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**Petroleum and natural gas industries —
Drilling and production equipment —**

**Part 1:
Side-pocket mandrels**

*Industries du pétrole et du gaz naturel — Équipement de forage et de
production —*

Partie 1: Raccords à poche latérale



Reference number
ISO 17078-1:2004(E)

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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 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 17078-1 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*.

ISO 17078 consists of the following parts, under the general title *Petroleum and natural gas industries — Drilling and production equipment*:

— *Part 1: Side-pocket mandrels*

The following parts are under preparation:

— *Part 2: Side-pocket mandrel gas lift valve and flow control devices*

— *Part 3: Latches, seals, and interface data for side-pocket mandrels and flow control devices*

Introduction

This part of ISO 17078 has been developed by users/purchasers and suppliers/manufacturers of side-pocket mandrel products intended for use in the worldwide petroleum and natural gas industry. This part of ISO 17078 is intended to provide requirements and information to all parties who are involved in the specification, selection, manufacture, testing and use of side-pocket mandrel products. Further, this part of ISO 17078 addresses supplier/manufacture requirements that set the minimum parameters with which each supplier/manufacture shall comply, in order to be able to claim conformity with this part of ISO 17078.

This has been structured to allow different quality control grades to support quality control, design-validation, design-verification, and product-functional testing. These variations allow the user/purchaser to select the grades that are required for a specific application. If the user/purchaser does not specify a specific grade for the following categories, the supplier/manufacture will meet the requirements of grade 3.

Well environmental service classes. There are four environmental service classes for side-pocket mandrel products that provide the user/purchaser with a range of choices to select products to meet varying environmental conditions.

Design-validation grades. There are three design validation grades for side-pocket mandrel products that provide the user/purchaser with a range of technical and performance requirements. Users of this part of ISO 17078 should be aware that requirements in addition to those outlined herein might be needed for individual applications. This part of ISO 17078 is not intended to inhibit a supplier/manufacture from offering, or the user/purchaser from accepting, alternative equipment or engineering solutions. Where an alternative is offered, the supplier/manufacture should identify any variations from this part of ISO 17078 and provide details.

Product-functional testing grades. There are three product functional testing grades for side-pocket mandrel products that provide the user/purchaser with a range of choices for validating that individual products manufactured under this part of ISO 17078 meet the design specifications.

Quality-control grades. There are three quality-control grades that provide the user/purchaser with varying grades of quality control requirements to meet specific preferences or applications. Additional quality upgrades can be specified by the user/purchaser as supplemental requirements.

Annexes A, B, C and D of this part of ISO 17078 are normative requirements; Annexes E and F are informative.

1

Petroleum and natural gas industries — Drilling and production equipment —

Part 1: Side-pocket mandrels

1 Scope

This part of ISO 17078 provides requirements for side-pocket mandrels used in the petroleum and natural gas industry. This part of ISO 17078 includes specifying, selecting, designing, manufacturing, quality control, testing, and preparation for shipping of side-pocket mandrels.

This part of ISO 17078 does not address nor include requirements for end connections between the side-pocket mandrels and the well conduit. The installation and retrieval of side-pocket mandrels is outside the scope of this part of ISO 17078. Additionally, this part of ISO 17078 does not include specifications for centre-set mandrels, or mandrels that employ or support tubing-retrievable flow control devices.

This part of ISO 17078 does not include gas-lift or any other flow-control valves or devices, latches, and/or associated wire line equipment that can or cannot be covered in other ISO specifications.

The side-pocket mandrels to which this part of ISO 17078 refers are independent devices that can accept installation of flow-control or other devices down-hole.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 6506-1, *Metallic materials — Brinell 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 9000:2000, *Quality management systems — Fundamentals and vocabulary*

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

ISO 11960:2001, *Petroleum and natural gas industries — Steel pipes for use as casing or tubing for wells*

ISO 15156-1, *Petroleum and natural gas industries — Materials for use in H₂S-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 H₂S-containing environments in oil and gas production — Part 2: Cracking-resistant carbon and low alloy steels, and the use of cast irons*

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ISO 15156-3, *Petroleum and natural gas industries — Materials for use in H₂S-containing environments in oil and gas production — Part 3: Cracking-resistant CRAs (corrosion-resistant alloys) and other alloys*

ANSI/NCSL Z540-1, *Calibration Laboratories and Measuring and Test Equipment General Requirements*¹⁾

ASME Boiler and Pressure Vessel Code, Section V, *Nondestructive Examination*²⁾

ASME Boiler and Pressure Vessel Code, Section VIII, *Pressure Vessels, Division 1, Rules for Construction of Pressure Vessels*

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

ASTM E94, *Standard Guide for Radiographic Examination*³⁾

ASTM E140, *Standard Hardness Conversion Tables for Metals*

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

ASTM E709, *Standard Guide for Magnetic Particle Examination*

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

SAE AMS-H-6875:1998, *Heat Treatment of Steel Raw Materials*⁵⁾

3 Terms and definitions

For the purpose of this document, the terms and definitions given in ISO 9000:2000 and the following apply.

3.1 acceptance

agreement/acknowledgement that side-pocket mandrel component(s) and/or assembly(ies) can be used without restriction

3.2 certificate of conformance

documentation declaring that a specific side-pocket mandrel meets the requirements of this part of ISO 17078 and the requirements of the functional specification

3.3 coating

internal and/or external application of a material to a side-pocket mandrel for corrosion protection, paraffin control, etc.

3.4 compressive load

force creating compression that may be applied to a side-pocket mandrel

1) NCSL International, 2995 Wilderness Place, Suite 107, Boulder, Colorado 80301-5404, USA.

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

3) ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959, USA.

4) British Standards Institute, Customer Services, 389 Chiswick High Road, London W4 4AL, UK.

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

3.5**date of manufacture**

date of manufacturer's final acceptance of finished products

NOTE The date is expressed as "day-month-year" in the format DD-MM-YYYY.

3.6**deflector**

internal device that guards landed side-pocket devices or discriminates the landing of side-pocket devices into the side-pocket mandrel pocket (receptacle for mandrel devices), but deflects non-side-pocket devices, thus allowing the latter to pass through the side-pocket mandrel, when being deployed down hole

3.7**design family**

group of products whose configurations, sizes, materials and applications are sufficiently similar that identical design methodologies can be used to establish the design parameters for each product within the family

3.8**design method**

method, procedure or equations used by the supplier/manufacturer to design a side-pocket mandrel product

3.9**design validation**

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

[ISO/TS 29001:2003]

NOTE See also 5.7.

3.10**design verification**

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

[ISO/TS 29001:2003]

3.11**dogleg**

change in well bore inclination

NOTE The "severity" of the dogleg is proportional to the change in inclination, typically measured in degrees.

3.12**drift outside diameter**

tube's ID through which all elements of the assembled side-pocket mandrel can pass

3.13**end connection**

thread(s) on the side-pocket mandrel end(s) used to attach the side-pocket mandrel to the tubing string

3.14**environmental service class**

category of environmental conditions for which the side-pocket mandrel product is designed to be used

NOTE See also 5.6.

3.15**external drifting**

test to observe the unencumbered or unrestricted passage of a side-pocket mandrel having a specific diameter through a drift test tool of specified inside diameter and length

3.16

external test pressure

differential pressure between the applied external pressure and internal pressure at which a side-pocket mandrel is tested for collapse resistance

3.17

full life cycle

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

3.18

functionality

capability of a side-pocket mandrel to conform to defined properties, characteristics and limits

3.19

gas passage undercut

clearance between the flow-control device and the pocket of the side-pocket mandrel through which injected media flow

3.20

heat

material originating from a final melt or cast lot

NOTE For re-melted alloys, the heat is the raw material originating from a single re-melted ingot.

3.21

internal drifting

test to observe the unencumbered or unrestricted passage of a drift bar having a specific diameter and length through a side-pocket mandrel to determine its full-bore capability

3.22

internal test pressure

differential pressure between the applied internal pressure and external pressure at which a side-pocket mandrel is tested for burst resistance

3.23

job lot

group or quantity of piece parts, sub-assemblies or assemblies that are grouped or processed together during the manufacturing process

3.24

latch

retention mechanism for a flow-control device that is landed in the side-pocket mandrel

3.25

latch profile

feature such as a lug or recess that is suitable for the reception of the locking mechanism within a side-pocket mandrel

3.26

linear indication

material inconsistency whose length is equal to or greater than three times the width of the material inconsistency

3.27

linear mass

mass per length of tubular product

3.28**manufacturing**

process(es) and action(s) performed by an equipment supplier/manufacturee that are necessary to provide finished component(s), assemblies, and related documentation that fulfil the requests of the user/purchaser and that meet the standards of the supplier/manufacturee

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

3.29**model**

side-pocket mandrels with unique components and functional characteristics that differentiate it from other side-pocket mandrels of the same type

NOTE Side-pocket mandrels can have a variety of end connections.

3.30**operating environment**

set of environmental conditions to which the product is exposed during its service life

NOTE Environmental conditions can include temperature, pressure, liquid composition and properties, gas composition and properties, solids, etc.

3.31**operational parameter**

requirement and/or restriction that the product is exposed to during its service life

EXAMPLES Operating environment, through-tubing drift, landing and retrieval of flow-control devices, passage of various tools through the side-pocket mandrel, injection of various well treatment chemicals/fluids, etc.

3.32**orienting profile**

design feature (e.g. orienting sleeve) of a side-pocket mandrel that acts together with certain wireline tools to aid in radial and vertical alignment of tools used to install and remove side-pocket landed equipment

3.33**perceptible leak**

any leak during a hydro test that can be observed

3.34**pocket**

parallel bore, including sealing surfaces and latching profiles, that is offset from and essentially parallel with the through-bore of the side-pocket mandrel

3.35**product functional-testing grade**

category based on a defined range of processes, method(s) and/or test(s) that are used by the supplier/manufacturee to demonstrate that a particular side-pocket mandrel has been manufactured to fully meet the functional and manufacturing requirements for that product

3.36**quality-control grade**

category based on a defined range of processes and/or method(s) that are used by the supplier/manufacturee to assure the quality of the materials and manufacturing process(es) used to produce a particular side-pocket mandrel

3.37**rated pressure**

maximum differential pressure, at the rated temperature, to which the side-pocket mandrel is designed to be subjected in normal operation

3.38

rated temperature

maximum temperature, at the rated pressure, to which the mandrel is designed to be subjected in normal operation in a well

3.39

rounded indication

material inconsistency that is circular or elliptical in shape, such that the length of the material inconsistency is less than three times its width

3.40

side-pocket mandrel

tubing-mounted device that accepts a flow-control or other device in a bore that is offset from and essentially parallel with the through-bore of the tubing product

NOTE This parallel bore includes sealing surfaces and latching profiles.

3.41

special-service side-pocket mandrel

side-pocket mandrel designed for special operations including chemical injection, CO₂ injection, hydraulic control, electrical control, or other applications where a secondary conduit terminates at the side-pocket mandrel

3.42

supplier/manufacturer

company, organization or entity that designs, manufactures and/or markets side-pocket mandrel products

3.43

technical specification

parameter(s) stating the operating limit(s) relating to the manufacture of the component parts or assemblies

3.44

tensile load

maximum force creating tension that may be applied to a side-pocket mandrel, as defined by the supplier/manufacturer

3.45

test pressure

maximum differential pressure between the applied pressure and atmospheric pressure, as specified by the pertinent test procedure, when the test is conducted in such a way that the article being tested is a "closed" system with no inputs or outputs allowed during the test time period

3.46

test temperature

temperature, as specified by the pertinent test procedure, at which the test is conducted

3.47

traceability

(job lot) ability to identify individual components as originating from a particular job lot, including the particular heat(s)

3.48

type

kind of side-pocket mandrel or other component (e.g. valve, flow control device, latch, wireline tool, etc.) that is distinguished by a particular method of being positioned and retrieved from a well, and that has a specific name and/or description

3.49**user/purchaser**

company, organization or entity that purchases, installs and/or uses side-pocket mandrel products

3.50**wireline**

one type of equipment and associated technique(s) used to perform various operations in a well using a continuous length of solid line (slick line) or stranded wire, appropriate spooling equipment at the surface and weight stem and specialized tools attached to the well (downhole) end of the wire

3.51**yield strength**

stress level measured at a specific test temperature beyond which the material plastically deforms and will not return to its original dimensions

NOTE The yield strength is expressed in units of force per unit area.

4 Abbreviated terms

AWS	American welding society
COC	certificate of compliance
EOEC	exclusive of end connections
ID	inside diameter
NDE	non-destructive examination method
OD	outside diameter
PQR	procedure qualification record
<i>Ra</i>	roughness, expressed in micrometers (micro-inches)
WPS	welding procedure specification
WPQ	welder performance qualification

5 Functional specification**5.1 General**

The user/purchaser shall prepare a functional specification to order products that conform to this part of ISO 17078. The specification shall specify the requirements and operating conditions listed in 5.2 through 5.10, as appropriate, and/or identify the supplier's/manufacture's specific product. These requirements and operating conditions may be conveyed by means of a dimensional drawing, a data sheet, a functional specification form (see Annex E), or other suitable documentation.

5.2 Functional characteristics

A side-pocket mandrel is a tubing-mounted device that accepts a flow-control or other device in a bore that is offset from and essentially parallel with the through-bore of the tubing product. This parallel bore includes sealing surfaces and latching profiles.

The user/purchaser shall specify, as applicable, the following functional characteristics:

- latch: nominal size and/or type and/or model(s) of the latch(es) used to secure the flow-control or other equipment to the side-pocket mandrel;
- seal bore: nominal seal bore size and configuration to accommodate the flow-control or other devices and/or the model(s) of the flow-control or other device(s) to be installed in the side-pocket mandrel;
- communication ports: location and configuration of the internal and external communication ports or outlets on the side-pocket mandrel and/or the specification for which the side-pocket mandrel is to be used and/or the model(s) of the flow-control or other device(s) to be installed in the mandrel;
- conduit ports: connection size and configuration for the external ports and outlets to which side-string, control or injection conduits are to be attached;
- tubing connections: top and bottom tubular connection(s) and the material and dimensions of the side-pocket mandrel that is connected to the tubing; or tubing size, thread, mass, grade, and material to which the side-pocket mandrel will be connected;
- loading conditions: loading conditions anticipated to be applied to the side-pocket mandrel, including but not limited to tensile loads, burst pressures, collapse pressures, bending stresses, etc.

5.3 Well parameters

5.3.1 General

The user/purchaser shall specify the well parameters listed in 5.3.2 through 5.3.5, as applicable.

5.3.2 Well-fluid parameters

Well-fluid parameters include production/injection composition, specific gravity, chemical/physical composition and the condition of the fluid and/or its components, in the form of solids (sand production, scale, paraffin, etc.), liquids, and/or gases to which the side-pocket mandrel will be exposed during its full life cycle, together with both the minimum and the maximum anticipated values of the production/injection pressures, pressure differentials, temperatures and expected flow rates.

5.3.3 Well physical parameters

The following physical well parameters shall be defined:

- size, material, mass and grade of the casing and tubing;
- well depth and trajectory from the vertical to the installed position;
- deviations and restrictions through which the product is required to pass;
- loading conditions anticipated to be applied to the side-pocket mandrel.

5.3.4 Allowable well operations

Expected well intervention(s) together with its (their) parameters include the following:

- acidizing, including acid composition, pressure, temperature, and acidizing velocity as well as exposure time, and any other chemicals used during the stimulation;
- fracturing, including proppant description, fracture fluid velocity, proppant/fluid ratio;

- sand consolidation operations;
- electric line, wireline, coiled tubing, snubbing, and other through-tubing conveyance methods;
- devices which might be run/installed via these means;
- size, type, and configuration of other products to be used in conjunction with the side-pocket mandrel, where applicable;
- hole deflections including “doglegs.” State the depth of any “dogleg” and its measured deviation.

5.3.5 Corrosion information

If the user/purchaser has access to the corrosion property data for the operating environment based on historical data and/or research, this information may be made available to the supplier/manufacturer; or the user/purchaser shall indicate to the supplier/manufacturer which material(s) has/have the ability to perform as required within the particular corrosion environment.

5.4 Operational parameters

The user/purchaser shall specify specific installation, testing and operational parameters to which the side-pocket mandrel will be subjected. These shall include but are not limited to the following:

- expected maximum external-to-internal differential pressure across the side-pocket mandrel;
- expected maximum internal-to-external differential pressure across the side-pocket mandrel;
- expected maximum tubing force on the mandrel;
- expected maximum temperature at the mandrel;
- expected maximum gas- and/or fluid-injection rate and rate of fluid production at the mandrel;
- expected installation, testing, and operational procedures.

There can be exceptional operating conditions that require side-pocket mandrel products that are clearly outside of the scope of this part of ISO 17078. In such cases, the user/purchaser and the supplier/manufacturer should work together to design mutually acceptable products to meet these requirements and the intent of this part of ISO 17078.

5.5 Compatibility with related well devices

5.5.1 General

The user/purchaser shall provide data/information such as maximum length, maximum outside diameter, etc. on any other related well products (e.g. sub-surface safety valves, wireline tools, electrical cables, injection conduits, tubing strings and associated equipment for dual completions, etc.) that will be run in conjunction with the side-pocket mandrel. This information may be conveyed by means of a dimensional drawing, a data sheet, or other suitable documentation. The purpose is to assure compatibility between the other well products and the side-pocket mandrel.

5.5.2 Polished bore dimensions

Table 1 specifies the polished bore dimensions required for side-pocket mandrels built in accordance with this part of ISO 17078. There can be occasions where the design of the side-pocket mandrel can require polished bore dimensions other than those listed. In those cases, agreement between user/purchaser and supplier/manufacturer shall be documented.

5.6 Environmental service classes

The user/purchaser shall specify one of the following four environmental service classes, the requirements for which are specified in detail in Annex A. See also 6.3.2.

- E1: “standard” service;
- E2: “H₂S” or “sour” service;
- E3: “CO₂” service;
- E4: “special” service, for which the user/purchaser shall specify the service characteristics.

5.7 Design validation

The user/purchaser shall specify one of the following three design-validation grades, the requirements for which are defined in Annex B. See also 6.6.

- V3: basic level of design validation;
- V2: intermediate level of design validation (destructive testing or FEA/strain gauge testing);
- V1: highest level of design validation (FEA/strain gauge testing and special wireline operational testing).

5.8 Product functional testing grades

The user/purchaser shall specify one of the following three product functional testing grades, the requirements for which are defined in Annex C. See also 6.7.

- F3: basic level of product functional testing;
- F2: intermediate level of product functional testing;
- F1: highest level of product functional testing.

5.9 Quality-control grades

The user/purchaser shall specify one of the following three quality control grades, the requirements for which are defined in Annex D. See also 7.4.4.

- Q3: basic level of quality control;
- Q2: intermediate level of quality control;
- Q1: highest level of quality control.

5.10 Additional requirements

The user/purchaser may specify additional design-verification, design-validation testing and/or product-functional testing that is deemed necessary for a specific application. These requirements shall be in addition to those included herein.

6 Technical specification

6.1 General

The supplier/manufacturer shall prepare the technical specification to meet the requirements defined in the user/purchaser's functional specification. The supplier/manufacturer shall also provide to the user/purchaser the product data sheet as defined in 7.2.2.

6.2 Technical characteristics

6.2.1 Criteria

The supplier/manufacturer shall design and manufacture the side-pocket mandrel product in accordance with the functional criteria listed in 6.2.2 through 6.2.8.

6.2.2 Flow control device

The side-pocket mandrel shall receive, secure and provide a sealing receptacle for the flow-control or other device that is installed in the side-pocket mandrel and the flow-control device shall remain secured in place until human intervention establishes otherwise.

6.2.3 Functional requirements

While the flow-control or other device is installed, the side-pocket mandrel shall perform in accordance with its functional specification.

6.2.4 Safe tool passage

The side-pocket mandrel, where applicable, shall allow safe passage of tools as specified in 5.3.4.

6.2.5 Corrosion requirements

The supplier/manufacturer may specify materials for a specific corrosion environment in the functional specification (see 5.3.5). The user/purchaser shall be notified that this material has performance characteristics suitable for all parameters specified in the well and production/injection parameters (see 5.4). This applies to metallic and non-metallic components. Before any change in materials from those indicated by the user/purchaser, agreement shall be obtained.

6.2.6 Operating parameters

The side-pocket mandrel shall perform in conjunction with the operating parameters and characteristics as specified in the functional specification.

6.2.7 Other tools in the annulus

Other equipment can be required to be installed in the annulus of the well in accordance with the functional specification. This may include such items as another tubing string, if the well is completed as a dual flowing or gas-lift well.

6.2.8 Auxiliary connections

Connections to attach auxiliary tubes/cables that are implemented with the side-pocket mandrel shall meet the required pressure, temperature, and environmental specifications for the side-pocket mandrel.

6.3 Design criteria

6.3.1 General

The supplier/manufacturer shall use the design criteria listed in 6.3.2 through 6.3.9 in designing the side-pocket mandrel(s). Side-pocket mandrels conforming to this part of ISO 17078 shall be manufactured to drawings and specifications that are substantially the same as those for a side-pocket mandrel that has passed the design-validation test. Additive dimensional tolerances of components shall be such that proper operation of the side-pocket mandrel is assured. The design shall take into account the effects of pressure containment and pressure-induced loads.

6.3.2 Material environmental service class

The supplier/manufacturer shall meet the environmental service requirements as specified by the user purchaser. Specifications of the material requirements to be met in association with each environmental service class are included in Annex A.

6.3.3 Sealing bore diameters

The pocket of the side-pocket mandrel shall be designed and manufactured to provide sealing bore diameters in accordance with this subclause.

The side-pocket sealing bores shall be offset relative to the through-bore centreline of the side-pocket mandrel. The as-machined centreline of all sealing bores within a side-pocket shall be concentric to within 0,127 mm (0.005 in) or a total indicator reading of 0,254 mm (0.010 in).

The side-pocket sealing bore(s) designed to accommodate the valve packing shall have an as-machined finish with a maximum $Ra = 1,6 \mu\text{m}$ (63 μin). Sections or regions of the side-pocket ID not designed for packing-to-bore sealing but through which the packing shall move shall have a finish with a maximum $Ra = 1,6 \mu\text{m}$ (63 μin) or an ID at least 1,27 mm (0.050 in) larger than the maximum ID of the sealing bore. The dimensions in Table 1 shall be utilized as the minimum and maximum sealing bore diametric dimensions, unless there is an explicit agreement between the user/purchaser and the supplier/manufacturer to use other dimensions for a specific application.

NOTE The finish, Ra , is dimensioned in units of micrometres (micro-inches). $63 Ra (\mu\text{in}) = 1,6 Ra (\mu\text{m})$.

Table 1 — Nominal sealing bore diameters for side-pocket mandrels

Nominal valve OD		Upper seal		Lower seal	
mm	in	mm	in	mm	in
25,4	1.00	$26,086 \pm 0,127$	1.027 ± 0.005	$26,086 \pm 0,127$	1.027 ± 0.005
38,1	1.50	$39,573 \pm 0,127$	1.558 ± 0.005	$37,998 \pm 0,127$	1.496 ± 0.005

6.3.4 Maximum drift OD

For external drift testing, the supplier/manufacturer shall specify the maximum drift OD of the side-pocket mandrel in the side-pocket mandrel product data sheet.

6.3.5 Temperature effects on the various tensile, compressive and bending loads

It is the responsibility of the supplier/manufacturer to take into consideration the anticipated temperature effects on the tensile, compressive and bending load capabilities. The combined load and pressure ratings of the side-pocket mandrel can be affected. If this occurs, the supplier/manufacturer shall inform the user/purchaser.

6.3.6 Elastomers and non-metallics

Design of elastomeric and non-metallic components shall be in accordance with the supplier/manufacturer's documented requirements.

6.3.7 Tensile and compressive loads

The tensile and compressive load-carrying capacity of the side-pocket mandrel shall be specified and documented by the supplier/manufacturer. These values are for the side-pocket mandrel exclusive of end connections. They shall be based on the critical cross-section of the side-pocket mandrel.

6.3.8 Performance rating

The supplier/manufacturer shall state the pressure, temperature and axial maximum tensile and/or compressive load conditions used to determine the performance ratings, as applicable for the products. This information may be provided in an operating performance envelope; an example is given in Annex G.

NOTE Compressive loading is not a relevant parameter in the performance rating under normal operating conditions. This information is typically not available on non-round shapes. It can be provided with specific testing.

6.3.9 Design methods

The supplier/manufacturer shall design the side-pocket mandrels using one or more of the following:

- a) finite element analysis;
- b) proprietary equations and/or methods;
- c) standard equations;
- d) experimental stress analyses;
- e) proof test analysis.

This part of ISO 17078 does not dictate the methods, equations or procedures for design purposes.

All pressure-containing parts shall be designed to satisfy the manufacturer's test pressures and to meet the conditions defined in the functional specification. The assumptions, calculations and/or other design criterion shall be detailed in the design file for that product.

NOTE It is good design practice for all exterior protrusions to be well rounded and/or bevelled to prevent handling difficulties as the side-pocket mandrels are lowered into or retrieved from the well. Good design practice is also for all interior surfaces to be free of sharp shoulders and crevices that have no design function but which can interfere with other tools that are passing through the side-pocket mandrel.

6.4 Design verification

Design verification shall be performed to ensure that each 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 Allowable design changes

6.5.1 General

Side-pocket mandrels of the same design family may use the same documented design-validation test results. A design family shall consist of side-pocket mandrel products that have configurations, materials, and applications that are sufficiently similar to utilize a common methodology for establishing their design

performance. Design changes that affect the pressure- or load-bearing capacity of the side-pocket mandrel are not permitted. Documentation of design changes shall be maintained in the product-design file.

6.5.2 Design changes

Design changes to existing products within a design family that meet the following requirements shall not change the product's status as being part of the design family and shall not change the product's validation status by association within a qualified design family.

- The design changes do not require a change in the common methodology for establishing design performance within the design family.
- The operational parameters for the product(s) that are undergoing a design change are consistent with the operational parameters for the design family.

A design that undergoes a substantive change as defined by the supplier/manufacturer becomes a new design requiring design-validation and product-functional testing. Justifications for design changes that are identified as non-substantive shall be documented.

For side-pocket mandrels with unique or multiple features, new feature(s) that do not constitute a substantive change of the design shall be tested in accordance with the supplier/manufacturer's documented requirements for design validation of that feature. Acceptance criteria and results shall be documented.

6.6 Design validation

6.6.1 General

The supplier/manufacturer shall, as a minimum, use these design-validation procedures to assure that each side-pocket mandrel design family fulfils the functional requirements.

6.6.2 Design validation

Design-validation testing shall be performed on each size, type and model of side-pocket mandrel to ensure that the side-pocket mandrel design meets the supplier/manufacturer's technical specifications. The design-validation grade specifies the design-validation process(es), procedure(s) and test(s) required for each design-validation grade. See Annex B for a detailed description of each specific process, procedure or test.

6.6.3 Optional design-validation testing

Some applications can require additional design-validation testing. These shall be specified by the user/purchaser in the functional specification.

6.7 Product-functional testing requirements

6.7.1 General

The supplier/manufacturer shall use the following test(s) and/or process(es) to demonstrate that each side-pocket mandrel that is produced fully meets the design specifications.

6.7.2 Product functional testing

The process or procedure(s) that shall be followed for each product functional testing grade are included in Annex C.

6.7.3 Optional product functional testing

Some functional specifications can require additional product functional testing. These shall be defined by the user/purchaser in the functional specification, and contractually agreed to by the user/purchaser and supplier/manufacture.

7 Supplier/manufacture requirements

7.1 General

This clause contains the detailed requirements to verify that each product manufactured meets the functional specifications as defined in Clause 5 and the technical specifications as defined in Clause 6. As a minimum, each of the topics in 7.2 to 7.9 shall be addressed by the supplier/manufacture.

7.2 Documentation and data control

7.2.1 General

The supplier/manufacture shall establish and maintain documented procedures to control all documents and data that relate to the requirements of this part of ISO 17078. The retained 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 auditable by the user/purchaser. All design-validation, design-verification and product-functional testing documents and data, as listed below, shall be maintained for five years after date of last manufacture:

- functional and technical specifications;
- supplier/manufacture's quality manual;
- required grade of QC (quality control) documentation as defined in 5.9;
- one complete set of drawings, written specifications, design calculations and design standards;
- instructions providing methods for the safe installation and use of the side-pocket mandrel. This document shall specify the operations that are permitted and shall identify those operations that can lead to failure and/or non-compliance with the functional and performance requirements;
- material type, yield strength and connection identification for the actual end connection(s) provided with the side-pocket mandrel (where applicable);
- welding procedure specification (WPS);
- weld procedure qualification record (PQR);
- welder/welding operator performance qualification (WPQ).

7.2.2 User/purchaser documentation

A product data sheet for each line item on each order shall be supplied upon delivery of the order to the user/purchaser.

The product data sheet shall contain at least the following, where applicable:

- name and address of supplier/manufacture;

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- manufacturer's assembly part number;
- manufacturer's product name;
- product type;
- product characteristics;
- metallic materials;
- non-metallic materials;
- drift diameters;
- overall length;
- temperature range for rated pressure;
- rated pressure;
- top/bottom connection(s);
- conveyance method;
- maximum conveyance OD, inclusive of running equipment, as applicable;
- retrieval method (if retrievable);
- quality-control grade;
- design-validation grade;
- technical/operations manual identification;
- product-functional testing grade;
- environmental service class.

7.2.3 Technical/operations manual

A technical/operations manual shall be available for products supplied in accordance with this part of ISO 17078 and shall contain at least the following information:

- manual reference number and revision level;
- product data sheet;
- operational procedures;
- pre-installation inspection procedures;
- storage recommendations;
- representative drawing showing major dimensions (ODs, IDs and lengths);
- special precautions and handling.

7.2.4 Design documentation

It is recommended that documentation of designs include methods, assumptions, calculations and design requirements. Design requirements include but are not limited to those criteria for size, test pressures, materials, environment (temperature limits, service class, chemicals) and other pertinent requirements upon which the design is based. Design documentation may be reviewed and verified by a qualified individual other than the individual who created the original design.

7.3 Product identification requirements

7.3.1 General

The supplier/manufacturer shall clearly identify and mark each side-pocket mandrel according to the requirements in 7.3.2 and 7.3.3.

7.3.2 Product identification

Each product furnished to this part of ISO 17078 shall be permanently identified using low stress marking devices, which include interrupted dot or rounded cold, die stamp, or vibratory methods. Supplier/manufacturer specifications shall define the method(s) and location of the markings. The following information, as a minimum, shall be marked on each side-pocket mandrel:

- supplier/manufacturer's name or mark;
- date (month and year) of manufacture;
- supplier/manufacturer's part number and unique traceable serial number.

Painted marking requirements shall include an arrow pointing up and word "UP" adjacent to the arrow in capital letters on the flat of oval side-pocket mandrels and the round of round side-pocket mandrels toward the upper swage.

If the manufacturer's part number does not include thread type, size and mass, then this information shall be added as additional information.

7.3.3 Traceability

All components, weldments, sub-assemblies and assemblies of equipment supplied in accordance with this part of ISO 17078 shall be traceable to a job lot, which, for components and weldments, shall also identify the heat(s) or batch lot(s) included. All components and weldments in a multi-heat or batch job lot shall be rejected if any heat or batch does not comply with specified requirements. Individual component identification shall be maintained to facilitate traceability until the manufacturer's final inspection has been completed.

Traceability for side-pocket mandrels is considered sufficient if the equipment and documentation meet the requirements of this part of ISO 17078 when it leaves the manufacturer's inventory.

7.4 Quality-control requirement

7.4.1 General

This part of ISO 17078 provides for three quality-control grades. Requirements for each of these grades are specified in 7.4.4.

7.4.2 Quality control personnel qualifications

All personnel performing quality-control activities directly affecting material and product quality shall be qualified in accordance with the supplier/manufacturer's documented requirements.

7.4.3 Manufacturing non-conformance

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

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

- reworked to meet the specified requirements;
- accepted without repair by concession of supplier/manufacturer's authorized personnel, provided the violated manufacturing criterion is categorized as unnecessary to satisfy the design acceptance criteria;
- rejected or scrapped.

Repaired and/or reworked assemblies or components shall be inspected in accordance with the appropriate quality-control grade.

7.4.4 Quality-control grade selection

This part of ISO 17078 provides three grades of quality control for side-pocket mandrel products, as shown in Table D.1. The user/purchaser shall specify, in the functional specification, the grade of quality control and/or additional requirements when desired.

- **Q3** certification of conformance, on request of the user/purchaser;
- **Q2** certificate of conformance, plus additional NDE and mill certification for manufacturer-specified critical (for example, pressure-containing/pressure-retaining) components, on request of user/purchaser;
- **Q1** certification of conformance, plus additional NDE and mill certification on all components, except common hardware items, on request of user/purchaser.

As a minimum, products shall be supplied to Q3 unless the user/purchaser specifies grade Q2 or Q1.

NOTE The user/purchaser can also specify an additional quality/certification system to apply to equipment supplied to this part of ISO 17078. See Annex D for a detailed description of each specific process, procedure or test.

7.4.5 Measuring/testing equipment calibration

7.4.5.1 Measuring and testing equipment used for acceptance shall be identified, inspected, calibrated and adjusted at specific intervals in accordance with documented specifications, ANSI/NCSS Z540-1, and this part of ISO 17078.

7.4.5.2 Pressure-measuring devices shall

- a) be readable to at least $\pm 0,5$ % of full-scale range or less as required to perform the specified measurement;
- 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 Material certifications

Supplier/manufacture's mill-test certificate of original material or supplier/manufacture's certification of test results are acceptable if the certifications include test results for mechanical properties and chemical composition for that heat of material. If the material is altered by subsequent processes that change its properties, then acceptance shall be based on either hardness or mechanical properties tested in accordance with ISO 6892 on specimens from the heat of material in question. These tests shall be completed using the heat-treat cycle comparable to that for which the material is to be qualified. If the initial test samples fails, then two additional tests shall be successfully performed in order to qualify the material. The material shall be rejected if the results of either of two additional tests do not meet specified requirements. If hardness is used for final acceptance, then hardness-strength correlations shall be documented by the supplier/manufacture for that type of material.

Yield strength in this part of ISO 17078 is defined as the 0,2 % yield offset strength in accordance with ISO 6892.

Acceptance of all materials, as defined above, shall be indicated either on the materials or in the records traceable to the materials.

Raw material used in the manufacture of components shall meet the following requirements:

- certificate of conformance stating that the raw material meets the supplier/manufacture's documented specifications;
- material test report so that the manufacturer can verify that the raw material meets the supplier/manufacture's documented specifications;
- mechanical and physical properties (as applicable):
 - metallic materials: Mechanical-property test procedures and practices shall be in accordance with ISO 6892 for the metallic materials used for traceable components,
 - elastomers and non-metallics: Mechanical-property test procedures for elastomeric and non-metallic compound types shall be in accordance with the supplier/manufacture's documented requirements.

7.5 Heat treatment requirements

The following specifies the heat treatment requirements.

- a) Heat treating 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-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 Section 5 of SAE-AMS-H-6875,
 - 2) procedures specified in Section 7 of BS 2M 54,
 - 3) supplier/manufacture's written specifications, including acceptance criteria that are not less stringent than the procedures identified above.

7.6 Welding requirements

7.6.1 General

The supplier/manufacture's welding control system shall include requirements for monitoring, updating and controlling the qualifications of welders/welding operators and the use of welding procedure specifications. Instruments utilized to verify temperature, voltage and amperage shall be serviced and calibrated in accordance with the side-pocket mandrel supplier/manufacture's written procedures.

All welding procedures, welders and welding operators shall be qualified in accordance with ASME Boiler and Pressure Vessel Code, Section IX. Base metals that are not classified under the ASME P-number grouping shall be qualified as unassigned metals in accordance with QW-424.1, ASME Boiler and Pressure Vessel Code, Section IX.

7.6.2 Welding consumables

Welding consumables shall conform to AWS or supplier/manufacture's written specifications. The supplier/manufacture shall have a written procedure for selection, storage and control of welding consumables. Materials of low hydrogen type shall be stored and used as recommended by the manufacturer of welding consumables to retain their original low hydrogen properties.

7.6.3 Welding procedures and qualification records

7.6.3.1 General

Welding shall be performed in accordance with welding-procedure specifications written and qualified in accordance with Article II of ASME Boiler and Pressure Vessel Code, Section IX. The WPS shall describe all the essential and nonessential variables as defined in ASME Boiler and Pressure Vessel Code, Section IX. The procedure-qualification record shall record all essential variables as defined in ASME Boiler and Pressure Vessel Code, Section IX of the weld procedure used for the qualification test(s).

7.6.3.2 Hardness testing

The test weldment for hardness testing shall have the same type of post-weld heat treatment as the final product. For side-pocket mandrel environmental service class E2, hardness tests across the weld, base material and heat-affected zone (HAZ) cross-section shall be performed in accordance with ISO 6508-1 and recorded as part of the PQR. Maximum hardness values for environmental class E2 service shall not exceed the requirements of ISO 15156-1, ISO 15156-2 and/or ISO 15156-3.

NOTE For the purposes of this provision, NACE MR-01-75 is equivalent to ISO 15156-1, ISO 15156-2 and/or ISO 15156-3.

7.6.4 Welder/welding operator performance qualification

Welders and welding operators shall be qualified in accordance with Article III of ASME Boiler and Pressure Vessel Code, Section IX. Records of welding performance qualifications (WPQ) test shall include all welding parameters as detailed in ASME Section IX.

7.7 Non-destructive examination (NDE) requirements

7.7.1 General

The supplier/manufacture's qualified representative shall inspect all accessible surfaces for cracks and damage, ensuring that the technical specification is met.

NDE shall be performed and accepted in accordance with the supplier/manufacture's written specification that shall include the requirements defined in 7.7. The size of the sample of the components to be tested shall

be in accordance with the appropriate quality-control grade level as indicated in Table D.1. All welds and adjacent heat-affected zones of the specified sample lot shall be non-destructively examined by one or more of the following methods: radiography, magnetic particle, ultrasonic or liquid penetrant as designated in the supplier/manufacturer's specification.

If the examination produces an unacceptable indication as specified in 7.7.6, 7.7.7, 7.7.8 and/or 7.7.9, 20 % of the side-pocket mandrels from the job lot shall be examined. If another indication is found to be unacceptable, then 100 % of the job lot shall be examined. Any unacceptable indications shall be removed, repaired and re-examined using the original NDE method. A "report of non-conformance" shall be generated for non-conforming items. The disposition of all non-conforming items shall be documented.

7.7.2 NDE personnel qualification

Non-destructive examination personnel shall be qualified in accordance with requirements specified in ISO 9712 Level II, or supplier/manufacturer's requirements that are not less stringent.

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

7.7.3 NDE personnel qualification records

Records that document the qualifications of NDE testing personnel shall be maintained by the supplier/manufacturer.

7.7.4 Visual examination personnel qualifications

Personnel performing visual examinations shall have an annual eye examination in accordance with ISO 9712, as applicable to the discipline to be performed. The qualifications for personnel performing visual examination shall be in accordance with the supplier/manufacturer's written requirements.

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

7.7.5 Hardness examinations

Hardness testing shall be performed in accordance with procedures specified in ISO 6506-1 (for Brinell hardness) or ISO 6508-1 (for Rockwell hardness). The hardness acceptance criteria shall be in accordance with the supplier/manufacturer's specifications. All hardness conversions shall be in accordance with ASTM E140 or in accordance with documented test results performed on a particular material.

7.7.6 Radiographic examinations

Radiographic testing shall meet the requirements of ASTM E94. The acceptance criteria shall be in accordance with ASME Boiler and Pressure Vessel Code, Section VIII, Division I, UW-5I.

7.7.7 Ultrasonic examinations

Ultrasonic testing shall be in accordance with ASME Boiler and Pressure Vessel Code, Section V, Article 5. The acceptance criteria shall be in accordance with ASME Boiler and Pressure Code, Section VIII, Division 1, Appendix 12.

7.7.8 Magnetic particle examinations

Magnetic particle examinations shall be in accordance with the requirements of ASTM E709. The acceptance criteria are as follows:

- no relevant indication with a major dimension equal to or greater than 5 mm (3/16 in);
- no more than ten relevant indications in any continuous 40 cm² (6 in²) area;

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- no more than three relevant indications in a line separated by less than 1,6 mm (1/16 in) (edge-to-edge);
- no relevant linear indications;
- no rounded indications greater than 3 mm (1/8 in) for welds whose depth is 16 mm (5/8 in) or less; or 5 mm (3/16 in) for welds whose depth is greater than 16 mm (5/8 in).

7.7.9 Liquid penetrant examination

Liquid penetrant examination shall be in accordance with the requirements of ASTM E165. These acceptance criteria are as follows:

- no relevant linear indications;
- no relevant rounded indication with a major dimension equal to or greater than 5 mm (3/16 in);
- no more than three relevant rounded indications in a line separated by less than 1,6 mm (1/16 in) (edge to edge);
- no rounded indications greater than 3 mm (1/8 in) for welds whose depths are 16 mm (5/8 in) or less; or 5 mm (3/16 in) for welds whose depth is greater than 16 mm (5/8 in).

7.7.10 Component dimensional examination

Components and assemblies shall be dimensionally inspected to assure proper function and compliance with design criteria and technical specifications. The frequency of these examinations shall be performed as specified in the supplier/manufacturer's written requirements.

7.7.11 NDE evaluations

When NDE testing is defined in the functional and/or the technical specification, it shall be performed as specified therein.

Each side-pocket mandrel shall have hardness tests performed in accordance with the supplier/manufacturer's written procedure. The test results shall meet acceptance criteria as detailed in 7.7.5. The results of each evaluation shall be documented.

7.8 Storage and shipping preparation

7.8.1 General

The supplier/manufacturer shall comply with the requirements in 7.8.2 to 7.8.5 for storage and shipping of side-pocket mandrel products.

7.8.2 Draining, cleaning and/or drying

The processes for draining, cleaning and/or drying of side-pocket mandrel products, after they have been tested, shall be specified in the supplier/manufacturer's written procedures. The minimum standard shall be that the products are free of any foreign matter and/or liquids.

7.8.3 Threaded connections and packing bores

All threaded connections and packing bores shall be protected as specified in the supplier/manufacturer's written procedures. Protection of the threaded connections shall meet ISO 11960, or for a non-ISO thread, the thread supplier/manufacturer's written requirements. The minimum standard for the protection of the packing bores shall be the coating of the packing bores with a rust inhibitor in accordance with the supplier/manufacturer's written procedures.

7.8.4 Painting of side-pocket mandrels

The painting of side-pocket mandrels shall be done in accordance with the supplier/manufacturer's written procedures, which shall include details of the required protection of all threads and side-pocket packing bores and seals from paint spray. As a minimum standard, paint shall not be allowed in the packing bores or on the threaded surfaces.

7.8.5 Permanent marking prior to coating

Prior to coating, all permanent marking that is required by this part of ISO 17078 shall be completed. Active threads shall be coated only with the surface treatment specified by the manufacturer.

7.9 Repair

Repair activities to side-pocket mandrels shall return the product to a condition meeting all requirements stated in this part of ISO 17078 or of the edition in effect at the time of original manufacture.

Annex A (normative)

Environmental-service requirements

A.1 Purpose

A.1.1 General

The purpose of this normative annex is to provide the specified requirements for each of the four environmental service classes that are specified in this part of ISO 17078 (see 5.6). The supplier/manufacturer shall establish criteria and select materials to meet the requirements of the following environmental-service classifications, or use materials agreed by the user/purchaser.

Tableau A.1 — Environmental-service classes

Environmental-service classes	Characteristics
E1 — Standard service (see A.1.2)	Non-sour service
E2 — Sulfide stress cracking service (see A.1.3)	H ₂ S (sour) service ^a
E3 — CO ₂ service (see A.1.4)	CO ₂ service ^b
E4 — Special service (see A.1.5)	Special service requirements defined by the user/purchaser

a In accordance with ISO 15156-1, ISO 15156-2 and ISO 15156-3.

NOTE For the purposes of this provision, NACE MR-01-75 is equivalent to ISO 15156-1, ISO 15156-2 and/or ISO 15156-3.

b There are no published International Standards for CO₂ service. Each individual application shall be evaluated on a case-by-case basis.

A.1.2 Class E1 — Standard service

Service in fluids that have an H₂S partial pressure less than those listed for “sulfide stress cracking” in ISO 15156-1, ISO 15156-2 and ISO 15156-3 and no CO₂ content. The standard material used for this service is 4130/4140 low-alloy steel (HRC 26 — 36). Other materials may be acceptable for this service if approved by the user/purchaser.

NOTE For the purposes of this provision, NACE MR-01-75 is equivalent to ISO 15156-1, ISO 15156-2 and/or ISO 15156-3.

A.1.3 Class E2 — Sulfide stress cracking or H₂S (sour) service

Service in fluids that have an H₂S partial pressure greater than those listed for “sulfide stress cracking” in ISO 15156-1, ISO 15156-2 and ISO 15156-3 and no CO₂ content. Materials used for this service shall be compatible with NACE standards. Any welding processes used for this service shall meet NACE requirements.

NOTE For the purposes of this provision, NACE MR-01-75 is equivalent to ISO 15156-1, ISO 15156-2 and/or ISO 15156-3.

A.1.4 Class E3 — CO₂ service

Service in fluids that have an H₂S partial pressure less than those listed for “sulfide stress cracking” in ISO 15156-1, ISO 15156-2 and ISO 15156-3 but do have CO₂ present. Examples of acceptable materials for this service, in order of resistance to CO₂ corrosion, are 9 Chrome, 410 Stainless Steel, 420 Stainless Steel, 13 Chrome, Super 13 Chrome, 22 Chrome, and Custom 450 Stainless Steel. Other materials may be acceptable for this service if approved by the user/purchaser.

NOTE For the purposes of this provision, NACE MR-01-75 is equivalent to ISO 15156-1, ISO 15156-2 and/or ISO 15156-3.

A.1.5 Class E4 — Special service (to be defined by user/purchaser)

This class may be used by the user/purchaser to specify “special” service requirements that are not otherwise covered in this part of ISO 17078. An example of this type of service might be a combination of both H₂S and CO₂.

Annex B
(normative)

Design-validation requirements

B.1 Purpose

B.1.1 General

Each design-validation grade requires a number of individual validation procedure(s), process(es) and test(s). The results shall be maintained in a design-validation file that shall be legible and retrievable. The file shall contain the test results that validate the design and shall be reviewed and approved by a qualified person other than the originator. This review shall confirm that, as a minimum, all of the design-validation requirements of this part of ISO 17078 have been met.

The specific procedures to be followed for each validation procedure, process and test shall be documented by the supplier/manufacturer. For all pressure tests, all test pressures and associated temperatures shall be recorded on a continuous, time-based data collection file (system) and these test pressure and temperature readings shall be maintained in the validation test file. Pressure measurements shall be accurate to within 1,0 % of full scale of the pressure-measurement device. Products qualified to a higher grade of design validation may be considered as qualified to any of the lower grades of design validation.

Three design validation grades with referenced clause requirements are shown in Table B.1.

Table B.1 — Design-validation grades

Criterion	Grade		
	V3	V2	V1
documentation	B.1.2.2	B.1.3.2	B.1.4.2
design review (burst, collapse, tolerance)	B.1.2.3	B.1.3.3	B.1.4.3
burst and collapse validation pressure test to destruction at ambient temperature	not required	B.1.3.4 or B.1.4.6	not required
pressure testing at rated temperature	B.1.2.4	B.1.3.5	B.1.4.4
internal pressure cycles	not required	B.1.3.6	B.1.4.5
finite element analysis/strain gauge	not required	not required	B.1.4.6
flow control – install/pull with kick-over tool	B.1.2.5	B.1.3.7	B.1.4.7
slick line operational test with kick-over tool	not required	not required	B.1.4.8
product-validation internal drift test	C.1.2.3	C.1.2.3	C.1.2.3
product-validation external drift test	C.1.2.4	C.1.2.4	C.1.2.4

B.1.2 Grade V3 — Basic level or grade of side-pocket mandrel design validation

B.1.2.1 General

Grade V3 design-validation tests shall be conducted in the order shown. One or more of the test-specimen side-pocket mandrel(s) selected for this test shall pass each of these tests. In addition, any one or more specimens selected for this test shall pass, as a minimum, the product-functional testing grade F3 tests listed in Annex C. These product-functional tests shall be conducted in the order listed, after all of the design-validation tests have been completed.

B.1.2.2 Documentation

The supplier/manufacturer shall demonstrate, by use of documented historical records, that the subject side-pocket mandrel product has been on the market for a minimum of two years, that a minimum of 200 mandrels of the subject product have been sold to end users, and that a minimum of 100 mandrels have been placed in service by end users.

B.1.2.3 Design review (burst, collapse, tolerance)

The supplier/manufacturer shall have conducted a design review on this side-pocket mandrel product. The design-review document shall include a review of the burst, collapse and tensile strength characteristics of the design, and the tolerance accumulations of the design to insure that it meets the technical specifications.

B.1.2.4 Pressure testing at maximum rated temperature

This is a hydrostatic or liquid-media internal-pressure test. The test shall be conducted at or above the rated pressure and maximum rated temperature. The tested mandrel shall hold the test pressure for a minimum of 5 min. The test pressure shall remain stable within $\pm 2\%$.

B.1.2.5 Flow control — Install/pull

This test is conducted with the side-pocket mandrel installed in a horizontal position in a vice, with the pocket located at the top of the mandrel, or in the “12 o’clock” position. A dummy flow control device with an appropriate latching mechanism shall be inserted into the mandrel pocket, latched in the pocket and retrieved from the pocket, using the supplier/manufacture’s procedures and acceptance criteria. This test shall be conducted using each of the latches, running tools, pulling tools and kick-over tools that are claimed to be compatible with this side-pocket mandrel. The tool string shall consist of a knuckle joint directly connected to the kick-over tool with appropriate weight bars and jars. The side-pocket mandrel shall have a pup joint having a minimum length of 1,22 m (4 ft) attached to the upper mandrel connection.

Side-pocket mandrels that do not have an orienting profile shall be tested at a minimum 15 degree angle from vertical inclination.

B.1.3 Grade V2 — Intermediate level or grade of side-pocket mandrel design validation

B.1.3.1 General

The grade V2 design-validation tests shall be conducted in the order shown. One or more of the test-specimen side-pocket mandrel(s) selected for this test shall pass each of these tests, with the exception that only one test specimen shall be burst-pressure tested to failure, and only one shall be collapse-pressure tested to failure. In addition, any one or more of the side-pocket mandrel(s) selected for this test, except for those that are failed in the burst- and collapse-pressure tests, shall pass, as a minimum, the product-functional testing grade F3 tests listed in Annex C. These product-functional tests shall be conducted in the order listed, after all of the design validation tests have been completed.

B.1.3.2 Documentation

The design file shall include all of the design-verification assumptions, calculations, model evaluations, test results and any other supporting documentation that has been used to verify the design.

B.1.3.3 Design review (burst, collapse, tolerance)

Comply with B.1.2.3.

B.1.3.4 Burst and collapse pressure test to destruction at ambient temperature

B.1.3.4.1 Burst

A minimum of one specimen of this design shall be internally pressure tested to failure. This shall be a hydro test at ambient temperature. When conducting this test, the pressures where permanent deformation occurs and where failure occurs shall be recorded.

B.1.3.4.2 Collapse

A minimum of one specimen of this design shall be externally pressure tested to failure. This shall be a hydro test at ambient temperature. When conducting this test, the pressures where permanent deformation occurs and where failure occurs shall be recorded.

B.1.3.5 Pressure testing at maximum rated temperature

Comply with B.1.2.4

B.1.3.6 Internal pressure cycles

This is an internal hydrostatic test. The internal pressure shall be raised to the rated pressure at ambient temperature, held at this value for a minimum of 2 min, with a maximum of 2 % pressure reduction and with no perceptible leaks, and then bled to atmospheric. This cycle shall be repeated a minimum of 10 times. On the last cycle, the pressure shall be held for a minimum of 5 min after the test side-pocket mandrel has been isolated from the pressure source.

B.1.3.7 Flow control — Install/pull

This test shall be conducted with the side-pocket mandrel installed in a horizontal position, in a vice, with the pocket located at the top, side, and bottom of the mandrel, or in the “12 o'clock,” “3 o'clock” and “6 o'clock” positions. In each orientation, a dummy flow control device with an appropriate latching mechanism shall be inserted into the mandrel pocket, latched in the pocket, and retrieved from the pocket, using the supplier/manufacturer’s procedures and acceptance criteria. This test shall be conducted using each of the latches, running tools, pulling tools, and kick-over tools that are claimed to be compatible with this side-pocket mandrel. The tool string shall consist of a knuckle joint directly connected to the kick-over tool with appropriate weight bars and jars. The side-pocket mandrel shall have a pup joint having a minimum length of 1,22 m (4 ft) attached to the upper mandrel connection.

Side-pocket mandrels that do not have an orienting profile shall be tested at a minimum 15 degree angle from vertical inclination.

B.1.4 Grade V1 — Highest level or grade of side-pocket mandrel design validation

B.1.4.1 General

The grade V1 design-validation tests shall be conducted in the order shown. One or more of the test specimen side-pocket mandrel(s) selected for this test shall pass each of these tests. In addition, any one or more specimens selected for this test shall pass, as a minimum, the product functional testing grade F3 tests listed

in Annex C. These product-functional tests shall be conducted in the order listed, after all of the design-validation tests have been completed.

B.1.4.2 Documentation

Comply with B.1.3.2.

B.1.4.3 Design review (burst, collapse, tolerance)

Comply with B.1.2.3.

B.1.4.4 Pressure testing at maximum rated temperature

Comply with B.1.2.4.

B.1.4.5 Internal pressure cycles

Comply with B.1.3.6.

B.1.4.6 Finite element analysis and strain-gauge test

B.1.4.6.1 Finite element analysis (FEA)

A finite element analysis shall be conducted to define, as a minimum, the rated pressure of the side-pocket mandrel under internal pressure, external pressure and tensile loading conditions. All assumptions and conclusions shall be documented as part of the analysis.

B.1.4.6.2 Strain-gauge test

Strain gauges, mounted both circumferentially and longitudinally on the side-pocket mandrel, shall be used to verify the finite element analysis in a full-scale test to the rated limits. To be acceptable, the measured strains shall be within 5 % of the values calculated by the FEA.

B.1.4.7 Flow control — Install/pull

Comply with B.1.3.7.

B.1.4.8 Slick-line operational test with kick-over tool

This test shall be conducted with the side-pocket mandrel installed at a 45° inclination with the pocket located at the top, side and bottom of the mandrel or in the “12 o'clock, 3 o'clock, and 6 o'clock” positions. A pup joint having a minimum length of 3,05 m (10 ft) shall be connected on the upper end of the mandrel and a pup joint with a minimum length of 1,83 m (6 ft) on the lower end. A lubricator stack shall be installed on the upper end of the top pup joint. In each orientation, a dummy flow-control device with an appropriate latching mechanism shall be inserted into the mandrel pocket, latched in the pocket and retrieved from the pocket using each of the kick-over tools that are claimed by the supplier/manufacturer to be compatible with this side-pocket mandrel, using the supplier/manufacturer's procedures and acceptance criteria. The kick-over tools shall be run into and out of the mandrels using slick line.

A further requirement of this test shall be to insert each of the kick-over tools into the bottom of the mandrel body without pup joints or other threaded accessories to verify that the tool, when inserted into the mandrel, does not trip the kick-over tool or hang up in the mandrel body at any point below the orienting sleeve. This test shall be re-run with the mandrel in a fixed (12 o'clock) position and the kick-over tool oriented and held at 10° increments from the top (12 o'clock) position to the bottom (6 o'clock) position.

Annex C
(normative)

Product-functional testing requirements

C.1 Purpose

C.1.1 General

Each product-functional testing grade requires a number of individual functional testing procedure(s), process(es) or test(s). The results of all of these shall be maintained in manufacturing or quality-control files.

The specific procedures to be followed for each functional test shall be documented by the supplier/manufacturer. For all pressure tests, test pressures shall be recorded on a continuous, time-based data collection file (system) and these pressure and temperature test readings shall be maintained. Pressure measurements shall be accurate to within 1,0 % of full scale of the pressure-measurement device.

Three product functional test grades with references to the subclauses specifying the requirements are shown in Table C.1

Table C.1 — Product functional testing grades

Criterion	Grade		
	F3	F2	F1
internal pressure test	C.1.2.2	C.1.3.2	C.1.4.2
external pressure test	not required	C.1.3.3	C.1.4.3
internal diameter drift test	C.1.2.3	C.1.3.4	C.1.4.4
external diameter drift test	C.1.2.4	C.1.3.5	C.1.4.5
installation/removal method — kick-over tool	not required	C.1.3.6	C.1.4.6

C.1.2 Grade F3 — Basic level or grade of side-pocket mandrel product functional testing

C.1.2.1 General

The product functional tests for grade F3 listed in C.1.2.2 through C.1.2.4 shall be conducted in the order shown.

C.1.2.2 Internal pressure test

This is a hydro or liquid-media internal pressure test. It shall be conducted on 100 % of the side-pocket mandrels in each job lot. It shall be conducted at or above the rated pressure and at ambient temperature. The tested mandrel shall hold the test pressure for a minimum of 5 min after stabilization of the pressure. To be considered stabilized, the pressure shall remain “constant” with a variation of less than ± 2 % of the test pressure. There shall be no perceptible leaks in the mandrel body.

C.1.2.3 Internal diameter drift test

A drift bar having a standard minimum length of 106,68 cm (42 in) (as specified in ISO 11960) shall pass unencumbered through the side-pocket mandrel with a flow-control device and latch in place in the mandrel pocket. The outside diameter of the drift bar shall be the drift internal diameter of the side-pocket mandrel being tested, with a tolerance in accordance with ISO 11960. This shall be performed on 100 % of the mandrels in each job lot. The drift bar shall be maintained and verified as part of the supplier/manufacturer's standard calibration program.

C.1.2.4 External diameter drift test

The side-pocket mandrel shall pass unencumbered through a section of casing or an equivalent tube or fixture that has an ID not greater than the drift OD of the side-pocket mandrel. This shall be performed on 100 % of the mandrels in each job lot. The minimum length of the piece of casing, tube or fixture shall be at least as long as the side-pocket mandrel. The internal diameter of the test casing, tube section or test fixture shall be maintained and verified as part of the supplier/manufacturer's standard calibration program.

C.1.3 Grade F2 — Intermediate level or grade of side-pocket mandrel product functional testing**C.1.3.1 General**

The product-functional tests for grade F2 listed in C.1.3.2 through C.1.3.6 shall be conducted in the order shown.

C.1.3.2 Internal pressure test

Comply with C.1.2.2.

C.1.3.3 External pressure test

This test is a hydro or liquid-media external pressure test. It shall be conducted on 5 % of each job lot or a minimum of one mandrel. It shall be conducted at or above the rated pressure and at ambient temperature. The tested mandrel shall hold the test pressure for a minimum of 5 min after stabilization of the pressure. To be considered stabilized, the pressure shall remain "constant" with a variation of less than ± 2 % of the test pressure.

C.1.3.4 Internal diameter drift test

Comply with C.1.2.3.

C.1.3.5 External diameter drift test

Comply with C.1.2.4.

C.1.3.6 Installation/removal method — Kick-over tool

This test is conducted with the side-pocket mandrel installed in a horizontal position in a vice, with the pocket located at the top of the mandrel or in the "12 o'clock" position. It shall be conducted on 5 % of each job lot or a minimum of one mandrel. A flow-control device with an appropriate latching mechanism shall be inserted into the mandrel pocket, latched in the pocket and retrieved from the pocket using the kick-over tool that the user/purchaser specifies, using the supplier/manufacturer's procedures and acceptance criteria. If no specific tool is specified, the supplier/manufacturer shall choose a tool and document this choice in the test record.

C.1.4 Grade F1 — Highest level or grade of side-pocket mandrel product functional testing

C.1.4.1 General

The product-functional tests for grade F3 listed in C.1.4.2 through C.1.4.6 shall be conducted in the order shown.

C.1.4.2 Internal pressure test

Comply with C.1.2.2.

C.1.4.3 External pressure test

This test is a hydro or liquid-media external pressure test. It shall be conducted on 100 % of each job lot or a minimum of one mandrel. It shall be conducted at or above the rated pressure and at ambient temperature. The tested mandrel shall hold the test pressure for a minimum of 5 min after stabilization of the pressure. To be considered stabilized, the pressure shall remain “constant” with a variation of less than ± 2 % of the test pressure.

C.1.4.4 Internal diameter drift test

Comply with C.1.2.3.

C.1.4.5 External diameter drift test

Comply with C.1.2.4.

C.1.4.6 Installation/removal method — Kick-over tool

This test is conducted with the side-pocket mandrel installed in a horizontal position in a vice, with the pocket located at the top of the mandrel or in the “12 o’clock” position. It shall be conducted on 100 % of each job lot or a minimum of one mandrel. A flow-control device with an appropriate latching mechanism shall be inserted into the mandrel pocket, latched in the pocket and retrieved from the pocket using the kick-over tool that the user/purchaser specifies, using the supplier/manufacturer’s procedures and acceptance criteria. If no specific tool is specified, the supplier/manufacturer shall choose a tool and document this choice in the test record.

Annex D (normative)

Quality-control requirements

D.1 Purpose

D.1.1 General

Each quality-control grade requires a number of individual procedure(s), process(es) or test(s). The results of all of these shall be maintained in manufacturing or quality-control files.

Three quality-control grades with references to the subclauses specifying the requirements are shown in Table D.1

Table D.1 — Quality control grade

Criterion	Grade		
	Q3	Q2	Q1
hardness testing	D.1.2.1	D.1.3.1	D.1.4.1
non-destructive examination	not required	D.1.3.2	D.1.4.2
documentation	D.1.2.2	D.1.3.3	D.1.4.3

D.1.2 Grade Q3 — Basic level or grade of side-pocket mandrel quality control

D.1.2.1 Hardness testing

The hardness of the side-pocket mandrel shall be determined at a minimum of two locations: one near the upper end and one near the lower end of the side-pocket upset area. This test shall be conducted on 100 % of the mandrels in each job lot. All hardness examinations shall be conducted in accordance with 7.7.5.

D.1.2.2 Documentation

If it is required by the user/purchaser, the documentation shall include a certificate of conformance (COC) for the side-pocket mandrel job lot.

D.1.3 Grade Q2 — Intermediate level or grade of side-pocket mandrel quality control

D.1.3.1 Hardness testing

The hardness of the side-pocket mandrel shall be determined at a minimum of three locations: one near the upper end and one near the lower end of the side-pocket upset area, and one in a weld zone. This test shall be conducted on 100 % of the mandrels in each job lot. All hardness examinations shall be conducted in accordance with 7.7.5.

D.1.3.2 Non-destructive examination

For quality-control level Q2, one of the following four tests shall be performed as specified by the supplier/manufacturer. It shall be performed on 5 % of the side-pocket mandrels of each job lot. The sampling process shall be in accordance with 7.7.1.

- Magnetic particle examination shall be in accordance with 7.7.8.
- Liquid penetrant examination shall be in accordance with 7.7.9.
- Radiographic examination shall be in accordance with 7.7.6.
- Ultrasonic examination shall be in accordance with 7.7.7.

D.1.3.3 Documentation

If it is required by the user/purchaser, the documentation shall include a certificate of conformance (COC) for the side-pocket mandrel job lot. It shall also contain additional NDE and mill certifications for supplier/manufacturer-specified critical components as specified in 7.4.6.

D.1.4 Grade Q1 — Highest level or grade of side-pocket mandrel quality control

D.1.4.1 Hardness testing

The hardness of the side-pocket mandrel shall be determined at a minimum of four locations: one near the upper end, one near the middle, and one near the lower end of the side-pocket upset area, and one in a weld zone. This test shall be conducted on 100 % of the mandrels in each job lot. All hardness examinations shall be conducted in accordance with 7.7.5.

D.1.4.2 Non-destructive examination

One hundred percent (100 %) of the side-pocket mandrels of each job lot shall undergo radiographic examination in accordance with 7.7.6.

D.1.4.3 Documentation

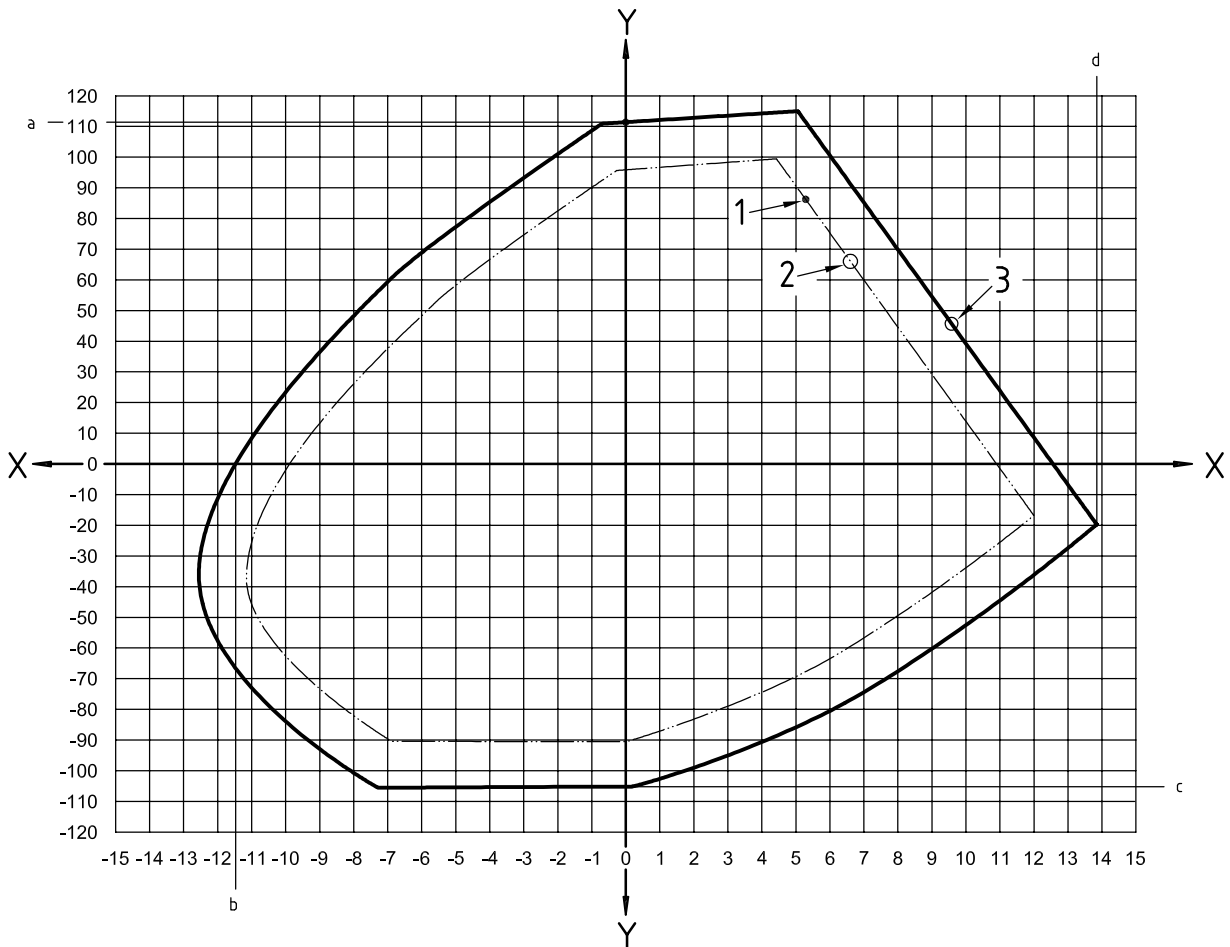
If it is required by the user/purchaser, the documentation shall include a certificate of conformance (COC) for the side-pocket mandrel job lot. It shall also contain additional NDE and mill certifications for all components as specified in 7.4.6.

Annex E (informative)

Operating performance envelope

E.1 Purpose

The side-pocket mandrel operating-performance envelope shown in Figures E.1 (with SI units) and E.2 (with customary US units) is based on a plot of pressure on the Y axis and axial load on the X axis. At the centre of the plot, both the pressure and axial load are 0,0. An increase in pressure (increase from 0,0 along the Y axis) indicates an increase in the burst pressure; a decrease is an increase in the collapse pressure. An increase in the axial load (increase from 0,0 along the X axis) indicates an increase in the tensile load; a decrease is an increase in the compressive load. The maximum operating temperature is determined from a combination of the pressure and the load and shall plot within the inner envelope.



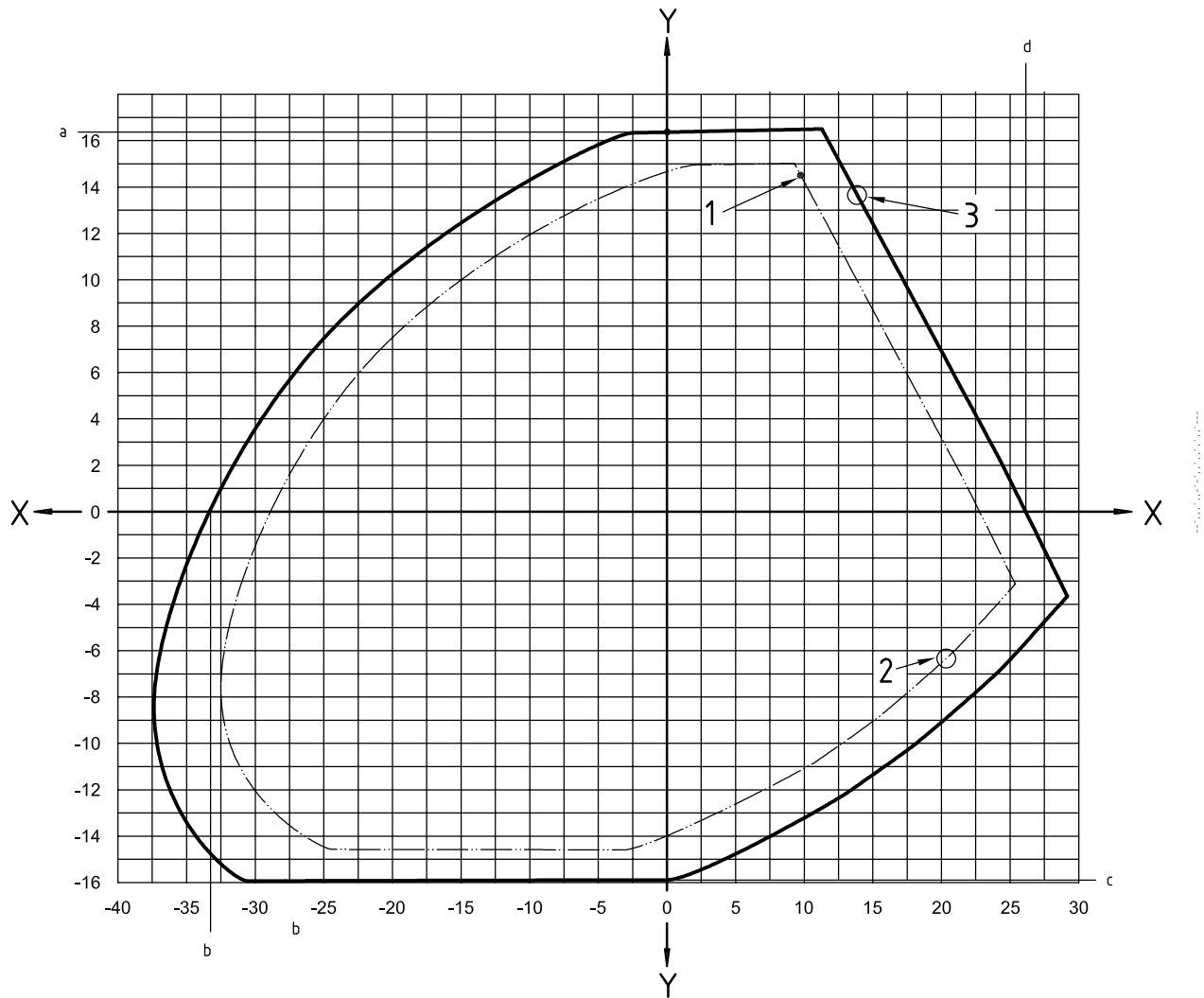
Key

- X axial load, expressed in meganewtons (+x, range of tension; -x, range of compression)
- Y pressure, expressed in megapascals (+y, range of burst pressure; -y, range of collapse pressure)
- 1 inner envelope
- 2 maximum temperature
- 3 room temperature
- a 112,7 MPa.
- b -1 156 kN.
- c -106,6 MPa.
- d 1 387 kN.

NOTE 1 Pressure is differential pressure.

NOTE 2 With respect to compressive loading, diagrams such as this are not feasible for non-circular cross-sections (e.g. oval configurations) without specific tests.

Figure E.1 — Example 1 of a typical operating pressure envelope (SI units)



Key

X axial load, expressed in pounds-force $\times 10^4$ (+x, range of tension; -x, range of compression)
 Y pressure, expressed in psi $\times 10^3$ (+y, range of burst pressure; -y, range of collapse pressure)

- 1 inner envelope
- 2 maximum temperature
- 3 room temperature

- a 16 350 psi.
- b -332 581 lb-f.
- c -15 902 psi.
- d 203 305 lb-f.

NOTE 1 Pressure is differential pressure.

NOTE 2 With respect to compressive loading, diagrams such as this are not feasible for non-circular cross-sections (e.g. oval configurations) without specific tests.

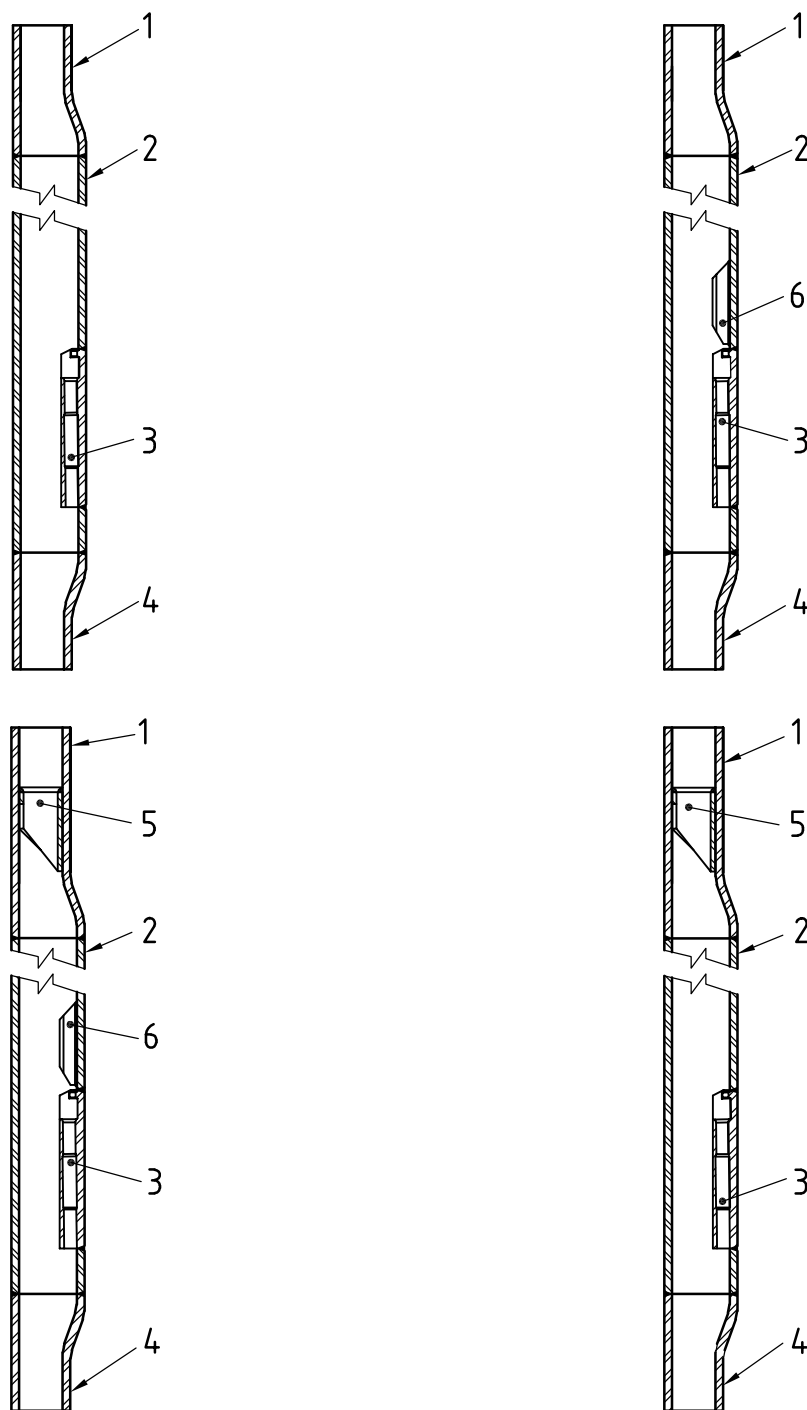
Figure E.2 — Example 2 of a typical operating pressure envelope (customary US units)

Annex F
(informative)

Schematics of side-pocket mandrels

F.1 General

The following drawings illustrate typical side-pocket mandrels.



Key

- | | | | |
|---|-------------|---|--------------------|
| 1 | upper swage | 4 | lower swage |
| 2 | body pipe | 5 | orienting sleeve |
| 3 | pocket | 6 | guard or deflector |

Figure F.1 — Schematics of typical side-pocket mandrels

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