Side-pocket Mandrels

1 Scope

This specification provides requirements for side-pocket mandrels used in the petroleum and natural gas industry.

It covers specifying, selecting, designing, manufacturing, quality control, testing, and preparation for shipping of side-pocket mandrels.

This specification addresses standard side-pocket mandrel designs, 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:

1) requirements for end connections between the side-pocket mandrels and the well conduit.

2) installation and retrieval of side-pocket mandrels

3) center-set mandrels or conventional gas lift mandrels.

4) gas lift or any other flow-control valves or devices, latches, and/or associated wire line equipment that are covered in API 19G2 and 19G3, or other API specifications.

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.

ANSI/NACE MR0175 [1]/ISO 15156 [2], *Petroleum and natural gas industries-Materials for use in H_2S-containing environments in oil and gas production*

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

API 1PER15K-1, *Protocol for Verification and Validation of HPHT Equipment*

API 5CT, *Casing and tubing*

API 13TR1, *Stress Corrosion Cracking of Corrosion Resistant Alloys In Halide Brines Exposed to Acidic Production Gas*

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*

API 20N Heat Treatment Services - Continuous Furnace 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*

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*

AWS A5 (all parts*) Steel Electrodes for Shielded Metal Arc Welding*

WS A5.01/A5.01M:2019 (R2024), Welding and Brazing Consumables – Procurement of Filler Materials and Fluxes

AWS A5.1/A5.1M:2020, Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding

AWS A5.18/A5.18M:2024, Specification for Carbon Steel Electrodes and Rods for Gas Shielded Arc Welding

AWS A5.9/A5.9M:2022, Specification for Bare Stainless Steel Welding Electrodes and Rods

AWS A5.14/A5.14M:2023, Specification for Nickel and Nickel-Alloy Bare Welding Electrodes and Rods

AWS A5.8/A5.8M:2021, Specification for Filler Metals for Brazing and Braze Welding

1 NACE International (now Association for Materials Protection and Performance), 15835 Park Ten Place, Houston, Texas 77084, hhttps://ampp.org

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

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

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

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 15156-1, *Petroleum and Natural Gas Industries — Materials for Use in H_2S-containing Environments in Oil and Gas Production — Part 1: General Principles for Selection of Cracking-resistant Materials*

ISO 15156-2, *Petroleum and Natural Gas Industries — Materials for Use in H_2S-containing Environments in Oil and Gas Production — Part 2: Cracking-resistant Carbon and Low Alloy Steels, and the Use of Cast Irons*

ISO 15156-3, *Petroleum and Natural Gas Industries — Materials for use in H_2S-containing Environments in Oil and Gas Production — Part 3: Cracking-resistant CRAs (Corrosion-resistant Alloys) and Other Alloys*

SAE AMS-2750, *Pyrometr*[4]

3 Terms and Definition

For the purpose of this specification, the following terms and definitions apply.

3.1 Terms and Definitions

3.1.1

acceptance

Side-pocket mandrel component(s) and/or assembly(ies) accepted for use without restriction.

3.1.2

certificate of compliance

COC

Document issued by an authorized party that states goods meet required standards or specifications.

3.1.3

coating/plating

A layer of a substance added to the surface of an item.

NOTE 1 This can be applied by a vapor, liquid, liquefiable, or mastic composition that, after application to a surface, is converted into a solid protective, decorative, or functional adherent film.

NOTE 2 Coating/Plating, which includes paints, can be: sprayed; thermally diffused; plated; or applied with hand tools (specific to the surface, environment, and application goals). [API 20P]

NOTE 3 Some surface treatments may be considered coatings.

3.1.4

compressive load

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

3.1.5

common hardware items

Standard, off the shelf mechanical components.

NOTE: These include bolts, nuts, washers, screws, pins, clips, similar fasteners and other items that are manufactured to recognized specifications such as ASTM, ASME, ANSI, SAE, or ISO dimensional/material standards.

3.1.6

conventional gas lift equipment

Equipment that is run into well and can be accessed only by retrieving the well tubing.

3.1.7

conventional gas lift flow control devices

Flow control devices (FCD) that are mounted either internally or externally on a conventional gas lift mandrel.

3.1.8

conventional gas lift mandrel

Mandrel that is run into well and the FCD that can be accessed only by retrieving the well tubing.

3.1.9

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.

3.1.10

design family

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

3.1.11

design method

Method, procedure, or equations used by the supplier/manufacturer to design a product.

3.1.12

design validation

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

3.1.13

design verification

Process of examining the result of a given design to determine conformity with specified requirements .

3.1.14

dogleg

Change in well bore inclination.

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

3.1.15

drift outside diameter

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

3.1.16

end connection

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

3.1.17

environmental compatibility

The environmental conditions equipment is designed to operate as intended.

3.1.18

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.

3.1.19

external test pressure

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

3.1.20

gas passage undercut

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

3.1.21

heat

Material originating from a final melt or cast lot having the same chemistry.

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

3.1.22

heat treatment

Heating and cooling a solid metal or alloy in such a way as to obtain desired properties.

NOTE: Heating for the sole purpose of hot working is not considered heat treatment.

3.1.23

heat treat lot

Group or quantity of piece parts, sub-assemblies or assemblies that are grouped or processed together during the heat treatment process.

3.1.24

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.

3.1.25

internal test pressure

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

3.1.26

job lot

Material or components having undergone the same process or series of processes as a single production lot.

3.1.27

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.

3.1.28

latch

Mechanism for installation, retention, or removal of a flow-control device that is landed in a side-pocket mandrel latch profile.

3.1.29

latch profile

Feature for the reception of the locking mechanism within a side-pocket mandrel.

Example: lug and recesses

3.1.30

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

3.1.31

linear mass
Mass per length of tubular product.

3.1.32

manufacturing
Process(es) and action(s) performed by an equipment supplier/manufacturer 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/manufacturer.

3.1.33

model
Products with unique components and functional characteristics that differentiate it from other products.

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

3.1.34

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

NOTE: Environmental compatibility such as: through-tubing drift, landing and retrieval of flow-control devices, passage of various tools through the side-pocket mandrel, and injection of various well treatment chemicals/fluids.

3.1.35

orienting profile
Design feature 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.

NOTE: An example is orienting sleeve.

3.1.36

pocket
Parallel bore that is offset from and essentially parallel with the through-bore of the side-pocket mandrel.

NOTE: Includes sealing surfaces and latching profiles.

3.1.37

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.

3.1.38

quality level
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.

3.1.39

rated temperature

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

3.1.40

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.

3.1.41

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.

3.1.42

supplier/manufacturer
A company, organization, or entity that designs, manufactures, and/or markets products.

3.1.43

tensile load
Maximum force creating tension that can be applied to a side-pocket mandrel, as defined by the supplier/manufacturer.

3.1.44

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.

3.1.45

test temperature

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

3.1.46

traceability

Ability to track the manufacturing history of a component, sub-assembly, or assembly.

3.1.47

type 1

Welds or metallic components that isolate pressure and/or may be loaded in tension as the result of axial loads on the product.

3.1.48

type 2

Welds or metallic components that are not classified as type 1.

3.1.49

user/purchaser

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

3.1.50

visible leak

Leakage of test fluid observed by any visual method during a pressure test.

3.1.50

wireline

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

3.1.51

working pressure

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

3.1.52

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.

3.2 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
Ra	roughness, expressed in micrometers (micro-inches)
UNS	unified numbering system
WPS	welding procedure specification
WPQ	welder performance qualification

4 Functional Specification

4.1 General

4.1.1 The user/purchaser should prepare a functional specification to order products that conform to 19G1. The functional specification shall specify the requirements and operating conditions listed in 4.2 through 4.9, as applicable, and/or identify the supplier's/manufacturer's specific product.

4.1.2 Requirements and operating conditions may be conveyed by means of a dimensional drawing, a data sheet, or other suitable documentation.

4.1.3 If not provided, the supplier/manufacturer shall generate this functional specification based on available information provided by user/purchaser.

4.2 Functional Characteristics

4.2.1 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.

4.2.2 The functional specification shall define, as applicable, the following functional characteristics:

a) Latch: nominal size and/or style and/or model(s) of the latch(es) used to secure the flow control or other equipment to the side-pocket mandrel

b) 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

c) 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

d) Conduit ports: connection size and configuration for the external ports and outlets to which side-string, control, or injection conduits are to be attached

e) 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

f) 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 loads, and temperature limits.

4.3 Well Parameters

4.3.1 General

The functional specification shall define the well parameters listed in 4.3.2 through 4.3.4, as applicable.

4.3.2 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), liquids, and/or gases to which the side-pocket mandrel will be exposed during its full lifecycle. In addition, both

the minimum and the maximum anticipated values of the production/injection pressures, pressure differentials, temperatures, and expected flow rates.

4.3.3 Well Physical Parameters

The following physical well parameters shall be defined:

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

b) well depth and trajectory from the vertical to the installed position;

c) deviations and restrictions through which the product is required to pass;

d) loading conditions anticipated to be applied to the side-pocket mandrel.

4.3.4 Allowable Well Operations

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

a) 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;

b) 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;

c) electric line, wireline, coiled tubing, snubbing, and other through-tubing conveyance methods;

d) devices that might be run/installed via these means;

e) size, style, and configuration of other products to be used in conjunction with the side-pocket mandrel, where applicable;

f) hole deflections including “doglegs” (state the depth of any “dogleg” and its measured deviation) and through bore restrictions above the side-pocket mandrel.

4.4 Operational Parameters

4.4.1 Functional Specification

The functional specification shall define specific installation, testing, and operational parameters to which the side-pocket mandrel will be subjected. These shall include the following:

a) expected maximum external-to-internal differential pressure across the side-pocket mandrel;

b) expected maximum internal to-external differential pressure across the side-pocket mandrel;

c) expected maximum tubing force on the side-pocket mandrel;

d) expected maximum temperature at the side-pocket mandrel;

e) expected maximum gas- and/or fluid-injection rate and the rate of fluid production at the side-pocket mandrel;

f) expected installation, testing, and operational procedures.

4.4.2 Exceptional Operating Conditions

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/manufacturer 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 more information regarding investigations of load cycling, see ASME BPVC Section VIII, Div 3, Article KD-3 or Article KD-4.

4.5 Compatibility with Related Well Devices

4.5.1 General

The functional specification shall provide data/information such as maximum length, maximum outside diameter (OD), 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) 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.

4.5.2 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 may require polished bore dimensions other than those listed. In those cases, agreement between user/purchaser and supplier/manufacturer shall be documented.

4.6 Environmental Compatibility

4.6.1 General

The following shall be identified to ensure environmental compatibility as applicable:

a) Production/injection/annulus fluid chemical and physical composition, including solids (sand production, scale) to which the equipment is exposed during its full operating life.

b) In cases where the user/purchaser has access to corrosion-property historical data and/or research that is applicable to the functional specification, the user/purchaser should state to the supplier/manufacturer which materials have the ability to perform as required within the anticipated service environment.

c) It is the equipment user/purchaser's responsibility to ensure that any material specified for use is satisfactory in the service environment. If the user/purchaser requires analysis for metals beyond conformance with NACE MR0175 in sour service, then those fluids, contaminants, and testing/qualification requirements shall be specified in the functional specification. For halide brine applications guidance is available in API 13TR1.

d) Any known characteristics of the well or well operations that would negatively impact the materials used in the equipment being provided.

NOTE 1: NACE MR0175 provides guidelines for selection of metallic materials in sour service for cracking resistance. NACE MR0175 prescribes laboratory testing procedures and methodologies that can qualify alloys for general use in all environments or as fit-for-service testing for a project specific environment. The standard addresses the following environmental variables: the minimum in situ water pH, the maximum chloride concentration, the maximum partial pressure of H2S in the gas phase, minimum and maximum temperatures, and the presence of solid elemental sulfur. It is important to consider both the immediate short-term environment and changes that may occur in the longer term, such as increases in the partial pressure of H2S due to reservoir souring from water injection. For the purposes of this document, NACE MR-01-75 is equivalent to ISO 15156-1, ISO 15156-2, and/or ISO 15156-3 as applicable.

NOTE 2: API 13TR1 provides guidance on brine compatibility.

4.6.2 Well Environment

The functional specification 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), liquid, and/or gas—to which the side pocket mandrel is exposed during its expected lifecycle. 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.

4.7 Design Validation

The validation grade requirements are defined in Annex A. (See also 5.6). The functional specification shall define one of the following four design validation grades:

a) 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 ºC (350 ºF) or less

b) V2: intermediate level of design validation (destructive 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 ºC (350 ºF) or less

c) 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 ºC (350 ºF) or less

d) 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 ºC (350 ºF)

4.8 Product Functional Testing Grades

The product functional testing grades are defined in Annex B. (See also 5.7). The functional specification shall define one of the following four product functional testing grades:

a) F3: basic level of product functional testing (internal pressure test, ID drift, and OD drift at 100 % of job lot)

b) F2: intermediate level of product functional testing (internal pressure test, ID drift, and OD drift at 100 % of job lot; external pressure test and kick-over tool (KOT) test per sampling plan [see 6.4.7])

c) F1: highest level of product functional testing (internal pressure test, ID drift, OD drift, external pressure test, and KOT at 100 % of job lot)

d) F1H: HPHT level of product functional testing (internal pressure test, ID drift, OD drift, external pressure test, and KOT at 100 % of job lot)

4.9 Quality Levels

The quality level requirements are defined in Annex C. (See also 6.4.4). The functional specification shall define one of the following four quality levels:

a) QL3: basic level of quality control (100 % hardness testing [two locations] and certificate of compliance [COC])

b) QL2: intermediate level of quality control (100 % hardness testing [three locations], NDE per sampling plan [see 6.4.7], and COC)

c) QL1: highest level of quality control; (100 % hardness testing [three locations], 100 % radiographic NDE, and COC with documentation package)

d) QL1H: 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 Technical Specification

5.1 General

The supplier/manufacturer shall prepare the technical specification to meet the requirements defined in the functional specification. The supplier/manufacturer's products shall conform to the technical specifications.

5.2 Technical Characteristics

5.2.1 Criteria

The supplier/manufacturer shall design and manufacture the side-pocket mandrel product in accordance with the functional criteria listed in 5.2.2 through 5.2.7.

5.2.2 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 intended intervention establishes otherwise. Additional devices may be attached to side-pocket mandrel by methods other than wireline and shall remain secured in place until intended intervention establishes otherwise.

5.2.3 Functional Requirements

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

5.2.4 Safe Tool Passage

The side-pocket mandrel, where applicable, shall allow safe passage of tools as specified in 4.3.4.

5.2.5 Operating Parameters

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

5.2.6 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.

5.2.7 Auxiliary Connections

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

5.3 Design Criteria

5.3.1 General

The supplier/manufacturer shall use the design criteria listed in 5.3.2 through 5.3.13 in designing the side-pocket mandrel(s). 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 combined loads.

5.3.2 Materials

Materials used for equipment construction shall be documented by the supplier/manufacturer and shall conform to the supplier/manufacturer documented specifications. Common hardware shall be provided to industry standards.

The user/purchaser may specify materials for the specific environment in the functional specification. If the supplier/manufacturer proposes to use another material, the supplier/manufacturer shall state that this material has performance characteristics suitable for all parameters specified in the well and production/injection parameters.

5.3.3 Material substitution

Material substitution is a temporary (not permanent) change to a production bill of material for a validated component which does not change the rating of the product. These temporary material substitutions are allowed without re-validation. The supplier/manufacturer's selection criteria for these substitutions shall be documented, and the substituted material shall conform to the design, functional, and technical requirements of the component/equipment.

Material substitutions shall be approval by a qualified person from the supplier/manufacturer and the supporting documentation incorporated into the manufacturing records for those units affected. In cases where the user/purchaser specifies material(s) of construction, deviations from such materials shall be notified and approved by user/purchaser.

5.3.4 Metals

The supplier/manufacturer’s specifications for type 1 or type 2 (except for common hardware items) components shall define the following characteristics critical to the performance of the material:

a) chemical composition limits;

b) melting practice;

c) heat treatment and/or cold work condition;

d) reduction ratio (RR);

e) mechanical property limits, as applicable:

i. tensile strength,

ii. yield strength,

iii. elongation,

iv. reduction of area (ROA),

v. hardness,

vi. Charpy impact toughness/test temperature.

5.3.4.1 **Determination of Mechanical Properties**

Specified mechanical properties shall be determined by tests conducted on a representative sample from the same heat (such as prolongation or sacrificial part). The material test sample shall experience the same thermomechanical processing and be heat treated with the same material it represents. For remelt materials the sample shall be from the same final remelt heat. The mechanical property results shall be documented on a certified material test report (MTR) (see 5.7).

5.3.4.2 **Test Pieces**

Separate test pieces removed prior to heat treatment may be utilized as representative samples with a documented and validated test procedure, when permitted by applicable specifications or by the user/purchaser.

When conformance to NACE MR0175 is specified, the metallic materials and weldments shall conform with the material requirements of NACE MR0175 (as applicable).

5.3.4.3 **Heat Treatment Requirements**

Heat treating of production parts shall be performed with heat-treating equipment that meets the requirements of 6.4.8 and has been calibrated and surveyed per the requirements of 6.4.9. Heat treatment operations shall necessitate only hardness testing per Table C.1 to demonstrate conformance with the heat treat requirements of the supplier/manufacturer's specifications.

Maintenance of heat treatment records requiring time and temperature charts of each heat treat cycle in addition to a COC shall be addressed by supplier manufactures in written documentation.

5.3.5 Castings

Castings shall not be used for components that isolate pressure and/or may be loaded in tension.

The production of castings shall conform to the same production processing and controls as applied to the successfully validated component and the qualification casting.

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

5.3.6 Surface Hardening

Where a surface hardening process is utilized, a test piece shall be evaluated to ensure the process conforms to the written specification and required acceptance criteria. This test piece shall be utilized during design validation/verification and production of HPHT side-pocket mandrels. The testing frequency of non-HPHT side-pocket mandrels shall be specified by supplier/manufactures.

5.3.7 Sealing Bore Diameters

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

The side-pocket sealing bores shall be offset relative to the through-bore centerline of the side-pocket mandrel. The as-machined centerline 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 a finish with a maximum $Ra = 1.6$ µm (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 $Ra = 1.6$ µm (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. All surface finish requirements shall be evaluated prior to heat treatment of the side-pocket mandrel.

NOTE The finish, Ra, is dimensioned in units of micrometers (micro-inches). 63 Ra (µin) = 1.6 Ra (µm).

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 ± 0.127	1.027 ± 0.005	26.086 ± 0.127	1.027 ± 0.005
38.1	1.50	39.573 ± 0.127	1.558 ± 0.005	37.998 ± 0.127	1.496 ± 0.005

5.3.8 Minimum Drift OD

For external drift testing, the supplier/manufacturer shall specify the minimum drift OD of the side-pocket mandrel in the side-pocket mandrel product data sheet. Minimum drift OD includes items that will be attached to side-pocket mandrel during the deployment that will affect its running OD.

5.3.9 Temperature Effects on Mandrel Ratings

5.3.9.1 Temperature Effects for V3, V2, and V1

When calculating the performance ratings of the design, the supplier/manufacturer shall utilize the temperature de-rating factors which are verified by a qualified person and in accordance with:

a) industry recognized published data, or

b) data established by the supplier/manufacturer, or

c) data provided by the material sub-supplier.

5.3.9.2 HPHT Temperature Effects for V1H

The supplier/manufacturer shall utilize temperature de-rated material properties test results for each base and weld material corresponding to the maximum rated temperature. This testing shall be conducted in accordance with ASTM E21 for mechanical properties.

5.3.10 Elastomers and Non-metallics

Incorporation of elastomers and non-metallic materials for pressure containment is outside of the scope of this specification. Design of elastomeric and non-metallic components for non-pressure containment applications shall be in accordance with the supplier/manufacturer's documented requirements.

5.3.11 Tensile and Compressive Loads

5.3.11.1 The tensile and compressive load-carrying capacity of the side-pocket mandrel shall be determined utilizing supplier/manufacturer-documented methods and procedures.

5.3.11.2 Tensile and compressive load ratings shall be documented for each design at ambient temperature and maximum rated temperature. These values are for the side-pocket mandrel exclusive of end connections (EOEC). The ratings for tensile and compression shall be calculated or tested utilizing a supplier/manufacturer approved procedure.

5.3.11.3 Designs under evaluation shall utilize the supplier/manufacturer-identified minimum cross section (minimum wall thickness) and minimum material yield strength. Tensile and compressive ratings shall indicate the side-pocket mandrel ratings at the minimum material yield strength rating. The minimum material yield strengths shall be defined in the material specifications.

5.3.11.4 Compressive loading information is typically not available on non-round shapes. It shall be provided if requested within the user/purchaser functional specifications (see 4.4).

5.3.12 Working Pressure Ratings and Test Pressures

6.3.12. 1 The supplier/manufacturer shall document the following criteria for each mandrel design:

a) internal test pressure: the pressure used for product functional tests shown in Table B.1;

b) internal working pressure rating: to be less than the internal test pressure;

c) external test pressure: the pressure used for product functional tests shown in Table B.1;

d) external working pressure rating: to be less than the external test pressure.

5.3.12.2 The documented working pressure ratings and test pressures shall be:

a) defined at the ambient and maximum rated temperatures;

b) EOEC ratings;

c) defined such that the test pressure shall be a minimum of 1.10× the working pressure ratings;

d) identified as exclusive of the application of external tensile or compressive forces;

e) defined utilizing the most critically stressed section(s) and the minimum material properties. The minimum material properties shall be defined in the material specifications.

For V1 and V1H mandrels, this information shall be provided on and in an operating performance envelope; an example is given in Annex D.

5.3.13 Design Methods

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

a) FEA;

b) proprietary equations and/or methods;

c) standard equations;

d) experimental stress analyses;

e) proof test analysis.

This specification does not dictate the methods, equations or procedures for design purposes.

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

NOTE It is good design practice for all exterior protrusions to be well rounded and/or beveled 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 that can interfere with other tools that are passing through the side-pocket mandrel.

5.4 Design Verification

Design verification shall be performed to ensure that each design meets the supplier's/manufacturer's technical specifications and the functional specification as applicable (see Section 4). Design verification includes activities such as design reviews, design calculations, physical tests, comparison with similar designs, and historical records of defined operating conditions. Design documentation shall include the requirements of this section and conform to the requirements of 6.2.

5.5 Allowable Design Changes

5.5.1 General

5.5.1.1 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 mandrels which consist of the same nominal OD, nominal ID, nominal length, and nominal thread profile. Additionally, all designs within a design family shall be compatible with the same wireline equipment as demonstrated during validation.

5.5.1.2 Material changes within a design family shall be subject to material requirements of section 5.3 and welding requirements of 6.5. Additionally, a material change within a design family shall be reviewed by a qualified person to demonstrate that the stress value and safety factor will not exceed what was initially validated.

5.5.1.3 Records of each design and their analysis within a design family are still subject to the requirements of 5.3.9 and 6.2.

5.5.2 Design Changes

5.5.2.1 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.

a) The design changes do not require a change in the common methodology for establishing design performance within the design family.

b) The operational parameters for the product(s) that are undergoing a design change are consistent with the operational parameters for the design family.

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

5.5.2.3 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's/manufacturer's documented requirements for design validation of that feature. Acceptance criteria and results shall be documented.

5.5.2.4 For design changes that affect the nominal OD, nominal ID, or nominal length of a validated design, any change that will equal or reduce the stress value when subjected to the same loads non-substantive with following exceptions. A new test of the OD and ID Drifts per B.1.3.3.1 and B.1.3.3.2 shall be required and there shall be no altering of any tool utilized in original design validation testing. All non-substantive changes shall be approved by a qualified individual.

5.6 Design Validation

5.6.1 General

The supplier/manufacturer shall use these design validation procedures stated in Annex B to assure that each side-pocket mandrel design fulfills the functional requirements.

5.6.2 Design Validation

Design validation testing shall be performed on each size and model of side-pocket mandrel to ensure that the side-pocket mandrel design meets the supplier's/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 A for a detailed description of each specific process, procedure, or test.

5.6.3 Applicability of Design Validation Grades

Minimum design validation grades shall be applied to the working pressure and temperature ranges defined in 4.7. Higher design validation grades may be applied to lower working pressure and temperature ranges.

5.6.4 Optional Design Validation Testing

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

5.7 Product Functional Testing Requirements

5.7.1 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.

5.7.2 Product Functional Testing

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

5.7.3 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/manufacturer.

6 Supplier/Manufacturer Requirements

6.1 General

This section contains the requirements to verify that each product manufactured meets the functional specifications as defined in Section 4 and the technical specifications as defined in Section 5. The topics in 6.2 to 6.9 shall be addressed by the supplier/manufacturer.

6.2 Documentation and Data Control

6.2.1 6.2.1 General

The supplier/manufacturer shall establish and maintain documented procedures to control all documents and data in accordance with API Q1 and this specification. All documents and data shall be available for review by the user/purchaser.

6.2.2 Design Validation, Verification, and Product Functional Testing

All design validation, design verification, and product functional testing documents and data, including items listed in items a) to h), shall be maintained per API Q1 after date of last manufacture:

a) functional and technical specifications;

b) required grade of quality level documentation as defined in 4.9;

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

d) instructions providing methods for the safe installation and use of the side-pocket mandrel. This specification 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;

e) material designation, material properties, and connection identification for the end connection(s) provided with the side-pocket mandrel (where applicable);

f) welding procedure specification (WPS);

g) weld procedure qualification record (PQR);

h) welder/welding operator performance qualification (WPQ).

6.2.3 Product Data Sheet

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:

a) name and address of supplier/manufacturer;

b) supplier’s/manufacturer's assembly part number;

c) supplier’s/manufacturer's product name;

d) product model;

e) metallic materials;

f) do metallic materials meet NACE MR-01-75 (ISO 15156);

g) elastomeric and/or non-metallic materials;

h) drift diameters;

i) overall length;

j) temperature range for working pressures;

k) internal and external working pressure ratings

l) compressive and tensile load ratings;

m) top/bottom connection(s);

n) quality level;

o) design validation grade;

p) technical/operations manual identification;

q) product functional testing grade;

r) compatible tools utilized during design validation;

   i. Tool supplier/manufacturer name;

   ii. Assembly description;

   iii. Part number;

   iv. Revision level.

6.2.4 Technical/Operations Manual

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

a) manual reference number and revision level;

b) product data sheet;

c) operational procedures including compatible tools;

d) pre-installation inspection procedures;

e) storage recommendations;

f) representative drawing showing major dimensions (ODs, IDs, and lengths);

g) special precautions and handling.

6.2.5 Design Documentation

Design documentation shall include methods, assumptions, calculations, and design requirements. Design requirements include criteria for size, test pressures, materials, environment (temperature limits, chemicals), and other pertinent requirements upon which the design is based. Design documentation shall be reviewed and verified by a qualified person other than the individual who created the original design.

6.3 Product Identification Requirements

6.3.1 General

The supplier/manufacturer shall clearly identify and mark each side-pocket mandrel according to the requirements of 6.3.2.

6.3.2 Product Identification

6.3.2.1 Products furnished in conformance with requirements of this specification shall be permanently identified using low-stress marking devices, such as interrupted dot or rounded cold, die stamp, or vibratory methods. Supplier/manufacturer specifications shall define the method(s) and location of the markings.

6.3.2.2 The following information shall be marked on each side-pocket mandrel:

a) supplier’s/manufacturer's name or mark;

b) date (month and year) of manufacture;

c) supplier’s/manufacturer's part number; and

d) unique traceable serial number.

6.3.2.3 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.

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

6.3.3 Traceability

6.3.3.1 Components, weldments, subassemblies and assemblies of equipment supplied in accordance with this specification, with the exception of common hardware items, shall be traceable to a job lot. Job lot traceability for components and weldments, shall also identify the heat(s) or batch lot(s) included, and applicable heat treatments. Common hardware items require only a COC as defined in para 6.4.6.7 a).

6.3.3.2 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 supplier's/manufacturer's final inspection has been completed.

6.3.3.3 Traceability for side-pocket mandrels is considered sufficient if the equipment and documentation meet the requirements of this specification when it leaves the supplier's/manufacturer's inventory.

6.4 Quality Control Requirement

6.4.1 General

6.4.1.1 Equipment produced according to this specification shall be manufactured under a quality management system that is in conformance to API Q1. There are four quality levels that may be specified by the user/purchaser. Quality requirements are summarized in Table C.1.

6.4.1.2 Quality control work shall be controlled by documented instructions that include, or reference, acceptance criteria. All documents and records that show conformance to this document shall be controlled and maintained in accordance with the requirements of API Q1.

6.4.1.3 Rounding in accordance with ASTM E29 may be used unless otherwise restricted by the drawing, material specification, or other controlling document.

6.4.2 Quality Control Personnel Qualifications

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

6.4.3 Non-conformance

6.4.3.1 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.

6.4.3.2 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:**

a) reworked to meet the specified requirements;

b) accepted without repair by concession of supplier's/manufacturer's authorized personnel, provided the violated manufacturing criterion is categorized as unnecessary to satisfy the design acceptance criteria;

c) c) rejected or scrapped.

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

6.4.4 Quality Level Selection

This specification provides four grades of quality levels for side-pocket mandrel products, as shown in Table C.1. The functional specification shall specify the quality level.

As a minimum, products shall be supplied to QL3.

6.4.5 Measuring/Testing Equipment Calibration

6.4.5.1 Measuring and testing equipment used for acceptance shall be identified, inspected, calibrated, and adjusted at specific intervals in accordance with, ANSI/NCSL Z540-1, and this specification.

6.4.5.2 Pressure-measuring devices shall:

a) be readable to at least ±0.5 % of full-scale range or less as required to perform the specified measurement; and

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

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

6.4.5.4 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.

6.4.6 Material Certifications

6.4.6.1 Supplier's/manufacturer's mill test certificate of original material or supplier's/manufacturer's certification of test results are acceptable if the certifications include test results for mechanical properties and chemical composition for that heat of material.

6.4.6.2 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 ASTM A370 on specimens from the heat of material in question.

6.4.6.3 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 fail, then two additional tests shall be successfully performed in order to qualify the material.

6.4.6.4 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/manufacturer for that material.

6.4.6.5 Yield strength in this specification is defined as the 0.2 % yield offset strength in accordance with ASTM A370.

6.4.6.6 Acceptance of materials, shall be indicated either on the materials or in the records traceable to the materials.

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

a) COC stating that the raw material meets the supplier's/manufacturer's documented specifications. COC's shall note the specifications and revision levels utilized for testing and be traceable to the material or services it represents. The issuer of the COC shall have access to the documents, e.g. mill test reports, inspection records, manufacturing records, that show conformance to the requirements.

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

c) Mechanical and physical properties (as applicable):

   i. Metallic materials: Mechanical-property test procedures and practices shall be in accordance with ASTM A370 or ISO 6892-1 for the metallic materials used for traceable components. When testing at elevated temperatures ASTM E21 shall be used.

   ii. Elastomers and non-metallics: Mechanical-property test procedures for elastomeric and non-metallic compounds shall be in accordance with the supplier's/manufacturer's documented requirements.

d) Where material properties have been altered after receipt, a unique identifier shall be assigned.

6.4.7 Sampling

Sampling plan inspections shall be applied where defined in this specification within the following limitations.

a) The supplier/manufacturer shall have a documented sampling plan procedure and sampled units shall be randomly selected. Sample shall be inspected according to the supplier's/manufacturer's documented specifications and the requirements of this standard. The inspections performed shall have the same practices and acceptance criteria as the 100 % inspections.

b) The job lot or batch being sampled shall conform to the limits defined in Table 2. Initial sample size is defined in PLAN I. If the examination produces a non-conformance in the initial sample, then an additional sample in accordance with PLAN II shall be examined. If another non-conformance is found in this second sample, then 100 % of the job lot shall be examined. All nonconforming items shall be dispositioned per 6.4.3.

Table 2—Sample Size

Lot Size	PLAN I	PLAN II
2–8	2	2
9–15	2	3
16–25	3	5
26–50	3	8
51–90	5	13
91–150	5	20
151–280	8	32
281–500	8	50
501–1200	13	80
1201–3200	13	125
3201+	20	200

c) If the number of pieces in the job lot is smaller than the sample size, then all pieces in the lot shall be examined.

d) Alternate sampling plans can be applied, which follow the requirements of a national or international specification such as ISO 2859-1 provided that the acceptance number c = 0 and the average outgoing quality limit (AOQL) does not exceed that of the appropriate sampling plan in Table 2 above. AOQL is calculated using the following formula:

$$AOQL = \left(y/n\right) - \left(y/N\right) \quad [1]$$

where:

y = 0.368 for c = 0

n = sample size

N = lot size

6.4.8 Furnace Instrumentation

The requirements for furnace instrumentation are as follows:

a) Automated cycle controlling and recording instruments shall be used.

b) Thermocouples shall be located in the furnace working zone(s) and protected from furnace atmospheres; where practical, thermocouples shall also be attached to the material being heat treated and used for the determination of attaining the required temperatures and times.

c) Temperature controlling and recording instruments used for the feat treatment processes shall possess an accuracy of at least +/_ 1% of their full-scale range.

d) Furnace instrumentation be calibrated in accordance with para 6.4.9.

6.4.9 Furnace Calibration Requirements

Furnace shall be surveyed within one year prior to heat-treating operations. When a furnace is repaired or rebuilt, a new survey shall be conducted before heat treating.

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

a) procedures specified in SAE AMS 2750,

b) procedures specified in API 20H and API 20N,

c) supplier’s/manufacturer's written specifications including acceptance criteria that are not less stringent than the procedures identified above.

6.5 Welding Requirements

6.5.1 General

6.5.1.1 For weldments, including overlays and brazing, the supplier's/manufacturer's welding control system shall include requirements for monitoring, updating, and controlling the qualifications of welders/welding operators and the use of WPS.

6.5.1.2 Instruments utilized to verify temperature, voltage, and amperage shall be serviced and calibrated in accordance with the side-pocket mandrel supplier's/manufacturer's written procedures.

6.5.1.2 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.

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

6.5.2 Welding Consumables

All welding and brazing consumables shall conform to the applicable AWS A5.xx/A5.xxM specification corresponding to their classification or supplier's/manufacturer's written specifications. The supplier/manufacturer shall have a written procedure for selection, storage, and control of welding consumables. Low-hydrogen materials shall be stored and used as recommended by the manufacturer of welding consumables to retain their original low-hydrogen properties.

6.5.3 Welding Procedures and Qualification Records

6.5.3.1 **General**

Welding shall be performed in accordance with welding-procedure specifications written and qualified in accordance with 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 PQR 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).

6.5.3.2 **Hardness Testing**

The test weldment coupon for hardness testing shall have the same post-weld heat treatment as the final product. For side-pocket mandrels meeting NACE MR-01-75, hardness surveys for welding procedure qualification shall include points across the weld metal, base material, and heat-affected zones (HAZs) cross section as per ANSI/NACE MR0175/ISO 15156-2.

Hardness testing shall be conducted using the Vickers method in accordance with ISO 6507-1 or the Rockwell method in accordance with ISO 6508-1, with the appropriate scale as permitted by corresponding specifications, and the results shall be recorded as part of the PQR. Maximum hardness values for sulfide stress cracking-resistant service shall not exceed the requirements of ISO 15156-1, ISO 15156-2, and/or ISO 15156-3, as applicable depending on the material.

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 as applicable.

6.5.4 Welder/Welding Operator Performance Qualification

Welders and welding operators shall be qualified in accordance with ASME Boiler and Pressure Vessel Code, Section IX. Records of WPQ tests shall include all welding parameters as detailed in ASME Section IX.

6.6 Non-destructive Examination (NDE) Requirements

6.6.1 General

6.6.1.1 The supplier's/manufacturer's qualified representative shall inspect all accessible surfaces for cracks and damage, ensuring that the technical specification is met. The procedure for visual examination shall be in accordance with the supplier's/manufacturer's written requirements.

6.6.1.2 Final acceptance NDE shall be performed and accepted after all thermal processing and prior to any surface conditioning that could affect the results. NDE shall be performed in accordance with the supplier's/manufacturer's written specification that shall include the requirements defined in 6.7. The size of the sample of the components to be tested shall be in accordance with the appropriate quality level as indicated in Table D.1. All welds and adjacent HAZs 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's/manufacturer's specification.

6.6.1.3 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.

6.6.2 NDE Personnel Qualification

NDE personnel shall be qualified in accordance with requirements specified in ISO 9712 Level II, ASNT SNT-TC-1A or supplier's/manufacturer's requirements that are not less stringent.

6.6.3 NDE Personnel Qualification Records

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

6.6.4 Visual Examination Personnel Qualifications

Personnel performing visual examinations shall have an annual eye examination in accordance with ISO 9712, or ASNT SNT-TC-1A as applicable to the discipline to be performed. The qualifications for personnel performing visual examination shall be in accordance with the supplier's/manufacturer's written requirements.

6.6.5 Hardness Examinations

Hardness testing shall be performed in accordance with procedures specified in ASTM-E10 (for Brinell hardness) or ASTM-E18 (for Rockwell hardness). The hardness acceptance criteria shall be in accordance with the supplier's/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.

NOTE For the purposes of this provision, ASTM-E10 is equivalent to ISO 6506-1 and ASTM-E18 is equivalent to 6508-1.

6.6.6 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-5l.

6.6.7 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.

6.6.8 Magnetic Particle Examinations

Magnetic particle examinations shall be in accordance with the requirements of ISO 10893-5 or ASTM E709.

Indications shall be described as one of the following:

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

b) linear indication: any indication in which the length is equal to or greater than three times its width;

c) rounded indication: any indication which is circular or elliptical in which the length is less than three times its width.

The acceptance criteria are as follows:

a) no relevant indication with a major dimension equal to or greater than 4.8 mm (3/16 in.);

b) no more than 10 relevant indications in any continuous 39 cm2 (6 in.2) area;

c) no more than three relevant indications in a line separated by less than 1.6 mm (1/16 in.) (edge-to-edge);

d) no relevant linear indications;

e) no rounded indications greater than 3 mm (1/8 in) for weld depths 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.).

6.6.9 Liquid Penetrant Examination

Liquid penetrant examination shall be in accordance with the requirements of ISO 10893-4 or ASTM E165. Indications shall be described as one of the following:

a) relevant indication is one with a major dimension greater than 1.6 mm (1/16 in.),

b) linear indication is any indication in which the length is equal to or greater than three times its width,

c) rounded indication is any indication in which the length is less than three times its width.

These acceptance criteria are as follows:

a) no relevant linear indications;

b) no relevant rounded indication with a major dimension equal to or greater than 5 mm (3/16 in.);

c) no more than three relevant rounded indications in a line separated by less than 1.6 mm (1/16 in.) (edge to edge);

d) no rounded indications greater than 3 mm (1/8 in) for weld depths are 16 mm (5/8 in.) or less; or 5 mm (3/16 in.) for weld depths greater than 16 mm (5/8 in);

e) no more than 10 relevant indications shall be present in any 39 cm2 (6 in.2) area.

6.6.10 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 and documented in the supplier's/manufacturer's written requirements.

The sampling frequency for QL3 and QL2 shall be as specified in para 6.4.7. the sampling frequency for QL1 and QL1H shall be 100%.

6.6.11 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's/manufacturer's written procedure. The test results shall meet acceptance criteria as detailed in 6.6.5. The results of each evaluation shall be documented.

6.7 Storage and Shipping Preparation

6.7.1 General

The supplier/manufacturer shall comply with the requirements in 6.7.2 to 6.7.5 for storage and shipping of side-pocket mandrel products.

6.7.2 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's/manufacturer's written procedures. The products shall be free of any foreign matter and/or liquids.

6.7.3 Threaded Connections and Packing Bores

All threaded connections and packing bores shall be protected as specified in the supplier's/manufacturer's written procedures. Protection of the threaded connections shall meet API 5CT, or for a non-ISO thread, the thread supplier's/manufacturer's written requirements. The protection of the packing bores shall be the coating of the packing bores with a rust inhibitor in accordance with the supplier's/manufacturer's written procedures.

6.7.4 Painting of Side-pocket Mandrels

The painting of side-pocket mandrels shall be done in accordance with the supplier's/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. The paint shall not be allowed in the packing bores or on the threaded surfaces.

6.7.5 Permanent Marking Prior to Coating

Prior to coating, all permanent marking that is required by this specification shall be completed (see 6.3.2). Active threads shall be coated only with the surface treatment specified by the supplier/manufacturer.

6.8 Repair

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

Annex A
(normative)

Design Validation Requirements

A.1 Purpose

A.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 and in a legible and retrievable method. The test results shall validate the design and be reviewed and approved by a qualified person other than the originator. This review shall confirm that all of the design validation requirements of this specification 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.

All design validation grades shall complete functional testing as detailed in para B.1.

Test procedures shall be documented and the tools utilized during testing shall have the following information retained in the design validation documentation:

a) Tool supplier/manufacturer name;

b) Assembly description;

c) Part number;

d) Revision level;

e) Tool operating instructions.

Four design validation grades with referenced section requirements are shown in Table A.1.

Table A.1—Design Validation Grades

Criterion	Grade			
	V3	V2	V1	V1H
Documentation	A.1.2.2	A.1.3.2	A.1.4.2	A.1.5.2
Design review (burst, collapse, tolerance)	A.1.2.3	A.1.3.3	A.1.4.3	A.1.5.3
Burst and collapse validation pressure test to destruction at ambient temperature Alternatively: FEA/Strain Gauge testing	Not required	A.1.3.4 A.1.4.6	Not required	Not required
Pressure testing at rated temperature	A.1.2.4	A.1.3.5	A.1.4.4	A.1.5.4
Internal pressure cycles	Not required	A.1.3.6	A.1.4.5	A.1.5.5
Finite element analysis/strain gauge	Not required	A.1.4.6 (Required if FEA/Strain Gauge is utilized)	A.1.4.6	A.1.5.6
Failure mode and effect analysis	Not required	Not required	Not required	A.1.5.7
Flow control—install/pull with KOT	A.1.2.5	A.1.3.7	A.1.4.7	A.1.5.8
Wireline operational test with KOT	Not required	Not required	A.1.4.8	A.1.5.9
KOT Non-activation Test	Not required	Not required	A.1.4.9	A.1.5.10
Complete Product Functional test	B.1.3	B.1.3	B.1.3	B.1.3

KOT = kick-over tool

A.1.2 Grade V3—Basic Grade of Side-pocket Mandrel Design Validation

A.1.2.1 General

Grade V3 design validation tests in A.1.2 shall be conducted.

A.1.2.2 Documentation

The design documentation 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.

Documentation shall be controlled per para 6.2.

A.1.2.3 Design Review (Burst, Collapse, Tensile and 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 ensure that it meets the technical specifications.

A.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 both the rated working pressure and maximum rated temperature. The tested mandrel shall hold the test pressure for a minimum of five minutes. The test pressure shall remain stable within ±2 %. Additionally, there shall be no visible leaks.

A.1.2.5 Flow Control—Install/pull

This test is conducted with the side-pocket mandrel installed in a horizontal position in a vise, with the pocket located at the top of the side-pocket mandrel, or in the "12 o'clock" position. A dummy flow control device with an appropriate latching mechanism shall be inserted into the side-pocket mandrel pocket, latched in the pocket, and retrieved from the pocket using the supplier's/manufacturer's procedures and acceptance criteria.

This test shall be conducted using each of the latches, running tools, pulling tools, and KOTs that are claimed to be compatible with this side-pocket mandrel. The tool string shall consist of a knuckle joint directly connected to the KOT 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 15º angle from vertical inclination.

A.1.3 Grade V2—Intermediate Grade of Side-pocket Mandrel Design Validation

A.1.3.1 General

The grade V2 design validation tests in A.1.3 shall be conducted.

A.1.3.2 Documentation

Perform A.1.2.2.

A.1.3.3 Design Review (Burst, Collapse, Tensile and Tolerance)

Perform A.1.2.3.

A.1.3.4 Burst and Collapse Pressure Test to Destruction at Ambient Temperature

Follow the requirements of A.1.3.4.1 through A.1.3.4.2. Alternatively, follow the requirements of A.1.4.6.

A.1.3.4.1 Burst

A minimum of one specimen of this design shall be internally pressure tested to failure. This specimen shall be hydro tested at ambient temperature. The pressure where failure occurs shall be recorded.

A.1.3.4.2 Collapse

A minimum of one specimen of this design shall be externally pressure tested to failure. This specimen shall be hydro tested at ambient temperature. The pressure where failure occurs shall be recorded.

A.1.3.5 Pressure Testing at Maximum Rated Temperature

Perform A.1.2.4.

A.1.3.6 Internal Pressure Cycles

This is an internal hydrostatic test. The internal pressure shall be raised to the internal test pressure at ambient temperature, held at this value for a minimum of two minutes 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 five minutes after the test side-pocket mandrel has been isolated from the pressure source. All pressure tests shall have a maximum of 2 % pressure reduction over the hold cycle and no visible leaks.

A.1.3.7 Flow Control—Install/pull

This test shall be conducted with the side-pocket mandrel installed in a horizontal position, in a vise, with the pocket located at the top, side, and bottom of the side-pocket 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 side-pocket mandrel pocket, latched in the pocket, and retrieved from the pocket using the supplier’s/manufacturer’s procedures and acceptance criteria. This test shall be conducted using each of the latches, running tools, pulling tools, and KOTs that are claimed to be compatible with this side-pocket mandrel. The tool string shall consist of a knuckle joint directly connected to the KOT 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 15º angle from vertical inclination.

A.1.4 Grade V1—Enhanced Grade of Side-pocket Mandrel Design Validation

A.1.4.1 General

The grade V1 design validation tests in A.1.4 shall be conducted.

A.1.4.2 Documentation

Perform A.1.2.2.

A.1.4.3 Design Review (Burst, Collapse, Tensile and Tolerance)

Perform A.1.2.3.

A.1.4.4 Pressure Testing at Maximum Rated Temperature

Perform A.1.2.4.

A.1.4.5 Internal Pressure Cycles

Perform A.1.3.6.

A.1.4.6 Finite Element Analysis and Strain-gauge Test

A.1.4.6.1 Finite Element Analysis (FEA)

An FEA shall be conducted to define, the rated working and test pressures of the side-pocket mandrel under internal pressure, external pressure, and tensile loading conditions at rated temperatures. All assumptions and conclusions shall be documented as part of the analysis.

A.1.4.6.2 Strain Gauge Test

Strain gauges, mounted circumferentially and longitudinally on the side-pocket mandrel, shall be used to verify the finite element analysis in a full-scale test to within 25 % to 100 % of the rated working pressure limits and not exceeding the end connection limits.

Internal pressure strain gauge testing shall be performed at a minimum. If strain gauge testing for external pressure and/or tensile loading are not included, documented explanation shall be provided as to why the FEA can be verified without including these conditions. Inability to perform external or tensile strain gauge testing shall not be utilized as justification for FEA model acceptance.

The measured strains shall be +/- 15 % of the values calculated by the FEA model that represents the actual strain gauge loading conditions. Acceptance of FEA model shall be based only on strains and not stresses. The 15 % criteria are not required in locations with low stresses (i.e. <68.9 MPa (<10 ksi)) and may be excluded. Exclusion of strain gauge results requires documented justification.

A.1.4.7 Flow Control—Install/pull

Perform A.1.3.7.

A.1.4.8 Wireline Operational Test with KOT

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 side-pocket 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 side-pocket 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 side-pocket mandrel pocket, latched in the pocket, and retrieved from the pocket using each of the KOTs that are claimed by the supplier/manufacturer to be compatible with this side-pocket mandrel, using the supplier’s/manufacturer’s procedures and acceptance criteria.

A.1.4.9 KOT Non-Activation Test

This test is not required on non-orienting SPMs. This test shall be conducted on orienting SPM’s installed in a horizontal position, in a vise, with the pocket located at the top or in the “12 o’clock” position. The KOT is inserted in the downhole side of the SPM with the nose of the KOT facing downhole and the trigger or finger located in the

top (12 o'clock) position. Push the KOT upward through the SPM until the trigger or finger contacts the orienting sleeve. Repeat the process by rotating the KOT at 10° increments from the top (12 o'clock) position to the bottom (6 o'clock) position.

Acceptance criteria: the KOT when inserted into the side-pocket mandrel, does not trip or hang up in the side-pocket mandrel body at any point below the orienting sleeve.

A.1.5 Grade V1H—HPHT Grade of Side-pocket Mandrel Design Validation

A.1.5.1 General

Design verification shall be performed in conformance with the requirements of Section 5.5 and the following:

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

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

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

d) If corrosion or corrosion/erosion parameters are included in the design, the design verification and validations shall allow for these parameters.

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

A.1.5.2 Documentation of Component Design Verification

A.1.5.2.1 Summary Test Report

A summary report of each component's design shall include:

- calculated stress;
- failure mode(s);
- maximum allowable stress;
- the temperature de-rated minimum yield strength.

Where applicable, documentation of FEA results shall include:

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

b) component dimensions used in FEA model at the locations of highest state of stress in the analysis;

c) material properties utilized in the FEA analysis;

d) assumptions utilized in the FEA analysis;

e) loading conditions;

f) boundary conditions;

g) mesh sensitivity study;

h) numerical analysis results, showing compliance to the acceptance criteria for each failure mode;

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

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

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

A.1.5.2.2 Validation Test Report

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

a) identification of product supplier/manufacturer;

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

c) identification of the validation test procedures used;

d) equipment description, and an assembly drawing;

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

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

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

A.1.5.3 Design Review (Burst, Collapse, Tensile, and Tolerance)

The supplier/manufacturer shall conduct a final design review compliant with A.1.2.3.and approve the design for the intended application and functional requirements. The final design review shall include the review and approval of the following:

a) functional requirements,

b) technical specification,

c) design verifications,

d) design validation records,

e) design outputs and a bill of materials including material specifications.

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

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

A.1.5.4 Pressure Testing at Maximum Rated Temperature

Perform A.1.2.4 with a ±1 % test pressure stability requirement.

A.1.5.5 Internal Pressure Cycles

Perform A.1.3.6 with a ±1 % test pressure stability requirement.

A.1.5.6 Finite Element Analysis and Strain Gauge Test

A.1.5.6.1 Finite Element Analysis (FEA)

An FEA shall be performed on components that isolate pressure and/or may be loaded as the result of axial loads on the equipment during run-in, setting, in situ, or retrieval for the maximum operating load cases at the maximum rated temperature to evaluate for plastic collapse, local failure, collapse from buckling, and failure from cyclic loading using ASME BPVC Section VIII, Division 2, Part 5 or ASME BPVC Section VIII Division 3, article KD-2 and the supplier/manufacturer documented design margins and load factors. When FEA has identified plastic strain in excess of 0.2 %, a ratcheting analysis shall be performed per ASME BPVC Section VIII, Division 3, KD-234 or ASME BPVC Section VIII, Division 2 Section 5.5.7. The minimum specified material performance data shall be obtained via testing per 6.4.6 and 5.3.4 of this specification. Localized stress discontinuities and localized yielding shall be evaluated by a qualified person to determine whether the design is acceptable or whether additional analysis is required.

These requirements of this section do not apply to components that are intended to be plastically deformed for them to perform correctly. Intentionally plastically deformed component designs shall conform to supplier/manufacturer documented design analysis methodology and acceptance criteria.

A.1.5.6.2 Strain Gauge Test

Perform A.1.4.6.2 with the following additions.

Strain gauges mounted in critical areas on the side-pocket mandrel identified from FEA results shall be rosette-style gauges. The result of this test shall be used to verify the finite element analysis in a full-scale strain gauge pressure test to not exceed 70 % of the maximum plastic deformation limit or non-linear strain to ensure no permanent damage to the side-pocket mandrel.

A.1.5.7 Failure Mode and Effects Analysis (FMEA)

The supplier/manufacturer shall conduct an FMEA, fault-tree analysis, or other reliability assessment method to determine whether validation testing per this annex validates the design for the intended application and further determine the requirements for additional validations.

Reliability assessment methods shall conform to the requirements of a national or international standard or to the supplier's/manufacturer's documented procedures that are based upon a national or international standard. The approved report of this assessment shall become a part of the tools design documentation.

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

A.1.5.8 Flow Control—Install/pull

Perform A.1.4.7.

A.1.5.9 Wireline Operational Test with KOT

Perform A.1.4.8.

A.1.5.10 KOT Non-Activation Test

Perform A.1.4.9

Annex B
(normative)

Product Functional Testing Requirements

B.1 Purpose

B.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.

Four product functional test grades with references to the subsections specifying the requirements are shown in Table B.1. Products successfully tested to more stringent grades of functional testing meet the requirements for less stringent grades.

Latches, FCD's, running and pulling tools utilized during testing shall be those that have been qualified as acceptable during the design validation testing.

Table C.1—Product Functional Testing Grades

Criterion	Grade			
	F3	F2	F1	F1H
Internal pressure test	B.1.3.2	B.1.4.2	B.1.5.2	B.1.6.2
External pressure test	Not required	B.1.4.3	B.1.5.3	B.1.6.3
ID drift test	B.1.3.3.1	B.1.4.4.1	B.1.5.4.1	B.1.6.4.1
OD drift test	B.1.3.3.2	B.1.4.4.2	B.1.5.4.2	B.1.6.4.2
Installation/removal method—KOT	Not required	B.1.4.5	B.1.5.5	B.1.6.5
ID = inside diameter; KOT = kick-over tool; OD = outside diameter				

B.1.2 Functional Test Documentation

A functional test report shall be prepared for each tool tested. The report shall include:

a) product supplier/manufacturer;

b) date of functional test;

c) model designation or other identification;

d) product number with unique serial number;

e) remarks (describing any non-specified equipment or procedures requested by supplier/manufacturer, unusual conditions observed during test, etc., as applicable);

f) testing limits applied and testing results compared to the acceptance criteria;

g) results of specific evaluations such as visual inspections, drift testing, as applicable;

h) running/pulling tools used (as applicable);

i) test fixtures, test fluids, and lubricants (as applicable);

j) test approval by a qualified person other than the person performing the test.

B.1.3 Grade F3—Basic Grade of Side-pocket Mandrel Product Functional Testing

B.1.3.1 General

The product functional tests for grade F3 listed in B.1.3.2 through B.1.3.3 shall be conducted in the order shown.

B.1.3.2 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 internal test pressure and at ambient temperature. The tested mandrel shall hold the test pressure for a minimum of five minutes 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 visible leaks in the side-pocket mandrel.

B.1.3.3 Drift testing

The order of drift testing is flexible.

B.1.3.3.1 ID Drift Test

A drift bar having a standard minimum length of 106.68 cm (42 in) (as specified in API 5CT) shall pass unencumbered through the side-pocket mandrel with a flow-control device and latch in place in the side-pocket mandrel pocket. The OD of the drift bar shall be the drift internal diameter of the side-pocket mandrel being tested, with a tolerance in accordance with API 5CT. This shall be performed on 100% of the side-pocket mandrels in each job lot. The drift bar shall be maintained and verified as part of the supplier's/manufacturer's standard calibration program.

B.1.3.3.2 OD Drift Test

The side-pocket mandrel shall not interfere witha 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 side-pocket 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 ID of the test casing, tube section, or test fixture shall be maintained and verified as part of the supplier's/manufacturer's standard calibration program.

B.1.4 Grade F2—Intermediate Grade of Side-pocket Mandrel Product Functional Testing

B.1.4.1 General

The product functional tests for grade F2 listed in B.1.4.2 through B.1.4.5 shall be conducted in the order shown.

B.1.4.2 Internal Pressure Test

Perform B.1.3.2.

B.1.4.3 External Pressure Test

This test is a hydro or liquid media external pressure test. It shall be conducted on a sample in accordance with 6.4.7 at or above the rated test pressure and at ambient temperature. The tested SPM shall hold the test pressure for a minimum of five minutes 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.

B.1.4.4 Drift Test

The order of drift testing is flexible.

B.1.4.4.1 ID Drift Test

Perform B.1.3.3.1.

B.1.4.4.2 OD Drift Test

Perform B.1.3.3.2.

B.1.4.5 Installation/removal Method—KOT

This test is conducted with the side-pocket mandrel installed in a horizontal position in a vise, with the pocket located at the top of the side-pocket mandrel or in the “12 o’clock” position. It shall be conducted on a sample in accordance with 6.4.7. A flow-control device with an appropriate latching mechanism shall be inserted into the side-pocket mandrel pocket, latched in the pocket, and retrieved from the pocket using the KOT that the user/purchaser specifies using the supplier’s/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.

Side-pocket mandrels that do not have an orienting profile shall be installed in a horizontal position with the pocket located in the “6 o’clock” position.

B.1.5 Grade F1—Enhanced Grade of Side-pocket Mandrel Product Functional Testing

B.1.5.1 General

The product functional tests for grade F1 listed in B.1.5.2 through B.1.5.5 shall be conducted on 100% of each job lot.

B.1.5.2 Internal Pressure Test

Perform C.1.3.2.

B.1.5.3 External Pressure Test

This test is a hydro or liquid media external pressure test and shall be conducted at or above the external test pressure and at ambient temperature. The tested SPM shall hold the test pressure for a minimum of five minutes 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.

B.1.5.4 Drift Test

The order of drift testing is flexible.

B.1.5.4.1 ID Drift Test

Perform B.1.3.3.1.

B.1.5.4.2 OD Drift Test

Perform B.1.3.3.2.

B.1.5.5 Installation/removal Method—KOT

This test is conducted with the side-pocket mandrel installed in a horizontal position in a vise, with the pocket located at the top of the side-pocket mandrel or in the “12 o’clock” position. A flow-control device with an appropriate latching mechanism shall be inserted into the side-pocket mandrel pocket, latched in the pocket, and retrieved from the pocket using the KOT that the user/purchaser specifies using the supplier’s/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.

Side-pocket mandrels that do not have an orienting profile shall be installed in a horizontal position with the pocket located in the “6 o’clock” position.

B.1.6 Grade F1H—HPHT Grade of Side-pocket Mandrel Product Functional Testing

B.1.6.1 General

The product functional tests for grade F1H listed in B.1.6.2 through C.1.6.5 shall be conducted on 100 % of each job lot.

B.1.6.2 Internal Pressure Test

This is a hydro or liquid media internal pressure test. It shall be conducted at or above the rated test pressure and at ambient temperature. The tested mandrel shall hold the test pressure for a minimum of 15 minutes after stabilization of the pressure. To be considered stabilized, the pressure shall remain constant with a variation of less than ±1 % of the test pressure. There shall be no visible leaks in the side-pocket mandrel.

B.1.6.3 External Pressure Test

This test is a hydro or liquid media external pressure test. It shall be conducted at or above the rated test pressure and at ambient temperature. The tested SPM shall hold the test pressure for a minimum of 15 minutes after stabilization of the pressure. To be considered stabilized, the pressure shall remain constant with a variation of less than ±1 % of the test pressure.

B.1.6.4 Drift Test

The order of drift testing is flexible.

B.1.6.4.1 ID Drift Test

Perform B.1.3.3.1.

B.1.6.4.2 OD Drift Test

Perform B.1.3.3.2..

B.1.6.5 Installation/removal Method—KOT

This test is conducted with the side-pocket mandrel installed in a horizontal position in a vise, with the pocket located at the top of the side-pocket mandrel or in the “12 o’clock” position. A flow-control device with an appropriate latching mechanism shall be inserted into the side-pocket mandrel pocket, latched in the pocket, and retrieved from the pocket using the KOT that the user/purchaser specifies using the supplier’s/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.

Side-pocket mandrels that do not have an orienting profile shall be installed in a horizontal position with the pocket located in the “6 o’clock” position.

Annex C
(normative)

Quality Control Requirements

C.1 Purpose

C.1.1 General

Each quality level 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.

Four quality levels with references to the subsections specifying the requirements are shown in Table C.1

Table C.1—Quality Control Level

Criterion	Grade			
	QL3	QL2	QL1	QL1H
Hardness testing	C.1.2.1	C.1.3.1	C.1.4.1	C.1.5.1
NDE	Not required	C.1.3.2	C.1.4.2	C.1.5.2
Final visual inspection	C.1.2.2	C.1.3.3	C.1.4.3	C.1.5.3
Documentation	C.1.2.3	C.1.3.4	C.1.4.4	C.1.5.4
NDE = non-destructive examination				

C.1.2 Grade QL3—Basic Level of Side-pocket Mandrel Quality Control

C.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 side-pocket mandrels in each job lot. All hardness examinations shall be conducted in accordance with 6.7.5.

C.1.2.2 Final Visual Inspection

A visual inspection shall be performed of all accessible surfaces by a qualified person after all testing is successfully completed. Observed damage shall be documented in the test report and the acceptance adjusted as applicable.

C.1.2.3 Documentation

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

C.1.3 Grade QL2—Intermediate Level of Side-pocket Mandrel Quality Control

C.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 the last in a weld zone. This test shall be conducted on 100 % of the side-pocket mandrels in each job lot. All hardness examinations shall be conducted in accordance with 6.6.5.

C.1.3.2 NDE

For quality level Q2, one of the following four tests shall be performed on a sample in accordance with 6.4.7:

- Magnetic particle examination shall be in accordance with 6.6.8.
- Liquid penetrant examination shall be in accordance with 6.6.9.
- Radiographic examination shall be in accordance with 6.6.6.
- Ultrasonic examination shall be in accordance with 6.6.7.

C.1.3.3 Final Visual Inspection

Perform C.1.2.2.

C.1.3.4 Documentation

If it is required by the user/purchaser, the documentation shall include a 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 6.4.6.

C.1.4 Grade QL1—Enhanced Level of Side-pocket Mandrel Quality Control

C.1.4.1 Hardness Testing

The hardness of the side-pocket mandrel shall be determined at four locations: one near the upper end, one near the middle, and one near the lower end of the side-pocket upset area, and the last in a weld zone. This test shall be conducted on 100 % of the side-pocket mandrels in each job lot. All hardness examinations shall be conducted in accordance with 6.6.5.

C.1.4.2 NDE

One hundred percent (100 %) of the side-pocket mandrels of each job lot shall undergo radiographic examination in accordance with 6.6.6. In those cases where radiographic examination results are inconclusive, ultrasonic examination shall be used to further assess those indications.

C.1.4.3 Final Visual Inspection

Perform C.1.2.2.

C.1.4.4 Documentation

If it is required by the user/purchaser, the documentation shall include a COC for the side-pocket mandrel job lot. It shall also contain additional NDE and mill certifications for all components as specified in 6.4.6.

C.1.5 Grade QL1H—HPHT level of Side-pocket Mandrel Quality Control

C.1.5.1 Hardness Testing

Perform C.1.4.1.

C.1.5.2 NDE

All pressure-containing welds shall be magnetic particle (6.6.8) or liquid penetrant (6.6.9) inspected for surface defects and shall be volumetrically inspected by radiographic examination in accordance with 6.6.6. In those cases where radiographic examination is inconclusive, ultrasonic examination (6.6.7) shall be used to further assess those indications. A final NDE shall be performed after all welding, post-weld heat treatment, straightening, and applicable machining operations on welded areas.

C.1.5.3 Final Visual Inspection

Perform C.1.2.2.

C.1.5.4 Documentation

Minimum documentation shall include a COC for the side-pocket mandrel job lot. It shall also contain additional NDE and mill certifications for all components as specified in 6.4.6 and functional test documentation (see C.1.2).

Annex D
(informative)

Operating Performance Envelope

D.1 Purpose

The side-pocket mandrel operating-performance envelope shown in Figure D.1 (with SI units) and Figure D.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 center 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.

The ratings utilized to create the performance envelope shall be the rated limits as established during the design verification process. The ratings shall be within the testing limits which are validated during validation testing.

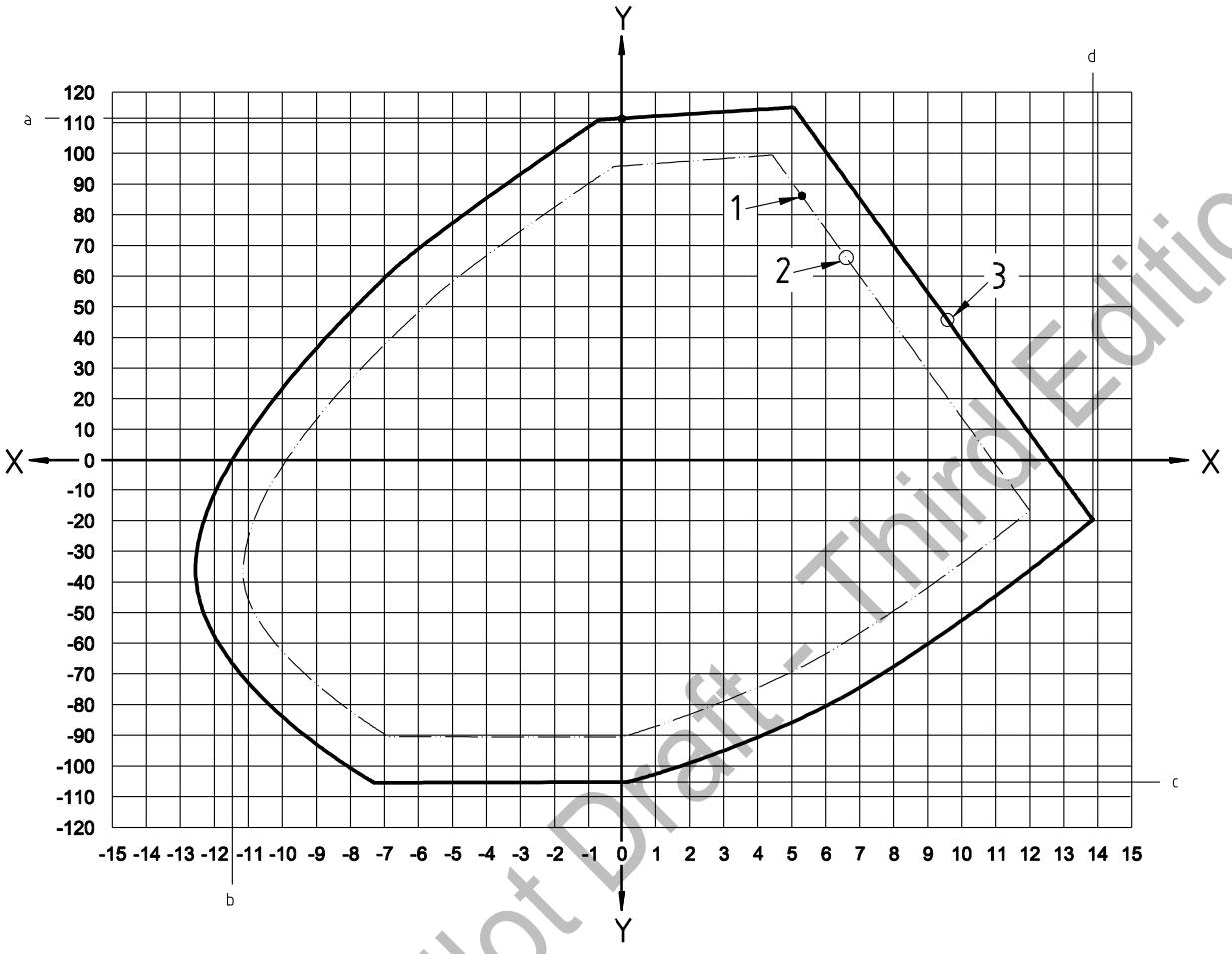

Figure D.1—Example 1 of a Rated Working Pressure Envelope (SI Units)

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.

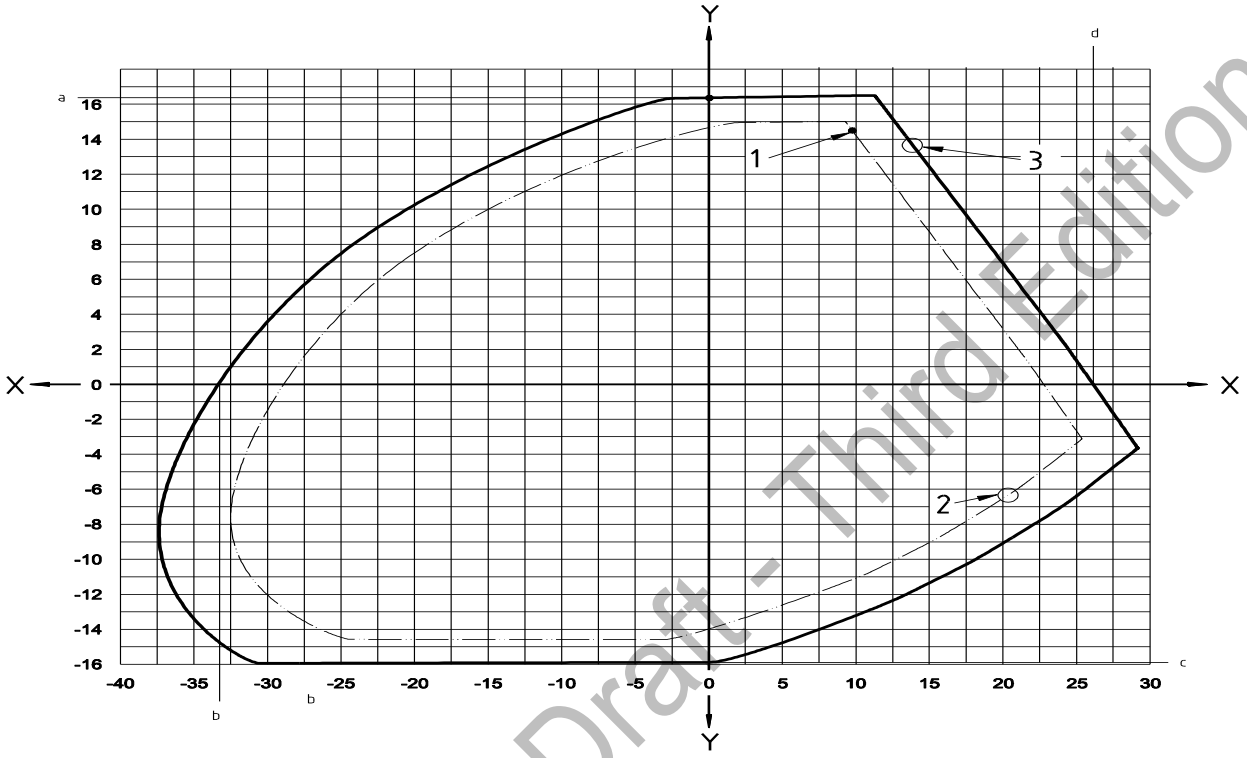

Figure D.2—Example 2 of a Working Pressure Envelope (Customary US Units)

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.

Annex E
(informative)

Schematics of Side-pocket Mandrels

The drawings in Figure E.1 illustrate typical side-pocket mandrels.

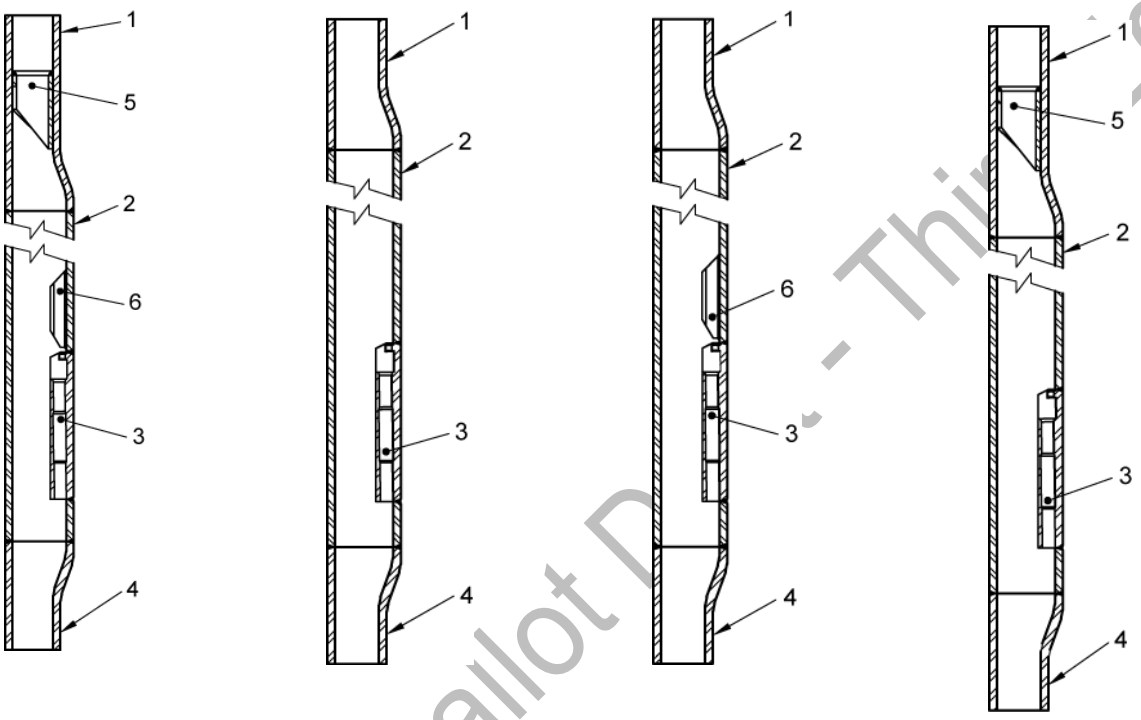

Figure E.1—Schematics of Typical Side-pocket Mandrels

Key

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

Bibliography

[1] API 19G2 Flow-control Devices for Side-pocket Mandrels

[2] API 19G3 Running Tools, Pulling Tools, and Kick-over Tools and Latches for Side-pocket Mandrels

[3] ASTM E29, Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

[4] ISO 6506-1, Metallic Materials — Brinell Hardness Test — Part 1: Test Method