equivalent, expressed in inches, of a USC fraction or a number with a fraction that has not been rounded.

The converted SI value, in millimeters, for the equivalent of a USC fraction or a number with a fraction is rounded to the appropriate number of places for the application.

E.2.3 Tolerances

Tolerances were calculated using Equation (E.1).

The USC value for the tolerance, except in the case of angular misalignment, was converted to the SI value based on the appropriate conversion factor.

The converted SI value for the tolerance, except in the case of angular misalignment, was rounded to the same number of decimal places as the SI value to which it was applicable.

E.3 Pipe Dimensions

E.3.1 Outside Diameter

The USC value for the outside diameter of pipe and couplings was converted to an SI value, D_m, expressed in millimeters, using Equation (E.2):

$$D_m = 25.4 \times D \tag{E.2}$$

where

D is the outside diameter, expressed in inches.

The converted SI value for the outside diameter of the pipe was rounded to the nearest 0.01 mm.

E.3.2 Wall Thickness

The USC value for wall thickness was converted to the SI value, t_m, expressed in millimeters, using Equation (E.3):

$$t_m = 25.4 \times t \tag{E.3}$$

where

t is the wall thickness, expressed in inches.

The converted SI value for wall thickness was rounded to the nearest 0.01 mm.

E.3.3 Inside Diameter

The SI value for the inside diameter of pipe, d_m, expressed in millimeters, is calculated (not converted) using Equation (E.4):

$$d_m = D_m - (2 \times t_m) \tag{E.4}$$

where

D_m is the outside diameter, expressed in millimeters;

t_m is the wall thickness, expressed in millimeters.

The calculated SI value for the inside diameter of the pipe was rounded to the nearest 0.01 mm.

E.3.4 Diameters and Lengths of Upsets

The USC value for the diameter and the length of upsets was converted to the SI value, U_m, expressed in millimeters, using Equation (E.5):

$$U_m = 25.4 \times U \tag{E.5}$$

where

U is the upset dimension, expressed in inches.

The converted SI value for the diameter and the length of upsets was rounded to the nearest 0.01 mm.

E.4 Plain-end Linear Mass

The plain-end linear mass, $W_{m,pe}$, expressed in SI units of kilograms per meter, was calculated (not converted) using Equation (E.6):

$$W_{m,pe} = 0.0246615 \times (D_m - t_m) \times t_m \quad \text{(E.6)}$$

where

D_m is the outside diameter, expressed in millimeters;

t_m is the wall thickness, expressed in millimeters.

The calculated SI value for plain-end linear mass was rounded to the nearest 0.01 kg/m.

E.5 Approximate Linear Mass

The USC value for approximate linear mass was converted to the SI value, W_m, expressed in kilograms per meter, using Equation (E.7):

$$W_m = 1.48816 \times m \quad \text{(E.7)}$$

where

m is the linear mass, expressed in pounds per foot.

The converted SI value for nominal linear mass was rounded to the nearest 0.01 kg/m.

E.6 Tensile Tests

E.6.1 Yield Strength

The USC value for yield strength was converted to the SI value, YS_m, expressed in megapascals, using Equation (E.8):

$$YS_m = 0.00689476 \times YS \quad \text{(E.8)}$$

where

YS is the yield strength, expressed in pounds per square inch.

The converted SI value for yield strength was rounded to the nearest megapascal.

E.6.2 Tensile Strength

The USC value for tensile strength was converted to the SI value, TS_m, expressed in megapascals, using Equation (E.9):

$$TS_{\rm m} = 0.00689476 \times TS \quad \text{(E.9)}$$

where

TS is the tensile strength, expressed in pounds per square inch.

The converted SI value for tensile strength was rounded to the nearest megapascal.

E.6.3 Elongation

The value for elongation, e_m, expressed as a percentage of values, was calculated (not converted) using Equation (E.10):

$$e_m = 1944.0 \times A_{\rm m}^{0.2} / U_{\rm m}^{0.9} \quad \text{(E.10)}$$

where

$A_{\rm m}$ is the cross-sectional area of the tensile-test specimen, expressed in square millimeters;

$U_{\rm m}$ is the specified tensile strength, expressed in megapascals.

The calculated SI value for elongation was rounded to the nearest 1.0 % for a value of 10.0 % and larger and to the nearest 0.5 % for a value less than 10.0 %.

E.7 Charpy Impact Energy

When the SI value for the impact-energy requirement was not determined by an equation (for example, as used in Table D.8 and other minimum requirements), the standard USC value was converted to the SI value, $C_{\rm m}$, expressed in joules, using Equation (E.11):

$$C_{\rm m} = 1.35582'C \quad \text{(E.11)}$$

where

$C_{\rm m}$ is the standard Charpy impact energy, expressed in Joules;

C is the standard Charpy impact energy, expressed in foot-pounds (e.g. Eight ft-lb, 15 ft-lb, 20 ft-lb, 30 ft-lb).

The converted standard SI value for energy was rounded to the nearest Joule.

E.8 Temperature

The temperature in degrees Fahrenheit (USC) was converted to a temperature in degrees Celsius (SI) using Equation (E.12):

$$C = (F - 32)'5/9 \quad \text{(E.12)}$$

where

C is the temperature, expressed in degrees Celsius;

F is the temperature, expressed in degrees Fahrenheit.

The converted SI values for temperatures were rounded to the nearest degree.

When the temperature being converted was over 600 °F, the number was rounded to the most rational value, i.e. rounded to the nearest 5 °C. For example, 750 °F converts to 399 °C but the rational conversion is 400 °C.

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