Subsurface Completion Isolation (Barrier) Valves and Related Equipment

1 Scope

This specification provides the requirements for subsurface completion isolation (barrier) valves (SCIV) and related equipment as they are defined herein for use in the petroleum and natural gas industries. Included are the requirements for design, design validation grades, quality levels, manufacturing, functional evaluation, repair, redress, handling, and storage. SCIVs provide a means of isolating the formation or creating a blockage in the tubular to facilitate the performance of pre- and/or post-production/injection operational activities in the well.

Additional requirements for HPHT products are included in Annex I.

When closed, the SCIV provides an obstacle or impediment to flow and/or pressure from above and/or below and a means of isolating the formation within a conduit. The SCIV is not designed as an emergency or fail-safe flow-controlling safety device.

This specification does not cover installation and maintenance, control systems such as computer systems, and control conduits not integral to the SCIV. Also not included are products covered under ISO 17078, ISO 16070, ISO 14310, ISO 10432, ISO 10423, and the following products: downhole chokes, wellhead plugs, sliding sleeves, casing-mounted flow-control valves, injection valves, well-condition-activated valves, or drill-stem test tools. This specification does not cover the end connections to the well conduit.

2 Normative References

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

API[1] Technical Report 5C3, *Calculating Performance Properties of Pipe Used as Casing or Tubing, Annex A*

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

API *Manual of Petroleum Measurement Standards* Chapter 10.4, *Determination of Sediment and Water in Crude Oil by the Centrifuge Method (Field Procedure*)

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

ANSI/NACE MR0175-2015/*ISO 15156, Petroleum and natural gas industries – Materials for use in H_2S-containing environments in oil and gas production*

ASME[2] Boiler and Pressure Vessel Code (BPVC), Section II, *Materials Specification—Part D: Properties*

ASME Boiler and Pressure Vessel Code (BPVC), Section VIII, *Rules for Construction of Pressure Vessels—Division 1, UW-40: Procedures for Post-weld Heat Treatment*

ASME Boiler and Pressure Vessel Code (BPVC), Section VIII, *Rules for Construction of Pressure Vessels—Division 2, Part 5: Design by Analysis*

ASME Boiler and Pressure Vessel Code (BPVC), Section VIII, *Rules for Construction of Pressure Vessels—Division 3: Alternative Rules for Construction of High Pressure Vessels*

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1 American Petroleum Institute, 200 Massachusetts Avenue, Washington, DC 20001, www.api.org.
2 American Society for Mechanical Engineers, 2 Park Avenue, New York, New York 10016, www.asme.org.

ASME Boiler and Pressure Vessel Code (BPVC), Section VIII, Division I, UW-51, *Radiographic Examination of Welded Joints*

ASME Boiler and Pressure Vessel Code (BPVC), Section VIII, Division 1, Appendix 8, *Methods for Liquid Penetrant Examination (PT)*

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

ASQ[3] H1331, *Zero Acceptance Number Sampling Plans*

ASTM[4] D395-16e1, *Standard Test Methods for Rubber Property—Compression Set*

ASTM D412-16, *Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers—Tension*

ASTM D429-14, *Standard Test Methods for Rubber Property—Adhesion to Rigid Substrates*

ASTM D638-14, *Standard Test Method for Tensile Properties of Plastics*

ASTM D790-17, *Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials*

ASTM D1414, *Standard Test Methods for Rubber O-Rings*

ASTM D1415-06 (2012), *Standard Test Method for Rubber Property—International Hardness*

ASTM D1708-13, *Standard Test Method for Tensile Properties of Plastics by Use of Microtensile Specimens*

ASTM D2240-15, *Standard Test Method for Rubber Property—Durometer Hardness*

ASTM D2990-17, *Standard Test Methods for Tensile, Compressive, and Flexural Creep and Creep-Rupture of Plastics*

ASTM E21-09, *Standard Test Methods for Elevated Temperature Tension Tests of Metallic Materials*

ASTM E23-16b, *Standard Test Methods for Notched Bar Impact Testing of Metallic Materials*

ASTM E94/E94M-17, *Standard Guide for Radiographic Examination Using Industrial Radiographic Film*

ASTM E111-04 (2010), *Standard Test Method for Young's Modulus, Tangent Modulus, and Chord Modulus*

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

ASTM E709, *Standard Guide for Magnetic Particle Testing*

ISO[5] 3601-1, *Fluid power systems – O-rings – Part 1: Inside diameters, cross-sections, tolerances and designa-tion codes*

ISO 3601-3, *Fluid power systems – O-rings – Part 3: Quality acceptance criteria*

ISO 6506 (all parts), *Metallic materials — Brinell hardness test*

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[3] American Society of Quality, 600 North Plankinton Avenue, Milwaukee, Wisconsin 53203, www.asq.org.

[4] ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, Pennsylvania 19428, www.astm.org.

[5] International Organization for Standardization, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, www.iso.org.

ISO 6508 (all parts), *Metallic materials — Rockwell hardness test*

ISO 9000, *Quality management systems — Fundamentals and vocabulary*

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

ISO 10414-1, *Petroleum and natural gas industries — Field testing of drilling fluids — Part 1: Water-based fluids*

ISO 18265, *Metallic materials — Conversion of hardness values*

ISO 23936-1, *Petroleum, petrochemical and natural gas industries – Non-metallic materials in contact with media related to oil and gas production – Part 1: Thermoplastics*

ISO 23936-2, *Petroleum, petrochemical and natural gas industries – Non-metallic materials in contact with media related to oil and gas production – Part 2: Elastomers*

NORSOK[6] M-710, *Qualification of non-metallic sealing materials and manufactures*

3 Terms and Definitions

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

3.1
assembly (noun)
Product comprised of more than one component.

3.2
ambient temperature
Prevailing temperature at test site.

3.3
base design
Design of a specified size, type, and model of SCIV that has passed the requirements of Annex B and meets the requirements of this specification.

3.4
blockage
barrier
Obstacle or impediment to flow and/or pressure.

3.5
casing
Pipe extending from the surface and intended to line the walls of a drilled well.

3.6
casing-mounted flow-control valves
Downhole valves permanently installed as a component of the casing or liner (pipe not extending from the surface and intended to line the walls of a drilled well).

3.7
city water
Water that is provided by the local water utility system, which may include inhibitors.

[6] Standards Norway, P.O. Box 252, NO-1326 Lysaker, Norway, www.standard.no.

3.8
closing mechanism
Device designed to block or impede flow at a designated point when closed.

3.9
common hardware
Non-traceable nuts, bolts, washers, screws, and spacers.

3.10
design margin
Ratio of the material minimum yield stress divided by the actual design stress in a component at the rated conditions.

3.11
design validation
Process of proving a design by testing to demonstrate conformity of the product to design requirements.

3.12
design verification
Process of examining the result of a given design or development activity to determine conformity with specified requirements.

3.13
downhole choke
Downhole device used to restrict flow rates through its ID and not intended to seal as a barrier.

3.14
drift diameter
Minimum ID of a SCIV, expressed as the OD of the drift bar used during assembly verification.

3.15
drill-stem test tools
Downhole tools temporarily set in place for the purpose of evaluating the production potential of the chosen formation.

3.16
end connection
SCIV equipment/tubular connecting interface.

3.17
environment
Set of conditions to which a product is exposed.

3.18
external means
Signal or method used to actuate a subsurface completion isolation (barrier) valve that is instigated by human intention.

3.19
fit
Geometric relationship between parts.

NOTE This includes the tolerance criteria used during the design of a part and its mating parts, including seals adjusted to or shaped for their purpose.

3.20
function
Operation of a product during service.

3.21
functional specification
Features, characteristics, process conditions, boundaries, and exclusions defining the performance and use requirements of the products.

3.22
functional test
Test processes performed to confirm proper operation of SCIV products.

3.23
heat
Material originating from a final melt, or for re-melt alloys, the raw material originating from a single re-melt ingot.

3.24
heat-lot
Material or components having undergone the same process or series of processes and being traceable to one heat of material.

3.25
heat treat lot
A group (lot) of components of material that have undergone the same process or series of processes in a single heat treatment furnace load or continuous furnace run and are uniquely identified.

3.26
heat treatment
Alternate steps of controlled heating and cooling of materials for the purpose of changing mechanical properties.

3.27
informative
Information intended to enlighten the user/purchaser or supplier/manufacturer, without containing requirements.

3.28
injection valve
Downhole valve that is normally closed and opened by injected flow within the primary conduit and used for long-term well injection to prevent backflow.

3.29
interchangeability
State of conforming within specified tolerances, to both fit and function of a safe design but not necessarily to the form.

3.30
job-lot
Batch of material or components that have undergone the same process or series of processes.

NOTE This may include more than one heat.

3.31
life cycle
Expected period of time or specified number of actuations that the product shall function according to the supplier/manufacturer's specifications.

3.32
manufacturing
Processes and actions performed by an equipment supplier/manufacturer that are necessary to provide a finished component(s), assembly(ies), and related documentation that fulfill the requests of the user/purchaser and meet the standards of the supplier/manufacturer.

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

3.33
minimum material condition
Minimum geometrical dimensions and material properties, as allowed by the design specification.

3.34
model
SCIV products with unique components and operating characteristics that differentiate them from other SCIV products of the same type.

3.35
normative
Information or procedures mandatory for the user/purchaser or supplier/manufacturer to comply with this specification.

3.36
operating manual/operator's manual
Document issued by the supplier/manufacturer that contains detailed data and instructions related to the design, installation, operation, and maintenance of SCIV products.

3.37
operating temperature range
Range defined by the minimum and maximum operating temperatures for products as specified by the supplier/manufacturer.

3.38
post-production/injection
Indicates the point in time when production/injection has begun.

3.39
pre-production/injection
Indicates the point in time prior to injection or production.

3.40
profile
Feature that is designed for the reception of a locking mechanism, ancillary tools, or SCIV tool.

3.41
proof test
Testing specified by the supplier/manufacturer that is performed to verify that the SCIV meets the requirements of the technical specification that are relevant to the validation testing performance.

3.42
qualified person
Individual or individuals with characteristics or abilities gained through training or experience, or both, as measured against established requirements, such as standards or tests that enable the individual to perform a required function.

3.43
rated pressure
Maximum SCIV pressure limit as defined by the supplier/manufacturer for external, internal, and differential pressures.

3.44
redress
Activities involving the replacement of nonmetallic components, shear devices used in functional testing, resetting of single-use tools, and common hardware.

3.45
repair
Activities beyond the scope of redress that may include disassembly, reassembly, and testing with or without the replacement of components, and may include machining, welding, heat treating, or other manufacturing operations that restore the equipment to its original performance.

3.46
resetting
Returning the tool to its original condition without redress or repair.

NOTE Single-use tools may require a redress.

3.47
room temperature
Temperature that is typically between 15 °C (60 °F) and 26 °C (80 °F).

3.48
sealing element
Device preventing passage (i.e. communication) of liquid and/or gas across the interface in which it is placed.

3.49
shear device
Component designed to disconnect by parting of the device under a predetermined load.

3.50
single-use product
Device designed for its primary function to be operated one time before redress/resetting.

3.51
size
Relevant dimensional characteristics (nominal tubing/casing) of the product as defined by the supplier/manufacturer.

3.52
sliding sleeve
Tubing-mounted device designed such that it is activated to open or close communication between the tubing and the tubing-to-casing annulus, or open hole annulus, by moving a sleeve.

3.53
special feature
Specific additional functional capability not validated by the validation testing in accordance with Annex B.

3.54
stabilization
The period during which the test parameters may be adjusted and monitored prior to performing the test.

3.55
stress relieving
Controlled heating of material to a predetermined temperature for the purpose of reducing any residual stresses.

3.56
subassembly
An assembly of components designated as a unit to become incorporated within a validated product.

3.57
substantive change
Change to the design, identified by the supplier/manufacturer, that affects the performance of the product in the intended service condition.

3.58
subsurface completion isolation (barrier) valve (SCIV)
Device positioned below the tubing hanger that is activated to open and/or close by external means and provides, when closed, a blockage from above and/or below and a means of isolating the formation within a conduit.

3.59
subsurface completion isolation (barrier) valve tool (SCIV tool)
Tool used with subsurface completion isolation (barrier) valves to perform their primary function(s) or provide another intended design function.

3.60
test vessel
Test apparatus that contains the SCIV.

3.61
type
SCIV product with unique characteristics that differentiate it from other SCIV equipment.

3.62
Type 1 component or weld
Component or weld that isolates pressure and/or may be loaded in tension as the result of axial loads on a valve during run-in, whether the valve is closed or open.

3.63
Type 2 component or weld
Component or weld that does not meet the criteria of Type 1 or common hardware.

3.64
validation test
Test performed to qualify a particular size, type, and model of SCIV product for a specific grade of service.

3.65
well-condition-activated valve
Downhole valve that is not activated by intervention or intentional action(s).

EXAMPLE Chemical- or temperature-activation methods.

3.66
wellhead plug
flow-control device located in the primary bore of a wellhead

4 Acronyms

AQL	acceptance quality level
BPD	barrels per day
COC	certificate of conformity
FEA	finite element analysis
ID	inside diameter
MTR	material test report
NDE	nondestructive examination
OD	outside diameter
QMS	quality management system
SCIV	subsurface completion isolation (barrier) valve

5 Functional Requirements

5.1 General

5.1.1 Functional Requirements

The user/purchaser shall prepare a functional specification for ordering products that conform with this specification and specify the requirements defined herein, as applicable, and/or identify the supplier/manufacturer's specific product by the unique identifier. These requirements and operating conditions may be conveyed by means of text, dimensional drawing, datasheet, or other suitable documentation. Table 1 provides a summary of the applicability of the annexes included within this specification.

Table 1—Annex Applicability Summary

Annex and Designation	Annex Title	Validation Grades			
		V1H	V1	V2	V3
A Informative	**SCIV system types and application overview**	**For information only**			
B Normative	Validation requirements for SCIVs	R	R	R	R
C Normative	Functional testing requirements	R	R	R	R
D Normative	Validation requirements for SCIV tools	Requirements apply to SCIV tools.			
E Normative	Performance envelopes	R	R	O	O
F Informative	Alternate (barrier) leakage test acceptance criteria	O	O	O	N/A
G Informative	Debris settling design validation	O	O	O	O
H Informative	Closure while flowing slurry test	O	O	O	O
I Normative	HPHT Annex	R	N/A	N/A	N/A
J Informative	API Monogram Program Annex	O	O	O	O

Key: **R** = Required; **O** = Optional, selected by user/purchaser; **N/A** = Not Applicable
NOTE Design validation of product types A, B, C is required before Type AA, BB, CC design validations are performed; see Annex B.

5.1.2 Product Types

5.1.2.1 The user/purchaser shall select one product type from Table 2. Validation testing requirements are specified in Annex B and functional testing requirements are specified in Annex C.

NOTE Product applications and types are discussed in Annex A.

Table 2—SCIV Types

	Isolates from Above	Isolates from Below	Isolates from Above and Below
Pre-production and/or injection SCIVs	Type A	Type B	Type C
Post-production/injection[a]	Type AA	Type BB	Type CC

[a] Post-production/injection valves are inclusive of pre-production and/or injection SCIV capabilities; for example type AA valves include the capabilities of type A valves.

5.1.2.2 Valve types A, B, and C are typically designed for use during the completion process, after which they become inactive. Details are listed below:

— Type A: SCIV designed to be a blockage from above, typically for fluid-loss control or reservoir protection and capable of being pressure tested from above;

— Type B: SCIV designed to be a blockage from below, typically for well control or reservoir protection and capable of being pressure tested from below;

— Type C: bi-directional SCIV designed to be a blockage from above and below and capable of being pressure tested in both directions.

5.1.2.3 Valve types AA, BB, and CC are designed for use in pre- and post-production/injection applications, where they can be actuated more than once, as specified by product design. Details are listed below:

— Type AA: SCIV designed to be a blockage from above, typically for fluid-loss control or reservoir protection and capable of being pressure tested from above; the valve operates open and closed and maintains its pressure integrity over its predetermined life cycle;

— Type BB: SCIV designed to be a blockage from below, typically for well control or reservoir protection and capable of being pressure tested from below; the valve operates open and closed and maintains its pressure integrity over its predetermined life cycle;

— Type CC: bidirectional SCIV designed to be a blockage from above and below and capable of being pressure tested in both directions; the valve operates open and closed and maintains its pressure integrity over its predetermined life cycle.

NOTE The rated pressures for bidirectional SCIVs are possibly not the same from above and below.

5.1.3 Design Validation Grades

The user/purchaser shall select one design validation grade from Table 3 for each product design being provided. These are proof of design evaluations that are performed on the base design. The detailed requirements for each validation grade are specified in Annex B.

Table 3—SCIV Validation Grade Summary

Validation grade	Description
V1H: Enhanced design validations for HPHT	Same as V1 with the addition of Annex I requirements.
V1: Enhanced design validations (V1 includes the requirements of V2)	Design validations and verifications are required to support the supplier/manufacturer rated limits. These include rated pressure range, temperature range, actuation functionality, and all other stated capabilities, and a performance envelope in accordance with Annex E. These products conform to V1 acceptance criteria as specified in Annex B.
V2: Design validations	Same as V1 except that these products conform to V2 acceptance criteria as specified in Annex B.
V3: Supplier/manufacturer's design validations and field history	Design evaluations are specified by the supplier/manufacturer and are intended to meet the requirements of this specification. Documented evidence of testing or evaluation results conforming to the supplier/manufacturer defined acceptance criteria meet this requirement. Alternatively, a documented field history of successful performance of products in an environment similar to that of the functional requirements, for products of the same size, type, and model; may be used; see B.3.2.3.2.

5.1.4 Quality Levels

The user/purchaser may select one quality level from Table 4 for each product design provided or may provide specific quality requirements. Products shall be supplied to QL2 unless otherwise specified. A summary of the quality level requirements is given in Table 6 and the detailed requirements for each level are given in Section 7.

Table 4—SCIV Quality Levels

Quality Levels	Description
QL1: Enhanced quality requirements (QL1 includes the requirements of QL2)	This includes material certifications, NDE documentation, traceability records, functional testing documentation and COCs for coatings, overlays, welding, brazing and heat treating. QL1 requires 100 % NDE inspection of Type 1 components.
NOTE Quality level selection QL1 or QL2 applies to all SCIV types and validation grades, with QL2 as the default selection. See Section 5.1.4.	

5.2 Functional Characteristics

The functional characteristics shall include, but not be limited to, the following, as applicable, for each SCIV and required tool:

a) type of control system and its limits;

b) methods of actuation (surface-controlled, subsurface-controlled);

c) type of SCIV closing mechanism (ball, flapper, sleeve, etc.);

d) holding the SCIV open without the use of the primary operating mechanism (temporary or permanent lock-open systems);

e) pump-through capability;

f) independent backup operating system;

g) specific number of cycles, actuations;

h) contingency opening/closing feature/procedure independent of 5.2 f);

i) conditions and/or mechanisms causing valve operation, and the conditions under which the valve is designed to close or open;

j) requirements for retrieval and/or repair;

k) acceptance of the introduction of debris to the wellbore upon actuation.

5.3 Well Parameters

The following well parameters shall be specified, as applicable:

a) well location (land, platform, subsea);

b) size, mass (weight), grade, and material of the casing and tubulars;

c) casing and/or tubing architecture, trajectory, deviations, maximum dog-leg severity;

d) setting depth (maximum required for application) and control fluid type/properties, supply pressure, supply line(s), and connection rating(s);

e) restrictions through which the SCIV shall pass and restrictions through which the SCIV tools/accessories shall pass.

5.4 Operational Parameters

The operational parameters shall include, but not be limited to, the following, as applicable, for each SCIV and required tools:

a) maximum rated pressure, for both external, internal, and differential pressures;

b) rated temperature range, for both maximum and minimum in static and operational conditions;

c) maximum allowable pressure drop at maximum flow rate through SCIV;

d) loading conditions, including combined loading (pressures, tension/compression, torque, bending, intermittent conditions, such as pressure testing with temporary test plugs) and the corresponding temperature limits anticipated;

e) any well-pumping operations, including parameters such as acidizing (e.g. composition of the acid), sand/proppant description, fluid flow rate, proppant/fluid ratio or sand/fluid ratio, pressure, temperature, and exposure time, and any other chemicals.

5.5 Environmental Compatibility

The following shall be identified for the SCIV and required tools to ensure environmental compatibility.

a) Anticipated production/injection/annulus fluid chemical and physical composition, including solids (sand production, scale, hydrates, asphaltenes, etc.) to which the SCIV is exposed during its life cycle. This information may include:

   1) completion fluid composition, pH, and existence of bromides (Zn, Ca, Na), formates (Cs, K, Na), chlorides (K, Ca, Na), acetates (Cs);

   2) mud composition type, mud density, and pH;

3) aromatic and aliphatic solvents where present (type/amount);

4) inhibitor treatments (type, concentration, and pH);

5) oxygen scavenger systems;

6) emulsifier systems;

7) continuous or batch treatment;

8) duration and temperature of exposure;

9) control line fluid type, density, and chemistry.

b) In cases where the user/purchaser has access to corrosion property data and/or research that is applicable to the functional specification, the user/purchaser shall state which material(s) have the ability to perform as required.

c) In cases where the user/purchaser elects to use materials specified by the supplier, the user/purchaser shall provide the necessary environmental conditions to enable the proper selection of materials for the environment.

d) At valve setting depth, the minimum, maximum, and typical values of the production/injection pressures and temperatures at the anticipated flow rates.

e) Environmental conditions during transportation, storage, and at surface prior to and during deployment.

5.6 Compatibility with Related Well Equipment

The following information, as applicable, shall be specified to ensure the compatibility of the SCIV and required tools with the related well equipment:

a) SCIV size and the external connection to the well tubulars;

b) the configuration of the external interface connections (these connections are not included in the evaluation of combined loading);

c) details of any devices being run through the SCIV, such as size, type, and configuration of the other devices;

d) internal receptacle profile(s) required in the SCIV for receiving related well equipment, including sealing bore, dimension(s), eccentricity, and respective locations;

e) requirement(s) for continuity of flow path and/or through bore access (size, length, etc.), passage of conduits (electrical/hydraulic, etc.) between valve OD and casing ID, and/or open-hole ID restrictions.

5.7 Optional User/Purchaser Selected Requirements

5.7.1 General

Due to the user/purchaser's preferences or the application's critical needs, the following optional validations have been included. Limits to their selection are included herein (see Table 1).

5.7.2 Alternate (Barrier) Leakage Test Acceptance Criteria

The user/purchaser may select this alternate (reduced) leakage test acceptance criteria for products where design validation level V1H, V1, or V2 has been selected. See Annex F for the detailed requirements.

5.7.3 Performance Envelope for V2

The user/purchaser may request a performance envelope supplied to illustrate the combined effects of pressure, temperature, and axial loads for V2 SCIVs; see Annex E.

5.7.4 Additional Validation Testing

The user/purchaser may select additional validation testing performed as defined in Annex G and/or in Annex H.

5.7.5 Additional Quality Requirements

The user/purchaser may require the performance of additional quality inspection operations.

6 Technical Specification

6.1 General

The supplier/manufacturer shall provide the user/purchaser with a technical specification that conforms to the requirements defined in the functional specification, or identifies in detail where variance(s) are offered. The supplier/manufacturer shall also provide the user/purchaser with the technical and manufacturing data required by 7.2.

In cases where the user/purchaser specifies material(s) of construction, deviations from such material(s) of construction shall require user/purchaser notification.

6.2 Technical Characteristics

The SCIV and SCIV-related tools shall perform in accordance with the functional specification, as stated in Section 5, and within the limitations defined in the product-specific operating manual and design criteria.

6.3 Design Criteria

6.3.1 General

SCIV and SCIV tool designs shall permit prediction and repeatability of conditions required for opening and/or closing. SCIV products shall be designed to meet the design validation requirements and the requirements of the functional specification. Final approval of the design shall be performed and documented by a qualified person(s) other than the person who created the original design.

6.3.2 Design Requirements

6.3.2.1 General

The supplier/manufacturer shall establish internal yield pressure, external pressure, minimum tensile/compressive strength ratings (excluding end connections), geometrical dimensions, and the operational capabilities necessary to meet the requirements of this specification.

External pressure, tensile, compression, and internal chamber ratings shall be established based on design calculations or full-scale testing using supplier/manufacturer approved methods by a qualified person(s).

The supplier/manufacturer shall identify all related tools necessary for the full functionality of the SCIV. The design requirements for the related tools and the interface with the specific SCIV shall conform to the functional specification. SCIV tools shall be designed and manufactured according to the requirements defined for QL2.

Temperature, environment, material properties, and combined loading effects on all materials used in SCIV products shall be considered when establishing the rated pressures and load capabilities. The design shall take into

account the effects of pressure containment and pressure-induced loads. Where applicable, specialized and/or intermittent conditions, such as pressure testing with temporary test plugs, shall also be considered in the design.

The additive dimensional tolerances shall be such that proper operation of the SCIV product is assured. SCIV products and components conforming to this specification shall be manufactured according to drawings and specifications that contain no substantive changes from those of the SCIV product that passed the applicable validation test.

Components and welds shall be identified as Type 1, Type 2, or common hardware in the design documentation.

6.3.2.2 Temperature and Environment Considerations

SCIV product design shall take into consideration the effects of temperature on all components. The upper temperature limit shall be the lowest high-temperature rating of any component of the SCIV. The lower temperature limit shall be the highest low-temperature rating of any component of the SCIV. De-rating of metal mechanical properties shall be in accordance with ASME BPVC, Section II, Part D or a reference approved by a qualified person of the supplier/manufacturer.

The supplier/manufacturer shall utilize temperature de-rated yield strength test results for each metallic material corresponding to the maximum rated temperature of the valve. Metal mechanical properties de-rating shall be verified and documented by a qualified person.

NOTE ASTM E21 provides guidance for yield strength de-rating.

SCIV product design shall take into account the effects of exposure to and/or retained fluid(s) supplied in the functional specification on all components. SCIV product design shall consider the effects of sand, chlorides, corrosion inhibitors, and any other chemicals routinely encountered in oil and gas production, as defined in the functional specification.

For sour environments, the materials selected shall be in conformance with the requirements of ANSI/NACE MR0175/ISO 15156.

6.3.2.3 Interchangeability

The design, tolerancing, and manufacture of SCIV components shall be conducted so that interchangeability of components and/or subassemblies of separately manufactured products is possible without affecting the performance of the assembled product.

6.4 Materials

6.4.1 General

Materials for each component shall be defined by the supplier/manufacturer and shall be suitable for the functional specification. All materials shall comply with the supplier/manufacturer's documented specifications.

The user/purchaser may specify materials for the specific corrosion 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 specified well and production/injection parameters to the user/purchaser. This applies to metallic and nonmetallic components.

6.4.2 Material Substitutions

Material substitutions for materials used in validated products are allowed without further design validation. The selection criteria for these substitutions shall be documented and the substituted material shall conform to the design, and to the functional and technical requirements of this specification. Material substitutions require approval by a qualified person from the supplier/manufacturer and the supporting documentation shall be incorporated into the manufacturing and design records.

6.4.3 Metals

6.4.3.1 General

Metallic materials used in the manufacture of Type 1 and Type 2 components of SCIVs shall meet the requirements in 6.4.3.2 and 6.4.3.3. For common hardware, see 6.4.3.5.

6.4.3.2 Specifications

The material specifications shall include the applied controls on the material, as applicable, to ensure performance to the documented requirements as follows:

a) chemical-composition limits;

b) heat-treatment requirements/conditions;

c) mechanical-property limits, as applicable:

— tensile strengths;

— yield strength (transverse and longitudinal);

— elongation;

— hardness;

— toughness, as defined by the supplier/manufacturer.

6.4.3.3 Mechanical Property Testing of Heat-treated Materials

The heat-treatment process parameters shall be defined in the heat-treatment procedures, as required to achieve the defined material properties. Material test reports provided by the material supplier and approved by the supplier/manufacturer, or the material test reports provided by the supplier/manufacturer, are acceptable documentation of the specified mechanical properties.

Hardness testing is the minimum mechanical property testing required after stress relieving.

6.4.3.4 Stress Relieving of Welds

Each welded component shall be stress-relieved as specified in the supplier/manufacturer's documented specifications or in accordance with ASME BPVC, Section IX. Hardness testing is required after stress relieving.

6.4.3.5 Common Hardware

Common hardware shall be provided to documented industry standards.

6.4.4 Non-metals

6.4.4.1 General

The supplier/manufacturer shall have a documented procedure that provides for the selection of nonmetallic material and compounds that conform to the supplier/manufacturer’s equipment specification. The procedure shall include at a minimum:

— functional requirements;

— technical specifications;

— operational parameters;

— environmental conditions;

— material type;

— geometric component design;

— required service life;

— chemical resistance to known well fluids.

The material type and specific compound shall be selected in accordance with the supplier/manufacturer's procedures and the requirements of the functional specification. Records of material type and compound selection shall be part of the design documentation.

Mechanical properties required by the material specification shall be validated by tests conducted on a material sample produced from the same batch of material that has seen the same thermal processing. Mechanical property test procedures shall be as follows:

a) tensile, elongation, modulus:

   — O-rings in accordance with ASTM D1414 or ASTM D412;

   — other elastomers in accordance with ASTM D412 (alternative ISO or ASTM methods may be used where applicable);

   — non-elastomers in accordance with ASTM D638 or ASTM D1708;

   NOTE For the purposes of these provisions, ISO 527–1 is equivalent to ASTM D638.

b) compression set (homogeneous elastomeric materials only):

   — O-rings in accordance with ASTM D1414 or ASTM D395;

   — all others in accordance with ASTM D395;

c) durometer hardness:

   — O-rings in accordance with ASTM D1415 or ASTM D2240;

   — other elastomers in accordance with ASTM D2240, Shore A;

   — thermoplastics and other materials in accordance with ASTM D2240 or ASTM D785 as applicable.

For thermoplastic materials, the supplier/manufacturer's specification shall include requirements and acceptance criteria for the parameters shown in Table 5, as applicable, determined per the specification listed in Table 5. The specification shall state if the parameters are measured on an actual component.

Table 5—Thermoplastic Material Properties

Parameter	Specification as Applicable
Tensile strength (at either break or yield as applicable)	ASTM D638 or D1708
Elongation (at either break or yield as applicable)	ASTM D638 or D1708

Parameter	Specification as Applicable
Modulus of elasticity	ASTM D638
Flexural modulus	ASTM D790
Creep failure	ASTM D2990

6.4.4.2 Bond Strength Validations

For designs requiring that the elastomer be bonded to a substrate, the adhesive bonding process shall be defined and validated with a bond test. The process validation criteria shall include controls for the elastomer, substrate, adhesives, and any required environmental controls. The bond test shall conform to the requirements of ASTM D429 or an equivalent referenced testing program, including surface preparation requirements, with evaluated and documented acceptance criteria. A minimum of three representative bonded samples shall be evaluated, and all samples shall conform to the defined acceptance criteria.

6.4.4.3 Other Materials

Materials and components that are not manufactured or supplied under the previously specified controls for metallic or nonmetallic materials shall have documented design requirements controlled by the supplier/manufacturer, and shall also have controls on materials to ensure performance to the documented requirements. All components/materials used in validated or delivered equipment, except common hardware, shall be verified as conforming to documented requirements. Each of the properties specified shall have a traceable and supplier/manufacturer-approved test report or COC from the component manufacturer for that batch and/or compound of material.

Material/component design validation shall conform to the technical specification.

6.5 Performance Envelope

A performance envelope, as specified in Annex E, shall be prepared for V1H and V1 SCIVs. For V2 SCIVs, a performance envelope shall be prepared when requested in the functional specification. The performance envelope of the supplier/manufacturer shall state and graphically illustrate the pressure, temperature, and axial load rating, as applicable, for the rated limits of the body of the specific product, exclusive of end connections.

The performance envelope may be based on test data and/or calculated data, except for V1H, which is a tested performance envelope. An example is given in Annex E.

6.6 Design Documentation

The instructions providing methods for the safe field use of the product shall be defined in the operating manual. See 7.2.2 for documentation requirements.

6.7 Design Verification

6.7.1 General

Design verification shall be performed to ensure that each SCIV design meets the supplier/manufacturer's technical specifications. Design verification includes activities such as design reviews, design calculations, physical tests, and comparison with similar designs.

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 used in the creation of component or assembly capabilities and/or ratings.

For V3, historical records of defined operating conditions may be used for design verification (see B.3.2.3.2). Verification results shall be approved by a qualified person, other than the person who created the original design, and records of the results shall become a portion of the design documentation.

HPHT products shall also conform to Annex I requirements.

The designs shall be analyzed to determine the supplier/manufacturer's rated limits. The minimum material condition and minimum material yield strength, at the rated temperature limits, shall be used in the calculations.

6.7.2 Design Calculations

6.7.2.1 General

Design calculations shall be performed using one or more of the following methodologies.

6.7.2.2 Distortion Energy Theory

The distortion energy theory, also known as the von Mises yield criterion, may be used for the design calculation of pressure-containing components.

NOTE ASME BPVC, Section VIII,, Division 3, KD-131(b) provides the equations to calculate the equivalent stress.

The equivalent stress shall be calculated and be limited by the supplier/manufacturer's documented design margin methodology and practice.

6.7.2.3 Triaxial Yield and Uniform Axial Equations

API 5C3, Annex A (Discussion of Equations for Triaxial Yield of Pipe Body) may be used to derive the triaxial yield stress of a cylinder.

Tensile (axial) stress calculations shall be performed per the requirements of API 5C3, Annex A, Section A.1.2.3 (Uniform Axial Stress).

6.7.2.4 Finite Element Analysis

Finite element analysis (FEA) is a design verification methodology that analyzes more complex geometries and/or complex loading where conventional verification methodologies are considered incomplete by the design engineer or qualified person. FEA methodology may be used for single or combined loading situations.

FEA analysis inputs and outputs shall be archived such that the study can be reevaluated/reproduced at a later date.

6.8 Design Validation

6.8.1 General

The SCIV designs produced in accordance with this specification shall have passed the applicable validation test required in the functional specification and specified in Annex B to qualify each size, type, and model. Successful completion of the validation testing process shall qualify other SCIVs of the same size, type, and model as the tested base design of SCIV.

Alternatively, product designs that have been validated in accordance with the requirements of Annex B of the previous editions of this specification may be considered as satisfying the requirements of Annex B of this edition, when the results are documented and approved by a qualified person. These designs shall be identified and documented as having been tested to the previous edition.

HPHT products shall also conform to Annex I requirements.

NOTE The testing requirements in this specification may not be representative of well conditions.

6.8.2 Supplier/manufacturer Requirements

Prior to validation testing, the SCIV shall be proof tested or evaluated to ensure that the valve meets the requirements of the technical specification with the supplier/manufacturer's specified design margins. The supplier/manufacturer shall provide the validation test facility with a SCIV of each size, type, and model, and a detailed test procedure that conforms to the requirements of this specification. Each product base design provided shall, at a minimum, conform to all the acceptance criteria of the validation test requirements of Annex B.

Pre-test and post-validation testing dimensional inspections of critical dimensions defined by the supplier/manufacturer shall be conducted and documented. For a successful test, all results shall be within the established acceptance criteria, approved by a qualified person(s), and maintained in the design file.

6.8.3 Special Feature Validations

Special features shall be validated by test to their rated limits or fully verified to documented procedures, including acceptance criteria, and shall be approved by a qualified person(s); see B.4.10. The procedures and results shall be incorporated into the design file. Special feature validation testing may be performed by the supplier/manufacturer. 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.

6.8.4 SCIV Tool Validation

SCIV tools shall be validated to the requirements of Annex D.

6.9 Design Changes

6.9.1 General

Design changes shall be approved by a qualified person(s) before implementation. All design changes shall be documented and reviewed by a qualified person against the design verification and design validation requirements to determine if the change is a substantive design change. A design that undergoes a substantive change becomes a new design requiring verification (see 6.7) and validation (see 6.8); however, scaling may be applied in accordance with 6.9.3. All products containing a substantive change shall meet the applicable verification and validation test requirements of the base design.

Design changes and changes to design documents shall require the same controls as those applied to the design that has passed the applicable validation and verification requirements of this specification.

The supplier/manufacturer shall, at a minimum, consider and document the following for each design change:

— stress levels of the modified or changed components compared with those of the base design;

— possible functional or operational changes introduced by the design change;

— interchangeability with existing components or previously manufactured assemblies.

6.9.2 Substantive Design Changes

6.9.2.1 General

Design validation for changes to components or subassemblies may be done by performing validation testing on only the component or subassembly rather than the entire assembly. The test(s) shall simulate the operating conditions that would be present if the entire assembly were tested. The supplier/manufacturer shall document

the detailed test results and analysis that demonstrate that the component or subassembly test adequately simulates the required loading conditions.

6.9.2.2 Changes Requiring User/Purchaser Notification after Product Delivery

Performance changes to the SCIV and/or SCIV tools that have been identified after product delivery by the supplier/manufacturer that reduce the specified functional requirements of the product or negatively impact the operation of existing product and/or secondary tools shall require notification to the user(s)/purchaser(s). This notification shall include a summary of performance changes and recommended disposition of all affected equipment.

6.9.3 Design Validation by Scaling

6.9.3.1 General

Scaling of SCIVs and tools of the same nominal size, type, and model is permitted by reference to a successfully validation-tested product in accordance with the requirements and limitations of 6.9.3.2 and 6.9.3.3.

6.9.3.2 Evaluation of a Scaled Design

To establish a scaled design, the supplier/manufacturer shall identify the Type 1 components of the validated design and establish the minimum design margins within those components at the maximum rated conditions and the specific mode of that stress. All design considerations and design margins applied to the validated design and its components shall be applied to the scaled design evaluation. The supplier/manufacturer shall establish the minimum design margins in the equivalent components within the scaled design. The minimum acceptable material condition, minimum acceptable material yield strengths, and maximum and minimum temperature effects on material properties shall be used.

The evaluation of the scaled design shall include a comparison of its calculated minimum design margins to those of the validated design. The minimum design margins of the scaled design shall not be less than the minimum design margins of the components of the validated design. The mode of stress and same method of calculation(s)/evaluation(s) shall be applied to the identified components of both product designs.

Adjustments to material thickness or yield strengths shall not negatively impact minimum design margins. The scaled product shall be evaluated by the supplier/manufacturer to ensure that it will meet the requirements of the validation test.

Each scaled product requires design verification, evaluation, and justification that the scaled design meets the requirements of this section. Documentation of the design scaling activities shall be included in the product's design documentation (see 6.6).

6.9.3.3 Additional Limitations of Scaling

Scaling has the following limitations:

a) Scaling shall not be used to validate products with higher rated pressure, higher axial loads, or a higher temperature range than the validated design.

b) The rated pressure shall not be scaled by more than 50 % below the validated design. For tool designs that are not pressure rated, this limit does not apply.

c) A valve with equalizing features cannot be scaled from a valve with no equalizing features.

6.10 Functional Test

Each manufactured product shall be successfully tested in accordance with the requirements of 7.10.1 and shall conform to all the acceptance criteria of the functional test requirements of Annex C.

6.11 Final Design Review and Approval

The supplier/manufacturer shall conduct a final design review and approve the design for the intended application and functional requirements. The final design review shall include the review and approval of the contents of 7.2.2.

This review shall be conducted by qualified individuals. The documentation of the design review shall include the attending member identifications, approval of the results by a qualified person other than the person who created the original design, and completed action items. Records of the final design review and approval shall be maintained with the design documentation.

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Documentation supplied with each unique SCIV and SCIV tool shall include a product operating manual, a functional testing report, and the documentation as summarized in the specific quality level requirements in Table 6.

7.2.2 Design Documentation

Documentation of designs for each size, type, and model shall include the following:

a) design requirements, including those pressures, operational loads, material, environmental, and other pertinent requirements on which the design is based;

b) design criteria;

c) functional and technical specifications;

d) methods, assumptions, comparison with previous designs (where applicable), design calculations, design reviews, design drawings, and manufacturing specifications;

e) material specifications and certifications, including yield strength as applicable;

f) design verification (see 6.7);

g) design validation report (see B.6);

h) operating manual that includes permitted operations; see 7.2.4

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