INTERNATIONAL STANDARD

**ISO 16070**

Second edition
2005-12-15

# Petroleum and natural gas industries — Downhole equipment — Lock mandrels and landing nipples

*Industries du pétrole et du gaz naturel — Équipement de fond de trou — Mandrins à clé d'ancrage et sièges d'ancrage*



Reference number
ISO 16070:2005(E)

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

 

# Contents

Page


Foreword ... iv

Introduction ... v

1 Scope ... 1

2 Normative references ... 1

3 Terms and definitions ... 3

4 Abbreviated terms ... 4

5 Functional specification ... 5
5.1 General ... 5
5.2 Functional characteristics of lock mandrels and landing nipples ... 5
5.3 Well parameters ... 5
5.4 Operational parameters ... 5
5.5 Environmental compatibility ... 6
5.6 Compatibility with the related well equipment ... 6
5.7 Quality documentation ... 6
5.8 Design validation ... 6

6 Technical specification ... 7
6.1 General ... 7
6.2 Technical characteristics of lock mandrels and landing nipples ... 7
6.3 Design criteria ... 7
6.4 Design verification ... 9
6.5 Design validation ... 10
6.6 Design changes ... 12
6.7 Functional test parameters ... 12

7 Supplier/manufacturer requirements ... 12
7.1 Documentation and data control ... 12
7.2 User/purchaser documentation ... 13
7.3 Product identification ... 14
7.4 Quality control ... 14
7.5 Functional testing ... 21

8 Repair ... 22

Annex A (informative) Example of landing nipple validation test dimensional check sheet ... 23

Bibliography ... 24

# Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 16070 was prepared by Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries*, Subcommittee SC 4, *Drilling and production equipment*.

This second edition cancels and replaces the first edition (ISO 16070:2001), which has been technically revised.

# Introduction

This International Standard 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 International Standard 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 International Standard addresses the minimum requirements with which the supplier/manufacturer is to comply so as to claim conformity to this International Standard.

This International Standard 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.

There are two quality documentation grades which provide the user/purchaser the choice of requirements to meet specific preference or application. Quality documentation grade Q2 is the minimum grade of documentation offered by this International Standard. Grade Q1 provides additional material documentation.

There are three design validation grades which provide the user/purchaser the choice of requirements to meet specific preference or application. Design validation grade V3 is the minimum grade and represents equipment where the validation method has been defined by the supplier/manufacturer. The complexity and severity of the validation testing increases as the grade number decreases.

Users of this International Standard should be aware that requirements above those outlined in this International Standard may be needed for individual applications. This International Standard 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 International Standard and provide details.

# Petroleum and natural gas industries — Downhole equipment — Lock mandrels and landing nipples

## 1 Scope

This International Standard 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 or other equipment, but does not cover the connections to the well conduit.

## 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.

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 13628-3, *Petroleum and natural gas industries — Design and operation of subsea production systems — Part 3: Through flowline (TFL) systems*

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

ISO 15156-1, *Petroleum and natural gas industries — Materials for use in $H_2S$-containing environments in oil and gas production — Part 1: General principles for selection of cracking-resistant materials*

ISO 15156-2, *Petroleum and natural gas industries — Materials for use in $H_2S$-containing environments in oil and gas production — Part 2: Cracking-resistant carbon and low alloy steels, and the use of cast irons*

ISO 15156-3, *Petroleum and natural gas industries — Materials for use in $H_2S$-containing environments in oil and gas production — Part 3: Cracking-resistant CRAs (corrosion-resistant alloys) and other alloys*

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

ASME Boiler and Pressure Vessel Code:2004[2)], Section V, *Non-destructive examination*

ASME Boiler and Pressure Vessel Code:2004, Section VIII, Division 1, *Rules for construction of pressure vessels*

ASME Boiler and Pressure Vessel Code:2004, Section IX, *Welding and brazing qualifications*

ASTM A 388/A 388M[3)], *Standard practice for ultrasonic examination of heavy steel forgings*

ASTM A 609/A 609M, *Standard practice for castings, carbon, low-alloy, and martensitic stainless steel, ultrasonic examination thereof*

ASTM D 395, *Standard test methods for rubber property — Compression set*

ASTM D 412, *Standard test methods for vulcanized rubber and thermoplastic rubbers and thermoplastic elastomers — Tension*

ASTM D 638, *Standard test method for tensile properties of plastics*

ASTM D 1414, *Standard test methods for rubber O-rings*

ASTM D 1415, *Standard test method for rubber property — International hardness*

ASTM D 2240, *Standard test methods for rubber property — Durometer hardness*

ASTM E 94, *Standard guide for radiographic examination*

ASTM E 140, *Standard hardness conversion tables for metals (relationship among Brinell hardness, Vickers hardness, Rockwell hardness, Rockwell superficial hardness, Knoop hardness, and scleroscope hardness)*

ASTM E 165, *Standard test method for liquid penetrant examination*

ASTM E 186, *Standard reference radiographs for heavy-walled [2 to 4 ½-in. (51 to 114-mm)] steel castings*

ASTM E 280, *Standard reference radiographs for heavy-walled [4 ½ to 12-in. (114 to 305-mm)] steel castings*

ASTM E 428, *Standard practice for fabrication and control of steel reference blocks used in ultrasonic examination*

ASTM E 446, *Standard reference radiographs for steel castings up to 2 in. (51 mm) in thickness*

BS 2M 54:1991[4)], *Specification for temperature control in the heat treatment of metals*

SAE-AMS-H-6875:1998[5)], *Heat treatment of steel raw materials*



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.

4) BSI, Customer Services, 389 Chiswick High Road, London W4 4AL, UK.

5) SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, USA.

## 3 Terms and definitions

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

NOTE For quality system terms used in the text of this International Standard but not defined below, see ISO 9000.

**3.1**
**ambient temperature**
prevailing temperature at test site

**3.2**
**critical component**
part that is pressure containing and/or load bearing

**3.3**
**design acceptance criteria**
defined limits placed on characteristics of materials, products, or services established by the organization, customer, and/or applicable specifications to achieve conformity to the product design

[ISO/TS 29001:2003]

**3.4**
**design validation**
process of proving a design by testing to demonstrate conformity of the product to design requirements

[ISO/TS 29001:2003]

**3.5**
**design verification**
process of examining the result of a given design or development activity to determine conformity with specified requirements

[ISO/TS 29001:2003]

**3.6**
**full life cycle**
expected period of time in which the product is specified to function according to the supplier's/manufacturer's specifications

**3.7**
**landing nipple**
receptacle containing a profile designed for the installation of a lock mandrel

**3.8**
**lock mandrel**
retention device used for flow control equipment or other equipment

**3.9**
**manufacturing**
process and action performed by an equipment supplier/manufacturer that are necessary to provide finished component(s), assembly(ies) and related documentation, that fulfil the requests of the user/purchaser and meet the standards of the supplier/manufacturer

NOTE Manufacturing begins when the supplier/manufacturer receives the order and is completed at the moment the component(s), assembly(ies) and related documentation are surrendered to a transportation provider.

**3.10**
**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

**3.11**
**operating environment**
set of conditions to which the product is exposed during its full life cycle

**3.12**
**production/injection conduit**
tubulars and equipment which provide the flow path between the reservoir and the christmas tree, including the riser for subsea applications

**3.13**
**profile**
feature designed to receive the lock mandrel's locking mechanism

**3.14**
**sealing device**
device preventing passage (i.e. communication) of liquid and/or gas across the interface between the lock mandrel and the landing nipple

**3.15**
**size**
relevant dimensional characteristics of the equipment as defined by the supplier/manufacturer

**3.16**
**test pressure**
pressure at which the equipment is tested based upon all relevant design criteria

NOTE See 6.5.1 for test pressure requirements.

**3.17**
**test temperature**
temperature at which the equipment is tested based upon all relevant design criteria

**3.18**
**type**
lock mandrel or landing nipple equipment with unique characteristics which differentiate it from other functionally similar lock mandrel or landing nipple equipment

**3.19**
**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



## 4 Abbreviated terms

— AQL Acceptance quality limit

— NDE Non-destructive examination

— TFL Through flowline

# 5 Functional specification

## 5.1 General

The user/purchaser shall prepare a functional specification for ordering products conforming to this International Standard 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 shall be specified, as applicable, 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).

## 5.3 Well parameters

The following well parameters shall be specified, as applicable, 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, and restrictions through which the lock mandrel and/or landing nipple pass;

d) anticipated loading conditions which might be applied to the lock mandrel and landing nipple.

## 5.4 Operational parameters

The following operational parameters shall be specified, as applicable, for the lock mandrel and landing nipple:

a) acidizing, including the acid composition, pressure, temperature, velocity, exposure time and any other chemicals used during the stimulation;

b) fracturing, including proppant description, fracture fluid velocity and proppant-to-fluid ratio;

c) sand consolidation operations;

d) type of well intervention, including service equipment such as electric line, slick line, braided line, coiled tubing, or snubbing equipment.

## 5.5 Environmental compatibility

The following shall be identified, as applicable, for the lock mandrel and landing nipple to ensure environmental compatibility:

a) 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;

b) both the minimum and the maximum anticipated values of the production/injection pressures, pressure differentials, temperatures and flow rates;

c) 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.

## 5.6 Compatibility with the related well equipment

### 5.6.1 Lock mandrels

The following information shall be specified, as applicable, 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 equipment in the landing nipple;

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

c) size, type, material, configuration and interface dimensions of the connection between the flow control equipment and the lock mandrel;

d) size, type and configuration of other products to be used with the lock mandrel.

### 5.6.2 Landing nipples

The following information shall be specified, as applicable, 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 dimension(s), outside diameter, inside diameter and their respective locations;

c) size, type and configuration of lock mandrels or other products to be used with the landing nipple.

## 5.7 Quality documentation

The quality documentation grade (i.e. Q1 or Q2 as given in 7.4) shall be specified by the user/purchaser.

## 5.8 Design validation

The design validation grade (i.e. V1, V2 or V3 as given in 6.5) shall be specified by the user/purchaser.

# 6 Technical specification

## 6.1 General

The supplier/manufacturer shall prepare the technical specification which responds to the requirements defined in the functional specification. The supplier/manufacturer shall also provide product data as defined in 7.2.1 to the user/purchaser.

## 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.c) and d) 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 5.3.c) and d) 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 6.3.2 and 6.5.2). 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 individual 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 that are substantially the same as those of the size, type, and model of lock mandrel and landing nipple 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 critical components of the product and the mode of stress. The supplier/manufacturer shall calculate the stress level in the critical 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 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 in accordance with ASME Boiler and Pressure Vessel Code:2004, Section II, Part D.

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

Materials and/or service shall be stated by the supplier/manufacturer and shall be suitable for the environment specified in the functional specification. The supplier/manufacturer shall have written specifications for all lock mandrel and landing nipple material. All materials used shall comply with the supplier's/manufacturer's written specifications.

The user/purchaser may specify materials for the specific corrosion environment in the functional specification. Should the supplier/manufacturer propose to use another material, the supplier/manufacturer shall state that this material has performance characteristics suitable for all parameters specified in the well and production/injection parameters. This applies to metallic and non-metallic components.

Except for seals, material substitutions in qualified lock mandrels and landing nipples are allowed without design validation testing provided that the supplier's/manufacturer's selection criteria are documented and meet all other requirements of this International Standard.

#### 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:

   1) tensile strength;

   2) yield strength;

   3) elongation;

   4) hardness.

**6.3.2.2.2** The mechanical properties specified in 6.3.2.2.1 shall be verified by tests conducted on a material sample produced from the same heat of material. The material sample shall undergo the same heat treatment process as the component it qualifies. Material subsequently heat-treated from the same heat of material shall be hardness tested after processing to confirm compliance with the hardness requirements of the supplier's/manufacturer's specifications. The hardness results shall verify through documented correlation that the mechanical properties of the material tested meet the properties specified in 6.3.2.2.1. The heat treatment process parameters shall be defined in the heat treatment procedure. Hardness testing is the only mechanical property test required after stress-relieving. Material test reports provided by the material supplier or the supplier/manufacturer are acceptable documentation.

**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:2004, Section VIII, Division 1, Subsection C, paragraphs UCS-56 and UHA-32.

#### 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 qualified in accordance with current 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 International Standard.

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 break);

   2) elongation (at break);

   3) 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 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.

#### 6.3.4 TFL equipment

For additional requirements for these products in TFL applications, see ISO 13628-3.

### 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.

#### 6.4.2 Scaling limits

**6.4.2.1** Lock mandrels and landing nipples, exclusive of sealing devices, of the same model, type, and design are considered to be design-verified 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.

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

c) Critical stress levels of the scaled product supplier/manufacturer identified critical components, stated as a percentage of material yield, shall not exceed those of the validated design at the same conditions.

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

**6.4.2.2** 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.

## 6.5 Design validation

### 6.5.1 General

This International Standard specifies three grades of design validation. The user/purchaser shall specify the grade of design validation required. Products shall be supplied to at least the design validation grade specified. Landing nipples shall be provided only in grades V2 or V3.

Products previously qualified in accordance with ISO 10432 or API Spec 14A, prior to the publication of this International Standard, shall be considered as meeting the design validation requirements at their relevant grade of this International Standard.

The grades of design validation are classified as follows.

— **V3** applies to equipment that satisfies all requirements of this International Standard except for validation testing.

— **V2** applies to equipment that satisfies all requirements of this International Standard including the testing in 6.5.2 and 6.5.3. All grade V2 equipment meets the requirements of grade V3.

— **V1** applies to equipment that satisfies all requirements of this International Standard including the testing in 6.5.4. All grade V1 equipment meets the requirements of both grades V3 and V2.

The supplier/manufacturer shall document the validation test procedure and results. The validation test pressure(s) shall exceed the rated working pressure(s) as determined by the supplier/manufacturer.

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

— material specifications;

— mill certifications 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 A shows an example of a check sheet for presenting the recorded data.

### 6.5.2 Validation testing of landing nipples — Grade V2

The landing nipple shall undergo grade V2 validation testing as follows.

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

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

c) After stabilization, the hold time for the pressure test shall be at least 15 min. Pressure variations shall not exceed ± 1 % of the applied test pressure.

d) All testing shall be performed at ambient temperature.

e) Single-piece surface-controlled safety valve landing nipples (SVLN) shall undergo pressure testing to confirm the maximum pressure rating of their control/communication capability. During the bore-pressure tests, the control line ports shall be monitored for leakage. If any leakage is detected from a control line port, the safety valve landing nipple fails the test.

f) Each SVLN that contains control fluid redirection feature(s) shall be bore-pressure tested at the rated working pressure of the SVLN in each alternative position of the control fluid redirection feature(s). This testing may be performed on typical components provided the operating components tested are of the same design, dimensions and clearances as those of the production SVLN and made of equivalent material. During these bore-pressure tests, the control line ports shall be monitored for leakage. If any leakage is detected from a control line port that is designated as isolated from the SVLN bore (in accordance with the SVLN Operating Manual), the SVLN fails the test. The supplier/manufacturer shall verify that the product is capable of performing at its rated temperature limits.

### 6.5.3 Validation testing of lock mandrels — Grade V2

The lock mandrel shall undergo grade V2 validation testing as follows.

a) The supplier/manufacturer shall perform the validation test of each size, type and model. The lock mandrel shall be installed in an equal or higher rated landing nipple or test device with the supplier's/manufacturer's specified running tool and procedures. The lock mandrel shall be subjected to pressure differential from above and below (as applicable) to the rated test pressures.

b) After stabilization, the hold time for the pressure shall be at least 15 min. Pressure variations shall not exceed ± 1 % of the applied test pressure. Once the hold time has elapsed, release the pressure.

c) The lock mandrel shall be retrieved from the landing nipple or the test device using the supplier's/manufacturer's specified pulling tool and procedures.

d) All pressure testing shall be performed at ambient temperature.

### 6.5.4 Validation testing of lock mandrels — Grade V1

The lock mandrel shall undergo grade V1 validation testing as follows.

a) The supplier/manufacturer shall perform the validation test of each size, type and model. The lock mandrel shall be installed in an equal or higher rated landing nipple or test device with the supplier's/manufacturer's specified running tool and procedures. The lock mandrel shall be simultaneously subjected to rated limits of pressure and temperature from above and below (as applicable).

b) After stabilization, the hold time for the pressure shall be at least 15 min. Pressure variations shall not exceed ± 1 % of the applied test pressure. Once the hold time has elapsed, release the pressure.

c) The lock mandrel shall be retrieved from the landing nipple or test device using the supplier's/manufacturer's specified pulling tool and procedures.

### 6.5.5 Validation testing of sealing devices

**6.5.5.1** Sealing devices shall be tested with water or other appropriate liquid to the rated limits of the lock mandrel to which it is to be affixed (simultaneously subjected to rated limits of pressure and temperature in the direction(s) of intended use). The supplier/manufacturer shall perform and document validation testing for each size, design, and material. A locking mandrel and landing nipple or test fixture may be used for validation testing. Acceptance criteria shall be in accordance with 6.5.4.b).

**6.5.5.2** 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.

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

#### 6.5.6 Special feature validation

The supplier/manufacturer shall identify those special features that shall be included in the functional 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 International Standard.

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

### 6.6 Design changes

**6.6.1** Changes to the design acceptance criteria of the lock mandrel/landing nipple equipment which may affect validation test performance or interchangeability shall require revalidation of the lock mandrel/landing nipple equipment.

**6.6.2** The supplier/manufacturer, as a minimum, shall consider the following when making design changes: stress levels of the modified or changed components; material changes; and functional changes. All design changes and modifications shall be identified, documented, reviewed and approved before their implementation. Design changes and changes to design documents shall require the same control features as the design which has passed the applicable validation test requirements of this International Standard.

### 6.7 Functional test parameters

Each lock mandrel and landing nipple shall be functionally tested in accordance with 7.5.

## 7 Supplier/manufacturer requirements

### 7.1 Documentation and data control

#### 7.1.1 General

The supplier/manufacturer shall establish and maintain documented procedures to control all documents and data that relate to the requirements of this International Standard. 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. Documentation shall be retained for a minimum of five years from the date of manufacture.

#### 7.1.2 Design documentation

Design verification and validation documents, and the information listed below, shall be maintained for five years after date of last manufacture:

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.

## 7.2 User/purchaser documentation

### 7.2.1 Product data sheets

Product data sheets shall be supplied at delivery to the user/purchaser as required in 6.1 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;

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 or from above and/or below, as applicable);

n) top connection(s);

o) bottom connection(s);

p) conveyance method;

q) maximum conveyance OD of running equipment;

r) retrieval method (if retrievable);

s) design validation grade;

t) 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 Quality documentation grades

This International Standard specifies two grades of documentation which shall be supplied with the equipment, and the user/purchaser shall specify the grade required, with Q2 as the minimum.

The grades of documentation are classified as follows:

— **Q2** certificate of conformance;

— **Q1** certificate of conformance and NDE and mill certification for the supplier's/manufacturer's specified critically stressed components.

### 7.4.2 Raw material

#### 7.4.2.1 Certification

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 so 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).

— Tensile testing shall be in accordance with ISO 6892.

— Hardness testing shall be in accordance with ISO 6506 or ISO 6508; alternatively, ISO 6507 may be used if ISO 6506 or ISO 6508 cannot be applied due to size, accessibility, or other limitations.

— Hardness conversion to other measurement units shall be in accordance with ASTM E 140, with the exceptions noted in ISO 15156 for materials which are intended for use in wells where corrosive agents can possibly be expected to cause stress-corrosion cracking.

NOTE For the purposes of these provisions, NACE MR0175 is equivalent to ISO 15156 (all parts).

##### 7.4.2.2.2 Non-metals

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

a) tensile, elongation, modulus:

1) O-rings: in accordance with ASTM D 1414;

2) all others: in accordance with ASTM D 412 (alternative ASTM methods are acceptable, where applicable);

3) non-elastomers: in accordance with ASTM D 638 (alternative ASTM methods are acceptable, where applicable);

b) compression set (homogeneous elastomeric compounds only):

— O-rings: in accordance with ASTM D 1414;

— all others: in accordance with ASTM D 395;

c) durometer hardness:

1) O-rings: in accordance with ASTM D 1415 or ASTM D 2240 with Shore M;

2) all others: in accordance with ASTM D 2240 (plastics and other materials may be Rockwell hardness tested where applicable).

### 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:

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 overlays

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

#### 7.4.3.3 Welding and brazing

Welding and brazing shall require the following:

a) welding and brazing procedure and personnel qualification shall be in accordance with ASME Boiler and Pressure Vessel Code:2004, 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:2004, Section IX.

#### 7.4.3.4 Qualification of heat-treating equipment

##### 7.4.3.4.1 Furnace calibration

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 SAE-AMS-H-6875:1998;

   2) procedures specified in BS 2M 54:1991;

   3) 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

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 International Standard when it leaves the supplier's/manufacturer's inventory.

### 7.4.5 Measuring/testing equipment calibration

**7.4.5.1** Measuring and testing equipment used for acceptance shall be identified, controlled, calibrated and adjusted at specific intervals in accordance with a nationally or internationally recognized standard such as NCSL Z540-1, supplier's/manufacturer's specifications, and traceable to a nationally registered certifying body.

**7.4.5.2** Pressure-measuring devices shall:

a) be readable to at least ± 0,5 % of full scale range;

b) be calibrated to maintain ± 2 % accuracy of full scale range.

**7.4.5.3** Pressure-measuring devices shall be used only within the calibrated range.

**7.4.5.4** Pressure-measuring devices shall be 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 and documented calibration 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.

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

b) All critically stressed components shall be magnetic-particle or liquid-penetrant inspected for surface defects to verify conformance to the supplier's/manufacturers' written specifications.

c) All pressure-containing welds shall be magnetic-particle or liquid-penetrant inspected for surface defects and shall be volumetrically inspected by radiographic or ultrasonic techniques to verify conformance to the supplier's/manufacturer's written specifications.

d) All pressure-containing castings and forgings shall be magnetic-particle or liquid-penetrant inspected for surface defects and shall be volumetrically inspected by radiographic or ultrasonic techniques to verify conformance to the supplier's/manufacturer's written specifications. The supplier/manufacturer may develop AQL inspection levels based on documented variation history.

#### 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 E 165;

b) acceptance criteria: in accordance with ASME Boiler and Pressure Vessel Code:2004, 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;

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

— 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;

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

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

c) 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:2004, Section V, Article 5;

b) acceptance criteria: in accordance with ASME Boiler and Pressure Code:2004, 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 E 428 and ASTM A 609;

b) acceptance criteria: in accordance with ASTM A 609 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 E 428 and ASTM A 388;

b) calibration:

— 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;

— flat bottom hole technique: distance amplitude curve (DAC) 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);

— 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 accompanied by a complete loss of back reflection;

2) flat bottom hole technique: indications equal to or larger than the indications observed from the calibration flat bottom hole;

3) 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 E 94;

b) acceptance criteria: in accordance with ASME Boiler and Pressure Vessel Code:2004, 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 E 94;

b) acceptance criteria, depending on thickness:

1) in accordance with ASTM E 186;

2) in accordance with ASTM E 280;