API / ISO LINE PIPE BULL PLUG TECHNICAL PROPOSAL

TECHNICAL PROPOSAL TP9801
Revision New

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AWHEM

TECHNICAL PROPOSAL - DOCUMENT NO. TP 9801

Rev. Number - New Release

Title: **API / ISO Line Pipe Bull Plug Specification**

Proposal: Proposal to API/ISO for inclusion of line pipe threaded bull plugs for service to 10,000 psi maximum working pressure ratings in industry standards API 6A and ISO 10423.

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SUPPORTING DOCUMENTATION FOR AWHEM PROPOSED LINE PIPE BULL PLUG SPECIFICATION

DESIGN ANALYSIS

LINE PIPE BULL PLUGS

METHODS FOR CALCULATING STRESS

- **Membrane Stress Intensity Plus Bending at Working Pressure**
- **Membrane Stress Intensity at Test Pressure**
- **Tensile Strength Stress Intensity at Last Full Thread Section at Test Pressure**
- **Thread Jump Out Stress Intensity at Test Pressure**
- **Thread Shear Out Stress at Test Pressure**

NOTE: Allowable Stresses in Each Case are Governed by API 6A Design Criteria

1.0 SCOPE

The scope of this guideline is to document the logic and methods for calculating the minimum yield strength of materials for components with line pipe threads (LPT) of various sizes and working pressures.

2.0 APPLICABLE REFERENCES AND SPECIFICATIONS

Line pipe threads are used to connect various components. This guideline will be directed to outlets with API line pipe threads. Thread data and formulas are taken from the following reference documents:

2.1 API Spec 5B

2.2 API Spec 6A

2.3 Journal of Engineering for Industry: "Strength of Thread Joints for Steel Pipe", W. O. Clinedinst, Adopted by API at the June 1963 Standardization Conference

3.0 METHODS FOR CALCULATING STRESSES

The minimum material yield strength required for the component at various sizes and working pressures is calculated using the following five (5) methods. The methods of calculating the stress and the related formulas are discussed below.

3.1 Membrane + Bending:

This method for calculating stress is primarily intended for an infinite length, thin wall cylinder. The Lame stress intensity stress plus bending is calculated from the following classical formula.

$$SI = P_w [(OD^2 + ID^2) / (OD^2 - ID^2)] + P_w$$

where:

OD is the outside diameter
ID is the inside diameter
P_w is the working pressure.

From API 6A, the ASME design methodology states that the primary + secondary stress intensity (SI) at working pressure must be $\leq$ 2 x allowable yield strength (S_y); therefore,

$$S_y = (SI) / 2$$

3.2 Membrane Stress:

The membrane stress intensity (SI) is calculated by:

$$SI = [(ID) / (OD - ID) + .5] \times P_T$$

where: P_T is the test pressure

From API 6A, the ASME design methodology states that the membrane stress intensity (SI) at hydrostatic test pressure must be $\leq$ the yield strength x 0 83; therefore,

$$S_y = (SI) / 0.83$$

3.3 Tensile Strength:

The stress intensity (SI) for a tension failure at a cross section under the last full thread is calculated from the following formula:

$SI = P_T (A_p / A_T)$

where, for internal threads (box):

$A_p = Pi \times OD^2 / 4$
$A_T = Pi \times (OD^2 - (ID + 2h_n)^2) / 4$

and where, for external threads (pin):

$A_p = Pi \times OD^2 / 4$
$A_T = Pi \times ((OD - 2h_n)^2 - ID^2) / 4$

and where,

A_p is the pressure area
A_T is the area under the last perfect thread
h_n is the thread height (see Table 2.1, API Std 5B for h_n)

From API 6A, the ASME design methodology states that the membrane stress intensity (SI) at hydrostatic test pressure must be ≤ the yield strength x 0.83; therefore,

$S_y = (SI) / 0.83$

3.4 Thread Jump Out:

The stress intensity (SI) for the thread jump out is calculated from an empirical formula developed by W O. Clinedinst (see reference in paragraph 2.3)

$SI = P_T \times R_A$

where: R_A is the ratio of pressure area (A_p) and the pull out area (hand tight) (A_H)

$A_p = Pi \times OD^2 / 4$

$A_H = A_T \times L_H \times [(2.39 \times (2h)^{0.59} \times OD^{-0.59}) / (0.5L_H + 0.14OD) + 1.0/(L_H + 0.14OD)]$

The calculation for A_H includes the empirical values developed by W. O. Clinedinst. Note: A conservative assumption is made to simplify this calculation; that is, that the allowable yield strength is equal to the ultimate strength.

where: L_H is the length of hand tight thread engagement, h is the thread height.

From API 6A, the ASME design methodology states that the membrane stress intensity (SI) at hydrostatic test pressure must be ≤ the yield strength x 0 83; therefore,

$S_y = (SI) / 0.83$

3.5 Thread Shear Out

The shear stress (S_s) of the threads is calculated from the following formula:

$S_s = (P_T \times (D_p)^2) / (D_S \times W_S \times N \times 4)$

where, for internal threads (box):

D_p is the pitch diameter at the hand tight plane (from Table 2.1, API Std 5B)
D_S is the major diameter of the male thread at the hand tight plane,

$D_S = D_p + (H - 2f_{cn})$ see Table 2.8 API Std 5B for H and f_{cn}

and where, for external threads (pin):

D_p is the pitch diameter at the hand tight plane (from Table 2.1, API Std 5B)
D_S is the minor diameter of the female thread at the hand tight plane,

$D_S = D_p - (H - 2f_{cn})$ see Table 2.8 API Std 5B for H and f_{cn}

and where,

W_S is the thread width at D_S.
$W_S = 2 (H - f_{cn}) \tan 30°$

N is the number of threads made up at power tight. The lead in taper will reduce the thread engagement by approximately 1 thread. The gauge tolerance for LPT is +/- 1 thread on male and female parts. Therefore, the minimum number of thread turns (N) is calculated by:

$N = (L_1 \times \text{threads/inch}) - 1 - 2 + A$

where:

L_1 is the length from end of pipe to hand tight plane
A is the number of thread turns from hand tight to power tight
L_1 and A are shown in Table 2.1 of API Std 5B

From the ASME's maximum shear stress theory, the allowable shear stress (S_s) $\leq 0.5\ S_y$; therefore,

$S_y = (S_s) / 0.5$

4.0 SUMMARY DATA

A minimum material yield strength for the component is calculated using each method shown in formulas 3 1 thru 3.5. When the results from each method are compared, the minimum material yield strength of the component will be the maximum calculated yield strength

LINE PIPE BULL PLUGS

Calculated Minimum Yield Strength Requirements for 10,000 psi W.P. Rating Using 60,000 psi Min. Y.S. Material

Size	Governing Stress	Req'd Min. Yield Strength (psi)
½	Tensile	28905
1	Tensile	32,213
2	Membrane	49,557
2 ½	Thread Shear	47,330
3	Thread Shear	49,320
4	Thread Shear	55,928

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PROPOSED PRESSURE RATINGS

PROPOSED API / ISO
BULL PLUG PRESSURE RATINGS (PSI)

Size	W.P.
½" to 4"	10,000

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TEST RESULTS

- **HYDROSTATIC**
- **GAS**

SUMMARY OF BULL PLUG HYDROSTATIC TESTING
BY THREE INDEPENDENT EQUIPMENT MANUFACTURERS
Date of Compilation 12/17/97

Size	Plug Yield Strength (ksi)	Fixture Yield Strength (ksi)	Make-up Turns Past Hand-Tight	Torque Make-Up (Foot Pounds)	Pressure at Leakage (ksi)
½"	62.6	62.6	2	700 (4)	56.1
	62.6	62.6	1 ½	170 (5)	42.7
	62.1	60.0	1	20	22.0
	62.1	60.0	1 ¼	40	30.0* (1)
	57.1	57.1	2	105	25.0* (1)
	57.1	57.1	2	105	25.0* (1)
1"	62.6	55.2	2	800 (4)	23.6
	62.6	55.2	1 ½	610 (5)	22.4
2"	55.2	56.5	1 ½	325 (4)	22.7* (1)
	55.2	56.5	1 ½	570 (4)	22.6* (1)
	60.0	60.0	2	380	21.0
	60.0	60.0	3	1380	17.0
	58.2	54.2	2	400	20.0
	58.2	54.2	3	770	16.0
2 ½"	55.2	56.5	1	1950 (4)	26.7
	55.2	56.5	1	1950 (4)	30.9
3"	55.2	56.5	1	2765 (4)	22.5
	55.2	56.5	1 ½	3025 (4)	17.5
	60.0	64.6	2 ½	2100	19.0
	60.0	64.6	2	1760	20.0
	55.7	**	2	1300	19.0
	55.7	**	2	1430	19.0
4"	56.5	59.8			
	56.5	59.8	1 ½	3900 (4)	16.7

Notes:
1) * Test Terminated - Connection still holding pressure
2) Parts undamaged by Testing
3) ** Mechanical Testing in process
4) Used tool joint thread compound. Disassembled and re-torqued with API RP5A3 thread compound
5) Used tool joint compound.

SUMMARY OF BULL PLUG GAS TESTING
BY THREE INDEPENDENT EQUIPMENT MANUFACTURERS
Date of Compilation 12/17/97

Size	Plug Yield Strength (ksi)	Fixture Yield Strength (ksi)	Make-up Turns Past Hand-Tight	Torque Make-Up (Foot Pounds)	Gas Pressure Held (ksi)
½"	62.1	60.0	2	220	12.5
	62.1	60.0	1 ¼	40	12.5
	57.1	57.1	2	105	17.5
	57.1	57.1	2	105	17.5
2"	60.0	60.0	2 ¾	600	12.7
	60.0	60.0	3	1380	12.7
2 ½"	55.2	56.5	1	1950	12.5
	55.2	56.5	1	1950	12.5
3"	55.2	56.5	1 ½	3025	12.5
	60.0	64.6	2	1760	12.5
	55.7	?	2	1300	12.5
4"	56.5	59.8	1 ½	3900	12.5

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TEST PROCEDURES

TEST PROCEDURE FOR HYDROSTATIC TEST

1. Apply a generous layer of API RP5A3 type thread grease to the bull plug threads and female test fixture.
2. Make up the bull plug to the test fixture hand tight, and record the number of turns.
3. Continue making up the bull plug 1-1/2 turns past hand tight for sizes ½" to 2" and 1 turn for sizes 2-1/2" to 4". Measure and record torque.
4. Enclose test fixture in a safety container, connect a chart recorder and proceed with the pressure testing.
5. Apply working pressure of 10,000 psi, hold for three minutes and bleed to zero.
6. Apply working pressure of 10,000 psi, hold for 15 minutes and bleed to zero.
7. Apply test pressure of 15,000 psi, hold for 15 minutes and bled to zero.
8. Apply pressure of 15,000 psi and increase pressure in 1000 psi/min increments until failure occurs.
9. Record failure pressure and the mode of failure.

NOTE: In case of failure I steps 5 through 7 apply more torque and record the number of turns and the torque required to create a seal.

PRESSURE TEST

PRESSURE PSI	TIME MIN	PASSED/ FAILED	PRESSURE FAILED	FAILURE MODE	COMMENTS
W.P	3 MIN.	P / F			
BLEED TO ZERO	N / A	N / A			
W.P	15 MIN.	P / F			
BLEED TO ZERO	N / A	N / A			
T.P	15 MIN.	P / F			
BLEED TO ZERO	N / A	N / A			
PRESSURE TO FAILURE 1000 PSI/MIN	N / A	N / A			

POST TEST INSPECTION

GAUGE STANDOFF FOR PLUG -.....

GAUGE STANDOFF FOR FEMALE TEST FIXTURE:-.. ....

TEST PROCEDURE FOR GAS TEST

1. With the bull plugs still made up from the previous hydraulic test, connect to a high pressure gas system, immerse in a water pit and proceed with gas testing.
2. If the bull plug from the previous hydraulic testing has been disassembled, make up the bull plug as described in the TEST PROCEDURE FOR HYDRAULIC TEST, and then proceed with step (1) above.
3. Apply 10,000 psi working pressure and allow to stabilize for 2 minutes. Hold pressure for three minutes, and bleed pressure to zero.
4. Apply 10,000 working pressure, allow to stabilize for two minutes and hold pressure for 60 minutes.
5. Increase pressure in step (4) above to 12,500 psi in increments of 500 psi/min and hold for 15 minutes.

NOTE:- In case of leakage in steps 3 or 4 attempt to create a seal by applying more make up torque to the plug. Record the amount of torque required and the number of turns added.

6. Disassemble the test fixtures and inspect the plug and the female fixture with the appropriate gauges. Record the standoff for the plug gauge and the female test fixture gauge.

GAS PRESSURE TEST

PRESSURE PSI	TIME MIN.	PASSED/ FAILED	PRESSURE FAILED	FAILURE MODE	COMMENTS
W.P	2MIN STABILIZE	N/A			
W.P	3 MIN.	P / F			
BLEED TO ZERO	N / A	N / A			
W.P	2 MIN. STABILIZE	N/A			
W.P	60 MIN.	P / F			
PRESSURE TO 12,500 @ 500 PSI/MIN	15 MIN	P/F			

POST TEST INSPECTION

GAUGE STANDOFF FOR PLUG:-.....

GAUGE STANDOFF FOR FEMALE TEST FIXTURE:-.....

SUPPORTING DOCUMENTATION FOR
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PROPOSED WORDING CHANGES TO API 6A

Specification for Wellhead and Christmas Tree Equipment

1 Scope

1.1 PURPOSE

This specification was formulated to provide for the availability of safe, dimensionally and functionally interchangeable wellhead and christmas tree equipment.

The technical content provides requirements for performance, design, materials, testing, inspection, welding, marking, handling, storing and shipping by the manufacturer. This specification does not apply to field use or field testing of wellhead and christmas tree equipment.

Critical components are those parts having requirements specified in this document.

1.2 APPLICATIONS

1.2.1 Coverage

This specification covers equipment utilized for pressure control systems for the production of oil and gas. Specific equipment covered by this specification is listed as follows:

a. Wellhead Equipment

- Casing Head Housings
- Casing Head Spools
- Tubing Head Spools
- Crossover Spools
- Multistage Head Housings & Spools

b. Connectors and Fittings

- Crossover Connectors
- Tubing Head Adapters
- Top Connectors
- Tees and Crosses
- Fluid Sampling Devices
- Adapter and Spacer Spools

c. Casing and Tubing Hangers

- Mandrel Hangers
- Slip Hangers

d. Valves and Chokes

- Single Completion Valves
- Multiple Completion Valves
- Actuated Valves
- Valves Prepared for Actuators
- Check Valves
- Chokes
- Surface and Underwater Safety Valves and Actuators for Offshore Service

e. Loose Connectors [Flanged, Threaded, Other End Connectors (O.E.C.), and Welded]

- Weld Neck Connectors
- Blind Connectors
- Threaded Connectors
- Adapter and Spacer Connectors
- Bull Plugs

f. Other Equipment

- Actuators
- Ring Gaskets

The typical equipment nomenclature used in this specification is shown in Figure 1.1 and Figure 1.2.

Appendix A provides purchasing guidelines to users for API Spec 6A equipment.

1.2.2 Service Conditions

a. General

Service conditions refer to classifications for pressure, temperature, and the various well-bore constituents and operating conditions.

b. Pressure Ratings

Pressure ratings indicate rated working pressures expressed as gage pressure (psig or MPa gage).

c. Temperature Ratings

Temperature ratings indicate temperature ranges, from minimum ambient to maximum flowing fluid temperatures, expressed in degrees Fahrenheit (°F) or degrees Celsius (°C).

d. Materials Class Ratings

Materials class ratings indicate the material for the equipment components. A guideline (not a requirement) for the basic well-bore constituents and operating conditions is covered in Appendix A.

1.3 PRODUCT SPECIFICATION LEVELS (PSL)

a. General

This specification establishes requirements for four product specification levels. These four PSL designations define different levels of technical requirements. Appendix A provides guidelines (not requirements) for selecting an acceptable PSL.

b PSL 1

PSL 1 includes practices currently being implemented by a broad spectrum of the industry for service conditions recommended in Appendix A of this specification.

c. PSL 2

PSL 2 includes all the requirements of PSL 1 plus additional practices currently being implemented by a broad

(Text continues on page 1-4)

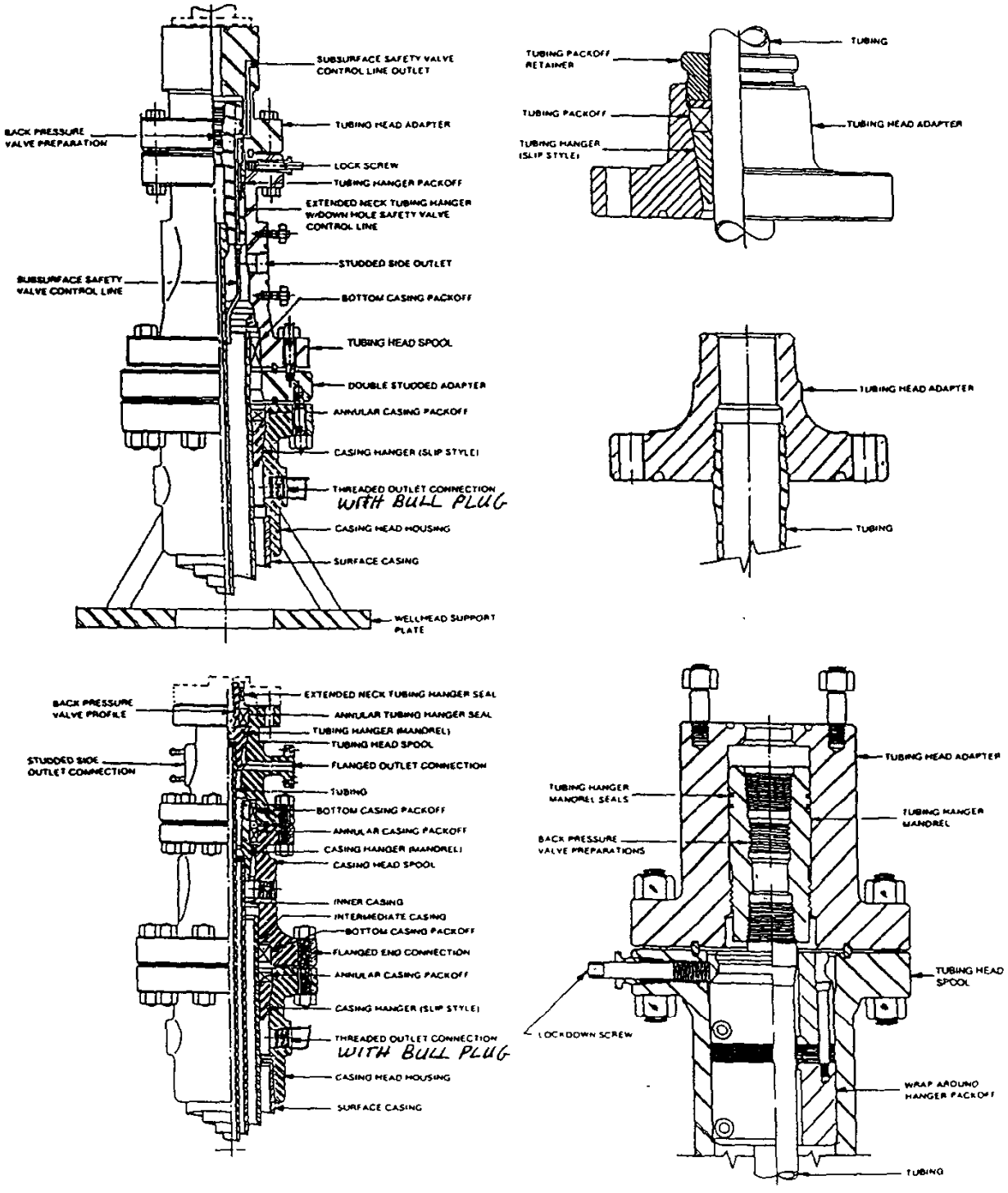

Figure 1.1—Typical Wellhead Assembly Nomenclature

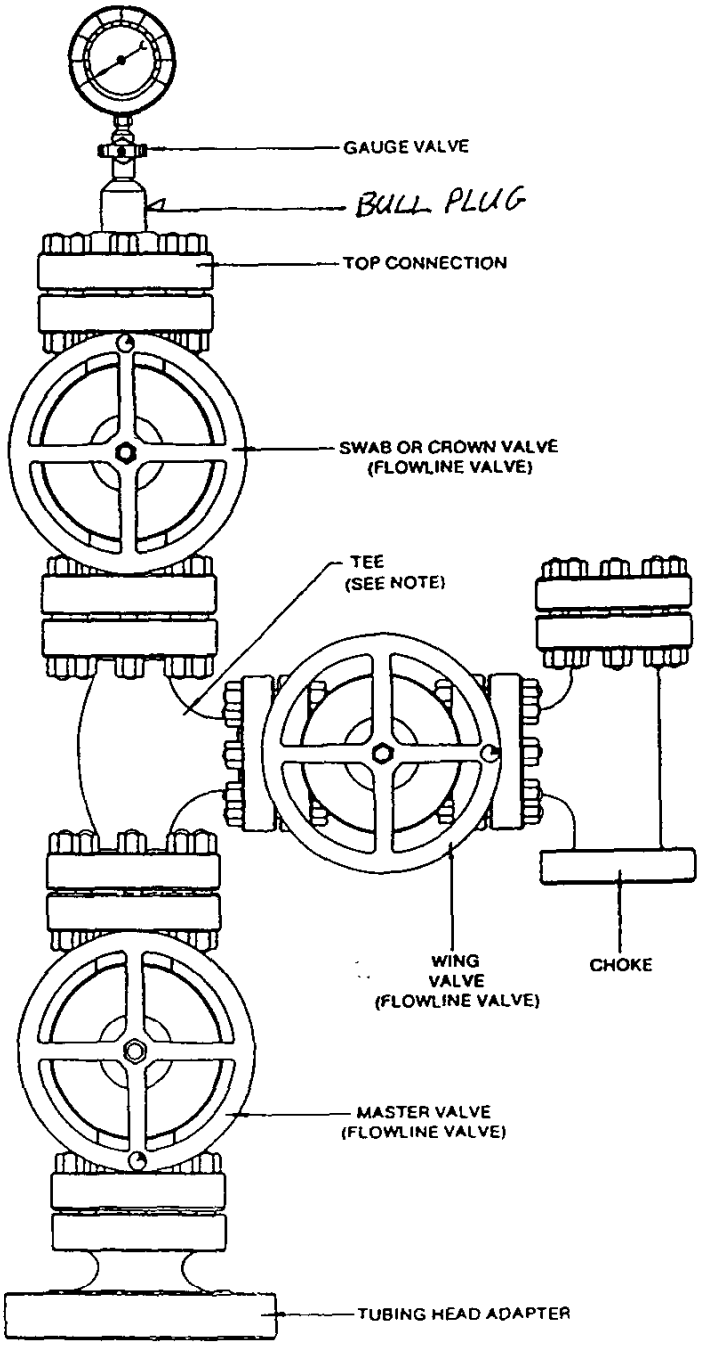

Figure 1.2—Typical Christmas Tree Nomenclature

2 References

2.1 GENERAL

Only those reference standards listed in Section 2.2 are considered part of this specification. Documents (sub-tier) that are referenced by those documents are not considered part of this specification.

When the latest edition is specified it may be used on issue and shall be mandatory 6 months from the date of revision. The replaced edition may be used up to 6 months from the date of the latest revision.

2.2 REFERENCE STANDARDS

This specification includes by reference, either in total or in part, other API, industry and government standards listed below:

The latest edition of these standards shall be used unless otherwise noted below:

API RP 6A3 Thread Compounds for Casing Tubing and Line Pipe.

- Spec 5B *Threading, Gaging, and Thread Inspection of Casing, Tubing and Line Pipe Threads*
- Spec 5CT *Casing and Tubing*
- Spec 5L *Line Pipe*

ANSI

- B1.1 *Unified Standard Inch Screw Threads*
- B1.2 *Gages and Gaging for Unified Inch Screw Threads*

ASME/ANSI

- B18.2.2 *Square and Hex Nuts*

ASME[1]

- *Boiler and Pressure Vessel Code, Sect. V, Nondestructive Testing, Article 5, UT Examination Methods for Materials and Fabrication Para. T522 & T542*
- *Boiler and Pressure Vessel Code, Section VIII, Division 1*
  - *a) Part UG-101: Proof Tests to Establish Maximum Allowable Working Pressure*
  - *b) Appendix 4: Rounded Indication Charts Acceptance Standard for Radiographically Determined Rounded Indications in Welds*
- *Boiler and Pressure Vessel Code, Section VIII, Division 2: Pressure Vessels — Alternate Rules*
  - *a) Appendix 4: Design Based on Stress Analysis*
  - *b) Appendix 6: Experimental Stress Analysis*
- *Boiler and Pressure Vessel Code, Section IX, Welding and Brazing Qualifications.*

ASNT[2]

- SNT-TC-1A *Personnel Qualification and Certification in Nondestructive Testing*, 1984 or latest edition

ASTM[3]

- A 193 *Alloy Steel and Stainless Steel Bolting Materials for High Temperature Service*
- A 194 *Carbon Alloy Steel Nuts for Bolts for High Pressure Temperature Service*
- A 307 *Carbon Steel Externally Threaded Standard Fasteners*
- A 320 *Alloy Steel Bolting Materials for Low Temperature Service*
- A 370 *Standard Methods and Definitions for Mechanical Testing of Steel Products*
- A 388 *Recommended Practice for Ultrasonic Examination of Heavy Steel Forgings*
- A 453 *Bolting Materials, High Temperature, 50 to 129 ksi Yield Strength, with Expansion Coefficients Comparable to Austenitic Steels*
- A 609 *Specification for Ultrasonic Examination for Carbon and Low-Alloy Steel Castings*
- A703/A703M *Specification for Steel Castings, General Requirements, for Pressure Containing Parts*
- D395 *Rubber Property—Compression Set*
- D412 *Rubber Properties in Tension*
- D471 *Rubber Property—Effect on Liquids*
- D573 *Rubber—Deterioration in an Air Oven*
- D865 *Rubber—Deterioration by Heating in Air (Test Tube Enclosure)*
- D1414 *Rubber O-Rings*
- D1415 *Rubber Property—International Hardness*
- D1418 *Rubber and Rubber Latices—Nomenclature*
- D2240 *Rubber Property—Durometer Hardness*
- E 10 *Standard Test Methods for Brinell Hardness of Metallic Materials*
- E 18 *Standard Test Methods for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials*

[1]American Society of Mechanical Engineers, 1950 Stemmons Freeway, Dallas, Texas 75207.

[2]American Society for Nondestructive Testing, 4153 Arlingate Plaza, Columbus, Ohio 43228-0518.

[3]American Society of Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103-1187.

3 Abbreviations/Definitions

3.1 ABBREVIATIONS

@	at .
ANSI	American National Standards Institute
API	American Petroleum Institute
ASME	American Society of Mechanical Engineers
ASME/SPPE	refers to the program described in ASME SPPE 1 and 2
ASNT	American Society for Nondestructive Testing
ASTM	American Society for Testing and Materials.
AWS	American Welding Society
cc	cubic centimeters
degrees F	degrees Fahrenheit (°F)
ID	inside diameter
max.	maximum
MIL-STD	Military Standard, U.S.A.
min.	minimum
MSS	Manufacturers Standardization Society of the Valve and Fittings Industry
NACE	National Association of Corrosion Engineers
NDE	nondestructive examination
OD	outside diameter
OEC	other end connector
PR1	Performance Requirement Level One
PR2	Performance Requirement Level Two
psi	pounds per square inch
PSL	Product Specification Level
SSV	surface safety valve
temp	temperature
USV	underwater safety valve

3.2 DEFINITIONS

3.2.1 acceptance criteria: Defined limits placed on characteristics of materials, products, or services.

3.2.2 accessible wetted surface: Those wetted surfaces which could be viewed for NDE purposes by direct line of sight. This excludes test ports, control line ports, lockdown screw holes and other penetrations of these types.

3.2.3 actuator: A mechanism for the remote or automatic operation of a valve or choke.

3.2.4 adapter: A pressure containing piece of equipment having end connections of different nominal sizes and/or pressure ratings, used to connect other pieces of equipment of different API nominal sizes and/or pressure ratings.

3.2.5 annular packoff: A mechanism that seals off annular pressure between the OD of a suspended tubular member or hanger and the ID of the head or spool through which the tubular member passes or hanger is suspended.

3.2.6 API monogram: A registered mark of the American Petroleum Institute, API.

3.2.7 as shipped condition: The condition of the product or equipment when it is ready for shipment.

3.2.8 authorized facility: A facility authorized under the applicable quality assurance program specified by the operator on the purchase order (applicable to SSV/USV equipment).

3.2.9 authorized quality assurance program: API or SSPE Quality Program (applicable to SSV/USV equipment).

3.2.10 back pressure valve: A check valve that is installed through the christmas tree, into the tubing hanger, and prevents well fluids from flowing out of the well.

3.2.11 body: Any portion of API Spec 6A equipment between end connections, with or without internal parts, which contains well-bore pressure.

3.2.12 bolting: Threaded fasteners (studs, nuts, bolts and capscrews) used to assemble pressure containing parts or join end or outlet connections.

3.2.13 bonnet: A pressure-containing closure for a body, other than an API end or outlet connection.

3.2.14 bottom casing packoff: A mechanism that seals off annular pressure between the OD of a suspended tubular member or hanger and the ID of the spool or tubing head adapter being placed over the suspended tubular or hanger.

3.2.15 bottom hole test adapter: See Top Connector

3.2.16 calibration: Comparison and adjustment to a standard of known accuracy.

3.2.17 carbon steel: An alloy of carbon and iron containing a maximum of 2% carbon, 1.65% manganese, and

3.2.15 bull plug - A threaded plug ~~with no center bore~~ ~~through~~ used to close off a threaded end or outlet connection.

4 Design and Performance—General Requirements

4.1 PERFORMANCE REQUIREMENTS—GENERAL

Performance requirements are specific and unique to the product in the as shipped condition. All products shall be designed to perform according to the requirements of this section and Section 10 while in the pressure and temperature ranges and the test fluids consistent with the material class in Table 4.3 for which they are rated. Other requirements include load capability, cycles, and operating force or torque. There are two Performance Requirement Levels, PR1 and PR2. The latter represents more rigorous performance requirements.

4.2 SERVICE CONDITIONS

4.2.1 Pressure Ratings

a. General

Equipment shall be designed to operate in only the following maximum rated working pressures:

psi	MPa
2,000	13.8
3,000	20.7
5,000	34.5
10,000	69.0
15,000	103.4
20,000	138.0

b. API Threaded Equipment Limitations

Equipment designed with ~~internal~~ API threaded end and outlet connections shall be limited to the thread sizes and rated working pressures in Table 4.1. Ratings do not include tubing and casing hangers.

c. Design Considerations

The design shall take into account the effects of pressure containment and other pressure-induced loads. Specialized conditions shall also be considered, such as pressure rating changes in crossover connectors and pressurizing with temporary test plugs. The effects of external loads (i.e., bending moments, tensions, etc.) on the assembly of components are not within the scope of this document.

4.2.2 Temperature Ratings

a. General

Equipment shall be designed to operate in one or more of the specified temperature ratings with minimum and maximum temperatures as shown in Table 4.2.

Minimum temperature is the lowest ambient temperature to which the equipment may be subjected. Maximum temperature is the highest temperature of the fluid that may directly contact the equipment.

b. Design Considerations

The design shall consider the effects of differential thermal expansion from temperature changes and temperature gradients which the equipment would experience in service.

4.2.3 Material Class Ratings

a. General

Equipment shall be designed with materials, including metallics, which meet requirements set forth in Table 4.3. Table 4.3 does not define either the present or the future wellhead environment, but provides materials classes for increasing levels of severity of service conditions and relative corrosivity.

Provided the mechanical properties can be met, stainless steels may be used in place of carbon and low alloy steels and

Table 4.1—Pressure Ratings for ~~Internal~~ API Threaded End or Outlet Connections

(1)	(2)	(3)	(4)	(5)
Type of API Thread	Size (in.) N.P.S.	Size (mm) OD	Rated Working Pressure (psi)	Rated Working Pressure (MPa)
Line Pipe (Nominal Sizes)	~~1/2 – 4~~ 5 – ~~2 1/2 – 6~~	21.3 ~~26.7 – 60.3~~ 73.0 – 168.3	10,000 ~~5,000~~ 3,000	69.0 ~~34.5~~ 20.7
Tubing, Nonupset and Ext. Upset Rnd. Thd.	1.050 – 4 1/2	26.7 – 114.3	5,000	34.5
Casing (8 Round, Buttress, and Extreme Line)	4 1/2 – 10 3/4	114.3 – 273.0	5,000	34.5
	11 3/4 – 13 5/8	298.5 – 339.7	3,000	20.7
	16 – 20	406.4 – 508.0	2,000	13.8

Table 5.1—API Material Property Requirements for Bodies, Bonnets, and End and Outlet Connections

(1)	(2)	(3)	(4)	(5)
API Material Designation	0.2% Yield Strength Minimum, psi (MPa)	Tensile Strength, Minimum, psi (MPa)	Elongation in 2 in. (50 mm), Minimum (%)	Reduction in Area, Minimum (%)
36K	36,000 (248)	70,000 (483)	21	No Requirement
45K	45,000 (310)	70,000 (483)	19	32
60K	60,000 (414)	85,000 (586)	18	35
75K	75,000 (517)	95,000 (655)	17	35

Table 5.2—API Material Applications for Bodies, Bonnets, and End and Outlet Connections

(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Pressure Ratings, psi (MPa)					
Part	2000 (13.8)	3000 (20.7)	5000 (34.5)	10,000 (69.0)	15,000 (103.4)	20,000 (138.0)
	API Material Designation					
Body,[a] Bonnet	36K, 45K 60K, 75K	36K, 45K 60K, 75K	36K, 45K 60K, 75K	36K, 45K 60K, 75K	45K, 60K 75K	60K, 75K
Integral End Connection						
Flanged	60K, 75K	60K, 75K	60K, 75K	60K, 75K	75K	75K
Threaded	60K, 75K	60K, 75K	60K, 75K	NA	NA	NA
Other	(See note)	(See note)	(See note)	(See note)	(See note)	(See note)
Loose Connectors						
Weld Neck	45K	45K	45K	60K, 75K	75K	75K
Blind	60K, 75K	60K, 75K	60K, 75K	60K, 75K	75K	75K
Threaded	60K, 75K	60K, 75K	60K, 75K	~~NA~~ 60K, 75K	NA	NA
Other	(See note)	(See note)	(See note)	(See note)	(See note)	(See note)

Note: As specified by manufacturer.

[a]Provided end connections are of the API material designation indicated, welding is done in accordance with Section 6 and design is performed in accordance with Section 4

Table 5.3—Charpy V Notch Impact Requirements (10 mm x 10 mm)

(1)	(2)	(3)	(4)	(5)	(6)
		Minimum Average Impact Value, ft-lb (J)			Minimum Lateral Expansion, in. (mm)
Temperature Classification	Test Temperature, °F (°C)	PSL 1	PSL 2	PSL 3	PSL 4
K	-75 (-60)	15 (20)	15 (20)	15 (20)	0.015 (0.38)
L	-50 (-46)	15 (20)	15 (20)	15 (20)	0.015 (0.38)
P	-20 (-29)	—	15 (20)	15 (20)	0.015 (0.38)
R	0 (-18)	—	—	15 (20)	0.015 (0.38)
S	0 (-18)	—	—	15 (20)	0.015 (0.38)
T	0 (-18)	—	—	15 (20)	0.015 (0.38)
U	0 (-18)	—	—	15 (20)	0.015 (0.38)
V	0 (-18)	—	—	15 (20)	0.015 (0.38)

10.2 API THREADED END AND OUTLET CONNECTIONS

10.2.1 General

~~Loose-threaded end and outlet connections are not covered by this specification.~~ This section gives requirements for integral equipment end and outlet connections, including tubing and casing hangers, which are API threaded.

10.2.2 Design

a. General

Internal and external API thread dimensions and tolerances shall conform with API Spec 5B.

b. API Thread Lengths

The length of internal API threads shall not be less than the effective thread length L2 of the external thread as described in Figure 10.3 and as stipulated in API Spec 5B.

10.2.2.2 API Thread Clearance

A clearance of *J* length minimum, as illustrated in API Spec 5B, shall be provided in all internal API threaded equipment.

10.2.2.3 API Thread Counterbores

End and outlet connections, equipped with internal threads, may be supplied with or without a thread entrance counterbore. Internal API threads, furnished without a counterbore, shall have the outer angles of 45° to a minimum depth of *P*/2 as illustrated in Figure 10.3 and Figure 10.4. Internal API threads, furnished with a counterbore, shall conform to the counterbore dimensions specified in Table 10.14 and the bottom of the counterbore shall be chamfered at an angle of 45°. As an alternate, counterbore dimensions may be as specified in API Spec 5B.

10.2.2.4 API Thread Alignment

API threads shall align with the axis of the end connection within a tolerance of +0.06 in./ft (5.0 mm/m or 0.3°) of projected axis.

10.2.2.5 End/Outlet Coupling Diameter

The outlet coupling diameter shall be of sufficient diameter to provide structural integrity of the API threaded part at rated pressure. This diameter shall not be less than the API tabulated joint or coupling diameter for the specified API thread.

10.2.3 Testing (Gaging)

API thread gages shall comply with the requirements for working gages as stipulated in 4.2 through 4.6 of API Spec 5B. API threads shall be gaged for standoff at hand-tight assembly. For API threads manufactured in accordance with this specification, use gaging practices as illustrated in Figures 10.4, 10.5 and 10.6. For API threads manufactured in accordance with API Spec 5B, use gaging practices as specified in API Spec 5B.

10.2.4 Marking

Threaded connectors shall be marked to conform with Section 8.

(Text continues on page 10-24)

Revise Section 10 by adding a new Section 10.21, as follows.

10.21 BULL PLUGS

10.21.1 General

This section covers API bull plugs. API bull plugs shall meet the requirements specified for loose connectors.

10.21.2 Design

The materials and designs of API bull plugs and all related components of the threaded connection must be considered in determining the working pressure and external load capacity.

10.21.2.1 Dimensions

API bull plugs shall conform to the dimensions and tolerances in Figure 10.25. Threaded connections shall conform to Section 10.2. Bull plugs smaller than ½" nominal pipe size and larger than 4" nominal pipe size are beyond the scope of this document.

10.21.2.2 Rated Working Pressure

The maximum rated working pressure for API bull plugs with line pipe threads ½" to 4" shall be 10,000 psi. Bull plugs of stronger materials, thread dimensions, and/or designs may be rated for pressures higher than 10,000 psi working pressure, but are beyond the scope of this document.

NOTE: Pressure ratings for API bull plugs specified in this document are based on API Material Designation of 60K per Table 5.1 for the plug and the mating part. API bull plugs installed into equipment not meeting the requirements of this specification may not be suitable for the rated working pressure.

10.21.2.3 Thread Engagement

Threaded connections shall comply with Section 10.2. API bull plugs with API Line Pipe Threads shall be assembled with mating parts in conformance with Table 10.51. API Thread Compounds recommended in API RP 5A3 or equivalent, shall be used.

10.21.3 Materials

API bull plug material shall conform to Section 5. Bull plugs and threaded connections with components of less than API Material Designation of 60K material are beyond the scope of this document.

10.21.4 Marking

API bull plugs shall be marked to conform to Section 8.

10.21.5 Storing and Shipping

API bull plugs shall be stored and shipped in accordance with Section 9.

Revise Section 8 by adding a new Section 8.10, as follows.

8.10 API Bull Plugs

a. API bull plugs nominal pipe size 1 ½" and larger.

API bull plugs nominal pipe size 1 ½" and larger shall conform to Table 8.1. API bull plugs may be marked on the exposed end or the flat of the hex , as applicable.

b. API bull plugs nominal pipe size 1" and smaller.

API bull plugs nominal pipe size 1" and smaller shall be marked with the designation "6A" and manufacturer's name or mark. API bull plugs may be marked on the exposed end or the flat of the hex, as applicable. API bull plugs with internal hex may be marked on the smaller, non exposed end.

Figure 10.25 - API Bull Plugs
See API Spec. 5B for Thread Dimensions

All Bull Plugs					Round Plugs	Plugs with External Hex			Plugs with Internal Hex		
Thread Size:	Diameter of Round	Minimum Length of Full Round	Depth of Counterbore	Diameter of Counterbore	Overall Length	Hex Size (across Flats)	Height of Hex	Length of Plug with External Hex	Internal Hex Size	Depth Of Hex	Length of Plug with Internal Hex
Nominal	D4	L4	C	d	L (Min)	He	B	Le (Min)	Hi	G	Li
1/2	0.840	0.7815	None	None	2.00	0.88	0.31	1.38	0.38	0.31	1.00
3/4	1.050	0.7935	None	None	2.00	1.06	0.38	1.50	0.56	0.31	1.00
1	1.315	0.9845	None	None	2.00	1.38	0.38	1.75	0.63	0.38	1.00
1 1/4	1.660	1.0085	1.06	0.88	2.00	-	-	-	-	-	-
1 1/2	1.900	1.0252	1.06	1.00	2.00	-	-	-	-	-	-
2	2.375	1.0582	1.06	1.50	4.00	-	-	-	-	-	-
2 1/2	2.875	1.5712	1.63	1.75	4.00	-	-	-	-	-	-
3	3.500	1.6337	1.63	2.25	4.00	-	-	-	-	-	-
3 1/2	4.000	1.6837	1.75	2.75	4.00	-	-	-	-	-	-
4	4.500	1.7337	1.75	3.00	4.00	-	-	-	-	-	-

Note:- Dimensions D4 and L4 are in accordance with API 5B. All other dimensions are +/- .03", unless otherwise specified.

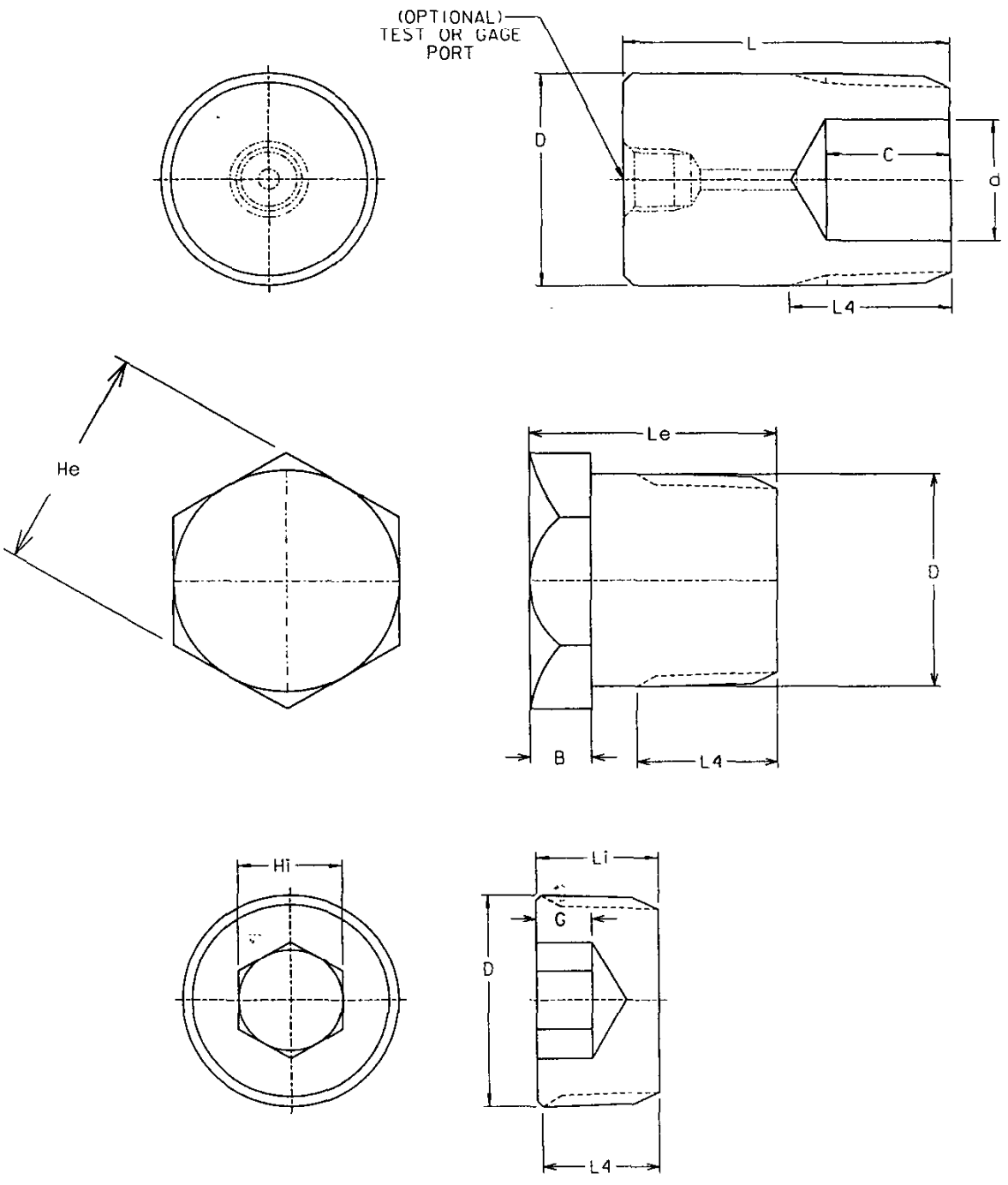

FIG.10.25 (CONTINUED)

TABLE 10.51

RECOMMENDED BULL PLUG INSTALLATION PROCEDURE

Size	Minimum Recommended Turns Past Hand-Tight Condition
½", ¾" and 1"	1 ½
2" thru 4"	2

Notes:

1) API thread compounds recommended in API RP5A3 or equivalent shall be used
2) Recommended turns past hand-tight is normally sufficient to contain rated W.P. and test pressures up to 15,000 psi. However, re-tightening up to an additional one or two turns may be required in some cases.
3) Threaded components must be in serviceable condition in order to provide leak-free performance.