

Threading and Gauging of Rotary Shouldered Connections

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Introduction

This standard is based on API Specification 7, *Specification for Rotary Drill Stem Elements*.

The function of this part of this standard is to define the connections design and the gauging required for rotary drill stem elements. It also defines the testing required to verify compliance with these requirements. As rotary drill stem elements are very mobile, moving from rig to rig, design control is an important element required to ensure the interchangeability and performance of product manufactured by different sources.

Users of this standard should be aware that further or differing requirements may be needed for individual applications. This standard is not intended to inhibit a vendor from offering, or the purchaser from accepting, alternative equipment or engineering solutions for the individual application. This may be particularly applicable where there is innovative or developing technology. Where an alternative is offered, the vendor should identify any variations from this standard and provide details.

Threading and Gauging of Rotary Shouldered Connections

1 Scope

This standard specifies the following requirements on rotary shouldered connections for use in petroleum and natural gas industries: dimensional requirements on threads and thread gauges, stipulations on gauging practice and gauge specifications, as well as instruments and methods for inspection of thread connections. These connections are intended primarily for use in drill-string components.

Other supplementary specifications can be agreed between interested parties for special tolerance requirements, qualification, testing, inspection, and finishing. This standard applies both to newly manufactured connections and connections that are recut after service. It should be realized that recut connections are subject to additional inspection and testing—the user is referred to API 7G-2 for such information.

This standard is applicable to preferred rotary shouldered connection designs. These are traceable to an internationally supported system of gauges and calibration that can be described as number (NC) style, regular (REG) style, or full-hole (FH) style.

2 Normative References

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

API Specification 5DP, *Specification for Drill Pipe*

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

ISO 1302 ¹, *Geometrical Product Specifications (GPS)—Indication of surface texture in technical product documentation*

ISO 10424-1, *Petroleum and natural gas industries—Rotary drilling equipment—Part 1: Rotary drill stem elements*

ISO 11961, *Petroleum and natural gas industries—Steel drill pipe*

ISO/IEC ² 17025, *General requirements for the competence of testing and calibration laboratories*

3 Terms, Definitions, Symbols, and Abbreviations

3.1 Terms and Definitions

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

3.1.1

bevel diameter

Outside diameter of the contact face of the rotary shouldered connection.

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

² International Electrotechnical Commission, 3, rue de Varembe, P.O. Box 131, CH-1211 Geneva 20, Switzerland, www.iec.ch.

3.1.2**blunt start**

A thread with removal of the incomplete thread at the starting end.

NOTE May also be referred to as Higbee or other similar name.

3.1.3**box connection****box end**

Threaded connection on oil country tubular goods with internal (female) threads.

3.1.4**box thread**

Internal (female) threads of a rotary shouldered connection.

3.1.5**break-in**

Procedure applied to newly manufactured threads to assure correct mating.

3.1.6**calibration system**

Documented system of gauge calibration and control.

3.1.7**cold rolling****(cold working)**

Plastic deformation of the surface of the connection at a temperature low enough to induce strain hardening.

3.1.8**first perfect thread**

Thread furthest from the sealing face on a pin, or closest to the sealing face on a box, where both the crest and the root are fully formed.

3.1.9**full depth thread**

Thread in which the thread root lies on the minor cone of an external thread or lies on the major cone of an internal thread.

3.1.10**full-hole (FH) style**

Type and size of rotary shouldered connection, covered by this standard, having thread form of V-040 or V-050.

NOTE The number relates to a historical drill pipe size.

3.1.11**gauge point**

Imaginary plane, perpendicular to the thread axis of rotary shouldered connections at which, C , the pitch diameter at gauge point is measured.

NOTE This plane is located 15.875 mm (0.625 in.) from the makeup shoulder of the pin or box connection (pin or box end), except on Working plug gauges, where it is located 34.925 mm (1.375 in.) from the reference face.

3.1.12**GOST Z style**

Type and size of the rotary shouldered connection, covered by a Russian standard, having the V-038R, V-040, or V-050 thread form.

NOTE The number designation is the pin-base diameter, rounded to units of millimeters.

3.1.13

H90 style

Type and size of rotary shouldered connection, having a 90° thread (90-V-050) form.

NOTE The number relates to a historical drill pipe size.

3.1.14

IF style

Type and size of the rotary shouldered connection, having the V-038R thread form.

NOTE The number relates to a historical drill pipe size; the thread form was historically V-065.

3.1.15

interchange standoff

Standoff between each member of a gauge set and a corresponding gauge higher in the ranking scheme: Grand Master or Regional Master, Reference Master, and Working gauge.

3.1.16

last engaged thread

Last thread of the pin near the makeup shoulder that is engaged with the box threads or the box thread farthest from the shoulder that is engaged with the pin threads.

3.1.17

lead

Distance parallel to the thread axis from a point on a thread turn and the corresponding point on the next turn, i.e. the axial displacement of a point following the helix one turn around the thread axis.

3.1.18

length of box threads

Length of threads in the box measured from the makeup shoulder to the last thread with full thread depth, measured at the intersection of the thread flank closest to the makeup shoulder with the crest of the thread.

3.1.19

makeup shoulder

Shoulder on a rotary shouldered connection carrying load when assembled.

3.1.20

manufacturer

Firm, company, or corporation that operates facilities capable of cutting the threads and is responsible for compliance with all the applicable provisions of this standard.

3.1.21

master gauge

Gauges used for calibration of other gauges.

NOTE These include Reference Master, Regional Master, and Grand Master gauges.

3.1.22

mating standoff

Standoff between the plug and ring members of a gauge set.

NOTE Interchange standoff is the standoff between each member and a gauge higher in the ranking scheme.

3.1.23

number connection (NC) style

Type and size of the rotary shouldered connection, having the V-038R thread form.

NOTE The number in the connection number is the first two digits of the pitch diameter of the pin thread at the gauge point, expressed in units of 2.54 mm (0.1 in.).

3.1.24

open-hole (OH) style

Type and size of rotary shouldered connection, having the V-076 thread form.

NOTE The number relates to a historical drill pipe size.

3.1.25

PAC style

Type and size of rotary shouldered connection, having the V-076 thread form.

NOTE The number relates to a historical drill pipe size.

3.1.26

pin connection

pin end

Threaded connection on oil country tubular goods with external (male) threads.

3.1.27

pin thread

External (male) threads of a rotary shouldered connection.

3.1.28

pitch

Axial distance between successive threads, which, in a single start thread, is equivalent to lead.

3.1.29

pitch cone

An imaginary cone of such apex angle and location of its vertex and axis that its surface would pass through a taper thread in such a manner as to make the axially measured widths of the thread ridge and the thread groove equal.

3.1.30

pitch diameter at gauge point

Diameter of the pitch cone at the gauge point.

3.1.31

product

Drill string component with rotary shouldered connection in accordance with this standard.

3.1.32

reference dimension

Dimension that is a result of two or more other dimensions.

3.1.33

regular (REG) style

Type and size of rotary shouldered connection, having thread forms of V-040, V-050, or V-055.

NOTE The number relates to a historical drill pipe size.

3.1.34

rotary shouldered connection

Thread connection used on drill stem elements that has coarse, tapered threads, and sealing shoulders.

3.1.35**SL H90 style**

Type and size of rotary shouldered connection, having a 90° (90-V-084) thread form and heavy truncation.

NOTE The number relates to a historical drill pipe size.

3.1.36**standoff**

Distance between faces of gauges, or gauge and product when mated.

3.1.37**stress-relief groove (or feature)**

Modification performed on rotary shouldered connections that removes a certain length of the unengaged threads of the pin or box.

NOTE This process reduces the likelihood of fatigue cracking in the highly stressed area both for box and pin threads due to a reduction of stress concentration.

3.1.38**taper**

Increase or decrease in the diameter of the pitch cone with length.

NOTE The taper is expressed in millimeters per millimeter (inch per foot) of thread length.

3.1.39**thread form**

Thread profile in an axial plane for a length of one pitch.

3.1.40**thread height**

Distance between the crest and root, normal to the axis of the thread.

3.1.41**tolerance**

Amount of variation permitted.

3.1.42**Working gauges**

Gauges used for gauging rotary shouldered connections.

3.2 Symbols

A	depth of the pin stress-relief groove below the thread root at the gauge point
B	depth of box stress-relief groove, measured from the minor thread cone
C	pitch diameter of thread at gauge point
C_{GP}	pitch diameter at Working gauge point
D_{BG}	diameter of box member at stress-relief groove
D_{CB}	diameter of cylinder of boreback stress-relief contour
D_{FG}	diameter of face groove and box counterbore in low-torque feature
D_{FP}	diameter of plug fitting plate
D_L	large diameter of pin at the intersection of the major cone and the pin shoulder
D_{LF}	diameter of cylindrical feature at the pin base on pin
D_{MP}	major diameter of plug gauge at gauge point

D_{MR}	minor diameter of ring gauge at gauge point
D_R	outside diameter of ring gauge
D_{PT}	diameter of optional pin ID taper
D_S	diameter of major diameter cone at the small end of the pin
D_{SRG}	diameter of pin stress-relief groove
d_b	diameter of ball for lead and taper gauges
d_{bh}	diameter of ball for thread height gauge
F_c	width of crest flat, product thread
F_r	width of root flat, product thread
f_c	crest truncation, product thread
f_{cg}	crest truncation, gauge thread
f_r	root truncation, product thread
f_{rg}	root truncation, gauge thread
H	reference thread height not truncated
h	product thread height truncated
h_{bg}	depth of box stress-relief groove, measured normal to taper cone
h_{cn}	height of product thread, compensated for taper
h_g	reference gauge thread height truncated
L_{BC}	depth of box
L_{BG}	length, shoulder face to groove of box member
L_{BT}	depth of box threads at last full depth thread
L_{CB}	boreback length
L_{CYL}	depth of cylinder of boreback contour
L_{GP}	distance from shoulder to gauge point
L_{PC}	length of pin
L_{Qc}	depth of box counterbore
L_{SRG}	length of relief groove on pin
L_X	length from shoulder to last thread scratch on boreback cylinder
L_{ct}	length of setting standard for thread lead, compensated for taper
L_{ft}	distance from shoulder to first full-depth pin thread
L_{pg}	total length of plug gauge
L_{rg}	total length of ring gauge
n	number of threads in 25.4 mm (1.0 in.)
p	pitch of thread (used also for lead, since all threads referenced are single-start)
Q	diameter of ring gauge counterbore
Q_c	diameter of product box counterbore
R	root radius, product thread
R_{FG}	radius at corners of low-torque grooves
R_{LF}	radius at end of pin-base cylinder feature
R_{bg}	radius at corners of box stress-relief groove
r_c	radius at corners of crest flat

r_r	radius at corners of root flat
S	mating standoff of gauges
S_0	standoff of certified Reference Master gauges
S_1	standoff of the Working plug gauge on a Reference Master gauge
S_2	standoff of the Working ring gauge on a Reference Master gauge
T	taper, millimeters of diameter per millimeter of length or inches of diameter per foot of length
T_{FP}	thickness of gauge fitting plate
ϕ	half of the included angle of the taper cone
θ	angle between the thread flank and the normal to the thread axis

3.3 Abbreviations

c/bore	counterbore
CW	cold (working) rolling: used as a marking
FF	full-face
FH	full-hole (style)
GOST	(Russian: ГОСТ) historical Soviet Standards institution
ID	inside diameter
IF	internal flush (style)
LH	left-hand
LT	low-torque modification
NC	numbered connection (style)
OD	outside diameter
OH	open-hole (style)
PAC	Phillip A Cornell (style)
ref	reference (dimension)
REG	regular (style)
RH	right-hand
SMYS	specified minimum yield stress
SRG	stress-relief groove

4 General Information

4.1 General

In this standard, data are expressed in both the International System (SI) of units and the U.S. customary (USC) system of units. Annex B and Annex C contain tables with the values in SI and USC units, respectively, and shall be followed as referenced herein. 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 considered 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.

Some of the dimensions in USC units have been converted from traditional fractional measurements. Depending on the rounding conventions used, tabulated dimensions and/or tolerances may differ by up to

0.002 in. from some existing manufacturing documents. These differences are to be considered acceptable and in compliance and shall not be cause of rejection. See Annex D for guidance on unit conversion and rounding.

NOTE Any style of rotary shouldered connection can be made in right-hand (RH) or left-hand (LH) versions; right-hand is assumed unless otherwise designated as LH; left-hand threads are not supported by the international system of gauges and calibration, except in the REG style.

4.2 Purchaser Supplied Information

In placing orders for equipment to be manufactured with rotary shouldered connections in accordance with this standard, the purchaser shall specify the following on the purchase order:

- a) number of this standard;
- b) thread style and size; and
- c) if necessary, supplementary requirements as detailed in Section 6, which are optional with the purchaser.

5 Threading

5.1 Thread Profile and Dimensions

5.1.1 Overall Dimensions

Rotary shouldered connections shall be furnished in the sizes and styles shown in Figures 1 and 2 and Table B.1. Dimensions of rotary shouldered connections shall conform to Table B.1, with the thread forms defined in Table B.2. The dimensions shown in Tables B.1 and B.2 that have no specified tolerance and do not have tolerances defined below, shall be considered reference dimensions. Deviations from these dimensions shall not be cause for rejection. The extent of the bevel of the small end of the pin is optional with the manufacturer.

Right-hand threads shall be considered standard. Left-hand threads may be made using this standard, but traceable gauging following this standard exists only in the REG style.

5.1.2 Pin Dimensions

The pin dimensions in Table B.1 shall be interpreted using Figures 1 and 2.

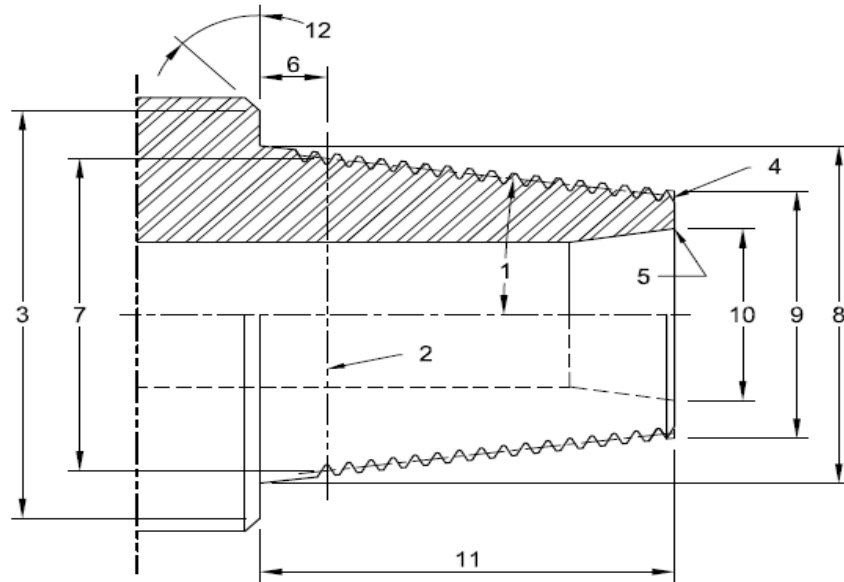
5.1.3 Pin Base Diameter

Pin base diameter dimensional requirements shall be as follows.

Rotary shouldered connections on drill collars shall have a cylindrical region at the base conforming to the dimension D_{LF} of Table B.1 and shall have a radius R_{LF} 1.6 mm $\pm$ 0.4 mm (0.063 in. $\pm$ 0.016 in.) at the pin base as shown in Figure 2, except when a stress-relief groove is used.

This feature reduces the stress concentration factor in this area. Rotary shouldered connections on products other than drill collars, such as tool joints, may have a tapered region at the pin base rather than a cylindrical region. In this case the radius at the intersection of the taper and the sealing face shall be 0.79 mm $\pm$ 0.12 mm (0.031 in. $\pm$ 0.005 in.), as shown in Figure 2.

The distance between the pin shoulder and the intersection of the pin base diameter or thread major cone with the thread flank at the first point of full thread depth shall not exceed L_{ft} (see Figure 2).

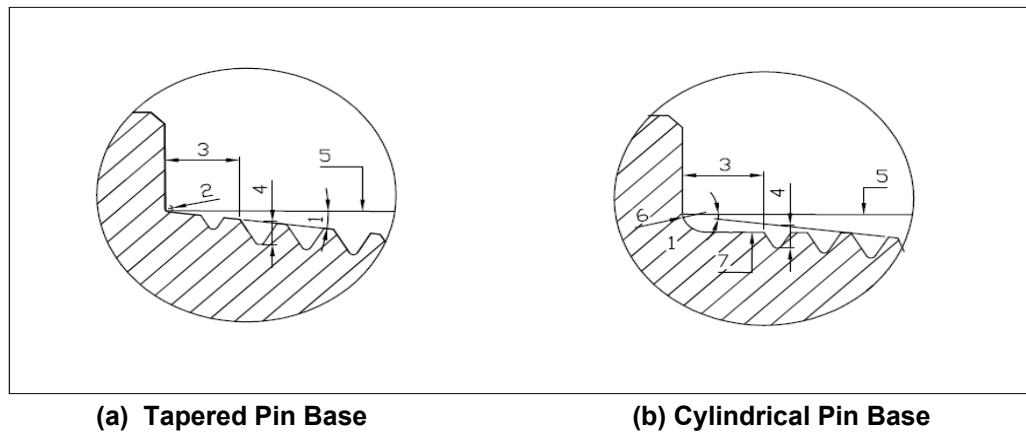


Key

- | | |
|--|---|
| 1 taper half-angle, ϕ | 7 pitch diameter at gauge point, C |
| 2 plane of gauge point | 8 large diameter, D_L |
| 3 connection bevel diameter; see 5.2 | 9 small diameter, D_S |
| 4 outside bevel angle optional to manufacturer; blunt start (see 3.1.2) is allowed | 10 diameter of optional tapered inside bevel D_{PT} (see 6.3.2) |
| 5 optional inside bevel (see 6.3.2) | 11 pin length, L_{PC} |
| 6 location of gauge plane 15.875 mm (0.625 in.) from shoulder | 12 connection bevel angle |

NOTE See Table B.1 (C.1) for dimensions.

Figure 1—Pin Connection (Pin End)



(a) Tapered Pin Base

(b) Cylindrical Pin Base

Key

- | | |
|---|--|
| 1 taper half-angle, ϕ | 5 large diameter, D_L |
| 2 internal radius with tapered base 0.79 mm (0.031 in.) min | 6 internal radius, R_{LF} , with cylinder base |
| 3 distance from shoulder to first full-depth pin thread, L_{FT} | 7 pin cylinder diameter, D_{LF} |
| 4 first point of full thread depth | |

Figure 2—Tapered and Cylindrical Pin Bases

5.1.4 Shoulder Contact Face

Shoulder contact faces of rotary shouldered connections shall be plane, and square with the thread axis, within 0.05 mm (0.002 in.). The surface finish of the contact face, before any surface treatment, shall be 0.8 μm (32 $\mu\text{in.}$) to 3.2 μm (125 $\mu\text{in.}$) R_a .

NOTE A minimum roughness is required to provide retention of thread compound during makeup; a maximum roughness is needed to ensure adequate sealing.

5.1.5 Standoff

Rotary shouldered connections shall be produced with standoff tolerances as specified in 7.2.

5.1.6 Lead Tolerance

The lead tolerance of rotary shouldered connections shall be as follows:

- ± 0.038 mm per 25.4 mm (0.0015 in. per in.) for any 25.4 mm (1.0 in.) between first and last full depth threads; and
- ± 0.114 mm (0.0045 in.) between first and last full depth threads, or the sum of 0.0254 mm (0.001 in.) for each 25.4 mm (1 in.) between first and last full depth threads, whichever is greater.

The method for determining lead is described in 7.4.

5.1.7 Taper Tolerance

The taper tolerance of rotary shouldered connections shall be as follows:

- pin thread: +0.0025 mm/mm to 0 mm/mm (+0.030 in./ft to 0 in./ft) average taper between first and last full depth threads; and
- box thread: 0 mm/mm to -0.0025 mm/mm (0 in./ft to -0.030 in./ft) average taper between first and last full depth threads.

The method for determining taper is described in 7.5.

5.1.8 Box Counterbore

The box counterbore shall have the diameter, Q_c , specified in Table B.1, and taper, T , as shown in the detail of Figure 3. The depth of the counterbore shall be L_{QC} as specified in Table B.1. The angle of the bevel at the intersection of the counterbore and the first threads is optional to the manufacturer but is typically 25° to 45°.

5.1.9 Thread Form

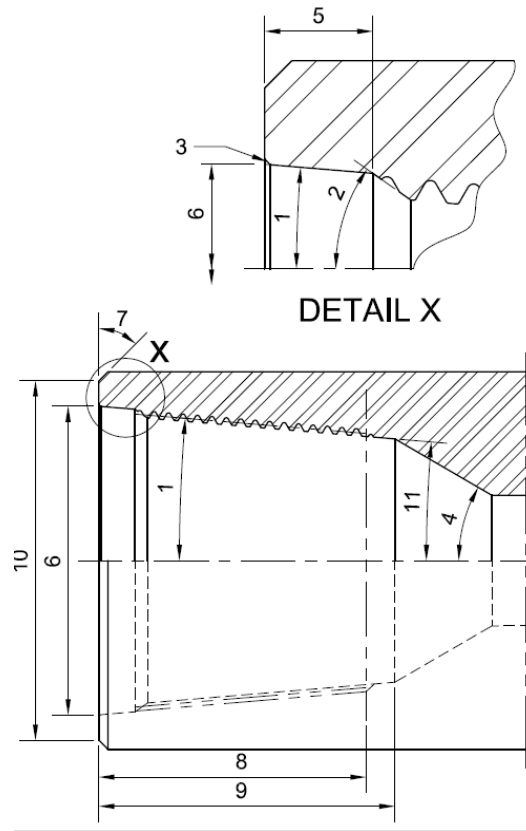
The thread form shall be as defined in Table B.2 and shown in Figures 4 and 5. The surface finish of the thread flanks and root before any surface treatment shall be 1.6 μm (63 $\mu\text{in.}$) R_a or better in order to maximize the fatigue life of the connection. This may be demonstrated using a sacrificial test piece on a process qualification basis.

The design intent for root radius, R , in Figure 4 is a tolerance of ± 0.025 mm (± 0.001 in.); this is not an auditable dimension but it is indirectly verified through the truncated thread height.

5.2 Bevels for Drill Collars and Tools that Mate Directly with Drill Collars

5.2.1 General

All connections shall have bevels on the outside surface with diameters detailed below. The bevel design is based on an angle of 45°.



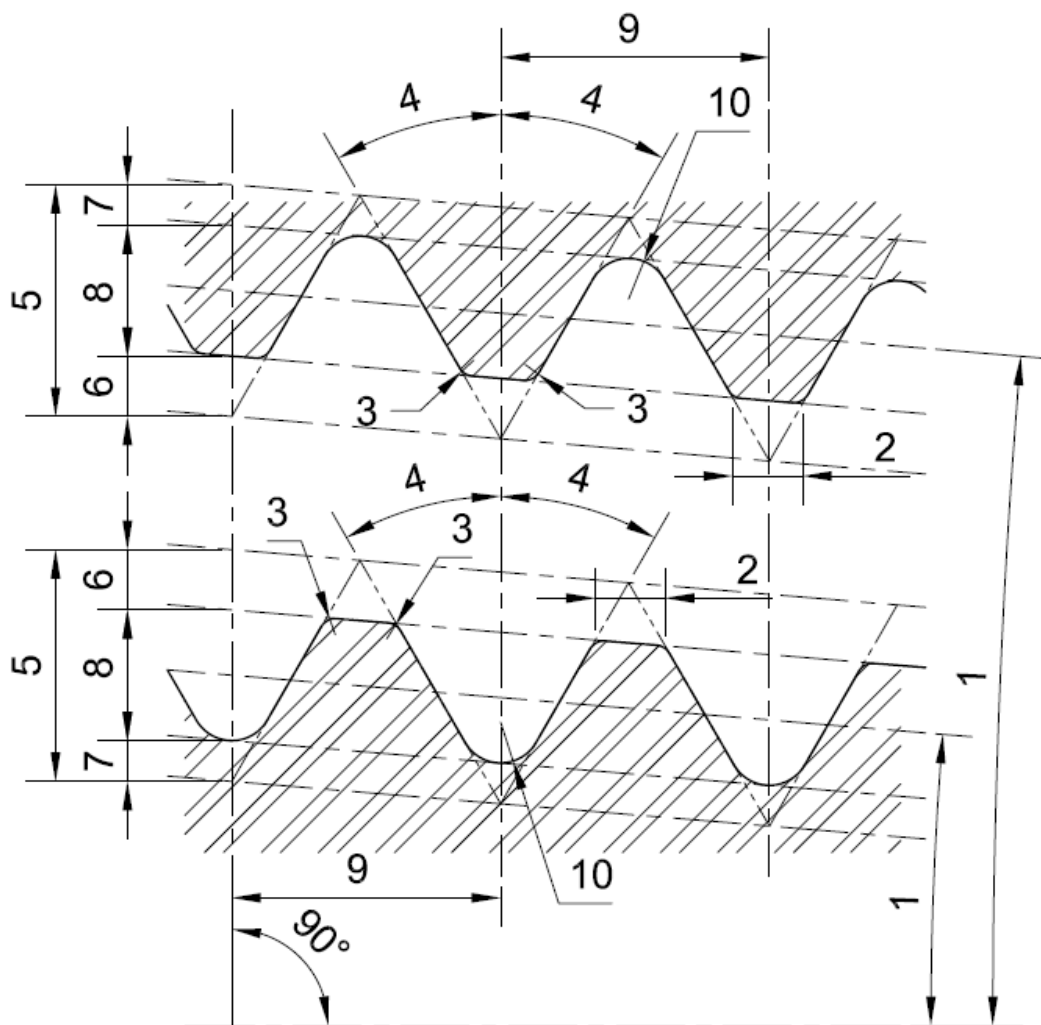
Key

- | | |
|--|--|
| 1 taper half-angle, ϕ | 7 bevel angle, $45^\circ \pm 10^\circ$ |
| 2 chamfer angle, typically 25° to 45° ; blunt start (see 3.1.2) is allowed | 8 depth of box threads, L_{BT} |
| 3 break edge or radius 0.8 mm (0.031 in.) max | 9 box depth, L_{BC} |
| 4 25° – 31° taper ^a | 10 connection bevel diameter |
| 5 counterbore depth, $L_{QC} +2.4/-0.8$ mm (+0.094/-0.031 in.) | 11 bore detail (see 6.3.3) |
| 6 counterbore diameter, Q_c | |

^a 45° maximum is allowed on drill bits and boxes that mate with bits.

NOTE See Table B.1 (C.1) for dimensions.

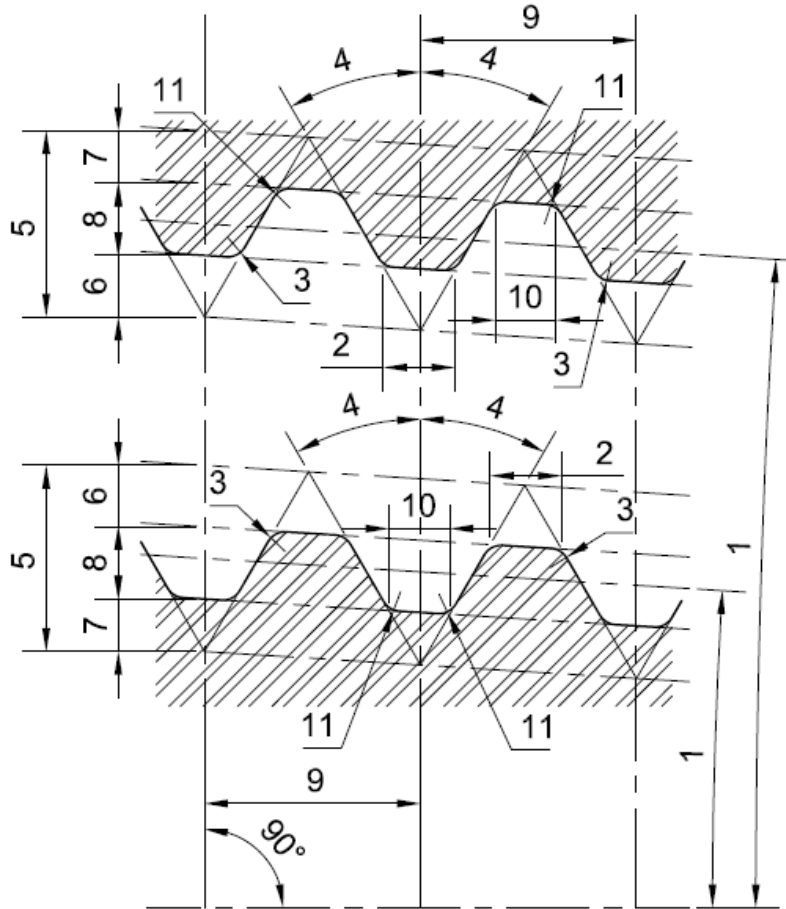
Figure 3—Box Connection (Box End)

**Key**

- | | | | |
|---|----------------------------------|----|------------------------------|
| 1 | taper half-angle, φ | 6 | crest truncation, f_c |
| 2 | crest flat, F_c | 7 | root truncation, f_r |
| 3 | crest corner radius, r_c | 8 | truncated thread height, h |
| 4 | thread half-angle, Θ | 9 | lead, p |
| 5 | thread height not truncated, H | 10 | root radius, R |

NOTE See Table B.2 (C.2) for dimensions.

Figure 4—Thread Forms V-038R, V-050, V-040



Key

1	taper half-angle, ϕ	7	root truncation, f_r
2	crest flat, F_c	8	truncated thread height, h
3	crest corner radius, r_c	9	lead, p
4	thread half-angle, Θ	10	root flat, F_r
5	thread height not truncated, H	11	root corner radius, r_r
6	crest truncation, f_c		

NOTE See Table B.2 (C.2) for dimensions.

Figure 5—Product Thread Form V-055 (also V-065 and V-076)

5.2.2 Purpose of Bevels

Bevels on connections serve two purposes. The first is to protect the outer edge of the sealing face from deformation in the form of mashes and fins. The second is to increase the contact pressure on the sealing face so as to minimize leaking and separation due to downhole bending.

Bevel diameters on the same ODs should be of equal size, within manufacturing tolerances, on mating pins and boxes to minimize the formation of grooves on the sealing faces. When mismatches of ODs greater than 6.35 mm (0.250 in.) occur, mismatches of bevel diameters will also occur.

Historically bevel diameters have been calculated every 6.35 mm (0.250 in.) based on 75 % of the shoulder width. This basic calculation is simple and depends only on the outside diameter and counter bore of the connection.

Effort has been made to preserve these historical bevel diameters because they are easy to calculate and have worked very well in most cases.

5.2.3 Methods to Calculate Bevel Diameters

The process is fully described in Annex E.

5.2.4 Other Considerations

Table B.3 has bevel diameters that cover a range from a suggested minimum OD to a maximum OD. For an OD falling between two listed values, the bevel diameter corresponding to the smaller OD shall be used. Table B.3 also contains a reference ID. The purpose of the reference ID is to be able to calculate shoulder loads that will not cause the seal face stress on mismatched ODs to exceed the SMYS of the product material.

When the ID of the pin connection (pin end) that mates directly with it is equal to or greater than the reference ID, the minimum OD listed for each connection in Table B.3 can be mated with the largest OD listed (or any OD in between) for that same connection in Table B.3 and the stress on the seal face will not exceed 100 % of SMYS.

The smallest bevel diameter shown in Table B.3 is the smallest bevel diameter recommended for each connection to avoid the risk that seal face stress generated by mismatches of ODs may exceed the SMYS. If a rotary shouldered connection is used on a product with smaller outside diameter than is listed in the table, the bevel diameter shall be set by agreement between the manufacturer and the purchaser.

Unless otherwise specified, bevel diameter tolerances shall be ± 0.4 mm (± 0.016 in.).

Bevel diameters in Table B.3 shall not apply to products that have specific requirements in API 5DP, API 7-1, ISO 10424-1, and ISO 11961, such as tool joints for drill pipe and HWDP, bits, or boxes that mate with bits.

For drilling equipment outside the scope of these standards, the manufacturer may specify a bevel diameter other than that listed in Table B.3.

5.3 Low-torque Feature

Several connections in larger sizes shall have modified bevel diameters and enlarged face counterbores when used on products with a large outside diameter. This allows the makeup torque to achieve adequate compressive stress on the sealing face while maintaining bending stiffness. These features are shown in Figure 6, and dimensions in Table B.4. These features shall be mandatory above the product diameter indicated in Table B.4.

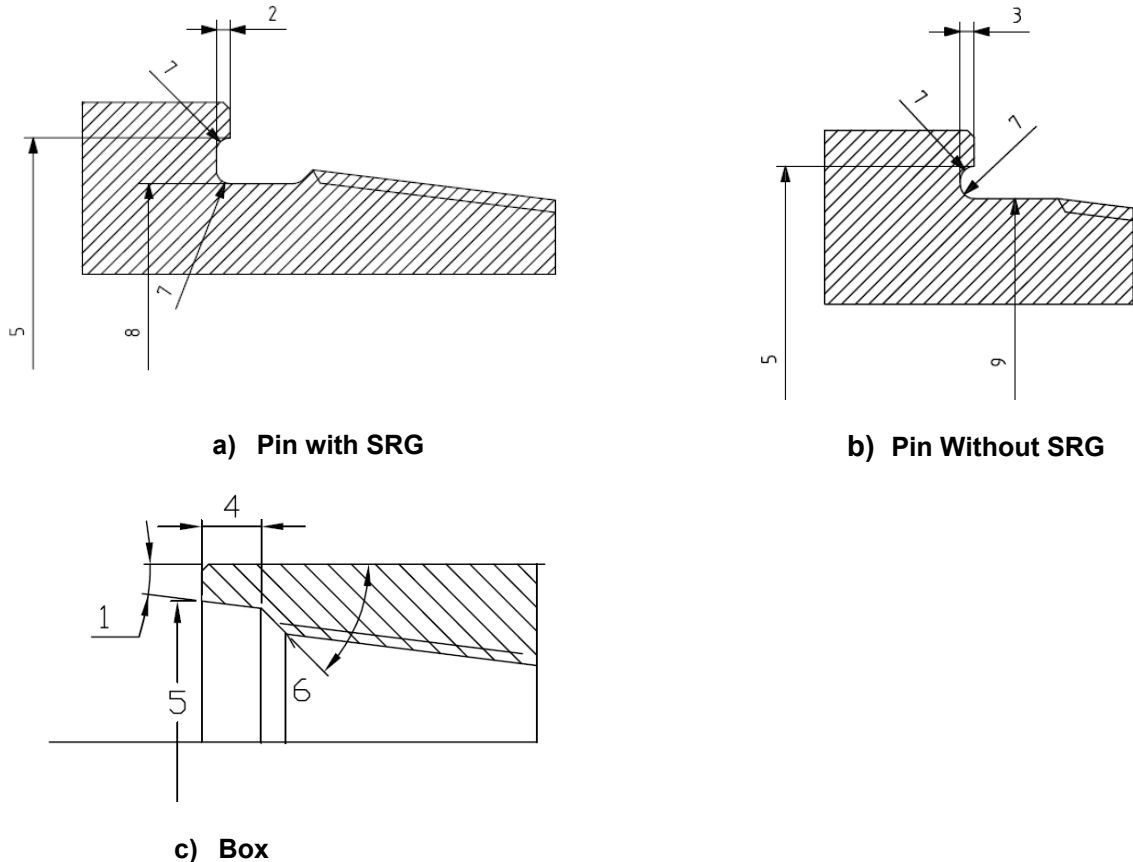
6 Product Optional Features

6.1 General

These features are required only if specified by the product specification (API 5DP or 7-1, ISO 10424-1 or ISO 11961), or on the product order. Some of the features noted below may be applied at the manufacturer's option.

6.2 Stress-relief Features

If fatigue failures in connections can be a problem, stress-relief features may be specified. Stress-relief features are of two basic designs: (1) a groove on the pin and a boreback contour for boxes or (2) a groove on both the pins and boxes. The boreback stress-relief contour is the recommended design for the box connection (box end). However, the box relief groove also has been shown to provide beneficial effects.



Key

- | | | | |
|---|---|----|---|
| 1 | taper half-angle, ϕ | 6 | $45^\circ \pm 1^\circ$ |
| 2 | face groove depth with stress relief groove, 6.4 mm +1.6/0 mm (0.25 in. +0.063/0 in.) | 7 | face groove radius, R_{FG} |
| 3 | face groove depth with pin cylinder [1.6 mm +0.8/0 mm (0.063 in. +0.031/0 in.)] | 8 | stress relief groove diameter, D_{SRG} |
| 4 | counterbore depth, 9.5 mm +2.4/-0.86 mm (0.375 in. +0.094/-0.031 in.) | 9 | pin cylinder diameter, D_{LF} |
| 5 | groove diameter, D_{FG} | 10 | radius 6.4 mm ± 0.8 (0.25 in. ± 0.031) |

NOTE See Table B.4 (C.4) for dimensions.

Figure 6—Low-torque Feature for Certain Connections with Large ODs

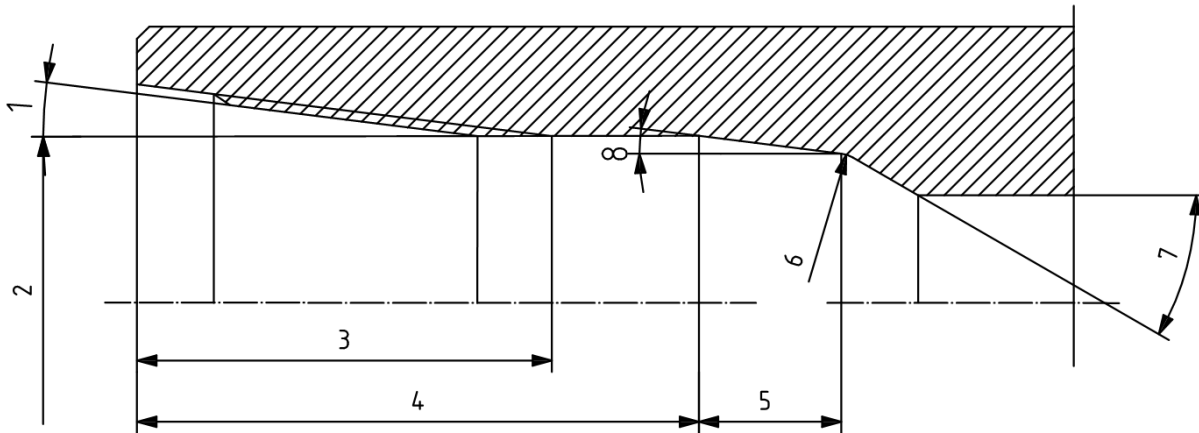
These features are shown in Figures 7 through 9. The dimensions for connections not listed here may be calculated according to the equations in Annex E. Stress-relief grooves at the pin shoulder and stress-relief grooves or borebacks at the base of the box thread shall conform to the dimensions shown in Table B.6.

Stress-relief grooves are recommended for use only on pin threads with pitch diameter, C , at gauge point greater than 89 mm (3.5 in.) so as to limit the reduction in cross section to less than 12.5 %

The boreback contour is recommended for use only on threads with pin length (L_{PC}) greater than 89 mm (3.5 in.).

Stress-relief grooves on pins cause a slight reduction in the tensile strength and 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 high tensile loads are expected, or if the pin inside diameter is larger than the inside taper dimension listed in Table B.5, calculations of this effect should be made.

Any transition radius to the stress-relief feature shall be smoothly blended to the groove.

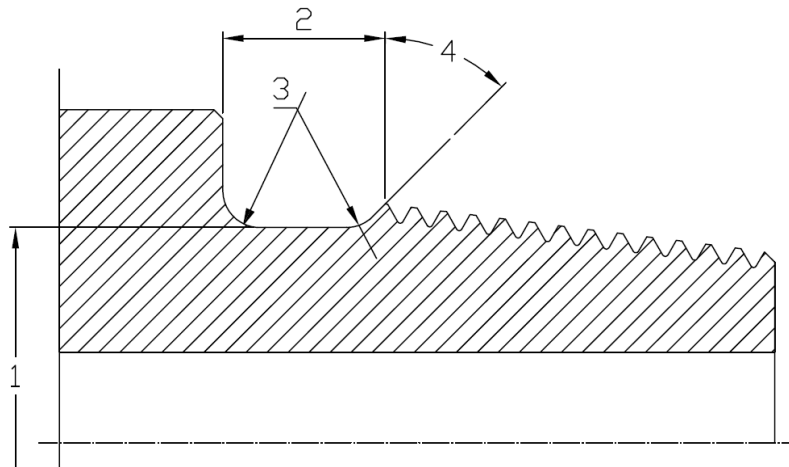


Key

- | | |
|--|--|
| 1 thread taper half-angle, φ , reference | 5 length of taper section, 50 mm $\pm$ 6 mm (2 in. $\pm$ 0.25 in.) |
| 2 boreback cylinder diameter, D_{CB} ,
3.2 μ m (125 μ in.) R_a finish | 6 transition radius, 25 mm (1.0 in.) |
| 3 depth to last scratch of thread, L_X | 7 transition cone, 30° maximum |
| 4 depth of boreback cylinder, L_{CYL} | 8 transition taper equal to thread taper |

NOTE See Table B.6 (C.6) for dimensions.

Figure 7—Box Boreback Feature



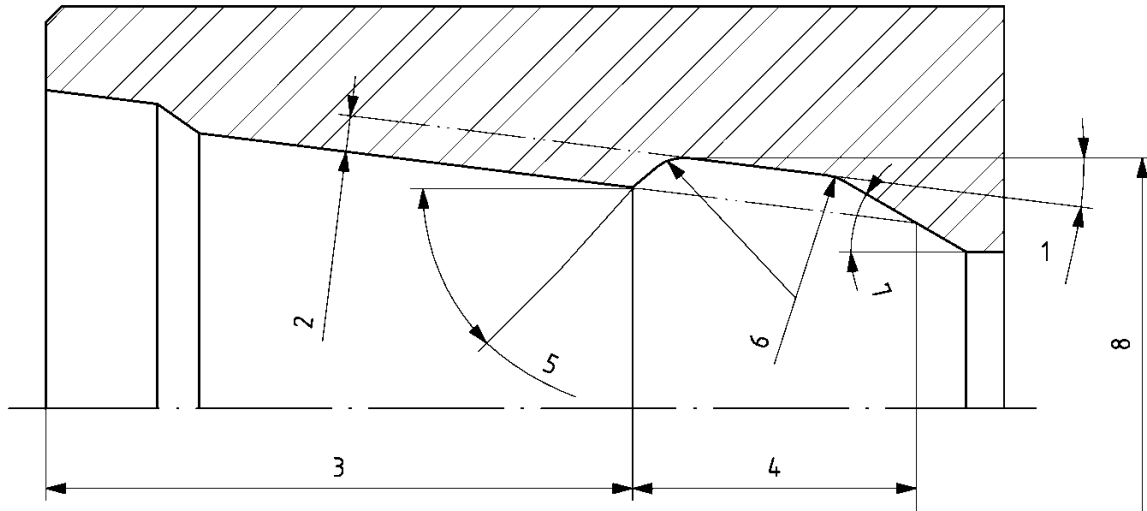
Key

- | | |
|---|--|
| 1 stress-relief groove diameter, D_{SRG} ,
1.6 μ m (63 μ in.) R_a finish | 3 radius 6.4 $\pm$ 0.4 mm (0.25 in. $\pm$ 0.016 in.),
1.6 μ m (63 μ in.) R_a finish, blended with D_{SRG} |
| 2 groove length, L_{SRG} ,
18.26 to 26.19 mm (0.719 to 1.031 in.) | 4 45° ref |

NOTE 1 The radius of Key 3 may undercut the shoulder if it does not reduce the area of the sealing face.

NOTE 2 See Table B.6 (C.6) for dimensions.

Figure 8—Pin Stress-relief Groove



Key

- | | |
|---|--|
| 1 taper equal to thread taper half-angle, φ | 5 groove edge angle, $45^\circ \pm 2^\circ$ |
| 2 box groove depth, h_{bg} | 6 groove radius, $6.35 \text{ mm} \pm 0.4 \text{ mm}$ ($0.25 \text{ in.} \pm 0.016 \text{ in.}$), $3.2 \mu\text{m}$ ($125 \mu\text{in.}$) R_a finish, blended to box groove, Key 2 |
| 3 length, face to groove of box member, L_{BG} , $5.16 \text{ mm} +0.4/0 \text{ mm}$ ($0.203 \text{ in.} +0.016/0 \text{ in.}$) | 7 transition cone angle, 30° maximum |
| 4 groove length, $38.1 \text{ mm} \pm 3.2 \text{ mm}$ ($1.5 \text{ in.} \pm 0.125 \text{ in.}$), 1.6 (63) finish | 8 box groove major diameter, D_{BG} |

NOTE See Table B.6 (C.6) for dimensions.

Figure 9—Box Stress-relief Groove

6.3 Optional Profile Features

6.3.1 General

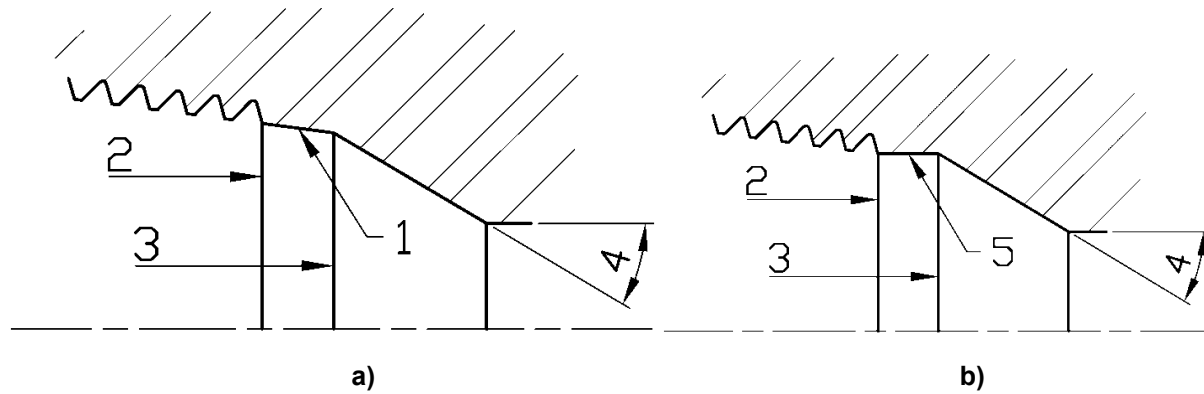
Several optional features have historically been used by some producers and are acceptable, but not required.

6.3.2 Inside Taper on Pin

An internal taper as shown in Key 1 of Figure 10 may be used on the end of pin connections (pin ends) unless otherwise specified, to ease the passage of service tools and reduce flow discontinuities. In this case, the internal diameter at the end of the pin shall be as listed in Table B.5 and shall be concentric to the axis of the connection. The taper angle shall be 10° to 30° . The diameter is based solely on historical practice. When this feature is not used there shall be a bevel at the end of the pin ID, with dimensions to be determined by the producer.

6.3.3 Unthreaded Area on Box

The unthreaded area on the box between L_{BT} and L_{BC} is most commonly finished as a continuation of the minor diameter of the box threads with the thread taper—this is shown in Figure 10a. At the producer's option, a cylindrical bore may be substituted as in Figure 10b. Threading may continue beyond the L_{BT} length.

**Key**

- | | | | |
|---|-------------------------------------|---|-------------------------------------|
| 1 | tapered bore with taper T | 4 | transition angle to box ID, 30° max |
| 2 | end of full depth threads, L_{BT} | 5 | optional cylindrical bore |
| 3 | total box depth, L_{BC} | | |

Figure 10—Unthreaded Area of Box Connection**6.4 Benchmarks****6.4.1 General**

At the manufacturer's option, or if specified by the customer, a benchmark may be used on both box and pin to serve as a witness of the original dimensions. This permits the evaluation of any rework of the shoulder face to repair damage in service. The benchmark shall be applied 3.18 mm (0.125 in.) from the face, on the pin base or on the box counterbore, and shall not be remarked unless the threads are remachined.

Benchmarks are commonly used on drill pipe tool joints. They shall not be used on pin connections (pin ends) with stress-relief grooves.

Two types of benchmarks are used, the cylinder benchmark and the stamped benchmark. Both are described below under 6.4.2 and 6.4.3, respectively.

6.4.2 Cylinder Benchmark

The cylinder benchmark consists of a turned cylinder in the box counterbore or a raised cylinder on the pin base, 3.18 mm (0.125 in.) long, as shown in Figures 11 and 12.

The diameter of the cylinder benchmark feature in the box is the counterbore diameter, Q_c , plus 0.79 mm (0.031 in.), tabulated as D_{PB} in Table B.5.

The diameter of the cylinder benchmark feature on the box (Key 1 of Figure 11) and the projected diameter of the counterbore (Key 4) shall both fall within the tolerance for Q_c in Table B.1.

6.4.3 Stamped Benchmark

The stamped benchmark consists of a 4.77 mm (0.188 in.) diameter circle with a bar tangent to the circle. The bar is located to the side of the circle nearest the makeup shoulder. The benchmark is stamped on the product so that the bar is parallel to the makeup shoulder and positioned 3.18 mm (0.125 in.) from the shoulder face as shown in Figure 13.

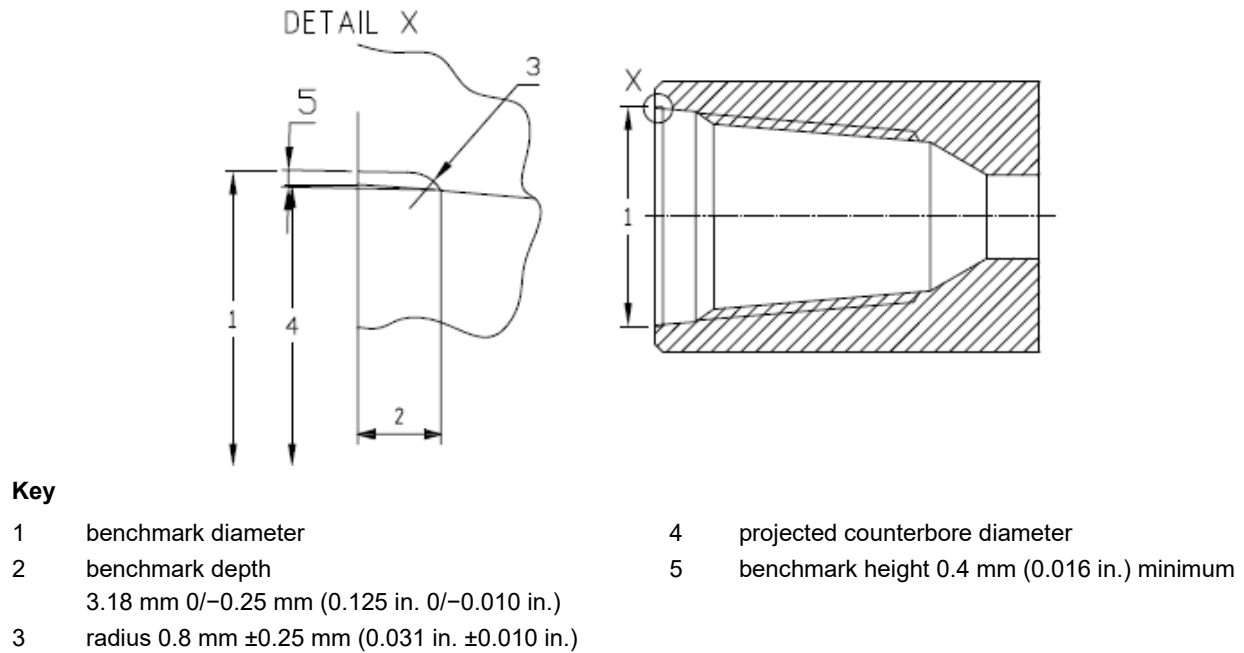


Figure 11—Cylinder Benchmark (Box)

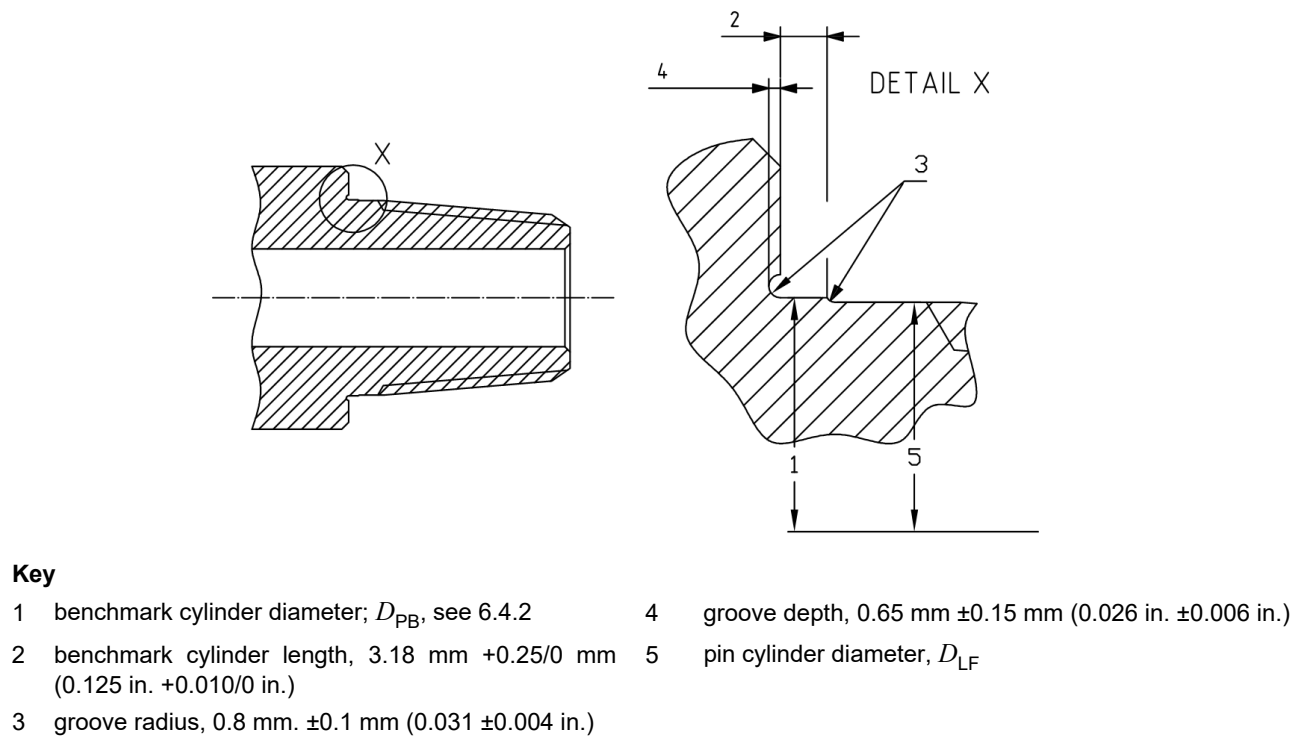
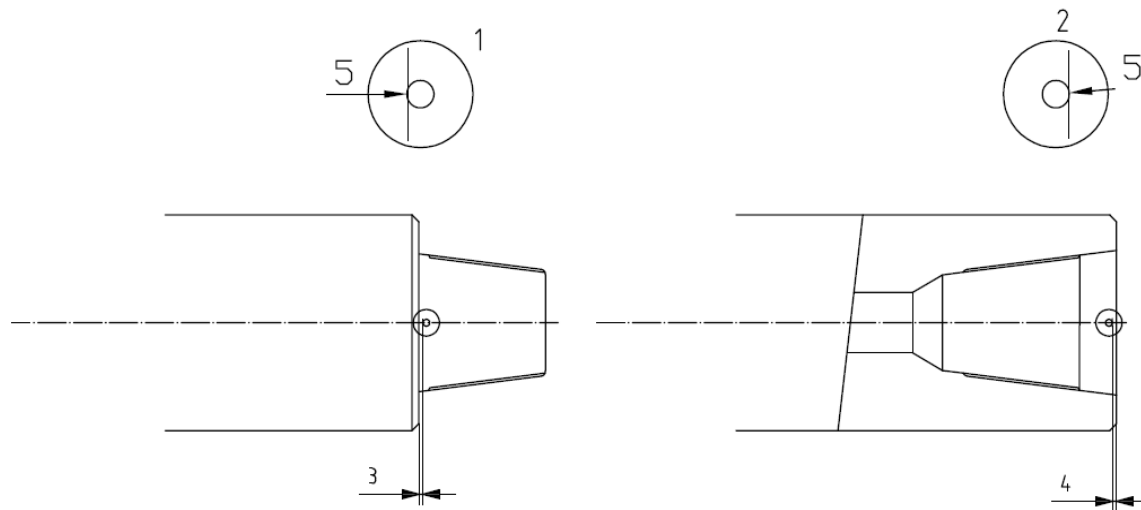


Figure 12—Cylinder Benchmark (Pin)



Key

- | | |
|---|---|
| 1 benchmark orientation (pin) | 4 benchmark location (box), 3.18 mm (0.125 in.) from shoulder |
| 2 benchmark orientation (box) | 5 benchmark diameter, 4.77 mm (0.188 in.) |
| 3 benchmark location (pin), 3.18 mm (0.125 in.) from shoulder | |

Figure 13—Stamped Benchmark

6.5 Surface Treatment

Surface treatment is required by API 5DP and API 7-1 and is not otherwise required by this standard. All gauging shall be done before surface treatment.

6.6 Cold Rolling

If so specified, or at the producer's option the roots of threads may be cold rolled after gauging. A connection shall be considered to conform to this specification if it meets the requirements of this standard before cold rolling. In such event, the connection shall also be stamped with a circle enclosing CW (an old symbol) to indicate cold rolling after gauging. A pin connection (pin end) shall be marked on the end of the pin. A box connection (box end) shall be marked in the box counterbore.

NOTE 1 Gauge standoff changes after cold working of threads; therefore, cold rolling of gauged connections can result in connections that do not fall within the gauge standoff of this standard. This does not affect the interchangeability of connections and improves the performance of connections in fatigue.

NOTE 2 Improper cold rolling can be damaging to the connection; cold rolling procedures are outside the scope of this document and are discussed in API 7-1 and ISO 10424-1.

6.7 Break-in

If so specified, the connection may be "broken-in" by repeated make and break of the connection before being placed in service. This shall be performed following a documented procedure. All gauging shall be done, before break-in.

7 Product Gauging

7.1 Gauging

7.1.1 General

Any manufacturer who desires to produce drill stem members utilizing rotary shouldered connections conforming to this specification shall own or have access to calibrated Reference Master gauges consisting

of mated sets of Reference Master plug(s) and Reference Master ring gauge(s) conforming to the requirements in 8.2.2.

All threads of rotary shouldered connections shall comply with the gauging requirements specified herein. These requirements are not intended in any way to restrict the use of any other instruments or methods to control manufacturing operations. In case of dispute, acceptance and rejection of the product shall be governed by the use of instruments for determining standoff, lead, taper and thread form described in this standard. The intent of this standard is that any thread element of the product shall be acceptable if any measurement of that element, measured as defined in 7.1.2 to 7.6, is found to be in conformance. That is, the variation of gauges, within tolerances, shall not be a reason for rejection.

The gauging elements of new rotary shouldered connections are described in Annex F.

7.1.2 Precautions

7.1.2.1 Temperature

All instruments shall be exposed to the same temperature conditions as the product to be inspected, for a time sufficient to eliminate any temperature difference.

Some materials used to make rotary shouldered connections, notably on non-magnetic drill collars, have thermal expansion coefficients significantly different from the steel used to make gauges. This effect can impact the measurement of standoff if the temperature is far from 20 °C (68 °F) and shall be taken into account.

NOTE Taking this into account can help in cases of dispute on the measurement.

7.1.2.2 Care of Instruments

The instruments described herein are precision instruments and shall be handled in a careful and intelligent manner, commensurate with the maintenance of the high accuracy and precision required for inspection under the requirements of this gauging practice (see Annexes G, H, and I for guidance). If any instrument is damaged, for instance inadvertently dropped or severely shocked, it shall not be used for inspection purposes until its accuracy has been reestablished.

7.1.2.3 Cleaning the Threads

All threads shall be cleaned thoroughly before gauging. If the gauging is made after shipment, the thread compound shall be removed with a brush having stiff bristles, using a suitable solvent.

7.2 Standoff Measurement

7.2.1 Standoff

The standoff of the Working gauge is intended as a method to locate the plane of the pitch diameter in relation to the sealing shoulder of the connection. It is dependent on the other elements of the thread, notably lead and taper. The effect of taper error is small when it is in conformance with the specification. The effect of lead error, even within tolerance, can be as large as that of the tolerance on pitch diameter at the gauge point, and lead must therefore be measured as well as standoff.

7.2.2 Working Gauges

The manufacturer shall have available Working gauges, as defined in Section 8 of this standard, to gauge product threads and shall maintain all Working gauges in such condition as to ensure that product threads, gauged as required herein, are acceptable (see Annex G for guidance on the care and use of Working gauges). The Working gauges shall comply with all the stipulations on calibration and retest as specified in Section 9. The use of Reference Master gauges in checking product threads should be minimized. Such use should be confined to cases of dispute that cannot be settled by rechecking the Working gauges against the

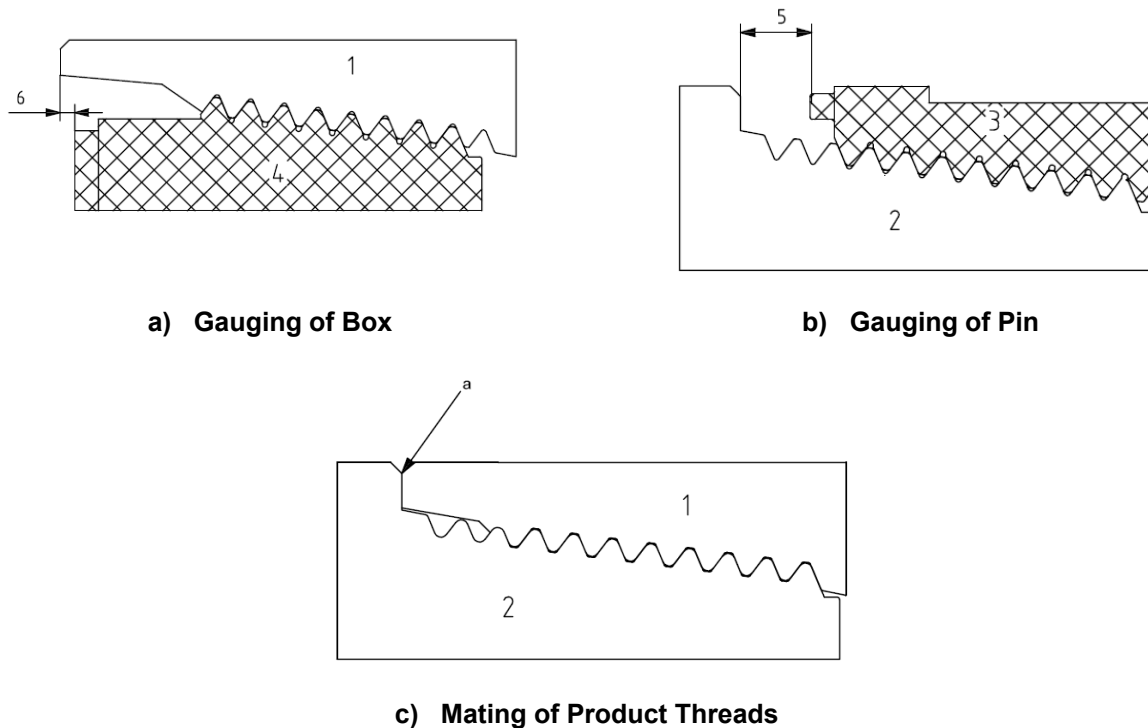
Reference Master. Good care should be exercised when the Reference Master gauge is assembled on a product thread. The purchaser of Reference Master gauges shall comply with all the stipulations on calibration and retest as given in Section 9.

7.2.3 Standoff Tolerances

Tolerances on standoff values shall be as shown in Figure 14 and the following shall also apply.

- a) Standoff of the Working ring gauge to the product pin: $S_2 + 0.25/-0.13$ mm ($S_2 + 0.010/-0.005$ in.).
- b) Standoff of the Working plug gauge to the product box: $(S - S_1) + 0.25/0$ mm [$(S - S_1) + 0.010/0$ in.].

The standoffs, S_1 and S_2 , of the Working gauges are defined in 8.1. These tolerances shall apply after the connection is finish-machined and before any anti-galling or cold-working surface treatment is applied to the pin or box connection (pin or box end). Gauge standoff may change after the application of surface treatment and may cause the standoff to exceed the limits specified for the connection and shall not constitute a cause for rejection. It is, therefore, permissible for a connection to be referenced to this standard if it meets its requirements before the application of the surface treatment.



Key

- | | | | |
|---|--------------------|---|---|
| 1 | product box | 4 | Working plug gauge |
| 2 | product pin | 5 | ring gauge standoff, $S_2 + 0.25/-0.13$ mm ($S_2 + 0.010/-0.005$ in.) ^b |
| 3 | Working ring gauge | 6 | plug gauge sits in $(S - S_1) + 0.25/0$ mm [$(S - S_1) + 0.010/0$ in.] |

^a At hand tight condition, a gap may exist at the face.

^b For drill bit pins only, standoff may be $S_2 + 0.25/-0.79$ mm ($S_2 + 0.010/-0.031$ in.).

Figure 14—Gauging Practice

7.3 Gauge Contact Points

The measurement of lead and taper shall be made as close as practical to the pitch cone of the thread. Contact points of lead and taper gauges shall, therefore, be of the ball-point type and should preferably be made of tungsten carbide or tantalum carbide. The dimensions of the ball-point contacts shall be such that they contact the thread flanks rather than the thread root. The ball-point diameters, d_b , meeting flank contact requirements are specified in Table B.7 (column 5). The contact point diameters, d_{bh} , for thread height gauges should be ball type with a diameter as specified in Table B.7 (column 7) and shall not contact the thread flank.

7.4 Lead Measurement

7.4.1 Lead Tolerances

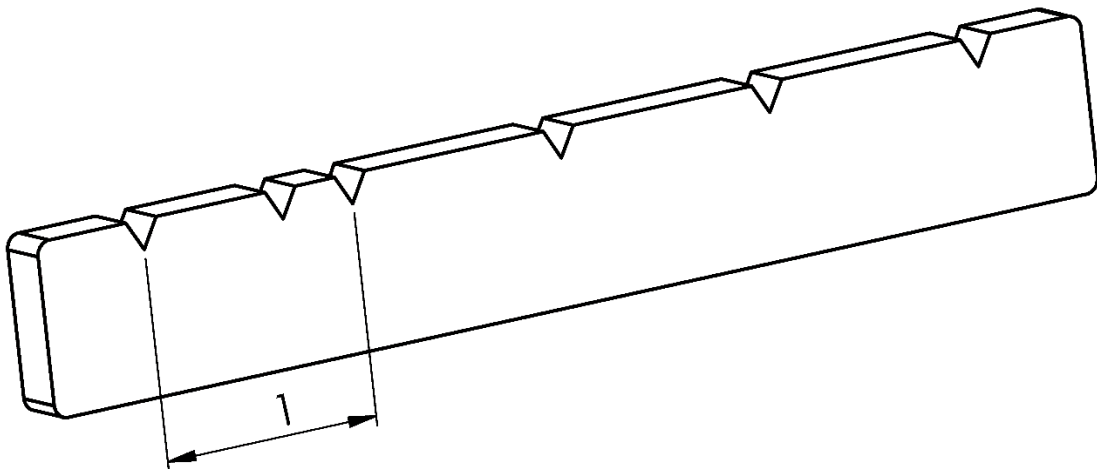
Lead tolerances shall be expressed in terms of mm per 25.4 mm (in. per 1 in.) of threads and cumulative error and lead errors shall be determined accordingly. For interval measurements over lengths other than 25.4 mm (1 in.), the observed errors shall be calculated to the basis of mm per 25.4 mm (in. per 1 in.). The cumulative error shall be made using the longest available setting length for the lead gauge.

The lead of threads shall be gauged with a lead gauge. The precision of the measuring mechanism shall be 0.013 mm (0.0005 in.) or smaller.

7.4.2 Lead Gauge Setting Standard

Lead gauge setting standards, similar to Figure 15, shall be so constructed as to compensate for the error in measuring lead parallel to the taper cone instead of parallel to the thread axis, according to the L_{ct} values shown in Table B.7.

The distance between any two adjacent notches of the template shall be a multiple of the thread lead compensated for taper, L_{ct} , within a tolerance of ± 0.003 mm (± 0.0001 in.), and between any two non-adjacent notches within a tolerance of ± 0.005 mm (± 0.0002 in.). The notches shall cover a span of at least 102 mm (4 in.) and shall include at least one interval of 1 inch or nearest odd pitch.



Key

1 multiple of compensated thread lead, L_{ct}

Figure 15—Standard Lead Template

7.5 Taper Measurement

7.5.1 Taper Errors

For all threads of rotary shouldered connections, taper tolerances shall be expressed in terms of millimeters per millimeter (inches per foot) of thread and taper errors shall be determined accordingly. The measurements are made for a suitable interval of thread length and the observed errors shall be calculated to the millimeters per millimeter (inches per foot) basis.

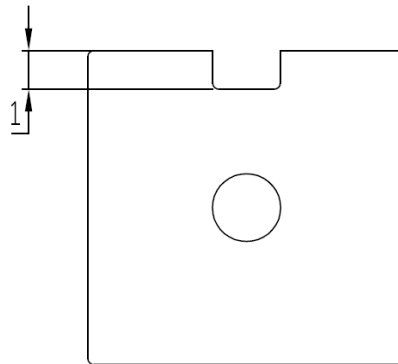
7.5.2 Taper Calipers

The taper of threads shall be measured with an instrument having a precision of 0.025 mm (0.001 in.) or higher within the measurement range used.

7.6 Thread Height Measurement and Gauges

Thread height shall be measured with an instrument having a precision of 0.013 mm (0.0005 in.) or better within the measurement range used.

A standard template as shown in Figure 16 shall be used for standardizing the height gauge. The standard templates shall be constructed to compensate for the error in measuring height normal to the taper cone instead of normal to the thread axis. For the U-groove on standard templates, the depth of the groove shall conform to the dimensions h_{cn} shown in Table B.7 (column 6) within a tolerance of ± 0.005 mm (± 0.0002 in.).



Key

1 compensated thread height, h_{cn}

Figure 16—Thread Height Setting Standard

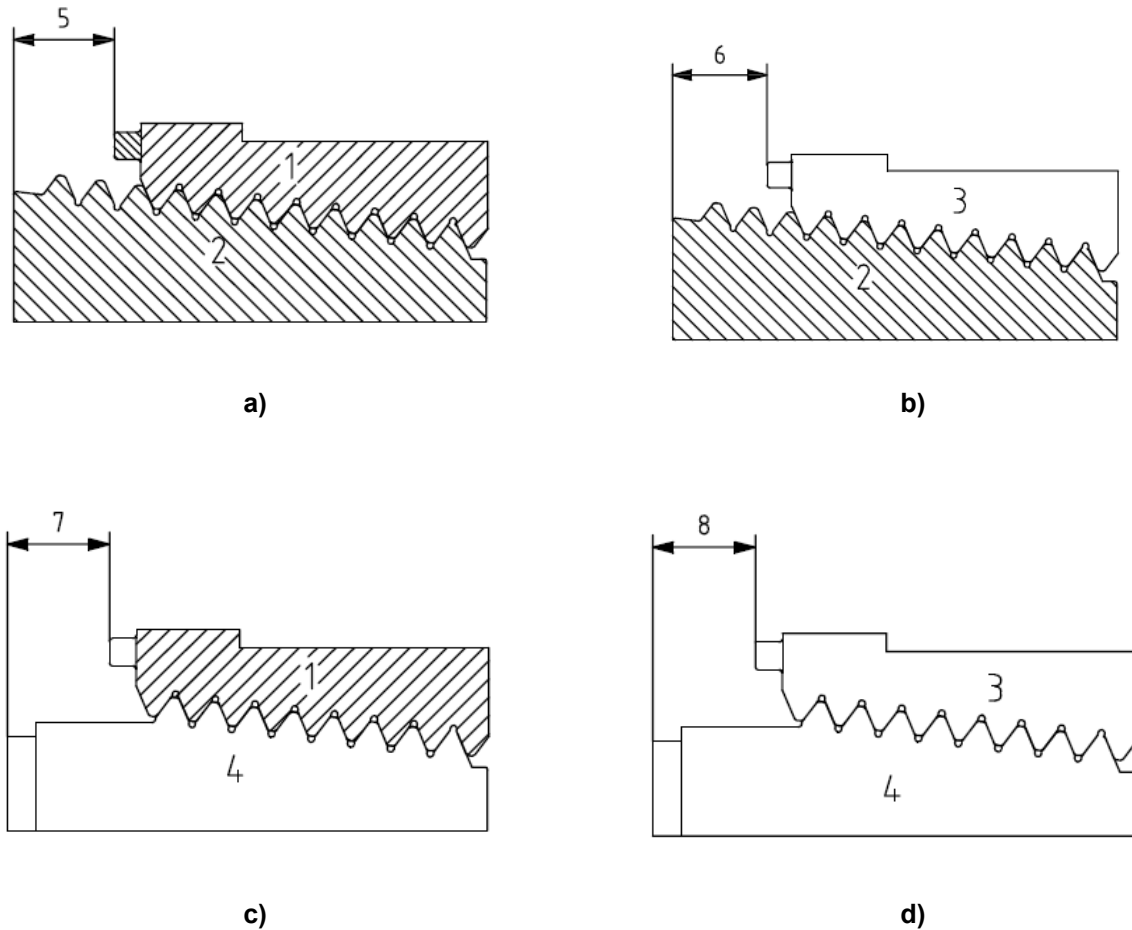
8 Gauges for Rotary Shouldered Connections

8.1 Gauge Relationship

The relationship between Reference Master gauges and Working gauges shall be as shown in Figure 17 wherein the certified Reference Master plug gauge is shown as the standard and the certified Reference Master ring gauge as the transfer standard. The standoff value, S_0 , of certified Reference Master gauges is the distance from the plane of the rotary shoulder on the plug gauge to the plane of the gauge point on the ring gauge. The certified Reference Master ring gauge is used to establish the standoff value, S_1 , of the Working plug gauge. The certified Reference Master plug gauge is used to establish the standoff value, S_2 , of the Working ring gauge. S_1 and S_2 are measured values that the Working gauges stand off from their certified Reference Master gauges and may be greater or less than S , up to the interchange limits of Table B.12. These values shall be recorded for each Working gauge member, together with the identification number of the Reference Master set from which they were derived.

The standoff value, S_0 , of certified Reference Master gauges (Figure 17a) shall be measured at $20\text{ }^{\circ}\text{C} \pm 1\text{ }^{\circ}\text{C}$ ($68\text{ }^{\circ}\text{F} \pm 2\text{ }^{\circ}\text{F}$). Verifications of Working gauges (Figures 17b to 17d) may be at any temperature as long as both the master and Working gauges have normalized to the same temperature.

The mating standoff of the Reference Master ring gauge against the Reference Master plug gauge as marked on the ring gauge is intended primarily as the basis for establishing the limits of wear or secular change in the Reference Master gauges.



Key

- | | | | |
|---|---------------------------------------|---|--|
| 1 | certified Reference Master ring gauge | 5 | $S_0 = S \pm 0.025\text{ mm}$ ($S \pm 0.001\text{ in.}$) |
| 2 | certified Reference Master plug gauge | 6 | Ring Gauge Interchange Standoff, S_2 |
| 3 | Working ring gauge | 7 | Plug Gauge Interchange Standoff, S_1 |
| 4 | Working plug gauge | 8 | $S \pm 0.025\text{ mm}$ ($S \pm 0.001\text{ in.}$) |

Figure 17—Gauge Relationships

8.2 Gauge Specifications

8.2.1 Specifications

The gauge specifications in this standard derive from API 7. All gauges manufactured before December 1, 2008 and conforming to the requirements of the 40th Edition of API 7 shall be considered to conform to this standard.

8.2.2 Master Gauges

Grand, Regional and Reference Master gauges shall conform to the dimensions specified in Tables B.8 to B.10 and Figures 18 and 19. For Master gauges, the gauge point for pitch diameter is located 15.875 mm (0.625 in.) from the measuring face. The major diameter of the plug gauge and the minor diameter of the ring gauge at this gauge point are listed in Table B.9 for reference.

Grand and Regional Master gauges shall conform to the tolerances specified in Table B.11. Reference Master gauges shall conform to the tolerances specified in Table B.12. Prior to use, all Regional and Reference Master gauges shall be calibrated as required in Section 9.

The same gauging principles and tolerances can be applied to the connections listed in Annexes J, K, and L and all thread dimensions can be calculated from the thread elements.

8.2.3 Working Gauges

Working gauges shall conform to the dimensions specified in Tables B.8 to B.10 and Figures 18 and 20, and to the tolerances specified in Table B.13. All Working plug gauges shall have the unused threads removed from the large end, except for gauges with mating standoff of 9.525 mm (0.375 in.) such as 1 and 1½ REG. To assure removal of the unused threads, the start of the first thread on the large end of the Working plug shall be located within the limits of 27.43 mm to 28.45 mm (1.080 in. to 1.120 in.) from the surface used to determine standoff.

For Working gauges, the gauge point for pitch diameter is located 34.925 mm (1.375 in.) from the measuring face.

8.2.4 General Design

Plug and ring gauges shall be through-hardened and ground. Hardness shall be a minimum of Rockwell C55, or equivalent hardness on a superficial scale.

Thread gauges may be specified as right-hand or left-hand. However, as of 2016, left-hand Reference Master gauges exist only for threads in the REG style. Imperfect threads at ends of plug and ring gauges shall be reduced to a blunt start.

Gauges shall be furnished with fitting plates as illustrated in Figures 19 and 20 except for gauges with mating standoff of 9.53 mm (0.375 in.) such as 1 and 1½ REG. These fitting plates, or the faces of gauges without fitting plates, shall be flat, and square to the axis of the pitch-cone, within 0.010 mm (0.0004 in.).

8.2.5 Root Form

The roots of gauge threads shall be sharp with a radius of truncation not to exceed 0.25 mm (0.01 in.), or undercut to a maximum width equivalent to the basic root truncation values given in Table B.2. The undercut shall be of such depth as to clear the basic sharp thread; otherwise, the shape of the undercut is not important.

8.2.6 Initial Standoff

New and reconditioned plug and ring gauges shall conform to the mating standoff dimension, specified in Table B.9, and the mating standoff tolerances specified in Tables B.11 to B.13.

The interchange standoff for plug and ring gauges against Grand, Regional, and Reference Master gauges shall conform to the nominal standoff of Table B.9 and the interchange standoff tolerances specified in Tables B.11 to B.13.

NOTE The requirements for interchange standoff place a restriction on the magnitude of the thread-element errors that can be present in gauges that meet both the mating and interchange standoff requirements. If the errors in certain thread elements are at or near the maximum limits allowed by Tables B.11 to B.13, then the errors on other thread elements

need to be well within the limits to compensate. Differences in lead in mated gauges can be partially or completely compensated by difference in taper.

8.2.7 External Elements

Dimensions L_{pg} , L_{rg} , D_R , Q , and fitting plate diameter, D_{FP} , shall conform to the dimensions given in Table B.10 and the tolerances given in Tables B.11 to B.13. The length of the controlled outside dimension, D_R , of the ring gauge is optional to the manufacturer. The fitting plate thickness, T_{FP} , shall not exceed 9.53 mm (0.375 in.) for connections with pitch diameter (C) 142.24 mm (5.6 in.) or smaller, and 11.1 mm (0.437 in.) for larger connections.

8.2.8 Surface Condition

The thread surfaces of gauges shall be ground to a surface roughness of 0.8 μm (32 $\mu\text{in.}$) R_a or better as defined in ISO 1302, and shall be free of surface imperfections (such as cracks) capable of damaging the mating surface.

8.2.9 Gauge Marking

8.2.9.1 General

Plug and ring gauges shall be permanently marked by the gauge manufacturer with the markings given in 8.2.9.2 through 8.2.9.7. The marking location on plug gauges shall be on the body, although marking on the handle is acceptable on gauges in small sizes when the handle is integral with the body. Any markings that are considered necessary by the gauge manufacturer may be added.

8.2.9.2 Size

The size or number of the gauge shall be as given in Table B.9, column 1.

8.2.9.3 Style

Style of connection shall be as given in Table B.9, column 1 with left-hand indication, if applicable, followed by the designation ROTARY.

EXAMPLES—NC ROTARY and REG LH ROTARY.

8.2.9.4 Class

The classes of gauges are one of the following:

- Working,
- Reference Master,
- Regional Master,
- Grand Master.

8.2.9.5 Manufacturer

The manufacturer shall assign an identification number to each gauge, unique for that manufacturer. The name or identifying mark of the gauge maker, together with the identification shall be placed on both plug and ring gauge. In the case of certified gauges, the certifying agency shall assign a unique number, and this shall also be marked.

8.2.9.6 Date

The date of certification shall be marked on Master gauges. In recertifying reconditioned gauges, the previous certification date shall be replaced with the date of recertification. Dates of retest, as required by 9.3.1.5, shall not be marked on master gauges.

8.2.9.7 Standoff

The initial mating standoff of Master gauges and Working gauges shall be marked on the ring gauge only. Mating standoff values determined by periodic retest as specified in 9.3.1.6 shall not be marked on Reference Master or Working gauges.

EXAMPLE 1

A certified Regional Master NC56 rotary gauge marked as follows:

- NC56 ROTARY REGIONAL MASTER,
- A B Company (or Mark) Identification Number,
- Date of Certification,
- Initial Mating Standoff,

EXAMPLE 2

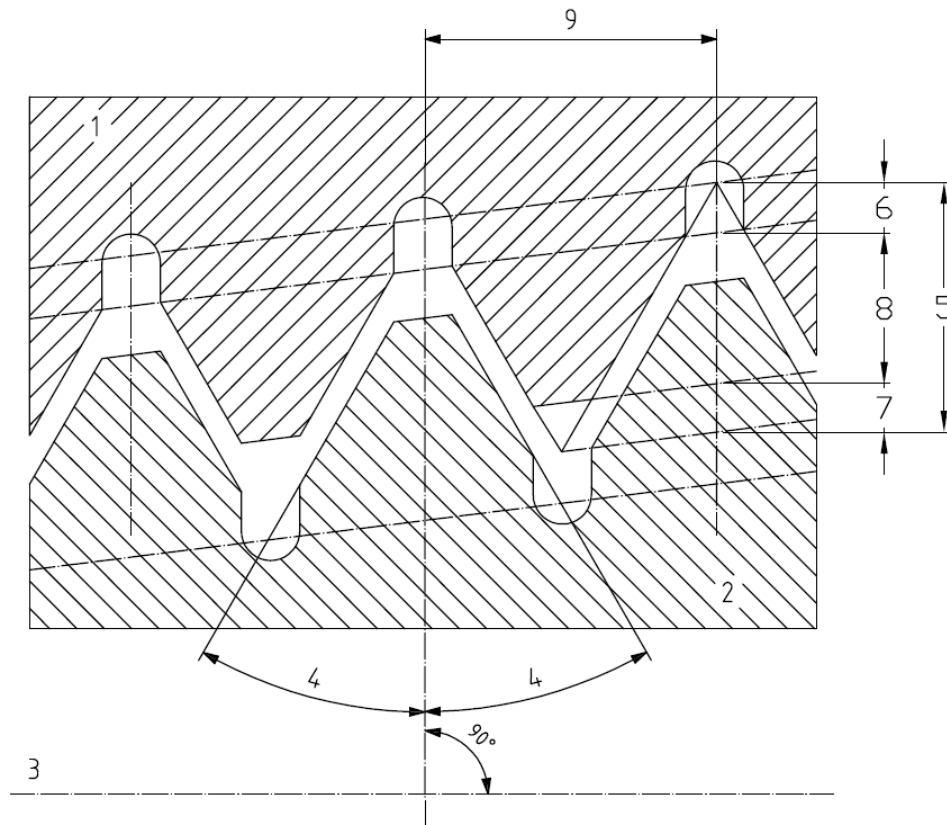
An NC56 Working gauge marked as follows:

- NC56 ROTARY WORKING,
- A B Company (or Mark) Identification Number,
- Initial Mating Standoff,

EXAMPLE 3

A certified Reference Master 4¹/₂ REG rotary gauge marked as follows:

- 4¹/₂ REG ROTARY REFERENCE MASTER,
- A B Company (or Mark) Identification Number,
- Date of Certification,
- Initial Mating Standoff,



Key

- | | | | |
|---|----------------------------------|---|--------------------------------------|
| 1 | ring gauge threads | 6 | gauge root truncation, f_{rg} |
| 2 | plug gauge threads | 7 | gauge crest truncation, f_{cg} |
| 3 | axis of thread | 8 | gauge truncated thread height, h_g |
| 4 | thread half-angle, ϕ | 9 | lead, p |
| 5 | thread height not truncated, H | | |

Figure 18—Gauge Thread Form