Specification for Lock Mandrels and Landing Nipples

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Contents

Page

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 quality documentation and 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, V2-H) which provide the user/purchaser the choice of requirements to meet specific preference or application. Design verification requirements were expanded and new or alternate technology operating systems are now covered. 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, or alternate technologies.

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 5B[1)], *Specification for threading, gauging, and thread inspection of casing, tubing, and line pipe threads*

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

API 14A, *Specification for Subsurface Safety Valves*

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

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

ASME Boiler and Pressure Vessel Code[2)], Section V, *Non-destructive examination*

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

ASME Boiler and Pressure Vessel Code, Section VIII, Division 2*: Alternative Rules,* 2013 Edition

ASME Boiler and Pressure Vessel Code, Section IX, *Welding and brazing qualifications*

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

ASTM A388/A388M[3)], *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*

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1) American Petroleum Institute, 1220 L Street NW, Washington, DC 20005-4070, USA.

2) American Society of Mechanical Engineers, Three Park Avenue, New York, NY 10016-5990, USA.

3) American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959, USA.

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 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, Rockwell superficial hardness, Knoop hardness, and scleroscope hardness)*

ASTM E165, *Standard test method for liquid penetrant examination*

ASTM E186, *Standard reference radiographs for heavy-walled [2 to 4 ½-in. (51 to 114-mm)] steel castings*

ASTM E280, *Standard reference radiographs for heavy-walled [4 ½ to 12-in. (114 to 305-mm)] steel castings*

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

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*

ANSI/NACE MR0175/ISO 15156 2009 (Parts 1, 2, and 3), *Petroleum and natural gas industries—Materials for use in H_2S-containing environments in oil and gas production*

3 Terms and definitions

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

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 provides control system communication.

3.5
design acceptance criteria
DAC
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.

3.6
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.

3.7
design validation
Process of proving a design by testing to demonstrate conformity of the product to design requirements.

3.8
design verification
Process of examining the result of a given design or development activity to determine conformity with specified requirements.

3.9
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.

3.10
full life cycle
Expected period of time in which the product is specified to function according to the supplier's/manufacturer's specifications.

3.11
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).

3.12
interface connection
Connection on the lock mandrel connecting flow control or other equipment.

3.13
landing nipple
Receptacle containing a profile designed for the installation of a lock mandrel.

3.14
lock mandrel
Retention device used for flow control device or other equipment.

3.15
model
Lock mandrel or landing nipple equipment with unique components and operating characteristics which differentiate it from other lock mandrel or landing nipple equipment of the same type.

3.16
operating environment
Set of conditions to which the product is exposed during its full life cycle.

3.17
production/injection conduit
Tubulars and equipment which provide the flow path between the reservoir and the christmas tree, including the riser for subsea applications.

3.18
profile
Feature designed to receive the lock mandrel's locking mechanism.

3.19
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.

3.20
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/manufacturer.

3.21
sealing device
Device preventing passage (i.e. communication) of liquid and/or gas across the interface between the lock mandrel and the landing nipple.

3.22
size
Relevant dimensional characteristics of the equipment as defined by the supplier/manufacturer.

3.23
stress factor
Ratio of the calculated stress to the temperature derated minimum yield strength of the material.

3.24
substantive design change
Change to the design, identified by the supplier/manufacturer, that affects the performance of the product in the intended service condition.

3.25
test pressure
Pressure at which the equipment is tested based upon all relevant design criteria.

NOTE See 6.5 for test pressure requirements.

3.26
test temperature
Temperature at which the equipment is tested based upon all relevant design criteria.

3.27
type
Lock mandrel or landing nipple equipment with unique characteristics which differentiate it from other functionally similar lock mandrel or landing nipple equipment.

3.28
type 1 component
Component that isolates pressure and/or may be loaded in tension or compression as the result of axial loads on the equipment.

4 Abbreviated terms

AQL Acceptance quality limit

BOM Bill of Materials

COC Certificate of Conformance

DAC Design Acceptance Criteria

FEA Finite Element Analysis

FMEA Failure Modes and Effects Analysis

HPHT High Pressure High Temperature

NDE Non-destructive examination

SVLN Safety Valve Landing Nipple

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.

5.2 Functional characteristics of lock mandrels and landing nipples

The following functional characteristics should be specified for lock mandrels and 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 term "weight" is often incorrectly used to mean mass, but this practice is deprecated.

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, changes in temperatures, and flow rates.

5.4 Operational parameters

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

a) anticipated loading conditions which might be 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, 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 full life cycle;

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 full lifecycle:

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 which 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 proposed to use another material, the supplier/manufacturer shall provide technical justification (e.g. supporting service history, test lab data, etc.) for the use of the proposed material in the specified environment.

2) It is the equipment user/purchaser's responsibility to select materials suitable for the intended service. 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 H2S 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 H2S 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;

a) landing nipple size, model, type, and material into which the lock mandrel is to be installed;

b) size, type, material, 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 which 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 products 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 Validation grades

The user/purchaser shall specify the minimum design validation grades as shown in Table 1 and Table 2. This specification provides four design validation grades (V3 to V0). The selected design validation grade applies to all applicable validation testing per 6.5.1 through 6.5.5.

The user/purchaser may request validation testing of a flow control device in conjunction with the lock mandrel from the supplier/manufacturer (see 6.5.3 to 6.5.5). Validation grade requirements for HPHT equipment is included in Annex C.

Table 1—Validation grades for lock mandrels

Design validation grade	Description
V0	Gas test at temperature and pressure (above and below) (6.5.5)
V1	Liquid test at temperature and pressure (above and below) (6.5.4)
V2	Liquid test at pressure (above and below) (6.5.3)
V3	Supplier/manufacturer defined (6.5.1)

Table 2—Validation grades for landing nipples

Design validation grade	Description
V2	Liquid test at pressure (above and below) (6.5.2)
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 which 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.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 (see 6.3.2, 6.5.3, and 6.5.4).

6.2.2 Characteristics of landing nipples

The landing nipple, including seals, shall have the capability to support the loading conditions as specified in 5.4 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 (see 6.3.1 and 6.5.1). Additionally, certain landing nipple designs contain control fluid redirection features and shall also perform in accordance with 6.5.2 f).

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, working and operating pressures, 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.

6.3.1.2 Lock mandrel and landing nipple equipment shall be manufactured to drawings and specifications without substantive changes to the equipment that has passed the validation test.

6.3.1.3 The supplier/manufacturer shall establish verified internal yield pressure, collapse pressure and minimum tensile strength, temperature limits, and rated working pressure, excluding end connections. The supplier/manufacturer shall identify the type 1 components of the product and the mode of stress. The supplier/manufacturer shall calculate the stress level in the type 1 component(s) based upon the maximum loads in the design input requirements to determine those components which are critically stressed.

Critically stressed components are those type 1 components which are stressed to 90 % or greater of the minimum design yield strength of the material.

The minimum material condition and minimum material yield strength shall be used in the calculations, which shall include consideration of temperature limit effects and thermal cycles. Metal mechanical properties de-rating shall be verified by a qualified person and in accordance with:

a) industry recognized published data, or

b) data established by the supplier/manufacturer, or

c) data provided by the material subsupplier.

NOTE ASME BPVC Section II, Part D contains temperature derated tensile strengths for many materials.

The design shall take into account the effects of pressure containment and pressure-induced loads. Specialized conditions, such as pressure testing with temporary test plugs, shall also be considered.

6.3.1.4 Component and subassembly identification and interchangeability shall be required within each supplier's/manufacturer's size, type and model, including working pressure rating of lock mandrel and landing nipple equipment. Additive dimensional tolerances of components shall be such that proper operation of the lock mandrel and landing nipple equipment is assured. This requirement applies to supplier/manufacturer-assembled equipment and to replacement components or sub-assemblies.

6.3.2 Materials

6.3.2.1 General

The supplier/manufacturer shall have written specifications for all materials used. If the user/purchaser does not specify materials, the supplier/manufacturer shall select materials suitable for the functional specification. Non-traceable common hardware items such as nuts, bolts, set screws, and spacers can be specified by reference to industry standards or description.

Material substitution, during equipment manufacture, is a temporary change to a BOM for a validated item. Material substitution shall not decrease the performance capabilities of the product and requires approval by a qualified person from the supplier/manufacturer.

The manufacturer's technical justification for each substitution shall be documented and the substituted material shall conform to the design, functional and technical requirements of this specification. In cases where the user/purchaser specifies material(s) of construction, deviations from such material(s) shall also require user/purchaser approval.

6.3.2.2 Metals

6.3.2.2.1 The supplier's/manufacturer's specifications shall define:

a) chemical composition limits;

b) heat treatment conditions;

c) mechanical property limits, as applicable:

1) tensile strength;

2) yield strength;

3) elongation;

4) hardness.

NOTE: The method of manufacture (e.g. Cast, Hot worked, cold worked, etc.) may be important to specify to achieve required physical properties.

6.3.2.2.2 The mechanical properties specified in 6.3.2.2.1 shall be verified by tests conducted on a representative material sample produced from the same heat, size, and heat treat lot of material. Mechanical testing shall be performed per 7.4.2.2.1 after all thermo-mechanical processing, with the exception of stress relief. Mechanical testing is not required after stress relieving provided the stress relief is performed in accordance with the manufacturer's written requirements designed to ensure the material retains sufficient strength to meet design requirements. Material subsequently stress relieved shall be hardness tested after processing to confirm compliance with the hardness requirements of the supplier's/manufacturer's specifications.

6.3.2.2.3 Each welded component shall be stress-relieved in accordance with the supplier's/manufacturer's written specifications and, where applicable, in accordance with the ASME Boiler and Pressure Vessel Code Section IX.

6.3.2.3 Non-metals

The supplier/manufacturer shall have documented procedures, including acceptance criteria, for evaluations or testing of sealing materials or other non-metals, to the limits for which the equipment is rated. Evaluations (or tests) shall verify the material used is suitable for use in the specific configuration, environment and application. These evaluations shall include the combination of: pressure, temperature, and the fluids compatible with the intended application.

Sealing materials previously validated (formerly termed qualified) in accordance with prior editions of this specification including ISO 16070 or the 10th or prior editions of ISO 10432 or API Spec 14A for the range of application shall be considered as meeting the design validation requirements of this specification.

The supplier's/manufacturer's written specifications for non-metallic compounds shall include handling, storage and labelling requirements, including the cure date, batch number, compound identification and shelf life appropriate to each compound and shall define those characteristics critical to the performance of the material, such as:

a) compound type;

b) mechanical properties, as a minimum:

    1) tensile strength (at yield or at break for thermoplastics);

    2) tensile strength (at break for elastomers);

    3) elongation (at break);

    4) tensile modulus (at 50 % or 100 %, as applicable);

c) compression set;

d) durometer hardness.

6.3.3 Performance rating

The supplier/manufacturer shall state the rated working pressure, temperature and axial load rating, as applicable, for the specific equipment. The individual performance capabilities of the lock mandrel and landing nipple equipment shall be provided so that their combined performance capability can be determined.

6.4 Design verification

6.4.1 General

Design verification shall be performed to ensure that each lock mandrel and landing nipple design meets the supplier's/manufacturer's technical specifications. Design verification includes activities such as design reviews, design calculations, physical tests, comparison with similar designs and historical records of defined operating conditions. Verification results shall be approved by a qualified person and records of the results shall become a portion of the design documentation.

6.4.2 Design Assumptions

The supplier/manufacturer shall apply a design margin to each component and/or assembly using a documented methodology and practice. The documented design margins shall be utilized in the creation of component or assembly capabilities and/or ratings.

The supplier/manufacturer shall verify that the product is capable of performing at the supplier/manufacturer stated performance limits. The minimum material condition and minimum material yield strength shall be used in the calculations.

6.4.3 Design Calculations

6.4.3.1 General

Equipment design calculations shall be performed using one of the following methodologies or supplier/manufacturer's defined methods.

6.4.3.2 Design Analysis Methods

6.4.3.2.1 Distortion Energy Theory

The distortion energy theory, also known as the von Mises yield criterion, may be used for the design calculation of pressure-containing components.

NOTE ASME BPVC section VIII, Div 3 KD-131 [b] provides the equations to calculate the equivalent stress.

The equivalent stress shall be calculated and be limited by the supplier's documented design margin methodology and practice.

Stress concentrations and discontinuities are beyond the scope of this methodology.

6.4.3.2.2 Triaxial Yield and Uniform Axial Equations

API TR 5C3 annex A (Discussion of equations for triaxial yield of pipe body) may be used to derive the triaxial yield stress of a cylinder

Tensile (axial) stress calculations may be performed per the requirements of API TR 5C3 Annex A section A.1.2.3 (Uniform axial stress).

6.4.3.2.3 Finite Element Analysis

Finite element analysis (FEA) is a design verification methodology that analyses more complex geometries and/or complex loading where conventional verification methodologies are considered incomplete by the design engineer or qualified person. FEA methodology may be used for single or combined loading situations.

FEA analysis inputs and outputs shall be archived such that the study can be reevaluated / reproduced at a later date.

6.5 Design validation

6.5.1 General

Supplier/manufacturer shall supply products to at least the design validation grade specified in the functional specification.

Products previously validated (formerly termed qualified) in accordance with prior editions of this specification or API 14A, shall be considered as meeting the design validation requirements at their relevant grade of this specification.

To meet the requirements of the validation test grade, the required test described shall be completed in conformance with the acceptance criteria and shall be completed without any repair or redress of the test lock mandrel or landing nipple.

Products validated to higher grades of design validation may be considered validated for lower grades of design validation in accordance with Table 3.

Table 3 - Design validation grade hierarchy

Design validation grade	Grades covered
V0	V3, V2, V1, V0
V1	V3, V2, V1
V2	V3, V2
V3	V3

The lock mandrel shall be installed within an equal or higher rated landing nipple or test device using the same profile/seal bore design, profile/seal bore dimensions, and profile/seal bore clearances as those of the production landing nipple. The lock mandrel shall be installed with the supplier's/manufacturer's specified running tool and procedures.

Sealing devices may be validated separately from the lock mandrel per 6.5.6 provided the acceptance criteria for the applicable lock mandrel validation grade is satisfied.

The product design conforming to this specification shall be manufactured to drawings and specifications that are substantially the same as those of the same size, type, and model of the product that was validated.

The supplier/manufacturer shall document the validation test procedure and results. The applied test pressure(s) shall exceed the rated working pressure(s) as determined by the supplier/manufacturer. The test pressure shall not fall below the rated working pressure during the hold period.

The supplier/manufacturer shall also have the following documents on file:

material specifications;

material test reports and drawings which show all the applicable dimensions;

materials and tolerances of components contained in the validation-tested product.

Pre- and post-test dimensional inspection of critical areas as determined by the supplier/manufacturer shall be documented, evaluated in accordance with the supplier's/manufacturer's specifications and the data maintained. Annex B shows an example of a check sheet for presenting the recorded data.

Validation grade V3 applies to both lock mandrels and landing nipples. The supplier/manufacturer defines the design validation method and acceptance criteria.

6.5.2 Validation testing of landing nipples

6.5.2.1 General

The supplier/manufacturer shall perform testing of each size, type and model of the landing nipple at the rated test pressure.

The test apparatus shall be capable of providing and recording pressures at the rated test pressure of the landing nipple.

6.5.2.2 Validation testing of landing nipple to V2 grade

Perform V2 validation testing to landing nipple(s) per Table 4.

Table 4-Landing Nipple V2 Validation Test

Step	Procedure and acceptance criteria	Data to be recorded
1)	Record test data and perform pre-test inspection as specified.	– validation test number – date
2)	Apply the test pressure at ambient temperature	– test media
3)	Wait for pressure to stabilize and then hold time shall be at least 15 minutes. **Acceptance Criteria:** Pressure variations shall not exceed +/- 1 % of the applied test pressure.	– test pressure – test time – pass / fail
4)	**Step applicable to SVLN only:** Apply test pressure to control / communication capability feature. Test pressure shall be the rated pressure of the control / communication capability feature and in the intended direction. During pressure testing, the control line port(s) shall be monitored for leakage. **Acceptance Criteria:** If any leakage is detected from a control line port, the ported landing nipple fails the test**.**	– test pressure – test time – pass / fail
5)	**Step applicable to landing nipple with control line redirection feature(s) only:** Apply test pressure to control fluid redirection capability feature. Test pressure shall be the rated pressure of the control fluid redirection feature and in the intended direction. Testing shall be performed in each alternative position of the control fluid redirection feature(s). During pressure testing, the control line port(s) shall be monitored for leakage. **Acceptance Criteria:** If any leakage is detected from a control line port, the ported landing nipple fails the test**.**	– test pressure – test time – pass / fail
6)	Bleed applied pressure.	– Test pressure
7)	Perform post-test dimensional inspection as specified.	– Inspection records

6.5.3 Validation testing of lock mandrels

6.5.3.1 General

At the direction of the user/purchaser, the validation testing on lock mandrels may be conducted with a flow control device installed on/in the lock mandrel. If installed, the leakage acceptance criteria for the validation test shall include the flow control device.

NOTE: If a flow control device is installed, the resulting operational capabilities and/or ratings of the lock mandrel may be limited by the flow control device.

The supplier/manufacturer shall perform the validation test of each size, type and model.

6.5.3.2 Validation testing of lock mandrel(s) to V2 grade

Perform V2 validation testing per Table 5.

Table 5-Lock Mandrel V2 Validation Test

Step	Procedure and acceptance criteria	Data to be recorded
1)	Record test data and perform pre-test inspection as specified.	– validation test number – date – inspection records
2)	Install the lock mandrel in an equal or higher rated landing nipple or test device with the supplier's/manufacturer's specified running tool and procedures	– lock mandrel part number – accessory part number – running tool part numbers – test landing nipple part number – installation procedures
3)	Apply the test pressure to lock mandrel from the first direction at ambient temperature.	– test media
4)	Wait for pressure to stabilize and then hold time shall be at least 15 minutes. **Acceptance Criteria:** Pressure variations shall not exceed +/- 1 % of the applied test pressure.	– test pressure – test time – pass / fail
5)	Bleed applied pressure.	– test pressure
6)	Apply the test pressure to lock mandrel from the opposite direction at ambient temperature.	– test media
7)	Wait for pressure to stabilize and then hold time shall be at least 15 minutes. **Acceptance Criteria:** Pressure variations shall not exceed +/- 1 % of the applied test pressure.	– test pressure – test time – pass / fail
8)	Bleed applied pressure.	– test pressure
9)	Retrieve the lock mandrel from the landing nipple or test device using the supplier's/manufacturer's specified pulling tools and procedures.	– pulling tool part numbers – pulling procedures
10)	Perform post-test dimensional inspection as specified.	– Inspection records

6.5.3.3 Validation testing of lock mandrel(s) to V1 grade

Perform V1 validation testing per Table 6.

Table 6-Lock Mandrel V1 Validation Test

Step	Procedure and acceptance criteria	Data to be recorded
1)	Record test data and perform pre-test inspection as specified.	– validation test number – date – inspection records
2)	Install the lock mandrel in an equal or higher rated landing nipple or test device with the supplier's/manufacturer's specified running tool and procedures	– lock mandrel part number – accessory part number – running tool part numbers – test landing nipple part number – installation procedures
3)	Apply the test pressure to lock mandrel from the first direction at the first temperature limit.	– test media
4)	Wait for pressure to stabilize and then hold time shall be at least 15 minutes. **Acceptance Criteria:** Pressure variations shall not exceed +/- 1 % of the applied test pressure.	– test pressure – test temperature – test time – pass / fail
5)	Bleed applied pressure.	– test pressure
6)	Apply the test pressure to lock mandrel from the opposite direction at the first temperature limit.	– test media
7)	Wait for pressure to stabilize and then hold time shall be at least 15 minutes. **Acceptance Criteria:** Pressure variations shall not exceed +/- 1 % of the applied test pressure.	– test pressure – test temperature – test time – pass / fail
8)	Change test temperature from the first temperature limit to the second temperature limit.	– test temperature

9)	Apply the test pressure to lock mandrel from first direction at the second temperature limit.	– test media
10)	Wait for pressure to stabilize and then hold time shall be at least 15 minutes. **Acceptance Criteria:** Pressure variations shall not exceed +/- 1 % of the applied test pressure.	– test pressure – test temperature – test time – pass / fail
11)	Bleed applied pressure.	– test pressure
12)	Apply the test pressure to lock mandrel from the opposite direction at the second temperature limit.	– test media
13)	Wait for pressure to stabilize and then hold time shall be at least 15 minutes. **Acceptance Criteria:** Pressure variations shall not exceed +/- 1 % of the applied test pressure.	– test pressure – test temperature – test time – pass / fail
14)	Bleed applied pressure.	– test pressure
15)	Retrieve the lock mandrel from the landing nipple or test device using the supplier's/manufacturer's specified pulling tools and procedures.	– pulling tool part numbers – pulling procedures
16)	Perform post-test dimensional inspection as specified.	– Inspection records

6.5.3.4 Validation testing of lock mandrels — Grade V0

Lock mandrels previously validated to validation grade V1 using nitrogen as the test media and meeting the acceptance criteria of table 7 meet the requirements of V0 validation grade.

Lock mandrels validated to grade V1 with a sealing device validated separately to grade V0 are considered validated to grade V0.

WARNING – Tests using gas, presents significant safety risks. Adequate precautions should be taken to ensure safety of personnel during testing. The gas volume should be considered by the supplier's/manufacturer's allowable pressure/volume curves for the test facility.

Perform V0 validation testing per Table 7.

Table 7-Lock Mandrel V0 Validation Test

Step	Procedure and acceptance criteria	Data to be recorded
1)	Record test data and perform pre-test inspection as specified.	– validation test number – date – inspection records
2)	Install the lock mandrel in an equal or higher rated landing nipple or test device with the supplier's/manufacturer's specified running tool and procedures	– lock mandrel part number – accessory part number – running tool part numbers – test landing nipple part number – installation procedures
3)	Apply the test pressure to lock mandrel from the first direction at the first temperature limit.	– test media
4)	Wait for pressure to stabilize and then hold time shall be at least 15 minutes. **Acceptance Criteria:** Zero bubbles of gas over the hold period after sufficient time has been allowed for stabilization. Accumulated gas bubbles shall be at atmospheric pressure.	– test pressure – test temperature – test time – pass / fail
5)	Bleed applied pressure.	– test pressure
6)	Apply the test pressure to lock mandrel from the opposite direction at the first temperature limit.	– test media
7)	Wait for pressure to stabilize and then hold time shall be at least 15 minutes. **Acceptance Criteria:** Zero bubbles of gas over the hold period after sufficient time has been allowed for stabilization. Accumulated gas bubbles shall be at atmospheric pressure.	– test pressure – test temperature – test time – pass / fail

8)	Change test temperature from the first temperature limit to the second temperature limit.	– test temperature
9)	Apply the test pressure to lock mandrel from first direction at the second temperature limit.	– test media
10)	Wait for pressure to stabilize and then hold time shall be at least 15 minutes. **Acceptance Criteria:** Zero bubbles of gas over the hold period after sufficient time has been allowed for stabilization. Accumulated gas bubbles shall be at atmospheric pressure.	– test pressure – test temperature – test time – pass / fail
11)	Bleed applied pressure.	– test pressure
1)	Apply the test pressure to lock mandrel from the opposite direction at the second temperature limit.	– test media
2)	Wait for pressure to stabilize and then hold time shall be at least 15 minutes. **Acceptance Criteria:** Zero bubbles of gas over the hold period after sufficient time has been allowed for stabilization. Accumulated gas bubbles shall be at atmospheric pressure.	– test pressure – test temperature – test time – pass / fail
3)	Bleed applied pressure.	– test pressure
4)	Retrieve the lock mandrel from the landing nipple or test device using the supplier's/manufacturer's specified pulling tools and procedures.	– pulling tool part numbers – pulling procedures
5)	Perform post-test dimensional inspection as specified.	– Inspection records

6.5.4 Validation testing of sealing devices

6.5.4.1 General

The supplier/manufacturer shall perform and document validation testing for each size, design, and material. Scaling is allowed per 6.7. A lock mandrel and landing nipple or representative test fixture (including seal bore dimensions and tolerances) may be used for validation testing. Any test fixture shall simulate the conditions that would be present if the lock mandrel or landing nipple were used.

Sealing devices previously validated to validation grade V1 using nitrogen as the test media and meeting the acceptance criteria of table 7 meet the requirements of V0 validation grade.

6.5.4.2 Sealing devices shall be tested with water, gas, or other appropriate liquid to the rated limits of the lock mandrel to which it is to be affixed (subjected to rated limits of pressure at temperature in the direction(s)

of intended use). The mass density of the test fluid shall be less than 1100 kg/m3 (68.67 lbm/ft3) and shall be visibly free from particulate matter or other material that could plug a small leak. Acceptance criteria shall be in accordance with 6.5).

6.5.4.3 A sealing device which has successfully passed validation testing is qualified for use on multiple products of similar dimensional requirements within the temperature and pressure differentials tested in accordance to the limits specified in section 6.7.2.

6.5.4.4 Verified and documented tests results or field performance data that met the rated limits prior to the publication of this specification, shall be considered as meeting the design validation requirements of this specification.

6.5.5 Special feature and operating technology validation

The supplier/manufacturer shall identify those special features or operating technologies that shall be included in the validation testing. Special features shall be validated by test or other appropriate means to their rated limits. The supplier/manufacturer shall identify, in design documentation, all special features included in the product design that are not validated by design validation testing in accordance with this specification.

The supplier's/manufacturer's design validation documentation shall include the design requirements, test procedures including acceptance criteria and test results of special features.

6.5.6 Validation Test Report

A final report of the testing shall be prepared and approved by qualified personnel and shall be retained as part of the design documentation for the product. The report shall include the following information as a minimum:

— Identification of product manufacturer;

— date and unique identification of the validation test report;

— identification of the validation test procedures used;

— equipment type, description, and an assembly drawing;

— running / pulling tools and accessory equipment;

— model designation or other unique product identification by manufacturer;

— product number (if applicable) and bill of materials identifying the components materials and traceability records;

— results of specific evaluations and tests such as; visual inspections, pre-test and post-test dimensional inspection of critical operational areas, and validation test reports.

6.6 Design changes

All design changes shall be documented and reviewed against the design verification and design validation to determine if the change is a substantive design change. A design that undergoes a substantive change becomes a new design requiring design verification as specified in 6.4 and design validation as specified in 6.5. Design changes identified as non-substantive shall include documented justification.

The supplier/manufacturer shall, as a minimum, consider the following:

- stress levels of the modified or changed components;
- material changes;
- functional changes.

Changes to a component or series of components may be identified as a substantive change and require design validation. This may be done by testing only the component or series of components, rather than the entire assembly. The test shall adequately simulate the loading conditions that would be present if the entire assembly were tested. The supplier/manufacturer shall document the detailed test results and analysis that demonstrate that the component test adequately simulates the required loading conditions. Evaluation results shall be approved by a qualified person other than the person performing them and records of the results shall become a portion of the design documentation.

6.7 Scaling limits

6.7.1 Lock mandrels and landing nipples, exclusive of sealing devices, of the same model, type, and design are considered to be validated if the following conditions are met:

a) The allowable variation in size shall be within ± 5 % of the nominal seal bore diameter of the validated design.

a) The supplier/manufacturer shall identify the type 1 components of the scaled product and the mode of stress in accordance with 6.3.1.3.

b) Stress levels of the scaled product supplier/manufacturer identified type 1 components, stated as a percentage of material yield, shall not exceed those of the validated design at the same conditions.

c) The loading mode and stress calculation(s) method shall be identical for the scaled product and the validated product.

6.7.2 Sealing devices of the same type, design, and material are considered to be design-validated when the allowable variation in size is within the range of ± 5 % of the nominal seal bore diameter of a validation-tested design.

6.8 Design documentation

Design verification and validation documents shall include:

a) functional and technical specifications;

b) required grade of quality documentation and design validation as specified in 5.7 and 5.8, respectively;

c) one complete set of drawings, written specifications and standards;

d) instructions providing methods for the safe assembly and disassembly of the lock mandrel and/or landing nipple and stating the operations which are permitted and preclude failure and/or non-compliance with the functional and performance requirements;

e) material type, yield strength and connection identification for the actual end connection(s) provided with the lock mandrel and landing nipple;

f) operations manual and product data sheet.

All documentation and data associated with design verification (see 6.4), design validation (see 6.5), design change justification (see 6.6), and the design file, shall be maintained for 10 years after date of last manufacture.

7 Supplier/manufacturer requirements

7.1 Documentation and data control

The supplier/manufacturer shall establish and maintain documented procedures to control all documents and data that relate to the requirements of this specification. These documents and data shall be legible and maintained to demonstrate conformance to specified requirements. All documents and data shall be retained in

facilities that provide an environment which prevents damage, deterioration, or loss. They shall be available upon request. Documents and data may be in the form of any type of media, such as hard copy or electronic media. All documents and data shall be available and auditable by the user/purchaser.

Quality documentation includes all documents and data necessary to demonstrate conformance. Quality documentation shall be retained by the supplier/manufacturer for a minimum of five years from date of manufacture or repair.

The organization shall validate those processes identified by the applicable product specification as requiring validation. If these processes are not identified, or there is no product specification involved, the processes requiring validation shall include, as a minimum, nondestructive examination, welding, and heat treating, if applicable to the product.

7.2 User/purchaser documentation

7.2.1 Product data sheets

Product data sheets shall be available and shall contain the following information, where applicable:

a) name and address of supplier/manufacturer;

b) supplier/manufacturer assembly number;

c) supplier/manufacturer product name;

d) product type or model;

e) product characteristic;

f) metallic materials;

g) non-metallic materials;

h) drift diameters;

i) overall length;

j) maximum outside diameter (OD);

k) minimum inside diameter (ID)

l) temperature range;

m) rated working pressure (internal) and minimum yield strength for landing nipple, as applicable;

n) rated working pressure for lock mandrel (from above and/or below when used with lock profile at a given minimum yield strength, as applicable)

o) top connection(s);

p) bottom connection(s);

q) conveyance method;

r) maximum conveyance OD of running equipment;

s) retrieval method (if retrievable);

t) design validation grade;

u) axial load rating.

7.2.2 Technical/operations manual

A technical/operations manual shall be available for the products supplied.

The technical/operations manual shall contain the following information:

a) manual reference number;

b) bill of material;

c) technical specification;

d) operational procedures;

e) pre-installation inspection procedures;

f) storage recommendations;

g) representative drawing identifying major dimensions (OD, ID, lengths);

h) special precautions and handling requirements;

i) assembly and disassembly instructions.

7.3 Product identification

Each product shall be permanently identified according to the supplier's/manufacturer's written specifications. Identification shall include:

a) the supplier's/manufacturer's name or trademark;

b) the part and/or assembly number;

c) the size, type and model;

d) a unique identifying serial number;

e) the rated working pressure (internal or from above and/or below, as applicable);

f) date of manufacture;

g) design validation grade.

7.4 Quality control

7.4.1 General

This section provides minimum quality control requirements to meet this specification. All quality control work shall be controlled by documented instructions that include acceptance criteria. A certificate of conformance shall be supplied with the equipment that the product meets the requirements of this international standard.

7.4.2 Raw material

7.4.2.1 Certification of quality control testing

Raw material used in the manufacture of components shall require the following:

a) a certificate of conformance stating that the raw material meets the supplier's/manufacturer's documented specifications;

b) a material test report shall be supplied in accordance with the supplier/manufacturer requirements to allow that the supplier/manufacturer can verify that the raw material meets their documented specifications.

7.4.2.2 Mechanical and physical properties

7.4.2.2.1 Metallic materials

For metallic materials, the following mechanical property test methods shall be used (6.3.2.2.1).

a) Mechanical testing shall be in accordance with one or more of the following specifications: ASTM A370, ASTM E8, or ISO 6892.

b) Hardness testing shall be in accordance with ASTM E10 or E18 ISO 6506 or ISO 6508. Alternatively, ASTM E384 or ISO 6507 shall be used when required under ANSI NACE MR0175 ISO 15156, and may be used if ISO 6506 or ISO 6508 cannot be applied due to size, accessibility, or other limitations.

c) Hardness conversion to other measurement units shall be in accordance with ASTM E 140, with the exceptions noted in ANSI NACE MR0175 ISO 15156 for materials which are intended for use in wells where corrosive agents can possibly be expected to cause environmental cracking.

7.4.2.2.2 Non-metals

Non-metals shall be tested to determine their mechanical properties as follows:

1) Elastomers

Tensile strength (at either break or yield as applicable)	ASTM D1414 or D412
Tensile modulus	ASTM D1414 or D412
Elongation	ASTM D1414 or D412
Compression set	ASTM D1414 or D395
Durometer hardness	ASTM D1415 or D2240

2) Thermoplastics

Yield strength (at break)	ASTM D638
Tensile strength (at break)	ASTM D638, ASTM D1708
Elongation (at yield)	ASTM D638
Elongation (at break)	ASTM D638, ASTM D1708
Modulus of elasticity	ASTM D638

7.4.3 Components undergoing additional processes

7.4.3.1 Certification

Components undergoing additional processes, such as heat treatment, welding or coatings shall require the following, as applicable:

a) a certificate of conformance stating that the materials and processes meet the supplier's/manufacturer's documented specifications;

b) a material test report so that the supplier/manufacturer can verify that the materials and processes meet the supplier's/manufacturer's documented specifications.

7.4.3.2 Coatings and Platings

Application of coatings and plating shall be controlled using documented procedures and instructions which include acceptance criteria.

7.4.3.3 Welding, Weld Overlay and brazing

Welding, including overlays and brazing, shall require the following:

a) welding, weld overlay, and brazing procedure and personnel qualification shall be in accordance with ASME Boiler and Pressure Vessel Code, Section IX;

b) material and practices not listed in the ASME Boiler and Pressure Vessel Code Section IX shall be applied using weld procedures qualified in accordance with the methods of ASME Boiler and Pressure Vessel Code, Section IX.

c) Welding for sour service shall meet the requirements of ANSI/NACE MR0175/ISO 15156.

7.4.3.4 Qualification of heat-treating equipment

7.4.3.4.1 Furnace calibration

When performed by the supplier/manufacturer, furnaces for heat treatment of production parts shall require the following.

a) Heat treatment of production parts shall be performed with heat-treating equipment that has been calibrated and surveyed.

b) Each furnace shall be surveyed within one year prior to heat-treating operations. When a furnace is repaired or rebuilt, a new survey shall be required before heat treatment.

c) Batch type and continuous type heat-treating furnaces shall be calibrated in accordance with one of the following procedures:

1) procedures specified in AMS 2750 or API 6A, or

2) supplier's/manufacturer's written specifications, including acceptance criteria which are not less stringent than the procedures identified above.

7.4.3.4.2 Furnace instrumentation

When performed by the supplier/manufacturer, the requirements for furnace instrumentation shall be as follows:

a) automatic controlling and recording instruments shall be used;

b) thermocouples shall be located in the furnace working zone(s) and protected from furnace atmospheres;

c) controlling and recording instruments used for the heat treatment processes shall possess an accuracy of ± 1 % of their full-scale range;

d) temperature controlling and recording instruments shall be calibrated at least once every three months until a documented calibration history can be established; calibration intervals shall then be established based on repeatability, degree of usage and documented calibration history;

e) equipment used to calibrate the production equipment shall possess an accuracy of ± 0.25 % of full-scale range.

7.4.4 Traceability

7.4.4.1 All components, weldments, subassemblies and assemblies of lock mandrel and landing nipple equipment shall be traceable except: common hardware items such as nuts, bolts, set screws and spacers.

7.4.4.2 Traceability shall be in accordance with the supplier's/manufacturer's documented procedures. All assemblies, components (including seals), weldments and subassemblies of equipment supplied shall be traceable to a job lot and a material test report. Components and weldments shall also have their included heat(s) or batch lot(s) identified. All components and weldments in a multi-heat or multi-batch lot shall be rejected if any heat or batch does not comply with the supplier's/manufacturer's specified requirements.

7.4.4.3 Traceability for lock mandrel and landing nipple equipment is considered sufficient if the equipment meets the requirements of this specification when it leaves the supplier's/manufacturer's inventory.

7.4.5 Measuring/testing equipment calibration

Inspection, measuring and testing equipment used by the supplier/manufacturer for acceptance shall be used only within its calibrated range and shall be identified, controlled, calibrated and adjusted at specific intervals in accordance with written procedures that are based on manufacturer's standards, or internationally recognized standards such as ISO / IEC 17025 or ANSI / NCSL Z540-3.

Technologies for inspections with verifiable accuracies equal to or better than those listed in this standard may be applied with appropriate documentation and when approved by a qualified person(s).

Calibration intervals for measuring and test equipment shall be established based on repeatability, amount of usage, environment and past history for that type of instrument. For standard, adjustable, hand measurement tools the initial calibration interval shall be three months until a recorded calibration history for that instrument can be established. Intervals may then be lengthened or shortened. The calibration interval cannot be increased by more than twice the previous interval and shall not exceed more than one year.

Non-standard, or non-adjustable measurement devices such as surface plates, threaded plug/ring gauges, coordinate measuring machines, optical comparators, etc. shall be calibrated initially and the calibration interval set based on equipment type, usage, and operating environment. Calibration intervals shall not exceed three years for this type of equipment.

Calibration standards used to calibrate measuring equipment shall be checked and approved at least once every three years by a qualified person using qualified equipment with traceability to the applicable national or international standards agency.

Instruments and calibration standards that have not been used during the calibration interval and that have been maintained in accordance with proper practice may have their calibration cycle extended for an amount equal to the designated cycle.

Pressure measuring devices shall be:

a) readable to at least ±0.5 % of full-scale range;
b) calibrated to maintain ± 2% accuracy of full-scale range;
c) used within the calibrated range; and
d) calibrated with a master pressure measuring device or a dead weight tester.

Calibration intervals for pressure measuring devices shall be a maximum of three months until documented calibration history can be established. Calibration intervals shall then be established based on repeatability, degree of usage, environment, and documented history.

7.4.6 NDE requirements

7.4.6.1 General

The NDE requirements shall be in accordance with the following.

a) All NDE instructions shall be approved by a Level III examiner qualified in accordance with ISO 9712 and per the supplier/manufacturer's written requirements.

NOTE For the purposes of these provisions, ASNT SNT-TC-1A is equivalent to ISO 9712.

b) All landing nipples and all critically stressed type 1 components shall be magnetic-particle inspected per 7.4.6.2.2 or liquid-penetrant inspected per 7.4.6.2.1 for surface defects.

c) All pressure-containing welds shall be magnetic-particle inspected per 7.4.6.2.2 or liquid-penetrant inspected per 7.4.6.2.1 for surface defects and shall be volumetrically inspected by radiographic per 7.4.6.2.6 or ultrasonic per 7.4.6.2.3 techniques.

d) All pressure-containing casting and forging components shall be magnetic-particle inspected per 7.4.6.2.2 or liquid-penetrant inspected per 7.4.6.2.1 for surface defects and shall be volumetrically inspected by radiographic per 7.4.6.2.7 to 7.4.6.2.8 or ultrasonic techniques per 7.4.6.2.4 to 7.4.6.2.5.

7.4.6.2 Methods and acceptance criteria

7.4.6.2.1 Liquid penetrant

Liquid-penetrant inspection shall be performed as follows:

a) method: in accordance with ASTM E165;

b) acceptance criteria: in accordance with ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, Appendix 8.

7.4.6.2.2 Wet magnetic particle examination

Wet magnetic particle examination shall be performed as follows:

a) method: in accordance with ISO 13665 or ASTM E709;

b) indications shall be described as one of the following:

1) relevant indication: only those indications with major dimensions greater than 1.6 mm (1/16 in.) shall be considered relevant whereas inherent indications not associated with a surface rupture (i.e., magnetic permeability variations, non-metallic stringers etc.) shall be considered non-relevant;

2) linear indication: any indication whose length is equal to or greater than three times its width;

3) rounded indication: any indication which is circular or elliptical and whose length is less than three times its width;

e) acceptance criteria:

1) any relevant indication greater than or equal to 4.8 mm (3/16 in.) is unacceptable;

2) no relevant linear indication is allowed for weldments;

3) no more than ten relevant indications in any 39 cm^2 (6 in^2) area are permitted;

4) four or more rounded relevant indications in a line separated by less than 1.6 mm (1/16 in.) are unacceptable.

7.4.6.2.3 Ultrasonic inspection of weldments

Ultrasonic inspection of weldments shall be performed as follows:

a) method: in accordance with ASME Boiler and Pressure Vessel Code, Section V, Article 5;

b) acceptance criteria: in accordance with ASME Boiler and Pressure Code, Section VIII, Division 1, Appendix 12.

7.4.6.2.4 Ultrasonic inspection of castings

Ultrasonic inspection of castings shall be performed as follows:

a) method: in accordance with ASTM E428 and ASTM A609;

b) acceptance criteria: in accordance with ASTM A609 at an ultrasonic testing quality level 1, as a minimum.

7.4.6.2.5 Ultrasonic inspection of forgings and wrought products

Ultrasonic inspection of forgings and wrought products shall be performed as follows:

a) method: in accordance with ASTM E428 and ASTM A388;

b) calibration as applicable:

1) back reflection technique: the instrument shall be set so that the first back reflection is 75 % ± 5 % of screen height when the transducer is placed on an indication-free area of the forging or wrought product;

2) flat bottom hole technique: distance amplitude curve shall be based on 3.2 mm (1/8 in.) flat bottom hole through 101.6 mm (4 in.) of metal and 6.4 mm (1/4 in.) flat bottom hole for metal distances exceeding 101.6 mm (4 in.);

3) angle beam technique: distance amplitude curve (DAC) shall be based on a notch of a depth equal to the lesser of 9.5 mm (3/8 in.) or 3 % of the normal section thickness [9.5 mm (3/8 in.) maximum], a length of approximately 25.4 mm (1 in.) and a width no greater than twice its depth;

c) acceptance criteria: the following forging or wrought product defects shall be basis for rejection:

1) back reflection technique: indications greater than 50% of the referenced back reflection.

2) a complete loss of back reflection, that cannot be attributed to geometry

3) flat bottom hole technique: indications equal to or larger than the indications observed from the calibration flat bottom hole or a complete loss of back reflection, that cannot be attributed to geometry;

4) angle beam technique: amplitude of the discontinuities exceeding those of the reference notch.

7.4.6.2.6 Radiographic inspection of weldments

Radiographic inspection of weldments shall be performed as follows:

a) method: in accordance with ASTM E94;

b) acceptance criteria: in accordance with ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, UW-51.

7.4.6.2.7 Radiographic inspection of castings

Radiographic inspection of castings shall be performed as follows:

a) method: in accordance with ASTM E94;

b) acceptance criteria, depending on thickness:

1) in accordance with ASTM E186;

2) in accordance with ASTM E280;

3) in accordance with ASTM E446.

The maximum defect classification for 1), 2) and 3) is given in Table 8.

Table 8 — Maximum severity level for defects in castings

Defect type	Maximum severity level
A	3
B	2
C	2 (all types)
D	None acceptable
E	None acceptable
F	None acceptable
G	None acceptable
NOTE The defect categories, types, and severity levels are defined in ASTM E186, ASTM E280, and ASTM E446, as applicable.	

7.4.6.2.8 Radiographic inspection of forgings

Radiographic inspection of forgings shall be performed as follows:

a) method: in accordance with ASTM E94;

b) acceptance criteria of which any of the following defects shall be basis for rejection:

– any type of crack or lap;

– any other elongated indication with length, L, and wall thickness, t, as follows:

1) $L >$ 6.4 mm (1/4 in.) for $t \leq$ 19 mm (3/4 in.)

2) $L > 1/3t$ for 19 mm $< t \leq$ 57.2 mm (3/4 in. $< t \leq$ 2 1/4 in.)

3) $L >$ 19 mm (3/4 in.) for $t >$ 57.2 mm (2 1/4 in.)

4) any group of indications in a line that have an aggregate length greater than t in a length of $12t$.

7.4.7 Personnel qualifications

7.4.7.1 Personnel performing NDE evaluations and interpretations for methods other than leak testing and visual inspection, shall be qualified in accordance with ISO 9712 to at least Level II, or equivalent. Personnel performing visual inspection or leak testing shall be qualified in accordance with the supplier/manufacturer's documented requirements.

NOTE For the purposes of these provisions, ASNT SNT-TC-1A is equivalent to ISO 9712.

7.4.7.2 Personnel performing NDE, visual or leak test examinations shall have an annual eye examination, as applicable to the discipline to be performed in accordance with ISO 9712.

NOTE For the purposes of these provisions, ASNT SNT-TC-1A is equivalent to ISO 9712.

7.4.7.3 All other personnel performing inspection for acceptance shall be qualified in accordance with the supplier/manufacturer's documented requirements.

7.4.8 Component dimensional inspection

All components shall be dimensionally inspected to assure proper function and compliance with design criteria and specifications. Inspection shall be performed during or after the manufacture of the components but prior to assembly, unless assembly is required for proper measurement. The supplier/manufacturer may develop a sampling plan that meets the requirements of an international or national standard such as ISO 2859-1 (AQL) or ANSI/ASQ Z1.4.

7.4.9 Surface inspection(s)

The supplier/manufacturer shall inspect all accessible surfaces for defects and damage before assembly (as applicable) of the lock mandrel and/or landing nipple and have documented procedures including acceptance criteria.

7.4.10 Non-metals inspection

7.4.10.1 Sampling procedures and the basis for acceptance or rejection of a batch lot shall be in accordance with ISO 2859-1, general inspection level II at a 2.5 AQL for O-rings and a 1.5 AQL for other sealing elements until a documented variation history can be established. Sampling procedures shall then be established based on the documented variation history.

7.4.10.2 Visual inspection of O-rings shall be in accordance with ISO 3601-3. Other sealing elements shall be visually inspected in accordance with the supplier's/manufacturer's documented specifications.

7.4.10.3 Dimensional tolerances of O-rings shall be in accordance with ISO 3601-1. Other sealing elements shall meet dimensional tolerances of the supplier's/manufacturer's written specifications.

NOTE For the purposes of this provision, SAE AS568 is equivalent to ISO 3601-1.

7.4.10.4 The durometer hardness of O-rings or other elastomeric sealing elements shall be determined in accordance with 7.4.2.2.2. A test specimen manufactured from each batch may be used.

7.4.11 Thread inspection

7.4.11.1 All API tapered thread tolerances, inspection requirements, gauging, gauging practice, gauge calibration and gauge certification shall be in accordance with API Spec 5B.

7.4.11.2 All other thread tolerances, inspection requirements, gauging, gauging practice, gauge calibration and gauge certification shall conform to the specified thread supplier's/manufacturer's written specifications.

7.4.12 Manufacturing non-conformance

The supplier/manufacturer shall establish and maintain documented procedures to ensure that an assembly or component that does not conform to specified requirements is prevented from unintended use or installation. This control shall provide for identification, documentation, evaluation, segregation (when applicable), and disposition of non-conforming assemblies or components.

The responsibility for review and authority for the disposition of non-conforming assemblies or components shall be defined by the supplier/manufacturer. Non-conforming assemblies or components may be:

- reworked to meet the specified requirements;
- accepted with or without repair by concession; or
- rejected or scrapped.

Repaired and/or reworked assemblies or components shall be inspected in accordance with documented specifications of the supplier/manufacturer which are no less stringent than those used for new products.

7.5 Assembly verification

7.5.1 Lock mandrel

Functional testing of lock mandrels shall be performed as follows.

Each lock mandrel shall be installed in, and retrieved from, a landing nipple or test device whose critical dimensions are representative of the actual landing nipple. This functional test may be performed with or without the sealing device. If the lock mandrel fails to set or retrieve properly, it fails the functional test.

The supplier/manufacturer shall document the functional test procedure and results.

7.5.2 Landing nipple

Verification of landing nipples shall be performed as follows:

a) Each landing nipple shall be 100% dimensionally inspected in accordance with the supplier's/manufacturer's technical specification.

b) Each landing nipple that contains a control-fluid redirection feature shall be functionally tested in accordance with the landing nipple operating manual. As a minimum, this shall include a body integrity pressure test at the rated working pressure of the landing nipple. Any leaks shall mean that the landing nipple fails the test.

c) The supplier/manufacturer shall document the functional test procedure and results.

8 Repair

Repair activities for lock mandrels and landing nipples shall restore the product to a condition meeting all requirements stated in this specification or the edition of this specification in effect at the time of original manufacture.

Annex A
(Informative)

API Monogram Annex

To be populated prior to publication

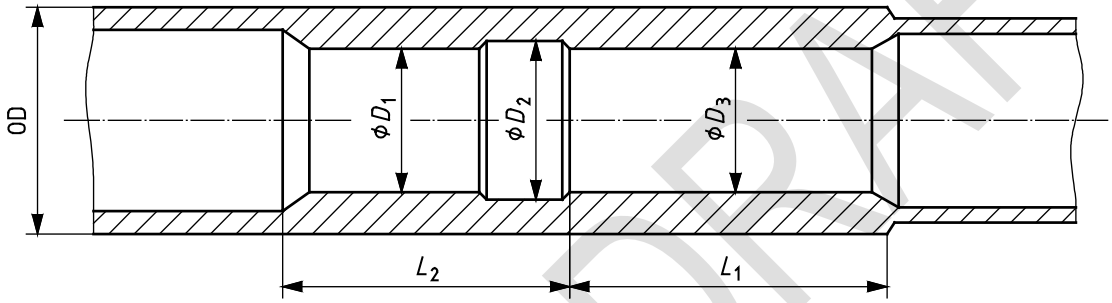
Annex B
(informative)

Example of landing nipple validation test dimensional check sheet

Work order No: _____

Serial No: _____ Test procedure:

_____



	Dimensions					
	OD	D_1	D_2	D_3	L_1	l_2
Nominal values						
Pre-test values						
Post-test values						

Comments:

Inspected by: _____ Engineer:

_____

Date: _____ Date:

_____

Annex C

(informative)

Requirements for Equipment in HPHT Environments

C.1 General

This annex may be specified for lock mandrel and landing nipple equipment for use in HPHT environments with a pressure rating greater than 103.4 MPa (15,000 psi) or with a temperature rating greater than 177 °C (350 °F). The requirements specified in this annex are in addition to Sections 1 through 8 of this specification. This annex was developed considering the guidelines of API TR 1PER15K-1.

This annex may be specified by the user/purchaser for non-HPHT equipment. Activities required by this annex shall be performed by a qualified person(s). All results shall conform to the acceptance criteria and be supported by approved documentation.

Design validation of landing nipples and lock mandrels for use in HPHT environments contains the following validation grades.

Lock Mandrels:
— V0-H: gas test per C.3.7 (Table C.3)
— V1-H: liquid test per C.3.6 (Table C.3)

Landing Nipples:
— V2-H: verification analysis per C.3

C.2 Technical Specification

C.2.1 General

The supplier/manufacturer shall provide a technical specification to the user/purchaser that conforms to the requirements defined in this annex and the requirements of the functional specification.

The user/purchaser should review the technical specification provided by the supplier/manufacturer and confirm that the proposed design meets the requirements of the functional specification.

C.2.2 Design requirements

C.2.2.1 General

Equipment manufactured according to this annex shall be designed and developed in conformance with API Specification Q1.

C.2.2.2 Metals

C.2.2.2.1 General

The supplier/manufacturer shall conform to the materials requirements defined in the technical specification and the following requirements.

These requirements apply for all type 1 components.

NOTE: Section 6.3.1 addresses requirements for critically stressed components. Critically stressed components are a subset of type 1 components for products supplied in accordance with this annex.

The supplier's/manufacturer's documentation shall define mechanical properties as applicable to the functional requirements of the equipment:

a) elongation;

b) Charpy impact toughness (ASTM E23);

c) yield strength (ASTM A370);

d) tensile strength (ASTM A370).

C.2.2.2.2 Temperature Effects

The supplier/manufacturer shall utilize temperature de-rated yield strength for type 1 components for each material corresponding to the maximum rated temperature. The temperature de-rated yield strength testing shall be determined from a documented procedure. Elevated temperature testing shall be conducted in accordance with ASTM E21 for yield strength. Metal mechanical properties de-rating shall be verified and documented. The test material samples shall be taken from heat(s) representative of those to be used for the intended components and shall be removed from midwall or midradius unless the equipment supplier/manufacturer determines that a more appropriate testing location is required. Alternate testing locations may be selected due to a component's highest stress location or, for cold worked material, lowest strength location due to material anisotropy.

Temperature effects for modulus of elasticity, and other relevant properties, should be considered.

C.2.2.2.3 Environmental Effects

For sour environments, the materials selected shall be in conformance with the requirements of ANSI/NACE MR0175/ISO 15156.

C.2.2.2.4 Castings

Castings shall not be used for type 1 components.

All castings shall conform to the requirements of API specification 20A, CSL3.

C.2.2.2.5 Surface Hardening

Where a surface hardening process is utilized, a coupon for each heat of material within the batch being heat treated is required. The coupon shall be evaluated to ensure the process conforms to the written specification and required acceptance criteria.

NOTE: The coupon can be a sacrificial part.

C.2.2.3 Non-metals

C.2.2.3.1 Compound Selection

The supplier/manufacturer shall have a documented procedure that provides for the selection of non-metallic material and compounds that conform to the supplier's/manufacturer's equipment specification. The documented procedure shall consider:

a) functional requirements;

b) technical specifications;

c) operational parameters;

d) environmental conditions;

e) supply chain limitations and compound availability;

f) material type and compound use history;

g) geometric component design;

h) required service life;

i) required approvals for material and compound;

j) required documentation for material and compound; and

k) chemical resistance to known well fluids.

The material type and specific compound shall be selected in accordance with the supplier's /manufacturer's procedures and the requirements of the functional specification. Records of material type and compound selection shall be part of the design documentation.

C.2.2.3.2 Elastomeric Compound Assessment

The supplier/manufacturer shall conduct compound assessment testing per documented procedures containing and/or referencing acceptance criteria. These assessments shall include (but may not be limited to) ageing testing, and compression set testing on elastomeric materials.

a) Ageing testing shall be conducted on an elastomeric compound per ISO 23936-2 clause 7.2 or the supplier's /manufacturer's documented procedure. The service temperature shall be equal or lower than the maximum rated operating temperature of the equipment.

b) Compression set testing shall be conducted on an elastomeric compound per ASTM D395 or ASTM D1414 when critical to equipment performance. This evaluation shall determine the retained elastic properties after prolonged action of compressive stresses.

c) When required by the functional specification, rapid gas decompression (RGD) testing shall be conducted by the supplier/manufacturer on an elastomeric material per ISO 23936-2, Annex B with an

acceptance criteria of 0 or 1 for the component cross section. Unless agreed otherwise between the supplier/manufacturer and the user/purchaser, testing parameters shall be

i. fluid composition;

ii. test temperature: 100 °C (±2 °C) [212 °F (±5 °F)];

iii. test pressure: 15 MPa (+1, −0.5 Mpa) [2176 psi (+145 psi, −73 psi)];

iv. depressurization rate: 2 Mpa/min (±0.2 Mpa/min) [290 psi/min (±29 psi/min)].

NOTE Ageing testing may require agreement between the user/purchaser and the supplier/manufacturer for test fluid(s), test temperatures, test pressures, test times, specimen shape, and trapped gas.

C.2.2.4 Material Specifications

The supplier/manufacturer shall establish requirements and acceptance criteria for all elastomers and thermoplastic materials. The specification shall state if the parameters are to be measured on the actual components.

For elastomeric materials, the supplier's/manufacturer's specification shall include requirements and acceptance criteria for the following parameters determined per the applicable specification listed in Table C.1 or equivalent.

Table C.1—Parameters for Elastomeric Materials

Parameter	Specification as Applicable
Tensile strength	ASTM D1414, ASTM D412
Tensile modulus	ASTM D1414, ASTM D412
Elongation	ASTM D1414, ASTM D412
Compression set	ASTM D395, ASTM D1414
Density	ASTM D297
Hardness	ASTM D2240, ASTM D1415

For thermoplastic materials, the supplier's/manufacturer's specification shall include requirements and acceptance criteria for the following parameters, as applicable, determined per the specification listed in Table C.2 or equivalent. The specification shall state if the parameters are measured on an actual component.

Table C.2—Parameters for Thermoplastic Materials

Parameter	Specification as Applicable
Tensile strength (at either break or yield as applicable)	ASTM D638 or D1708
Elongation (at either break or yield as applicable)	ASTM D638 or D1708
Modulus of elasticity	ASTM D638
Flexural modulus	ASTM D790
Creep failure	ASTM D2990

C.2.2.5 Bond Strength Validations

For designs requiring that the elastomer be bonded to a substrate, the adhesive bonding process shall be defined and validated with a bond test. The process validation criteria shall include controls for the elastomer, substrate, adhesives, and any required environmental controls. The bond test shall conform to the requirements of ASTM D429 or an equivalent testing program including surface preparation requirements, with evaluated and documented acceptance criteria.

C.2.2.6 Other Materials

Materials and components that are not manufactured or supplied under the previously specified controls for metals or non-metals materials shall have documented design requirements controlled by the supplier/manufacturer and shall also have the necessary applied controls on material to ensure performance to the documented requirements. All components/materials used in tested or delivered equipment, except common hardware that do not affect DAC [per API Q1], (such as; nuts, bolts, set screws and spacers), shall be verified as conforming to documented requirements. Each of the properties specified shall have a traceable and supplier/manufacturer approved test report or COC from the component manufacturer for that batch and/or compound of material.

The design validation of other materials and components shall conform to the technical specification.

C.3 Design Verification Requirements

C.3.1 General

Design verification shall be performed with the following additional requirements:

a) The designs shall be analyzed to determine the supplier's /manufacturer's stated performance limits, including the supplier/manufacturer defined rated test pressure. The minimum material condition and minimum material yield strength including the applicable temperature de-rating, shall be used in the calculations.

b) The supplier/manufacturer shall apply a design margin to each component and/or assembly using a documented methodology and practice. The documented design margins shall be utilized in the creation of component or assembly capabilities and/or ratings.

c) The performance limits of the product shall be determined on an individual component basis at the maximum rated temperature. The design shall consider all operational loading conditions defined in the functional requirements and by the technical specifications. A stress analysis methodology that considers the applied loads and combined stresses shall be used to determine the maximum state of stress of each component of the assembly other than that of common hardware.

d) If corrosion or corrosion/erosion allowances are included in the design, the design verification shall consider these allowances.

e) Special features, which are components or sub-assemblies that provide additional functional capability not validated in defined tests, shall be identified and verified through documented procedures and acceptance criteria.

C.3.2 Risk Analysis

The supplier/manufacturer shall conduct an FMEA, fault-tree analysis, or other assessment method to determine if verification/validation per this annex sufficiently validates the design for the intended application.

Assessment methods shall conform to the requirements of a national or international standard or to the supplier/manufacturers documented procedures. The assessment report shall be approved by a qualified person and shall become part of the design documentation.

NOTE: API TR 1PER15K-1 provides guidance and recommended procedures for conducting a FMEA.

C.3.3 Design Analysis

Finite Element Analysis (FEA) shall be performed on type 1 metallic components as shown in Figure C.1.

The FEA shall include the maximum operating load cases at the maximum rated temperature to evaluate for plastic collapse, local failure and buckling using ASME BPVC Section VIII, Division 2, Part 5 or ASME BPVC Section VIII Division 3, article KD-2. The load factors defined by ASME BPVC Section VIII, Division 3 or ASME BPVC Section VIII, Division 2 can be substituted with values as defined by supplier/manufacturer. The design margins defined by the supplier/manufacturer shall be met.

NOTE: a load factor is a value without units multiplied against the design load parameter used in ASME BPVC analyses. The load factor is not the same as a stress factor.

When FEA has identified plastic strain in excess of 0.2 %, a ratcheting analysis shall be performed per ASME BPVC Section VIII, Division 3, KD-234 or ASME BPVC Section VIII, Division 2 clause 5.5.7. The material performance data shall be obtained via testing per C.3.2.2.2.

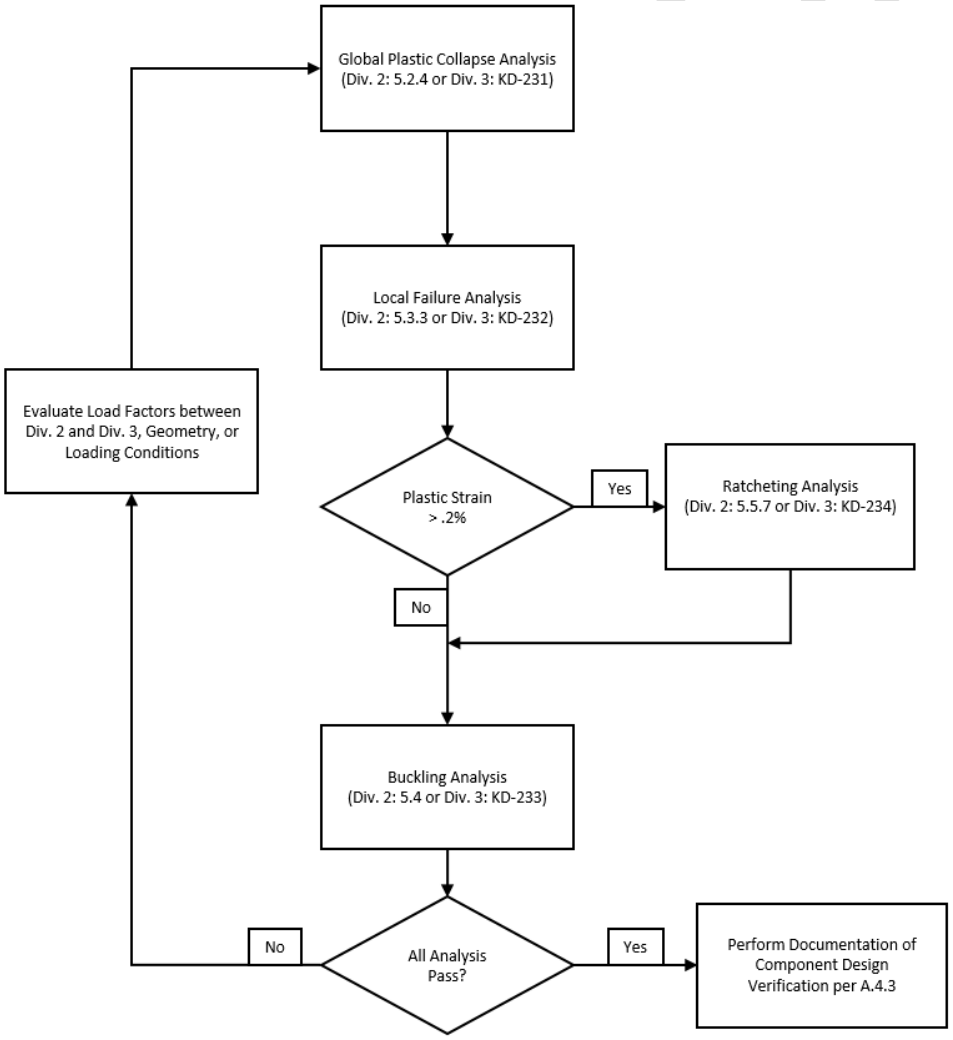


Figure C.1—HPHT Design Flow Chart

The functional specification should consider cyclic loading and its effect on the applicable equipment.

When cyclic loading is identified in the functional specification, a fatigue screening shall be performed per ASME BPVC Section VIII, Division 2, Paragraph 5.5.2. If the design exhibits fatigue sensitivity, a fatigue analysis shall be performed per API 579/ASME FFS-1 using a justified safety factor on anticipated operating life.

NOTE: fatigue analysis may require additional material properties.

Localized stress discontinuities and localized yielding shall be evaluated to determine if the design is acceptable or if additional analysis is required. These requirements do not apply to components which are intended to be plastically deformed in order for them to perform correctly. Intentionally plastically deformed component designs shall conform to supplier/manufacturer documented design analysis methodology and acceptance criteria.

C.3.4 Documentation of Component Design Verification

C.3.4.1 A summary report of each type 1 metallic component's design shall include:

a) calculated stress;

b) stress mode;

c) maximum temperature;

d) temperature de-rated minimum yield strength;

e) applied loads; and

f) acceptance criteria.

C.3.4.2 Where applicable, documentation of FEA results shall include:

a) description of the numerical method used, including name and version of computer software;

b) component dimensions which resulted in the highest state of stress;

c) boundary conditions;

d) loading conditions;

e) mesh sensitivity review;

f) maximum allowable stress;

g) analysis results, showing the acceptance criteria utilized;

h) stress-strain curve;

i) mesh parameters; and

j) evidence of verification by a qualified person other than the individual who created the original analysis.

The FEA study shall be electronically archived such that the study is capable of being re-evaluated.

The design verification summary report shall be approved by a qualified person other than the one who developed and tested the original design and it shall be included in the design documentation.

C.3.5 Design Validation Requirements

C.3.5.1 General

This section contains the requirements for design validation of lock mandrels for use in HPHT environments and contains two grades of design validation. Design validation testing of landing nipples and lock mandrels shall conform to section 6.5.

The HPHT validation grades for sealing device(s), or assembly consisting of sealing device and lock mandrel are designated as follows:

— V1-H: liquid pressure reversal plus temperature cycles
— V0-H: gas pressure reversal plus temperature cycles

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

Sealing devices may be validated to the same validation grade requirements or higher via component level testing.

Equipment shall be validated to their rated limits according to the requirements of this annex.

NOTE: The user/purchaser may request an installation at maximum rated temperature of the sealing device prior to conducting the validation test.

All design validation activities shall be documented in the product's design documentation.

The supplier/manufacturer shall perform an inspection both pre and post testing on all type 1 components. The supplier/manufacturer shall document all parameters and results of the evaluations that demonstrate conformance to this Annex.

All tests described in this annex shall be completed without any repair or redress of the tested assembly.

All results shall conform to the acceptance criteria and be supported by approved documentation.

C.3.5.2 Validation Testing Steps for V1-H grade

Table C.3-Lock Mandrel V1-H Validation Test

Step	Procedure and acceptance criteria	Data to be recorded
1)	Record test data and perform pre-test inspection as specified.	– validation test number – date – inspection records
2)	Install the lock mandrel in an equal or higher rated landing nipple or test device with the supplier's/manufacturer's specified running tool and procedures	– lock mandrel part number – accessory part number – running tool part numbers – test landing nipple part number – installation procedures – test temperature
3)	Apply the test pressure to lock mandrel from the first direction at the first temperature limit.	– test media
4)	Wait for pressure to stabilize and then hold time shall be at least 60 minutes. **Acceptance Criteria:** Pressure variations shall not exceed +/- 1 % of the applied test pressure during the hold time.	– pressure direction – test pressure – test temperature – hold time – pass / fail
5)	Bleed applied pressure.	– test pressure
6)	Apply the test pressure to lock mandrel from the opposite direction at the first temperature limit.	– test media
7)	Wait for pressure to stabilize and then hold time shall be at least 60 minutes. **Acceptance Criteria:** Pressure variations shall not exceed +/- 1 % of the applied test pressure during the hold time.	– pressure direction – test pressure – test temperature – hold time

		– pass / fail
8)	Bleed applied pressure.	– test pressure
9)	Perform Steps 3, 4, and 5	– same as Steps 3, 4, and 5
10)	Change test temperature from the first temperature limit to the second temperature limit.	– test temperature
11)	Perform Steps 3 – 9 at second temperature limit	– same as Steps 3 - 9
12)	Change test temperature from the second temperature limit to the first temperature limit.	– test temperature
13)	Apply the test pressure to lock mandrel from either direction at the first temperature limit.	test media
14)	Wait for pressure to stabilize and then hold time shall be at least 60 minutes. **Acceptance Criteria:** Pressure variations shall not exceed +/- 1 % of the applied test pressure during the hold time.	– pressure direction – test pressure – test temperature – hold time – pass / fail
15)	Bleed applied pressure and cool down to ambient temperature.	– test pressure
16)	Retrieve the lock mandrel from the landing nipple or test device using the supplier's/manufacturer's specified pulling tools and procedures.	– retrieval tool part numbers – retrieval procedures
17)	Perform post-test inspection as specified.	– Inspection records

C.3.5.3 Validation Testing Steps for V0-H grade

Validation test to C.4.6 using 15-minute hold times and using nitrogen gas as the test media. After stabilization, acceptance criteria is a maximum of 5 bubbles of gas over a 5-minute period. If more than 5 bubbles of gas are observed in a 5-minute period, perform test again its entirety. Accumulated gas bubbles shall be at atmospheric pressure.

C.4 Validation Test Report

C.4.1 General

A final report of the testing shall be prepared and approved by qualified personnel and shall be retained as part of the design documentation for the product. The report shall include the following information as a minimum:

a) Identification of product manufacturer;

b) date and unique identification of the validation test report;

c) identification of the validation test procedures used;

d) equipment type, description, and an assembly drawing;

e) model designation or other unique product identification by manufacturer;

f) product number (if applicable) and bill of materials identifying the components materials and traceability records;

g) results of specific evaluations and tests with acceptance criteria evaluation such as; visual inspections, photographs, pre-test and post-test dimensional inspection of critical operational areas, and validation test reports.

C.4.2 Design Validation Scaling

The scaling of validated designs shall conform to the requirements of 6.7 and the following additional requirements.

a) The supplier/manufacturer shall identify the type 1 components of the scaled product and the mode of stress in accordance with 6.3.1.3 and C.4.3;

b) Scaling shall not be used to increase equipment ratings.

C.4.3 Final Design Approval

The supplier/manufacturer shall conduct a final design review and approve the design for the intended application and functional requirements. The final design review shall include the review and approval of the following:

a) functional requirements,

b) technical specification,

c) design verifications,

d) design validation records including any evaluation for scaling, if applicable,

e) bill of materials,

f) drawings,

g) material and manufacturing specifications.

This review shall be conducted by qualified individuals. The documentation of the design review shall include the attending member identifications, approval of the results by a qualified person other than the person who created the original design, completed action items shall be included in the equipment's design documentation. Records of the final design review and approval shall be maintained as part of the product's design documentation.

NOTE: Designs developed per this requirement may be part of an additional third party review depending on the specific application of equipment.

C.5 Manufacturing Requirements

C.5.1 General

Equipment produced according to this annex shall be manufactured according to a quality management system that conforms to API Q1 and supplier/manufacturer requirements.

C.5.2 Serialization

Type 1 components shall be individually serialized. Prior to product assembly the individual serialization information for these components shall be verified and included on the assembly documentation for that product.

Non-metal components shall be serialized and traceable to the manufacturer, production batch (sometimes called a job lot), production date, and if applicable, expiration date (or shelf life). Records of traceability shall be maintained.

C.5.3 Non-metallic Material Supplier Qualifications

The supplier/manufacturer shall purchase goods and services only from approved suppliers.

The supplier/manufacturer shall develop and/or receive from the supplier of nonmetal components a process specification that details the controls necessary for the production of the nonmetal item to meet the supplier/manufacturer's specifications.

Each supplier shall be evaluated annually to ensure that the applicable controls of all materials, compounds and component processes effectively ensure consistent conformance to the material and technical specifications. These evaluations shall be performed by qualified individuals.

Supplier evaluation records shall identify the materials/components that are approved to be provided by each specific supplier. Supplier documented evaluation records shall include the necessary corrective measures and verification of their implementation.

C.5.5 Functional Testing Requirements

C.5.5.1 General

The supplier/manufacturer shall document all parameters and results of functional testing to demonstrate that the equipment has been successfully assembled and tested per the supplier's/manufacturer's procedures. Functional test results shall be recorded, dated and signed by a qualified person and shall be retained as part of the manufacturing documentation.

A pressure test shall be performed on each product by pressurizing to the supplier rated pressure. In the event that the equipment has design or operational features that does not allow testing to the requirements of this specification, the supplier/manufacturer shall document the incompatibility and shall identify the proposed revised test steps/conditions and technically justify the revision(s). The supplier/manufacturer shall include the justification of any changes to the functional test in the product's design documentation.

Unless otherwise specified by the supplier/manufacturer, gas pressure-relieving (bleed-down) operations shall be performed at a rate of 6.9 bar (100 psi) per minute or less when the pressures are less than 103.4 bar (1500 psi).

Unless otherwise specified, all pressure test holds shall have a minimum duration of 15 minutes after pressure stabilization.

C.5.5.2 Functional Testing Parameters

An internal pressure test shall be performed on each landing nipple by pressurizing to internal rated working pressure for 15 minutes after stabilization. Acceptance criteria shall be no visible leakage and pre- and post-test dimensional inspection of critical areas as determined by the supplier/manufacturer shall be documented, evaluated in accordance with the supplier's/manufacturer's specifications and the data maintained.

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[13] ISO 23936-1, *Petroleum, petrochemical and natural gas industries—Non-metallic materials in contact with media related to oil and gas production—Part 1: Thermoplastics*

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5) American Society for Nondestructive Testing, PO Box 28518, 1711 Arlingate Lane, Columbus, OH 43228-0518, USA.

6) Department of Defense Single Stock Point, Building 4, Section D, 700 Robbins Avenue, Philadelphia, PA 19111-5098, USA.

7) NACE International, PO Box 218340, Houston, TX 77218, USA.