

Side-pocket Mandrels

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Introduction

This specification 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 specification 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 specification addresses supplier/manufacture requirements that set the minimum parameters with which each supplier/manufacture shall comply, to be able to claim conformity with this specification.

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.

This specification 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 specification and provide details.

Design validation grades. There are four design validation grades for side-pocket mandrel products that provide the user/purchaser with a range of technical and performance requirements. Users of this specification should be aware that requirements in addition to those outlined herein might be needed for individual applications.

Product functional testing grades. There are four 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 specification meet the design specifications.

Quality control grades. There are four 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 B, C, and D of this specification are normative requirements; Annexes E and F are informative.

Side-pocket Mandrels

1 Scope

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

This specification addresses standard side-pocket mandrel designs as well as high pressure and/or high temperature (HPHT) equipment rated greater than 103.43 MPa (15,000 psi) and/or greater than 177 °C (350 °F) wellbore conditions as proffered by API 1PER15K-1.

This specification 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 specification. Additionally, this specification does not include specifications for center-set mandrels, mandrels that employ or support tubing-retrievable flow control devices or side-pocket mandrels that incorporate non-metallic materials for pressure containment.

This specification 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 API specifications.

The side-pocket mandrels to which this specification 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 specification. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

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

API 20H, *Heat Treatment Services—Batch Type for Equipment used in the Petroleum and Natural Gas Industry*

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

ASME Boiler and Pressure Vessel Code, Section V, *Non-destructive 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 VIII, *Rules for Construction of Pressure Vessels, Division 2, Alternative Rule*
ASME Boiler and Pressure Vessel Code, Section VIII, *Rules for Construction of Pressure Vessels, Division 3, Alternative Rules for Construction of High Pressure Vessels*

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

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.

ASTM A370, *Standard Test Methods and Definitions for Mechanical Testing of Steel Products*³

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

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

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

ASTM E94, *Standard Guide for Radiographic Examination*

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*

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 6892-1, *Metallic materials — Tensile testing — Part 1: Method of test at room temperature*

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*

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*

SAE AMS-2750, *Pyrometry*⁴

3 Terms and Definitions

For the purpose of this specification, the following terms and definitions 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 compliance

COC

Documentation declaring that a specific device meets the requirements of this product specification.

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

⁴ SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, USA.

3.3**coating**

Application of a thin film of one material on the surface of another material for defined purposes.

3.4**compressive load**

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

3.5**date of manufacture**

Date of supplier's/manufacture's final acceptance of finished products.

3.6**deflector or discriminator**

A section designed into side-pocket mandrel that allows passage of side-pocket devices, but prevents entry of through-tubing equipment other than the desired side-pocket device.

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/manufacture to design a product.

3.9**design validation**

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

3.10**design verification**

Process of examining the technical details and specifications of a given design by calculation, comparison, or investigation to substantiate conformity with specified requirements.

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**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 (ID) and length.

3.15**external test pressure**

Differential test pressure between the applied external pressure and internal pressure that a product is tested for to determine collapse resistance.

3.16**full life cycle**

Expected period of time over which the product shall function according to the supplier's/manufacturer's specifications.

3.17**functionality**

Definition or description of the performance of a product with associated properties, characteristics and limits.

3.18**gas passage undercut**

Clearance between the flow-control device and the pocket of the side-pocket mandrel through which injected media flows.

3.19**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.

3.20**heat treatment**

Specified time sequence of controlled heating and cooling of materials for the purpose of changing physical or mechanical properties.

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 test pressure between the applied internal pressure and external pressure that a product is tested for to determine burst resistance.

3.23**job lot**

Group or quantity of piece parts, subassemblies, or assemblies that are grouped or processed together during the manufacturing process.

3.24**kick-over tool****KOT**

Device used to orient or align a pulling or running tool for installation or retrieval of a flow-control device into or out of a side-pocket mandrel.

3.25**latch**

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

3.26**latch profile**

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

3.27**linear indication**

Any indication, identified by non-destructive examination (NDE), whose length is equal to or greater than three times the width.

3.28**linear mass**

Mass per length of tubular product.

3.29**manufacturing**

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

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

3.30**model**

Products with unique components and functional characteristics that differentiate it from other products of the same type.

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

3.31**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.

3.32**operational parameter**

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

EXAMPLE 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.

3.33**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.

3.34**perceptible leak**

Any leak during a hydro test that can be detected.

3.35**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.

3.36**product functional-testing grade**

Category based on a defined range of processes, method(s), and/or test(s) that are used by the supplier/manufacturer to demonstrate that a particular product has been manufactured to fully meet the functional and manufacturing requirements.

3.37**quality control grade**

Category based on a defined range of processes and/or method(s) that are used by the supplier/manufacturer to assure the quality of the materials and manufacturing process(es) used to produce a particular product.

3.38**rated pressure**

Maximum differential pressure, at the rated temperature, to which the product is designed to be subjected in operation.

3.39**rated temperature**

Maximum temperature, at the rated pressure, to which the product is designed to be subjected in operation.

3.40**rounded indication**

Any indications, identified by NDE, that is circular or elliptical in shape, such that the length is less than three times its width.

3.41**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.

3.42**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.

3.43**supplier/manufacturer**

Company, organization, or entity that designs, manufactures, and/or markets products.

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.

NOTE Each test pressure has a related test temperature, as specified by the pertinent test procedure.

3.46**test temperature**

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

3.47**traceability**

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

3.48**type**

Product with unique characteristics that differentiate it from other functionally similar products.

3.49**user/purchaser**

Company, organization, or entity that purchases, installs and/or uses products defined by this product standard.

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
BOM	bill of materials
COC	certificate of compliance
EOEC	exclusive of end connections

FEA	finite element analysis
FMEA	failure modes and effect analysis
HAZ	heat-affected zone
HPHT	high pressure and/or high temperature
ID	inside diameter
KOT	kick-over tool
NDE	non-destructive examination
OD	outside diameter
PQR	procedure qualification record
<i>Ra</i>	roughness, expressed in micrometers (micro-inches)
UNS	unified numbering system
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 specification. 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, 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 side-pocket 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 5.3.4, 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 lifecycle, 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 and acid returns, pressure, temperature, and acidizing velocity as well as exposure time and any other chemicals used during the stimulation;
- sand consolidation and fracturing operations, including sand/proppant description and volume, fluid flow rate, proppant/fluid ratio, or sand/fluid ratio, chemical composition, pressure, and temperature;
- electric line, wireline, coiled tubing, snubbing, and other through-tubing conveyance methods;
- devices that 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).

5.4 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 side-pocket mandrel;
- expected maximum temperature at the side-pocket mandrel;
- expected maximum gas- and/or fluid-injection rate and the rate of fluid production at the side-pocket 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 specification. In such cases, the user/purchaser and the supplier/manufacture should work together to design mutually acceptable products to meet these requirements and the intent of this specification.

NOTE Equipment under standard operating conditions have very low load cycles over their operational life. For information regarding investigations of load cycling, see ASME BPVC Section VIII, Div 3, Article KD-3 or Article KD-4.

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 (OD), etc. on any other related well products (e.g. subsurface 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 specification. 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/manufacture shall be documented.

5.6 Environmental Compatibility

5.6.1 General

If the user/purchaser has access to the corrosion property data of the operating environment based on historical data and/or research, they shall state to the supplier/manufacture which material(s) has the ability to perform as required within the corrosion environment per the requirements of 5.6.3 as applicable. Otherwise, material compatibility shall be specified according to 5.6.2.

5.6.2 Well Environment

The user/purchaser shall identify the density, chemical/physical composition, and the condition of the fluid and/or its components—including solid (total suspended solids, sand production, scale, cement, etc.), liquid, and/or gas—to which the side pocket mandrel is exposed during its expected lifecycle. Both the minimum and the maximum anticipated values of the production/injection pressures, pressure differentials, temperatures, and flow rates shall be identified. Other operational parameters may be defined as necessary.

5.6.3 Material Designation

If the user/purchaser chooses to specify materials for sour service, the requirements for compliance to ANSI NACE MR0175/ISO 15156 shall be stated.

5.7 Design Validation

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

- V3: basic level of design validation; side-pocket mandrels with a working pressure rating of 68.9 MPa (10,000 psi) or less and a rated temperature of 176.7 °C (350 °F) or less
- V2: intermediate level of design validation (destructive testing or finite element analysis [FEA]/strain gauge testing); side-pocket mandrels with a working pressure rating of 68.9 MPa (10,000 psi) or less and a rated temperature of 176.7 °C (350 °F) or less
- V1: highest level of design validation (FEA/strain gauge testing and special wireline operational testing); side-pocket mandrels with working pressure rating of 103.4MPa (15,000 psi) or less and a rated temperature of 176.7 °C (350 °F) or less
- V1H: HPHT level of design validation (FEA/strain gauge testing, special wireline operational testing, and failure modes and effect analysis [FMEA]); side-pocket mandrels with pressure ratings exceeding 103.4MPa (15,000 psi) and/or 176.7 °C (350 °F)

5.8 Product Functional Testing Grades

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

- F3: basic level of product functional testing (internal pressure test, ID drift, and OD drift at 100 % of job lot)
- F2: intermediate level of product functional testing (internal pressure test, ID drift, and OD drift all at 100 % of job lot; external pressure test and kick-over tool (KOT) test per sampling plan [see 7.4.7])
- F1: highest level of product functional testing (internal pressure test, ID drift, OD drift, external pressure test, and KOT all at 100 % of job lot)
- F1H: HPHT level of product functional testing (internal pressure test, ID drift, OD drift, external pressure test, and KOT all at 100 % of job lot)

5.9 Quality Control Grades

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

- Q3: basic level of quality control (100 % hardness testing [two locations] and certificate of compliance [COC])
- Q2: intermediate level of quality control (100 % hardness testing [three locations], NDE per sampling plan [see 7.4.7], and COC)
- Q1: highest level of quality control; (100 % hardness testing [three locations], 100 % radiographic NDE, and COC with documentation package)
- Q1H: HPHT level of quality control. (100 % hardness testing [four locations], 100 % radiographic and surface NDE, COC with documentation package, and a final visual inspection)

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.