FINAL DRAFT

INTERNATIONAL STANDARD

ISO/FDIS 16070

ISO/TC 67/SC 4

Secretariat: **ANSI**

Voting begins on:
2001-05-03

Voting terminates on:
2001-07-03

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 a clé d'ancrage et sièges d'ancrage

Please see the administrative notes on page iii

Reference number
ISO/FDIS 16070:2001(E)

ISO/CEN PARALLEL PROCESSING

The CEN Director General has advised the ISO Secretary-General that this final draft International Standard covers a subject of interest to European standardization. Consultation on the ISO/DIS had the same effect for CEN members as a CEN enquiry on a draft European Standard. In accordance with subclause 5.1 of the Vienna Agreement, this final draft, established on the basis of comments received, is hereby submitted to a parallel two-month FDIS vote in ISO and formal vote in CEN.

Positive votes shall not be accompanied by comments.

Negative votes shall be accompanied by the relevant technical reasons.

In accordance with the provisions of Council Resolution 15/1993, this document is **circulated in the English language only.**

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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 3.

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 International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

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

Annexes A and B of this International Standard are for information only.

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 with this International Standard.

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

There are three quality control grades which provide the user/purchaser the choice of requirements to meet their preference or application. Quality control grade Q3 is the minimum grade of quality offered by this International Standard. Quality control grade Q2 provides additional inspection and verification steps and quality control grade Q1 is the highest grade provided.

There are three design validation grades which provide the user/purchaser the choice of requirements to meet their 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 normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

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 10422, *Petroleum and natural gas industries — Threading, gauging and thread inspection of casing, tubing and line pipe threads — Specification*

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*

ASME Boiler and Pressure Vessel Code, Section V:1998, *Non-destructive testing*

ASME Boiler and Pressure Vessel Code, Section VIII:1998, *Pressure vessels*

ASME Boiler and Pressure Vessel Code, Section IX:1998, *Welding and brazing qualifications*

ASTM A388/A388M, *Standard practice for ultrasonic examination of heavy steel forgings*

ASTM A609/A609M, *Standard practice for castings, carbon, low-alloy, and martensitic stainless steel, ultrasonic examination thereof*

ASTM 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 D638, *Standard test method for tensile properties of plastics*

ASTM D1414, *Standard test methods for rubber O-rings*

ASTM D1415, *Standard test method for rubber property — International hardness*

ASTM D2240, *Standard test methods for rubber property — Durometer hardness*

ASTM E94, *Standard guide for radiographic testing*

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 E428, *Standard practice for fabrication and control of steel reference blocks used in ultrasonic inspection*

ASTM E446, *Standard reference radiographs for steel castings up to 2 in. (51 mm) in thickness*

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

NACE MR 0175:1999, *Sulfide stress cracking resistant metallic materials for oilfield equipment*

SAE-AMS-H-6875:1998, *Heat treatment of steel raw materials*

3 Terms and definitions

For the purposes of this International Standard, 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
design acceptance criteria
defined limits placed on characteristics of materials, products, or services established by the manufacturer to ensure conformance to the product design

3.3
full life cycle
expected period of time in which the product shall function according to the manufacturer's specifications

3.4
landing nipple
any receptacle containing a profile designed for the installation of a lock mandrel

3.5
lock mandrel
retention device used for flow control or other equipment

3.6
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.

3.7
model
lock mandrel or landing nipple with unique components and operational characteristics that distinguish it from other lock mandrels or landing nipples of the same type

3.8
operating environment
set of conditions to which the product is exposed during its full life cycle

3.9
profile
feature that is designed for the reception of the lock mandrel's locking mechanism

3.10
production/injection conduit
all tubular and equipment which provide the flow path between the reservoir and the christmas tree, including the riser for subsea applications

3.11
sealing device
device preventing contact of liquid and/or gas across the interface between the lock mandrel and the landing nipple

3.12
size
diameter of a landing nipple seal bore or the related lock mandrel diameter

3.13
test pressure
pressure at which the equipment is tested based upon all relevant design criteria

3.14
test temperature
temperature at which the equipment is tested based upon all relevant design criteria

3.15
type
lock mandrel and/or landing nipple distinguished by a particular method of being positioned and retrieved from a well

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 which conform with this International Standard and specify the following requirements and operating conditions, as appropriate, 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 Lock-mandrel and landing-nipple functional characteristics

The lock-mandrel and landing-nipple functional characteristics should include but are not limited to:

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 for the lock mandrel and landing nipple:

a) size, mass, material and grade of the casing and tubing;

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 are to be applied to the lock mandrel and landing nipple.

5.4 Operational parameters

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

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

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

c) type of sand consolidation operations;

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

5.5 Environmental compatibility

The following shall be identified 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, being 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 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 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 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 control

The quality control grade shall be specified, i.e. one of the three grades (Q1, Q2 or Q3) of quality control stipulated in 7.4.

5.8 Design validation

The design validation grade shall be specified, i.e. one of the three grades (V1, V2 or V3) of design validation stipulated in 6.5. When requested by the user/purchaser, an operating envelope for the validation grade V1 lock mandrel and sealing device shall be supplied. An example of the presentation of an operating envelope is shown in annex A.

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 defined in 7.2.1 to the user/purchaser.

6.2 Lock-mandrel and landing-nipple technical characteristics

6.2.1 Lock-mandrel characteristics

The following criteria shall be met:

a) the lock mandrel shall be located and/or seal at the specified location and remain so until intentional intervention defines otherwise;

b) while installed, the lock mandrel shall perform in accordance with the functional specification;

c) where applicable, the lock mandrel shall not compromise well-intervention operations as specified in 5.4.

6.2.2 Landing-nipple characteristics

While in service, the landing nipple shall meet the requirements of the functional specification.

6.3 Design criteria

6.3.1 Materials

Materials, and where necessary the service, shall be stated by the supplier/manufacturer and shall be suitable for the environment specified in the functional specification.

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

6.3.2 Performance rating

The supplier/manufacturer shall state the pressure, temperature and axial load rating, as applicable for the specific products. This information may be provided in an operating performance envelope; a lock mandrel example is given in annex A.

6.3.3 TFL equipment

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

6.4 Design verification

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.

6.5 Design validation

6.5.1 General

This International Standard provides three grades of design validation for the product. The user/purchaser shall specify the grade of design validation required. Products shall be supplied to design validation grade V3 unless the user/purchaser specifies grade V2 or grade V1. Landing nipples are provided in grades V2 or V3 only.

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 manufacturer shall document the validation test procedure and results, and 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 manufacturer shall be documented, evaluated in accordance with the manufacturer's specifications and the data maintained. Annex B shows an example of a check sheet for presenting the recorded data.

Lock mandrels and landing nipples, exclusive of sealing devices, of the same model, type, and design are considered to be design validated when all of the following criteria are met.

a) The size shall be within ± 5 % of the actual diameters of the validated design.

b) The manufacturer shall identify the critically stressed components of the validation-tested product and the mode of stress. The manufacturer shall calculate the critical stress level in the identified component(s) based upon the maximum loads applied during testing. The minimum acceptable material condition and minimum acceptable material yield shall be used in the calculations and the calculations shall include consideration of temperature limit effects on the material properties. This data shall be identified in the design record.

c) Critical stress levels, stated as a percentage of material yield, shall not exceed those of the validated design at the same conditions.

d) The mode of stress and identical method of calculation(s) shall be applied.

Sealing devices of the same type, design, and material are considered to be design validated when the size is within the range of 0 % to −10 % of the actual diameters of a validation tested design.

6.5.2 Landing-nipple validation testing — Grade V2

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

a) The 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 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 alternate 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 manufacturer shall verify that the product is capable of performing at its rated temperature limits.

6.5.3 Lock-mandrel validation testing — Grade V2

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

a) The manufacturer shall perform the validation test of each size, type and model. The lock mandrel shall be installed in a representative landing nipple or test device with the 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. Release the pressure.

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

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

6.5.4 Lock-mandrel validation testing — Grade V1

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

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

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 manufacturer's specified pulling tool and procedures.

d) All pressure testing shall be performed at the rated temperatures of the lock mandrel.

6.5.5 Sealing-device validation testing

6.5.5.1 General

For sealing devices the supplier/manufacturer shall perform and document validation testing for each size, design and material. Once a sealing device has successfully passed validation testing, it is qualified for use on multiple products of similar dimensional requirements within the temperature and pressure differentials tested. Sealing devices 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 of this International Standard.

All sealing devices shall be tested in the direction(s) of intended use and design requirements.

6.5.5.2 Sealing-device validation-testing apparatus

The apparatus for validation testing of the sealing device shall be as follows.

a) The tested sealing device and the gland, mandrel and sealing-bore surfaces shall be of the identical configuration, dimension and tolerances as used for the production products. A locking mandrel and landing nipple or test fixture may be used for validation testing.

b) When a test fixture is used it shall be designed to apply the pressures, temperatures and loads in a manner comparable to that of the production products.

c) Testing components/fluids shall be designed to perform the test procedure within the required parameters.

d) The sealing device design, materials, test results and all test pressures, temperatures, fluid descriptions shall be documented.

6.5.5.3 Sealing device validation testing procedure

Use the following procedure for validation testing of the sealing device.

a) Install the sealing device into the test apparatus following the manufacturer's procedures. Verify that all equipment and fluids can safely meet the required pressures, temperatures and accuracy.

b) Adjust and stabilize the assembled test apparatus to the sealing device's minimum rated temperature ± 5 %. Adjust and stabilize the differential pressure on the sealing device to 25 % (± 2 %) of the maximum rated test pressure. Hold and continuously record the temperature and pressure for a minimum of 15 min. Ensure the pressure and temperature measurements remain within the tolerances for a successful test.

c) Repeat step b) at (100 $^{+5}_{0}$) % of the maximum rated test pressure keeping all other parameters unchanged.

d) Release the pressure.

e) Repeat step b) at the maximum rated temperature ± 5 % keeping all other parameters unchanged.

f) Repeat step e) at (100 $^{+5}_{0}$) % of the maximum rated test pressure.

g) Release the pressure.

h) A visual inspection of the sealing device shall confirm whether it meets the manufacturer's acceptance criteria following this testing.

6.6 Design changes

All design changes shall be documented and reviewed against the design verification and design validation parameters. Changes to the design outside the limits of the design acceptance criteria which may affect the performance of the product in the intended service condition, lead to a new design requiring design verification as specified in 6.4 and design validation as specified in 6.5. Justification for design changes identified as not impacting the design acceptance criteria shall be documented. The manufacturer/supplier shall, as a minimum, consider the following:

a) stress levels of the modified or changed components;

b) material changes;

c) functional changes.

6.7 Functional test parameters

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

6.8 Optional validation testing

Some applications may require additional testing to be agreed between the user/purchaser and manufacturer/supplier.

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 International Standard. These documents and data shall be maintained to demonstrate conformance to specified requirements. All documents and data shall be legible and shall be sorted and retained in such a way that they are readily retrievable in facilities that provide a suitable environment to prevent damage or deterioration and to prevent loss. 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 audible by the user/purchaser.

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) manufacturer's quality manual and required QC documents as specified in 7.4;

c) required grade of QC and design validation as specified in 5.7 and 5.8 respectively;

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

e) 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;

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

g) 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 at least the following information, where applicable:

a) name and address of supplier/manufacturer;

b) manufacturer assembly number;

c) 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) temperature range;

l) rated working pressure;

m) top connection(s);

n) bottom connection(s);

o) conveyance method;

p) maximum conveyance OD of running equipment;

q) retrieval method (if retrievable);

r) quality control grade;

s) design validation grade;

t) axial load rating.

7.2.2 Technical/operations manual

A technical/operations manual shall be available for all products supplied in accordance with this International Standard.

The technical/operations manual shall contain at least 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 (outside diameters, inside diameters, lengths);

h) special precautions and handling requirements;

i) assembly and disassembly instructions.

7.3 Product identification

Each product furnished in accordance with this International Standard shall be permanently identified according to the manufacturer's written specifications. Identification shall include:

a) the 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;

f) the date of original manufacture.

7.4 Quality control

7.4.1 Quality control grades

This International Standard provides three grades of quality control for the product. The user/purchaser shall specify the grade of quality control. Equipment shall be supplied to quality control grade Q3 unless the user/purchaser specifies grade Q2 or grade Q1.

The grades of quality control for the product are classified as follows:

— **Q3** Certificate of conformance.

— **Q2** Certificate of conformance as well as an additional NDE and mill certification for the manufacturer's specified critical components.

— **Q1** Certificate of conformance as well as an additional NDE and mill certification for all components, except common hardware items such as nuts, bolts, set screws, and shear pins/screws (unless these components are critical to the operation of the tools primary function).

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 documented specifications;

b) a material test report so that the manufacturer can verify that the raw material meets the supplier's documented specifications.

7.4.2.2 Mechanical and physical properties

7.4.2.2.1 Metallic materials

Tensile testing shall be in accordance with ISO 6892 for the metallic materials used for traceable components. Hardness testing shall be in accordance with ISO 6506-1 or ISO 6508-1; ISO 6507-1 may be used when ISO 6506-1 or ISO 6508-1 cannot be applied due to size, accessibility, or other limitations. Hardness conversion to other measurement units shall be in accordance with ASTM E140, with the exceptions noted in NACE MR 0175 for materials which are intended for use in wells where corrosive agents can possibly be expected to cause stress-corrosion cracking.

7.4.2.2.2 Non-metallic materials

Mechanical properties of non-metallic materials shall be tested as follows:

a) tensile, elongation, modulus:

   1) O-rings in accordance with ASTM D1414;

   2) all others in accordance with ASTM D412 (alternate ASTM methods are acceptable, where applicable);

   3) non-elastomers in accordance with ASTM D638 (alternate ASTM methods are acceptable, where applicable);

b) compression set (homogeneous elastomeric compounds only):

   1) O-rings in accordance with ASTM D1414;

   2) all others in accordance with ASTM D395;

c) durometer hardness:

   1) O-rings in accordance with ASTM D1415 or ASTM D2240 with shore M;

   2) all others in accordance with ASTM D2240 (plastics and other materials may be tested using ASTM Rockwell procedures 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 manufacturer's documented specifications;

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

7.4.3.2 Coatings and overlays

Coatings and overlays shall be controlled using documented 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 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.

7.4.3.4 Heat-treating-equipment qualification

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 inspected.

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

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, Section 5;

   2) procedures specified in BS 2M 54:1991, Section 7;

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

7.4.3.4.2 Instruments

Requirements for instruments are 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 Job lot traceability

All components, weldments and subassemblies of equipment supplied shall be traceable to a job lot. 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 specified requirements.

7.4.4.2 Items requiring traceability

Traceability of components, weldments, subassemblies and assemblies shall be in accordance with the grade specified in 7.4.1.

7.4.4.3 Document retention

Required documentation for traceability shall be retained for a minimum of five years from the date of origination.

7.4.5 Calibration systems

7.4.5.1 Measuring and testing equipment used for acceptance shall be identified, inspected, calibrated and adjusted at specific intervals in accordance with an internationally recognized standard, 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 If a pressure gauge is utilized, pressure measurements shall be made only within the range of 25 % to 75 % of the full span of the pressure gauge.

7.4.5.4 Pressure measuring devices shall be periodically calibrated with a master pressure measuring device or a dead weight tester at 25 %, 50 % and 75 % of full scale.

7.4.5.5 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

7.4.6.1 Requirements

7.4.6.1.1 All NDE instructions shall be approved by a Level III examiner qualified in accordance with ISO 9712.

7.4.6.1.2 All primary springs shall be magnetic-particle or liquid-penetrant inspected to verify conformance with the manufacturers' written specifications.

7.4.6.1.3 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 with the manufacturer's written specifications.

7.4.6.1.4 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 with the manufacturer's written specifications. The 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 carried out as follows:

a) method: in accordance with ASTM E165;

b) acceptance criteria: in accordance with ASME Boiler and Pressure Vessel Code, Section VIII:1998, *Pressure Vessels*, Division 1, Appendix 8.

7.4.6.2.2 Wet magnetic particle examination

Wet magnetic particle examination shall be carried out as follows:

a) method: in accordance with ISO 13665;

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 in which the length is equal to or greater than three times its width;

   3) rounded indication: any indication which is circular or elliptical in which the 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) shall be considered unacceptable;

   2) no relevant linear indications shall be allowed for weldments;

   3) no more than ten relevant indications shall be present in any 39 cm^2 (6 in^2) area;

   4) four or more rounded relevant indications in a line separated by less than 1,6 mm (1/16 in) shall be considered unacceptable.

7.4.6.2.3 Ultrasonic inspection of weldments

Ultrasonic inspection of weldments shall be carried out as follows:

a) method: in accordance with ASME Boiler and Pressure Vessel Code, Section V:1998, *Non-destructive Examination*, Article 5;

b) acceptance criteria: in accordance with ASME Boiler and Pressure Code, Section VIII:1998, *Pressure Vessels*, Division 1, Appendix 12.

7.4.6.2.4 Ultrasonic inspection of castings

Ultrasonic inspection of castings shall be carried out 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, minimum.

7.4.6.2.5 Ultrasonic inspection of forgings and wrought products

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

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

b) calibration:

   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 (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);

   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 of which any of 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 carried out as follows:

a) method: in accordance with ASTM E94;

b) acceptance criteria: in accordance with ASME Boiler and Pressure Vessel Code, Section VIII:1998, *Pressure Vessels*, Division 1, UW-51.

7.4.6.2.7 Radiographic inspection of castings

Radiographic inspection of castings shall be carried out as follows:

a) method: in accordance with ASTM E94;

b) acceptance criteria:

   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 1.

Table 1 — Maximum defect classification for castings

Defect type	Maximum defect classification
A	3
B	2
C	2 (all types)
D	None acceptable
E	None acceptable
F	None acceptable
G	None acceptable

7.4.6.2.8 Radiographic inspection of forgings

Radiographic inspection of forgings shall be carried out as follows:

a) method: in accordance with ASTM E94;

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

1) any type of crack or lap;

2) any other elongated indication with length, L, and wall thickness, d, as follows:

— $L > 6{,}4$ mm (1/4 in) for $d \leqslant 19$ mm (3/4 in)

— $L > 1/3\ d$ for 19 mm $< d \leqslant$ 57,2 mm (3/4 in $< d \leqslant$ 2 1/4 in)

— $L > 19$ mm (3/4 in) for $d >$ 57,2 mm (2 1/4 in)

3) any group of indications in a line that have an aggregate length greater than d in a length of 12 d.

7.4.7 Personnel qualifications

7.4.7.1 Personnel performing NDE shall be qualified in accordance with ISO 9712, Level II minimum for evaluation and interpretation.

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

7.4.7.3 All other personnel performing inspection for acceptance shall be qualified in accordance with 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.

7.4.9 Surface defect inspection(s)

The supplier/manufacturer shall inspect all accessible surfaces for cracks and damage, ensuring that the technical specification is met, before assembly of the lock mandrel and/or landing nipple.

7.4.10 Non-metallic materials 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 manufacturer's documented specifications.

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

7.4.10.4 The durometer hardness of O-rings or other elastomeric sealing elements shall be determined in accordance with ASTM D2240 or ASTM D1415. A test specimen manufactured from each batch may be used.

7.4.11 Thread inspection

7.4.11.1 All tapered thread tolerances, inspection requirements, gauging, gauging practice, gauge calibration and gauge certification shall be in accordance with ISO 10422.

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

7.4.12 Manufacturing non-conformities

Non-conformities shall be corrected in accordance with the manufacturer's quality plan. Weld repair shall be restricted to the weld only.

7.5 Functional testing

7.5.1 Lock mandrel

Functional testing of lock mandrels shall be carried out as follows.

a) 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 carried out with or without the sealing device. If the lock mandrel fails to set or retrieve properly, it fails the functional test.

b) The manufacturer shall document the functional test procedure and results.

7.5.2 Landing nipple

Functional testing of landing nipples shall be carried out as follows:

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

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

8 Repair and/or re-manufacture

Repair/re-manufacture activities for lock mandrels and landing nipples shall include the return of the product to a condition meeting all requirements stated in this International Standard or the edition of this International Standard in effect at the time of original manufacture.

Annex A
(informative)

Lock mandrel operating envelope

Figure A.1 represents an example of an operating envelope composed of the individual components for validation-grade V1. Values for pressure are plotted on the x-axis and those for temperature on the y-axis. Where more than one envelope is specified, the intersecting area defines the overall operating envelope of the final assembly.

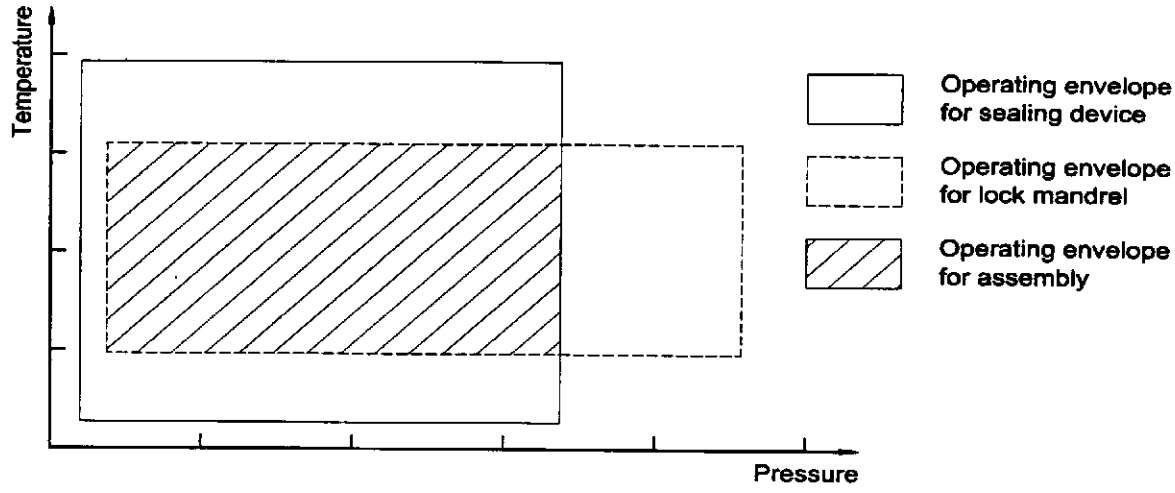


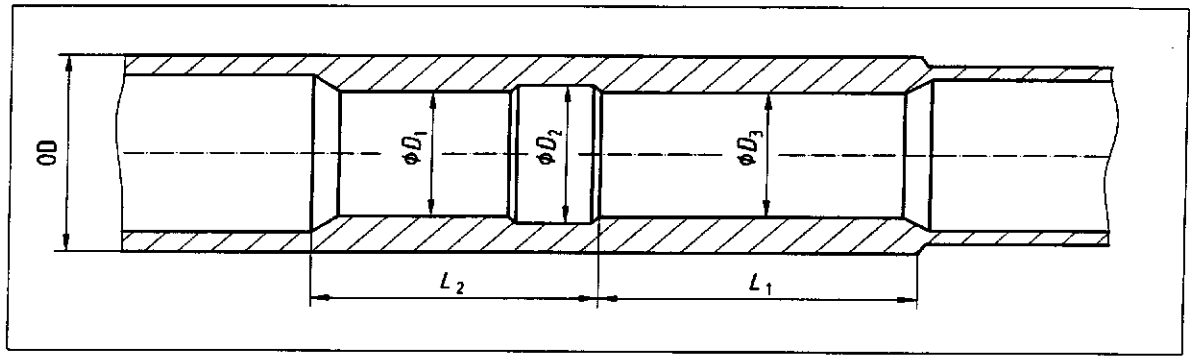
Figure A.1 — Example of an operating envelope boundary for a lock mandrel

Annex B
(informative)

Example of landing-nipple validation-test dimensional check sheet

Work order No: _____ Revision grade: _____

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: _____

Bibliography

[1] ISO/IEC Guide 22:1996, *General criteria for supplier's declaration of conformity*

[2] ISO/IEC Guide 44:1985, *General rules for ISO or IEC international third-party certification schemes for products*

[3] ISO 9000:2000, *Quality management systems — Fundamentals and vocabulary*

[4] ISO 11960, *Petroleum and natural gas industries — Steel pipes for use as casing or tubing for wells*

[5] ISO 10432, *Petroleum and natural gas industries — Downhole equipment — Subsurface safety valve equipment*

[6] API Spec 14A, *Specifications for subsurface safety valve equipment*

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