

Lock Mandrels and Landing Nipples

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Introduction

This specification has been developed by users/purchasers and suppliers/manufacturers of lock mandrels and landing nipples intended for use in the petroleum and natural gas industry worldwide. This specification is intended to give requirements and information to both parties in the selection, manufacture, testing, and use of lock mandrels and landing nipples. Furthermore, this specification addresses the minimum requirements with which the supplier/manufacturer is to comply to claim conformity to this specification.

This specification has been structured to allow for grades of increased requirements in design validation. These variations allow the user/purchaser to select the grade required for a specific application.

This edition has been revised to include one set of quality requirements. There are six design validation grades for lock mandrels (V3, V2, V1, V0, V1-H, and V0-H) and three design validation grades for landing nipples (V3, V2, and V2-H) that provide the user/purchaser the choice of requirements to meet specific preference or application. Design verification requirements were expanded. The complexity and severity of the validation testing increases as the grade number decreases.

Users of this specification should be aware that requirements above those outlined in this specification may be needed for individual applications. This specification is not intended to inhibit a supplier/manufacturer from offering, or the user/purchaser from accepting, alternative equipment or engineering solutions. This may be particularly applicable where there is innovative or developing technology. Where an alternative is offered, the supplier/manufacturer should identify any variations from this specification and provide details.

Lock Mandrels and Landing Nipples

1 Scope

This specification provides the requirements for lock mandrels and landing nipples within the production/injection conduit for the installation of flow control or other equipment used in the petroleum and natural gas industries. It includes the interface connections to the flow control device or other equipment, but does not cover flow control devices, the connections to the well conduit, alternate technologies, or other requirements covered by other existing API or ISO specifications

2 Normative References

The following referenced documents are indispensable for the application of this document. The way in which these referenced documents are cited determines the extent (in whole or part) to which they apply. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

API Specification 5B, *Specification for Threading, Gauging, and Thread Inspection of Casing, Tubing, and Line Pipe Threads*

API Technical Report 5C3, *Calculating Performance Properties of Pipe Used as Casing or Tubing, Seventh Edition*

API Specification 6A, *Specification for Wellhead and Tree Equipment*

API Specification 14A, *Specification for Subsurface Safety Valves*

API Specification 20A, *Carbon Steel, Alloy Steel, Stainless Steel, and Nickel Base Alloy Castings for Use in the Petroleum and Natural Gas Industry*

API 579-1/ASME FFS-1, *Fitness-For-Service*

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

ANSI/NACE MR0175¹/ISO 15156 (all parts), *Petroleum and natural gas industries—Materials for use in H₂S-containing environments in oil and gas production*

ASME² Boiler and Pressure Vessel Code, Section V, *Non-destructive examination*

ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, *Rules for construction of pressure vessels*

ASME Boiler and Pressure Vessel Code, Section VIII, Division 2, *Alternative Rules*

ASME Boiler and Pressure Vessel Code, Section IX, *Welding and Brazing Qualifications*

ASNT SNT-TC-1A,³ *Personnel Qualification and Certification in Nondestructive Testing*

¹ NACE International (formerly the National Association of Corrosion Engineers), 1440 South Creek Drive, Houston, Texas 77084-4906, www.nace.org.

² American Society of Mechanical Engineers, Two Park Avenue, New York, New York 10016-5990, www.asme.org.

³ American Society for Nondestructive Testing, PO Box 28518, 1711 Arlingate Lane, Columbus, Ohio 43228-0518.

ASTM A370,⁴*Standard Test Methods and Definitions for Mechanical Testing of Steel Products*

ASTM A388/A388M, *Standard Practice for Ultrasonic Examination of Heavy Steel Forgings*

ASTM A609/A609M, *Standard Practice for Castings, Carbon, Low-alloy, and Martensitic Stainless Steel, Ultrasonic Examination Thereof*

ASTM D297, *Standard Test Methods for Rubber Products—Chemical Analysis*

ASTM D395, *Standard Test Methods for Rubber Property — Compression Set*

ASTM D412, *Standard Test Methods for Vulcanized Rubber and Thermoplastic Rubbers and Thermoplastic Elastomers — Tension*

ASTM D429, *Standard Test Methods for Rubber Property—Adhesion to Rigid Substrates*

ASTM D638, *Standard Test Method for Tensile Properties of Plastics*

ASTM D790, *Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials*

ASTM D1414, *Standard Test methods for Rubber O-rings*

ASTM D1415, *Standard Test Method for Rubber Property — International Hardness*

ASTM D1708, *Standard Test Method for Tensile Properties of Plastics by Use of Microtensile Specimens*

ASTM D2240, *Standard Test Methods for Rubber Property — Durometer Hardness*

ASTM D2990, *Standard Test Methods for Tensile, Compressive, and Flexural Creep and Creep-Rupture of Plastics*

ASTM E8, *Standard Test Methods for Tension Testing of Metallic Materials*

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

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

ASTM E21, *Standard Test Methods for Elevated Temperature Tension Tests of Metallic Materials*

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

ASTM E94, *Standard Guide for Radiographic Examination*

ASTM E140, *Standard Hardness Conversion Tables for Metals Relationship among Brinell Hardness, Vickers Hardness, Rockwell Hardness, Superficial Hardness, Knoop Hardness, and Scleroscope Hardness, and Leeb Hardness*

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

ASTM E186, *Standard Reference Radiographs for Heavy-walled [2 to 4 1/2-in. (51 to 114-mm)] Steel Castings*

ASTM E280, *Standard Reference Radiographs for Heavy-walled [4 1/2 to 12-in. (114 to 305-mm)] Steel Castings*

⁴ American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, Pennsylvania 19428-2959, USA.

ASTM E384, *Standard Test Method for Knoop and Vickers Hardness of Materials*

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

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

ASTM E709, *Standard Guide for Magnetic Particle Testing*

ISO 2859-1,⁵*Sampling procedures for inspection by attributes — Part 1: Sampling schemes indexed by acceptance quality limit (AQL) for lot-by-lot inspection*

ISO 3601-1, *Fluid power systems — O-rings — Part 1: Inside diameters, cross-sections, tolerances and size identification code*

ISO 3601-3, *Fluid power systems — O-rings — Part 3: Quality acceptance criteria*

ISO 6506-1, *Metallic materials — Brinell hardness test — Part 1: Test method*

ISO 6507-1, *Metallic materials — Vickers hardness test — Part 1: Test method*

ISO 6508-1, *Metallic materials — Rockwell hardness test — Part 1: Test method (scales A, B, C, D, E, F, G, H, K, N, T)*

ISO 6892, *Metallic materials — Tensile testing at ambient temperature*

ISO 9712, *Non-destructive testing — Qualification and certification of personnel*

ISO 10432:2004, *Petroleum and natural gas industries — Downhole equipment — Subsurface safety valve equipment*

ISO 16070:2005, *Petroleum and natural gas industries — Downhole equipment — Lock Mandrels and Landing Nipples*

ISO 13665, *Seamless and welded steel tubes for pressure purposes — Magnetic particle inspection of the tube body for the detection of surface imperfections*

ISO 18265, *Metallic materials – Conversion of hardness values*

ISO 23936-2:2011, *Petroleum, petrochemical and natural gas industries—Non-metallic materials in contact with media related to oil and gas production—Part 2: Elastomers*

SAE AMS 2750E,⁶*Pyrometry*

SAE AS568, *Aerospace Size Standard for O-rings*

3 Terms and Definitions

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

⁵ International Organization for Standardization, 1, ch. de la Voie-Creuse, Case postale 56, CH-1211 Geneva 20, Switzerland, www.iso.org.

⁶ SAE International (formerly the Society of Automotive Engineers), 400 Commonwealth Drive, Warrendale, Pennsylvania 15096-0001, www.sae.org.

3.1**ambient temperature**

Prevailing temperature at test site.

3.2**compound**

Combination of constituent elements of the formulation of a nonmetallic material from a supplier.

3.3**control fluid redirection**

Feature, when activated, that provides control system communication.

3.4**design acceptance criteria**

Defined limits placed on characteristics of materials, products, or services established by the organization, customer, and/or applicable specifications to achieve conformity to the product design.

3.5**design margin**

Ratio of the material yield stress divided by the actual design stress in a given component.

NOTE Design margins account for a level of reduced performance capability to compensate for uncertainties in the potential loading (applied stress) and the intrinsic variations in the mechanical properties, such as yield strength, ultimate strength, endurance strength, and modulus of elasticity, that have distribution about their mean values.

3.6**design validation**

Process of proving a design by testing to demonstrate conformity of the product to design requirements.

3.7**design verification**

Process of examining the result of a given design or development activity to determine conformity with specified requirements.

3.8**flow control device**

Installed interfacing accessory devices providing flow control functionality through the lock mandrel.

NOTE Examples include, but are not limited to, check valves, instrument hangers, equalizing devices, blanking plugs, and pump-through devices.

3.9**high-pressure, high-temperature equipment****HPHT**

Equipment assigned a pressure rating greater than 103.4 MPa (15,000 psig) or a temperature rating greater than 176.7 °C (350 °F).

3.10**interface connection**

Connection on the lock mandrel connecting flow control or other equipment.

3.11**landing nipple**

Receptacle containing a profile designed for the installation of a lock mandrel.

3.12**lock mandrel**

Retention device used for a flow control device or other equipment.

3.13**model**

Lock mandrel or landing nipple equipment with unique components and operating characteristics that differentiate it from other lock mandrel or landing nipple equipment of the same type.

3.14**operating conditions**

Set of conditions to which the product is exposed during its operating life.

3.15**production/injection conduit**

Tubulars and equipment that provide the flow path between the reservoir and the christmas tree, including the riser for subsea applications.

3.16**profile**

Feature designed to receive the lock mandrel's locking mechanism.

3.17**qualified person**

Individual with documented abilities gained through training or experience, or both, as measured against established requirements, such as standards or tests that enable the individual to perform a required function effectively.

3.18**rated working pressure**

Landing nipple internal pressure design limit or lock mandrel differential pressure design limit from above and/or below, as established by the supplier/manufacture.

3.19**sealing device**

Device preventing passage (i.e. communication) of liquid and/or gas across the interface between the lock mandrel and the landing nipple.

3.20**size**

Relevant dimensional characteristics of the equipment as defined by the supplier/manufacture.

3.21**stress level**

Ratio of the calculated stress to the temperature derated minimum yield strength of the material.

3.22**substantive design change**

Change to the design, identified by the supplier/manufacture, that affects the performance of the product in the intended service condition.

3.23**test pressure**

Pressure at which the equipment is tested based upon all relevant design criteria.

NOTE See 6.5 for test pressure requirements.

3.24

test temperature

Temperature at which the equipment is tested based upon all relevant design criteria.

3.25

type

Lock mandrel or landing nipple equipment with unique characteristics that differentiate it from other functionally similar lock mandrel or landing nipple equipment.

3.26

Type 1 component

Metallic component that isolates pressure and/or may be loaded in tension as the result of axial loads on the equipment.

4 Abbreviated Terms

AQL	acceptance quality limit
BOM	bill of materials
COC	certificate of conformance
D	diameter
FEA	finite element analysis
FMEA	failure modes and effects analysis
HPHT	high-pressure high-temperature
ID	inside diameter
L	length
NDE	non-destructive examination
OD	outside diameter
RGD	rapid gas decompression
SVLN	safety valve landing nipple
t	wall thickness

5 Functional Specification

5.1 General

The user/purchaser shall prepare a functional specification for ordering products conforming to this specification and specify the following requirements and operating conditions, as applicable, and/or identify the supplier's/manufacturer's specific product. These requirements and operating conditions may be conveyed by means of a dimensional drawing, data sheet, or other suitable documentation.

NOTE Lock mandrels and landing nipples may require the two components to be used as an assembly; therefore, the ratings of that assembly are established by the design and material ratings of the combined assembly.

A representative schematic of a lock mandrel and landing nipple are shown in Figure 1.

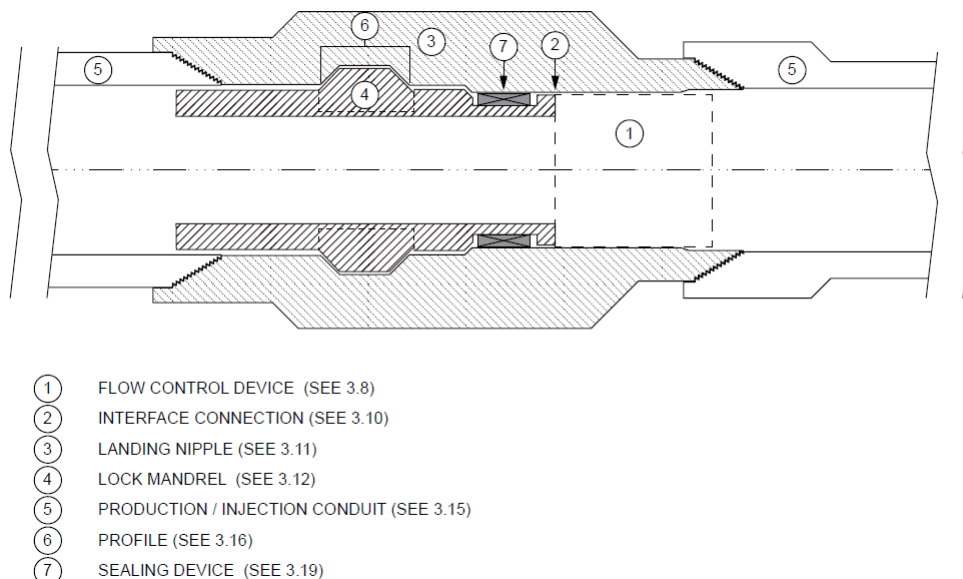


Figure 1—Landing Nipple and Lock Mandrel Schematic

5.2 Functional Characteristics of Lock Mandrels and Landing Nipples

The following functional characteristics should be specified for lock mandrels and/or landing nipples:

- a) conveyance method;
- b) locking mechanism;
- c) no-go;
- d) selectivity;
- e) sealing device;
- f) dimensions;
- g) passage of lines (electrical and/or hydraulic) in the annulus (for landing nipples only); and
- h) control fluid redirection

5.3 Well Parameters

The following well parameters should be specified for the lock mandrel and landing nipple:

- a) size, mass, material, and grade of the casing and tubing;
 NOTE The terms “weight” and “mass” are used interchangeably when referring to casing and tubing.
- b) well depth and angle from the vertical to the installed position;
- c) casing and tubing architecture, deviations, special drift, and restrictions through which the lock mandrel and/or landing nipple pass;
- d) expected minimum and maximum values of production/injection pressures, pressure differentials, temperatures, thermal cycles, and flow rates

5.4 Operational Parameters

The following operational parameters should be specified for the lock mandrel and landing nipple:

- a) loading conditions applied to the lock mandrel and landing nipple;
- b) well stimulation operations, including its parameters, such as acidizing (composition of the acid, pressure, temperature, acid flow rate, and the exposure time), as well as any other chemicals used during the stimulation; production/injection fluid composition, mass, chemical, and/or physical composition, fluid velocity or rate, and the condition of the fluid and/or its components [i.e. solid (sand production, scale, etc.), liquid, and/or gaseous], to which the lock mandrel and landing nipple is exposed during its operating life;
- c) fracturing, including proppant description, fracture fluid velocity, and proppant-to-fluid ratio
- d) sand consolidation operations;
- e) type of well intervention, including service equipment such as electric line, slick line, braided line, coiled tubing, or snubbing equipment;
- f) cyclical loading conditions.

NOTE For information regarding investigations of load cycling, see ASME BPVC Section VIII, Div 3, Article KD-3 or Article KD-4.

5.5 Environmental Compatibility

The following should be identified for the lock mandrel and landing nipple to ensure environmental compatibility during its operating life:

- a) production/injection fluid composition, mass, chemical, and/or physical composition;
- b) condition of the fluid and/or its components [i.e. solid (sand production, scale, etc.), liquid, and/or gaseous];
 - 1) In cases where the user/purchaser has access to corrosion property historical data and/or research that is applicable to the functional specification, the user/purchaser should state to the supplier/manufacturer which material(s) has the ability to perform as required within the corrosion environment. Should the supplier/manufacturer propose to use another material, the supplier/manufacturer shall provide technical justification (e.g. supporting service history, test laboratory data, etc.) for the use of the proposed material in the specified environment
 - 2) It is the equipment user's/purchaser's responsibility to select materials suitable for the intended service and any requirements for conformance with ANSI/NACE MR0175/ISO 15156. If the user/purchaser requires analysis for metals beyond conformance with ANSI/NACE MR0175/ISO 15156, then those fluids, contaminants, and testing/qualification requirements should be specified in the functional specification. Likewise, for nonmetallics, if required, the fluids, contaminants, and testing/qualification requirements should be specified in the functional specification
- c) additional functional requirements as follows for the selection materials where applicable:
 - 1) completion and packer fluid composition, pH, and existence of bromides (Zn, Ca, Na), formates (Cs, K, Na), chlorides (K, Ca, Na), acetates (Cs);
 - 2) mud type, mud density, and pH; aromatic and aliphatic solvents where present (type/amount);
 - 3) inhibitor treatments (type, concentration, and pH);
 - 4) oxygen scavenger systems;

- 5) emulsifier systems
- 6) continuous or batch treatment;
- 7) chemical composition;
- 8) duration and temperature of exposure;
- 9) control line fluid type, density, and chemistry.

NOTE ANSI/NACE MR0175/ISO 15156 prescribes laboratory testing procedures that can qualify alloys for general use in all environments or as fit-for-service testing for a project-specific environment. The standard requires the following environmental variables: the minimum in situ water pH, the maximum chloride concentration, the maximum partial pressure of H_2S in the gas phase, minimum and maximum temperatures, and the presence of solid elemental sulfur. It is important to consider both the immediate short-term environment and changes that may occur longer term, such as increases in the partial pressure of H_2S due to reservoir souring from water injection.

5.6 Compatibility with the Related Well Equipment

5.6.1 Lock Mandrels

The following information should be specified to ensure the compatibility of the lock mandrel with the related well equipment:

- a) size and/or type of the lock mandrel required to position the flow control device in the landing nipple;
- b) landing nipple size, model, type, and material into which the lock mandrel is to be installed;
- c) size, type, material, and configuration of the flow control device;

5.6.2 Landing Nipples

The following information should be specified to ensure the compatibility of the landing nipples with the related well equipment:

- a) top and bottom tubular connection(s), the material and dimensions of the landing nipple that is connected to the tubing;
- b) internal receptacle profile(s), sealing bore size(s), outside diameter, inside diameter(s), and their respective locations;
- c) size, type, and configuration of lock mandrels or other product to be used with the landing nipple
- d) control line size, control line fitting, control line fluids, and other parameters applicable to landing nipples with control-fluid redirection feature

5.7 Design Validation Grades

The user/purchaser shall specify the minimum design validation grades from the options shown in Table 1 (lock mandrels) and Table 2 (landing nipples). The selected design validation grade applies to all applicable validation testing.

If design validation grade V0-H, V1-H, or V2-H is specified, the requirements of Annex C shall apply.

The user/purchaser may request validation testing of a flow control device used in conjunction with the lock mandrel.

Table 1—Validation Grades for Lock Mandrels

Design Validation Grade	Description
V0-H	Nitrogen gas test at temperature and pressure (above and below) with temperature cycling (C.3.5.3)
V1-H	Liquid test at temperature and pressure (above and below) with temperature cycling (C.3.5.2)
V0	Nitrogen gas test at temperature and pressure (above and below) (6.5.3.4)
V1	Liquid test at temperature and pressure (above and below) (6.5.3.3)
V2	Liquid test at pressure (above and below) (6.5.3.2)
V3	Supplier/manufacturer defined (6.5.1)

Table 2—Validation Grades for Landing Nipples

Design Validation Grade	Description
V2-H	Liquid test at pressure (6.5.2.2) NOTE Additional verification requirements per Annex C.
V2	Liquid test at pressure (6.5.2.2)
V3	Supplier/manufacturer defined (6.5.1)

NOTE V0 and V1 are not applicable for landing nipples

6 Technical Specification

6.1 General

The supplier/manufacturer shall prepare the technical specification that responds to the requirements defined in the functional specification

6.2 Technical Characteristics of Lock Mandrels and Landing Nipples

6.2.1 Characteristics of Lock Mandrels

The lock mandrel, including sealing devices, shall have the capability to support the loading conditions as specified in 5.3 d) and 5.4 a) and to locate and seal as intended at the specified location and remain so under the stated conditions of pressure, temperature, and axial loads, as applicable.

6.2.2 Characteristics of Landing Nipples

The landing nipple, including seals, shall have the capability to support the loading conditions as specified in 5.3 and 5.4 and to receive and seal the lock mandrel as intended at the specified location under the stated conditions of pressure, temperature, and axial loads, as applicable. Additionally, certain landing nipple designs contain control fluid redirection features and shall also perform in accordance with Table 4.

6.3 Design Criteria

6.3.1 Design Requirements

6.3.1.1 Design requirements shall include methods, assumptions, and calculations, and shall include those criteria for size, test, rated working pressure, materials, environment (temperature limits, chemicals), and other pertinent requirements upon which the design is based. Design documentation shall be reviewed and verified by a qualified person other than the individual who created the original design.