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## **Introduction**

This specification has been developed by users/purchasers and suppliers/manufacturers, of subsurface safety valves intended for use in the petroleum and natural gas industry worldwide. This specification is intended to give requirements and information to both parties in the selection, manufacture, testing, and use of subsurface safety valves. Furthermore, this specification addresses the minimum requirements with which the supplier/manufacturer is to comply so as to claim conformity with this specification.

Users of this specification should be aware that requirements above those outlined in this specification may be needed for individual applications. This specification is not intended to inhibit a supplier/manufacturer from offering, or the user/purchaser from accepting, alternative equipment or engineering solutions. This may be particularly applicable where there is innovative or developing technology. Where an alternative is offered, the supplier/ manufacturer should identify any variations from this specification and provide details.

The International System of Units (SI) is used in this specification; however, US Customary (USC) or other units are also shown for reference.

The requirements for lock mandrels and landing nipples contained in prior editions of this specification are now included in API 14L.

This specification has been structured with design validation grades of increased requirements allowing the user/purchaser to select the validation grade required for a specific application.

There are eight design validation grades for SSSVs and two design validation grades for ASVs to provide the user/purchaser the choice of requirements to meet a specific preference or application. New to the 13<sup>th</sup> edition are design validation grades V1-HR to V3-R for SSSVs, and V4-A and V3-A for ASVs. Design validation grades V1-H to V3 are for products with Test Agency Validation tests meeting requirements listed in Annex N. V1-HR and V1-H are for high pressure high temperature (HPHT) applications with specific requirements listed in Annex H. The complexity and severity of the validation testing increases as the grade number decreases.

Changes to this specification in 13<sup>th</sup> edition:

- 1) New normative annex, Annex N for Test Agency Validation requirements performed prior to the 12<sup>th</sup> edition (previously Annex B in 11<sup>th</sup> edition);
- 2) New normative annex, Annex O for Annular Safety Valves;
- 3) Validation grades V4-1 or V4-2 are no longer included as these were for products validated prior to the 12<sup>th</sup> Edition;
- 4) For the additional validation grades V1-HR, V1-R, V2-R, V3-R, the suffix -R designates that the Test Agency Validation test meets the requirements of Annex B of this edition, and other required validation testing found in this specification. Validation grades without the suffix -R designates that the Test Agency Validation was performed prior to the 12<sup>th</sup> edition (previously Annex B in 11<sup>th</sup> edition) and meets the requirements of Annex N and other required validation testing found in this specification.

## Subsurface Safety Valve Equipment

### 1 Scope

This specification provides the requirements for subsurface safety valves (SSSVs), Annular Safety Valves (ASVs) and the secondary tools as defined herein necessary to operate the features included within them, including all components that establish tolerances and/or clearances that may affect performance or interchangeability of the SSSV or ASV components. It includes repair operations and the interface connections to control conduits and/or other equipment but does not cover the connections to the primary well conduit.

**NOTE** The SSSV is an emergency fail-safe device. The products covered within this specification are installed and operated to the requirements of API 14B.

This specification does not cover installation, maintenance, control systems for SSSV or ASV, computer systems, and control conduits not integral to the downhole SSSV. Also not included are products and capabilities covered under API 19G Parts 1 through 4, API 14L, API 11D1, API 6A, API 17C, API 19V, API 19AC and other products with API specifications.

Redress activities for SSSVs and secondary tools are addressed in API 14B and are outside the scope of this specification.

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

API Specification 5B, *Specification for Threading, Gauging, and Thread Inspection of Casing, Tubing, and Line Pipe Threads*

API Specification 11D1, *Packers and Bridge Plugs*, Fourth Edition

API Recommended Practice 13B-1, *Recommended Practice for Field Testing Water-based Drilling Fluids*

API Recommended Practice 14B, *Design, Installation, Repair and Operation of Subsurface Safety Valve Systems*

API Specification 14L, *Specification for Lock Mandrels and Landing Nipples*

API Specification 17F, *Specification for Subsea Production Control Systems*, Second Edition

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

NACE MR 0175/ISO 15156 1 (all parts), Petroleum and natural gas industries — Materials for use in H<sub>2</sub>S-containing environments in oil and gas production

ASME *Boiler and Pressure Vessel Code (BPVC)*<sup>2</sup>, Section V: *Nondestructive examination*<sup>1</sup>

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<sup>1</sup> NACE International, 15835 Park Ten Place, Houston, Texas 77084, [www.nace.org](http://www.nace.org).

<sup>2</sup> ASME International, 2 Park Avenue, New York, New York 10016-5990, [www.asme.org](http://www.asme.org).

*ASME Boiler and Pressure Vessel Code (BPVC), Section VIII; Division 1; UW-51: Radiographic Examination of Welded Joints*

*ASME Boiler and Pressure Vessel Code (BPVC), Section VIII, Division 2:2011: Alternative Rules—Rules for Construction of Pressure Vessels*

*ASME Boiler and Pressure Vessel Code (BPVC), Section VIII; Division 3:2011: Alternative Rules for Construction of High Pressure Vessels—Rules for Construction of Pressure Vessels*

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

*ASTM A388/A388M<sup>3</sup>, Standard Practice for Ultrasonic Examination of Heavy Steel Forgings*

*ASTM A609/A609M, Standard Practice for Castings, Carbon, Low-alloy, and Martensitic Stainless Steel, Ultrasonic Examination Thereof*

*ASTM D395, Standard Test Methods for Rubber Property—Compression Set*

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

*ASTM D624, Standard Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers*

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

*ASTM D785, Standard Test Method for Rockwell Hardness of Plastics and Electrical Insulating Materials*

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

*ASTM D792, Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement*

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

*ASTM D1415, Standard Test Methods for Rubber Property—International Hardness*

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

*ASTM D2240, Standard Test Methods for Rubber Property—Durometer Hardness*

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

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

*ASTM E94, Standard Guide for Radiographic Examination*

*ASTM E127, Standard Practice for Fabrication and Control of Metal, Other than Aluminium, Reference Blocks Used in Ultrasonic Testing*

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<sup>3</sup> ASTM International, 100 Barr Harbor Drive, West Conshohocken, Pennsylvania 19428, [www.astm.org](http://www.astm.org).

ASTM E140, *Standard Hardness Conversion Tables for Metals Relationship Among Brinell Hardness, Vickers Hardness, Rockwell Hardness, Superficial Hardness, Knoop Hardness, Scleroscope Hardness, and Leeb Hardness*

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

ASTM E186, *Standard Reference Radiographs for Heavy Walled [2 to 4<sup>1</sup>/<sub>2</sub> in. (51 to 114 mm)] Steel Castings*

ASTM E280, *Standard Reference Radiographs for Heavy Walled [4<sup>1</sup>/<sub>2</sub> to 12 in. (114 to 305 mm)] Steel Castings*

ASTM E446, *Standard Reference Radiographs for Steel Castings Up to 2 in. (50.8 mm) in Thickness*

ASTM E709, *Standard Guide for Magnetic Particle Examination*

ISO 34-2 <sup>4</sup>, *Rubber, vulcanized or thermoplastic—Determination of tear strength—Part 2: Small (Delft) Test Pieces*

ISO 48, *Rubber, vulcanized or thermoplastic—Determination of hardness (hardness between 10 IRHD and 100 IRHD)*

ISO 812, *Rubber, vulcanized or thermoplastic—Determination of low-temperature brittleness*

ISO 1432, *Rubber, vulcanized or thermoplastic—Determination of low-temperature stiffening (Gehman test)*

ISO 2859-1, *Sampling procedures for inspection by attributes—Part 1: Sampling schemes indexed by acceptance quality limit (AQL) for lot by lot inspection*

ISO 3601-1, *Fluid power systems—O-rings—Part 1: Inside diameters, cross-sections, tolerances and designation codes*, Fifth Edition

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

ISO 6506-1, *Metallic materials—Brinell hardness test—Part 1: Test method* ISO 6507-1, *Metallic materials—Vickers hardness test—Part 1: Test method*

ISO 6508-1, *Metallic materials—Rockwell hardness test—Part 1: Test method (scales A, B, C, D, E, F, G, H, K, N, T)*

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

ISO 9001

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

ISO 10005, *Quality management systems—Guidelines for quality plans*

ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*

ISO/IEC 17050,

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<sup>4</sup> International Organization for Standardization, 1, ch. de la Voie-Creuse, Case postale 56, CH-1211 Geneva 20, Switzerland, [www.iso.org](http://www.iso.org).

ISO 23936-2:2011, *Petroleum, petrochemical and natural gas industries—Non-metallic materials in contact with media related to oil and gas production—Part 2: Elastomers*

SAE AMS 2750<sup>5</sup>, (R) *Pyrometry*

### **3 Terms, Definitions, Acronyms, Abbreviations, and Symbols**

#### **3.1 Terms and Definitions**

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

##### **3.1.1**

##### **annular flow isolation assembly**

##### **AFIA**

Device integral to the ASV which contains a closure mechanism which prevents uncontrolled annular flow when closed.

NOTE The annular packer assembly can contain anchoring capabilities.

##### **3.1.2**

##### **annular packer assembly**

Device integral into the ASV with a packing element used for blocking fluid (liquid or gas) communication through the annular space between conduits by sealing the space between them.

NOTE The annular packer assembly can contain anchoring capabilities.

##### **3.1.3**

##### **annular safety valve**

##### **ASV**

A subsurface assembly comprised of an annular flow isolation assembly and annular packer assembly which prevents uncontrolled annular well flow when closed.

##### **3.1.4**

##### **ASV rated working pressure**

##### **ASV RWP**

The lesser of

- a) the annular packer assembly differential rating or,
- b) the differential rating of the annular flow isolation assembly with the valve closed.

NOTE The internal yield pressure rating of the annular flow isolation assembly can be different than the differential rating of the ASV with the valve closed.

##### **3.1.5**

##### **by-pass flow area**

The flow area which passes through the ASV closure mechanism and circumvents the packing element.

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<sup>4</sup> International Organization for Standardization, 1, ch. de la Voie-Creuse, Case postale 56, CH-1211, Geneva 20, Switzerland, [www.iso.org](http://www.iso.org).

<sup>5</sup> SAE International (formerly the Society of Automotive Engineers), 400 Commonwealth Drive, Warrendale, Pennsylvania 15096-0001, [www.sae.org](http://www.sae.org).

### **3.1.6**

#### **closure mechanism**

Interconnected components with the primary function to shut off well flow.

NOTE The closure mechanism does not include common fasteners used to secure the mechanism.

### **3.1.7**

#### **compound**

Combination of constituent elements of the formulation of a nonmetallic material.

### **3.1.8**

#### **design acceptance criteria**

##### **DAC**

Defined limits placed on characteristics of materials, products, or services established by the organization, customer, and/or applicable specifications to achieve conformity to the product design.

[API Q1]

### **3.1.9**

#### **design margin**

Ratio of the material yield stress divided by the actual design stress in a given component.

NOTE Design margins account for a level of reduced performance capability to compensate for uncertainties in the potential loading (applied stress) and the intrinsic variations in the mechanical properties such as yield strength, ultimate strength, endurance strength, and modulus of elasticity that have distribution about their mean values.

### **3.1.10**

#### **design validation**

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

NOTE Design validation can include one or more of the following (this is not an all-inclusive list):

- a) prototype tests,
- b) functional and/or operational tests of production products,
- c) tests specified by industry standards and/or regulatory requirements,
- d) field performance tests and reviews.

[API Q1]

### **3.1.11**

#### **design verification**

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

NOTE Design verification activities can include one or more of the following (this is not an all-inclusive list):

- a) confirming the accuracy of design results through the performance of alternative calculations,
- b) review of design output documents independent of activities of design and development,
- c) comparing new designs to similar proven designs.

[API Q1]

### **3.1.12**

#### **dynamic seal system**

Components of a hydraulic SSSV actuator that function together to open and/or close the SSSV.

NOTE This typically includes the actuator piston, associated seals, backups, guide rings, and any other piston-related components, as well as the bore in which the piston operates.

### **3.1.13**

#### **end connection**

Thread or other mechanism providing equipment-to-tubular interface.

### **3.1.14**

#### **environment**

Set of conditions to which the product is exposed.

### **3.1.15**

#### **failure**

Any condition of SSSV/ASV equipment that can prevent the equipment from performing to the functional requirements of this specification.

### **3.1.16**

#### **fail-safe device**

Device which, upon loss of the control signal, automatically shifts to a closed position.

### **3.1.17**

#### **fit**

Geometric relationship between parts.

NOTE This includes the tolerance criteria used during the design of a part and its mating parts, including seals.

### **3.1.18**

#### **function**

Operation of a product during service.

### **3.1.19**

#### **functional test**

Testing conducted to demonstrate that equipment satisfies operational performance requirements.

### **3.1.20**

#### **functionally equivalent component**

Component(s) in a scaled design that perform the same primary function as the component(s) in the validated base design.

### **3.1.21**

#### **heat treatment**

#### **heat treating**

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

### **3.1.22**

#### **high-pressure, high-temperature equipment**

#### **HPHT**

Equipment assigned a pressure rating greater than 103.4 MPa (15,000 psig) or a temperature rating greater than 176.7 °C (350 °F).

NOTE Requirements for high-pressure, high-temperature (HPHT) equipment are included in Annex H.

### **3.1.23**

#### **interchangeability**

Ability to replace one component/subassembly with another component/subassembly without any subsequent requirement to adjust or alter it or the mating components/subassemblies, while retaining conformance to the assembled products performance.

### **3.1.24**

#### **lock mandrel**

Retention device used for flow control equipment or other equipment.

[API 14L]

### **3.1.25**

#### **manufacturer**

Principal agent in the design, fabrication, and furnishing of equipment, who chooses to conform with this specification.

### **3.1.26**

#### **manufacturing**

Process and action performed by an equipment supplier/manufacturer that are necessary to provide finished component(s), assembly(ies), and related documentation that fulfil the requests of the user/purchaser and meet the standards of the supplier/manufacturer.

### **3.1.27**

#### **mass loss corrosion**

#### **weight loss corrosion** (deprecated term)

Loss of metal in areas exposed to fluids that contain water or brine and carbon dioxide (CO<sub>2</sub>), oxygen (O<sub>2</sub>), or other corrosive agents.

### **3.1.28**

#### **model**

SSSV equipment with unique components and operating characteristics that differentiate it from other SSSV equipment of the same type.

NOTE The same model can have any of a variety of end connections.

### **3.1.29**

#### **operating cycle**

Starting from either open or closed position, moving to the opposite position, and returning to the original position.

NOTE An example of an operating cycle may be the closure mechanism moving from fully closed to fully opened and returning back to fully closed.

### **3.1.30**

#### **operating life**

Expected period of time or number of operating cycles that the product shall function.

### **3.1.31**

#### **operating manual**

Publication issued by the supplier/manufacturer that contains detailed data and instructions related to the installation, operation, and maintenance of equipment.

### **3.1.32**

#### **orifice (bean)**

Designed restriction causing a pressure drop in velocity-type subsurface-controlled subsurface safety valves (SSCSVs).

### **3.1.33**

#### **packing element**

Seal on an annular packer assembly that blocks fluid communication by sealing on the ID of the conduit.

### **3.1.34**

#### **profile**

Feature that is designed for the reception of a locking mechanism.

#### **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.

### **3.1.35**

#### **ratcheting**

Progressive incremental inelastic deformation or strain that can occur in a component that is subjected to variations of mechanical stress, thermal stress, or both (thermal stress ratcheting is partly or wholly caused by thermal stress).

[ASME BPVC Section VIII, Division 3]

### **3.1.36**

#### **rated working pressure**

##### **RWP**

The lesser of

- a) the SSSV internal pressure rating, or
- b) the differential rating with the valve closed.

### **3.1.37**

#### **redress**

Any activity involving the replacement of qualified parts [cf. **repair** (3.1.31)].

NOTE The definition for qualified parts is provided in API 14B.

### **3.1.38**

#### **repair**

Any activity beyond the scope of redress that includes disassembly, reassembly, and testing with or without the replacement of parts and may include machining, welding, heat treating, or other manufacturing operations that restore the equipment to its original performance [cf. **redress** (3.1.30)].

[API 14B]

### **3.1.39**

#### **seal component**

Component or assembly preventing passage (i.e., communication) of liquid and/or gas, not including sealing devices.

NOTE Examples of seal components include O-rings, v-rings, t-seals, and metal seal rings.

**3.1.40**  
**sealing device**

Device preventing passage (i.e., communication) of liquid and/or gas across the interface between the lock mandrel or WRSV and the landing nipple.

**3.1.41**  
**secondary tool**

Tools and other equipment used with SSSVs to perform a secondary function(s) or provide another intended design function.

NOTE Secondary tools may include communication tools, exercise tools, permanent lock open, temporary lock open, and accessory tools.

**3.1.42**  
**size**

Relevant dimensional characteristics of the equipment as defined by the supplier/manufacturer.

**3.1.43**  
**sour service**

Exposure to oilfield environments that contain H<sub>2</sub>S and can cause cracking of materials by the mechanisms addressed in ANSI/NACE MR0175.

NOTE Adapted from ANSI/NACE MR0175-1.

**3.1.44**  
**special feature**

Specific component or subassembly that provides a functional capability that is not validated during the validation test conducted in accordance with Table 1.

NOTE Special features may include items such as ambient chambers, fluid charged chambers, equalization flow, lock open, exercise, communication devices, mechanisms that provide fail-safe activation, control fluid redirection features, or electronic sensing and control. This list of special features is not fully inclusive.

**3.1.45**  
**stress corrosion cracking**

Cracking of metal involving anodic processes of localized corrosion and tensile stress (residual and/or applied) in the presence of water and dissolved halides and/or H<sub>2</sub>S.

NOTE Dissolved halide salts, H<sub>2</sub>S, O<sub>2</sub> and/or other oxidants, and elevated temperature increase the susceptibility of metals to this mechanism of attack.

**3.1.46**  
**stress cracking**

A generic term to refer to either stress corrosion cracking (3.1.45), or sulfide stress cracking (3.1.54), or both within this specification.

**3.1.47**  
**stress relief**

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

### **3.1.48**

#### **subassembly**

Subordinate unit consisting of two or more components assembled for incorporation as an integral portion of a product that may be independently performance tested before its integration.

### **3.1.49**

#### **substantive design change**

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

### **3.1.50**

#### **subsurface-controlled subsurface safety valve**

##### **SSCSV**

SSSV actuated by the characteristics of the well.

NOTE These devices are usually actuated by the differential pressure through the SSSCV (velocity-type) or by tubing pressure at the SSSCV.

### **3.1.51**

#### **subsurface injection safety valve**

##### **SSISV**

SSSV that is opened by injected flow and used to prevent backflow.

NOTE These devices are usually actuated by the differential pressure through the subsurface injection safety valve (SSISV) (velocity-type) or by tubing pressure at the SSISV (tubing-pressure-type).

### **3.1.52**

#### **subsurface safety valve**

##### **SSSV**

Device whose design function is to prevent uncontrolled well flow when closed.

NOTE SSSVs can be installed and retrieved by wireline or pump-down methods (wireline-retrievable) or be an integral part of the tubing string (tubing-retrievable).

### **3.1.53**

#### **subsurface safety valve equipment**

Subsurface safety valve and all components that establish tolerances and/or clearances that can affect its performance or interchangeability.

### **3.1.54**

#### **sulfide stress cracking**

##### **SSC**

Cracking of metal involving corrosion and tensile stress (residual and/or applied) in the presence of water and H<sub>2</sub>S.

NOTE SSC is a form of hydrogen stress cracking and involves embrittlement of the metal by atomic hydrogen that is produced by acid corrosion on the metal surface. Hydrogen uptake is promoted in the presence of sulfides. The atomic hydrogen can diffuse into the metal, reduce ductility, and increase susceptibility to cracking. High strength metallic materials and hard weld zones are prone to SSC.

[NACE MR0175/ISO 15156]

### **3.1.55**

#### **surface-controlled subsurface safety valve**

##### **SCSSV**

SSSV controlled from the surface by hydraulic, electrical, mechanical, or other means.

### **3.1.56**

#### **test agency**

Organization that provides a test facility and administers a test program that meets the validation test requirements of Annex B or Annex N in this specification.

### **3.1.57**

#### **test section**

Test apparatus that contains the SSSV and provides for connection to a test facility's validation test apparatus.

### **3.1.58**

#### **type**

SSSV equipment with unique characteristics that differentiate it from other functionally similar SSSV equipment.

NOTE See 4.3 for various types of SSSV.

### **3.1.59**

#### **validation test**

Test performed to qualify a particular size, type, and model of equipment for a specific validation grade.

## **3.2 Acronyms, Abbreviations, and Symbols**

|         |   |
|---------|---|
| AFIA    | annular flow isolation assembly             |
| AQL     | acceptance quality limit                    |
| ASV     | annular safety valve                        |
| ASV RWP | annular safety valve rated working pressure |
| CAD     | computer-aided design                       |
| CFD     | computational fluid dynamics                |
| COC     | certificate of conformance                  |
| DAC     | design acceptance criteria                  |
| FEA     | finite element analysis                     |
| FMEA    | failure modes and effects analysis          |
| HPHT    | high-pressure, high-temperature             |
| ID      | inner diameter                              |
| MTR     | material test report                        |
| NDE     | nondestructive examination                  |
| OD      | outer diameter                              |
| QMS     | quality management system                   |
| RGD     | rapid gas decompression                     |
| RWP     | rated working pressure                      |
| SCSSV   | surface-controlled subsurface safety valve  |
| SITP    | shut-in tubing pressure                     |

|       |   |
|-------|---|
| SSCSV | subsurface-controlled subsurface safety valve |
| SSISV | subsurface injection safety valve             |
| SSSV  | subsurface safety valve                       |
| TRSV  | tubing-retrievable safety valve               |
| WRSV  | wireline-retrievable safety valve             |
| $L$   | length  |
| $t$   | thickness                                     |

## **4 Functional Specification**

### **4.1 General**

**4.1.1** The user/purchaser should prepare a functional specification for ordering products that conform to this specification and specify the following requirements and operating conditions, as applicable, and/or identify the supplier's/manufacture's specific product. These requirements and operating conditions may be conveyed by means of a dimensional drawing, data sheet, or other suitable documentation. If not provided, the supplier/manufacture shall generate a functional specification.

**4.1.2** Annular Safety Valves (ASVs) shall comply with the requirements in Annex O.

**4.1.3** The functional specification shall specify the following, but not be limited to:

- a) suitability for service conditions, such as resistance to corrosion, corrosion-erosion, solid contaminant accumulation, and service temperatures;
- b) specified loads and characteristics including temporary test conditions, possible cyclical loading conditions and changes to those parameters over the operating life, thermal gradients, external loadings, etc.;

**NOTE** SSSVs under standard operating conditions have very low load cycles over their operational life. For information on the investigation of load cycling, see ASME BPVC Section VIII, Division 3, Article KD-3 or Article KD-4.

- c) operating life requirements;
- d) applicable industry standards and/or regulatory requirements;
- e) possible combinations of various well design criteria (these may be in the form of a desired operating envelope for the product).

**NOTE** Guidance on developing a functional specification can be found in ISO 13879.

The user/purchaser may identify the supplier/manufacture's specific product along with any applicable functional or technical changes. In making this selection the user/purchaser can evaluate the requirements of Section 4.

### **4.2 SSSV Functional Characteristics**

The SSSV functional characteristics shall include the following when applicable:

- a) type of SSSV control (e.g., surface-controlled, subsurface-controlled, injection-controlled);

- b) type of SSSV retrieval (e.g., tubing-retrievable, wireline-retrievable, coil-tubing-retrievable, through-flowline-retrievable, etc.);
- c) type of SSSV closing mechanism (e.g., ball, flapper, etc.);
- d) internal self-equalizing capability;
- e) temporary or permanent lock-open system;
- f) control fluid communication from the surface-controlled subsurface safety valve (SCSSV) to any other subsurface device (e.g., an insert SSSV);
- g) pump-through capability;
- h) any redundant/independent backup operating systems.

### **4.3 Well Parameters**

The following characteristics shall be specified as applicable:

- a) well location (land, platform, subsea);
- b) size, mass, grade, and material of the casing and tubing;
- c) water depth, setting depth (maximum required for application), and control system parameters [control fluid type/properties, supply pressure, supply line(s), and connection rating(s), etc.];
- d) casing and/or tubing architecture, trajectory, deviations, maximum dog leg severity;
- e) restrictions through which the SSSV shall pass and restrictions/profiles through which the SSSV service tools/accessories shall pass;
- f) requirements for passage of additional lines (electrical, hydraulic), between the valve outer diameter (OD) and the casing inner diameter (ID);
- g) annulus fluid gradient;
- h) well type—injector and/or producer.

### **4.4 Operational Parameters**

#### **4.4.1 Required Parameters**

**4.4.1.1** The rated working pressure (RWP) and the rated temperature range shall be specified for the SSSV:

**4.4.1.2** The following conditions under which the SSSV will operate (flow conditions) and the conditions under which the valve closes (see API 14B) shall be specified:

- a) loading conditions, including combined loading (pressures, tension/compression, torque, bending) and the corresponding temperature extremes anticipated to be applied to the valve;

- b) at valve setting depth, the minimum and maximum values of the production/injection pressures and temperatures at the anticipated flow rates;
- c) composition of the production/injection fluid (gas/oil/water) and density of each component.

#### **4.4.2 Optional Parameters**

The following operational parameters should be specified for the SSSV if applicable:

- a) control system parameters [such as actuation mechanism, control system type/properties, supply requirements, supply line(s) and connection rating(s), closed loop feedback, etc.];
- b) inclination at setting depth if any (true vertical depth, measured depth);
- c) maximum allowable pressure drop at maximum production flow rate through SSSV;
- d) well stimulation operations, including its parameters, such as acidizing (composition of the acid, pressure, temperature, acid flow rate, and the exposure time), as well as any other chemicals used during the stimulation;
- e) well cementing operations, including its parameters, such as cement types and volumes, spacers, plugs, pressure, and flow rates;
- f) sand consolidation and fracturing operations, including sand/proppant description, fluid flow rate, proppant/fluid ratio or sand/fluid ratio, chemical composition, pressure, and temperature;
- g) well-servicing activities through the safety valve: size, type, and configuration of secondary tools or other devices to be run with or through the valve;
- h) injection rate range for SSISV.

#### **4.5 Environmental Compatibility**

- a) Production/injection/annulus fluid chemical and physical composition, including solids (sand production, scale, etc.), to which the SSSV 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 corrosion environment.
- c) It is the equipment user/purchaser's responsibility to confirm 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, then those fluids, contaminants, and testing/qualification requirements shall be specified in the functional specification. Likewise, for nonmetallics, if analysis is required beyond 5.3.3.3.2 a), the fluids, contaminants, and testing/qualification requirements shall be specified in the functional specification.

**NOTE** NACE MR0175/ISO 15551 prescribes laboratory testing to determine a materials performance when exposed to H<sub>2</sub>S. The standard utilizes the following environmental variables: the minimum in situ water pH, the maximum chloride concentration, the maximum partial pressure of H<sub>2</sub>S 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 can occur longer term, such as increases in the partial pressure of H<sub>2</sub>S due to reservoir souring from water injection.

## **4.6 Compatibility with Related Well Equipment**

The following information, as applicable, shall be specified to provide compatibility of the SSSV and secondary tools with the related well equipment:

- a) SSSV size, type, material, and the configuration of the interface connections (these connections are not included in the evaluation of combined loading);
- b) internal profile(s), sealing bore dimension(s), outside diameter, inside diameter, and their respective locations relative to the SSSV;
- c) intervention requirements;
- d) requirement(s) for passage of conduits (electrical/hydraulic) between valve OD and casing ID, this may include associated clamps/securing mechanism(s).

## **4.7 Insert SSSV Considerations**

API 14B addresses the installation of an insert SSSV assembly in a primary locked open tubing-retrievable safety valve (TRSV).

## **4.8 User/Purchaser Grade Selection**

### **4.8.1 Validation Grade**

The user/purchaser should specify the validation grade required for the SSSV from Table 1.

**NOTE 1** Previous editions of API 14A described the classes of service for SSSVs. In this edition, classes of service have been replaced by validation grades (a cross-reference from classes of service to validation grades is provided in Table 1).

**NOTE 2** In the validation grades, the suffix -R designates that the Test Agency Validation test meets the requirements of Annex B. Validation grades without the suffix -R designates that the Test Agency Validation was performed prior to the 12th edition and meets the requirements of Annex N.

### **4.8.2 HPHT Requirements**

SSSVs with a RWP greater than 103 MPa (15,000 psi) or a temperature rating greater than 177 °C (350 °F) (HPHT service) or when specified by the user/purchaser, shall conform to Annex H.

### **4.8.3 Additional Testing**

**4.8.3.1** The user/purchaser may select additional testing as detailed in Annex E and Annexes I to L as listed in Table 2.

**4.8.3.2** When specified by the user/purchaser, a rated performance envelope shall be provided according to Annex M for validation grades V3, and V2.

**4.8.3.3** When specified by the user/purchaser, an ageing evaluation shall be conducted by the supplier/manufacture [see 5.3.3.3.2 d)] on an elastomeric material.

**4.8.3.4** When specified by the user/purchaser, a rapid gas decompression evaluation shall be conducted by the supplier/manufacture on an elastomeric material [see 5.3.3.3.2 e)].

**Table 1—Cross-reference of Classes of Service to Validation Grades**

| <b>Validation Grade</b> | <b>Comments</b>   | <b>Historical Class of Service (API 14A)</b>               |
|-------------------------|---|--|
| V3                      | Validation grade V3 (see 5.5.1 and 5.5.3) contains the validation test requirements specified in Annex N and additional supplier/manufacture tests in Annex D. It also contains requirements for special feature validation (see 5.5.9) and electronics qualification (see G.7), if applicable. |  |
| V3-R                    | Validation grade V3 (see 5.5.1 and 5.5.3) contains the validation test requirements specified in Annex B and additional supplier/manufacture tests in Annex D. It also contains requirements for special feature validation (see 5.5.9) and electronics qualification (see G.7), if applicable. | None- new to this edition                                  |
| V2                      | Validation grade V2 (see 5.5.1 and 5.5.4) contains the validation test requirements specified in Annex N and additional supplier/manufacture tests in Annex D. It also contains requirements for special feature validation (see 5.5.9) and electronics qualification (see G.7), if applicable. |  |
| V2-R                    | Validation grade V2 (see 5.5.1 and 5.5.4) contains the validation test requirements specified in Annex B and additional supplier/manufacture tests in Annex D. It also contains requirements for special feature validation (see 5.5.9) and electronics qualification (see G.7), if applicable. | None - New to this edition                                 |
| V1                      | Validation grade V1 (see 5.5.5) SSSVs meet all the requirements of Annex N in this edition of API 14A plus additional testing detailed in Annex G.  |  |
| V1-R                    | Validation grade V1 (see 5.5.5) SSSVs meet all the requirements of Annex B in this edition of API 14A plus additional testing detailed in Annex G.  | None- new to this edition                                  |
| V1-H                    | Validation grade V1-H (see Annex H) SSSVs meet all the requirements of Annex N in this edition of API 14A plus additional testing detailed in Annex G, Annex J, and Annex L.  |  |
| V1-HR                   | Validation grade V1-H (see Annex H) SSSVs meet all the requirements of Annex B in this edition of API 14A plus additional testing detailed in Annex G, Annex J, and Annex L.  | None- new to this edition                                  |
| N/A                     | This edition of API 14A does not provide requirements for Class 3 or Class 4 SSSVs.<br>Material requirements for all SSSVs are defined in Sections 4 and 5.   | 3—stress cracking service<br>4—mass loss corrosion service |

**Table 2—Additional Tests**

| <b>Annex Identification</b> | <b>Annex Title</b>   | <b>General Description of Content</b>  | <b>Purpose</b>  |
|-----------------------------|--|--|---|
| E                           | Alternative requirements for closure mechanism minimal leakage | Provides alternative leakage acceptance criteria for the functional test                             | Provides more stringent leak rate acceptance criteria                                 |
| I                           | Extended sand endurance testing                                | Enhanced sand endurance testing  | Evaluates the ability of the valve design to close and seal in sandy conditions       |
| J                           | Combined loads operational test                                | Validation of closed end rated performance envelope limits   | Confirms the ability of the SSSV to operate at the limits of the performance envelope |
| K                           | Gas slam closure testing                                       | Testing requirements for high-rate slam closures   | Evaluates closure of SSSV in increased flow rate gas wells                            |
| L                           | Dynamic seal system test                                       | Testing requirements for primary dynamic seal systems at intermediate positions at static conditions | Evaluates gas sealing integrity of the dynamic seal system                            |

## **5 Technical Specification**

### **5.1 Technical Requirements**

**5.1.1** The supplier/manufacturer shall prepare and provide to the user/purchaser the technical specification that demonstrates that the equipment meets the requirements of the functional specification.

**5.1.2** An SSSV produced according to this specification shall be designed and manufactured under a quality management system (QMS) that conforms to API Q1 or equivalent.

### **5.2 Technical Characteristics of SSSV**

The following criteria shall be met:

- a) SSSV shall close and effectively shut in the flow when predefined conditions are met;
- b) SCSSV and SSISV shall close upon loss of operational signal;
- c) the SSSV shall be located and/or seal at the specified location and remain so until intentional intervention defines otherwise;
- d) the SSSV shall allow well-intervention operations (see 4.5.2);
- e) the SSSV and secondary tools shall conform to the functional specification and within the limitations defined in the product-specific operating manual and design criteria.

### **5.3 Design Criteria**

#### **5.3.1 General**

**5.3.1.1** SSSV designs shall permit prediction and repeatability of rates, pressures, or other conditions required for closure over the operating life of the product.

**5.3.1.2** Secondary tool designs shall permit prediction and repeatability of the stated capabilities.

#### **5.3.2 Design Requirements**

**5.3.2.1** Documentation of designs and design changes shall include methods, assumptions, formulas, calculations, and design requirements (see 6.2.1.2). Design requirements shall include, but not be limited to, those criteria for size, test, working and operating pressures, materials, environment (temperature limits, validation grade, chemicals), and other pertinent requirements upon which the design is based. Final design documentation shall be reviewed and verified by a qualified person other than the individual who created the original design.

**5.3.2.2** Equipment conforming to this specification shall be manufactured to drawings and specifications that do not have any substantive design changes from those of the size, type, and model equipment that have passed the applicable validation tests.

**5.3.2.3** The supplier/manufacture shall establish verified internal yield pressure, collapse pressure, tensile load strength, operating temperature range, control chamber pressure rating if applicable, and RWP, excluding end connections. The design shall take into account the effects of pressure containment and pressure-induced loads. Specialized conditions such as testing with temporary test plugs shall also be identified and reviewed and addressed as is necessary.

**5.3.2.4** The supplier/manufacture shall identify the critically stressed components of the product and the mode of stress. The supplier/manufacture shall calculate the critical stress level in the identified component(s) based upon the worst-case loads in the design input requirements.

**5.3.2.5** The minimum material condition and minimum material yield strength shall be used in the calculations. The calculations shall include consideration of the effects of temperature on material properties. Metal mechanical properties temperature derating shall be verified by a qualified person and in accordance with

- a) industry recognized published data, or
- b) data established by the supplier/manufacture, or
- c) data provided by the material subsupplier.

**NOTE** ASME BPVC Section II, Part D contains temperature derated tensile strengths for many materials.

**5.3.2.6** The following apply to supplier/manufacture-assembled equipment and replacement components or subassemblies:

- a) additive dimensional tolerances of components and subassemblies shall allow the equipment to perform as designed, without limitation, regardless of the date or batch of manufacture;
- b) for each unique assembly, the components or subassemblies shall be interchangeable among other batch lots of the same unique assembly and shall produce a product that continues to meet the design validation requirements and the technical specifications.

**5.3.2.7** SSSV profiles for lock mandrels and lock mandrel sealing devices shall conform with the requirements of API 14L, design validation grade V2, for landing nipples, and with the applicable requirements defined in API 14L. In any aspect that the requirements of this specification are more stringent, they shall apply.

**5.3.2.8** When requested in the functional specification and accepted by the manufacturer, the supplier/manufacturer shall provide to the user/purchaser the preventive and remedial recommendations to address the potential for accumulated contaminants such as scale, paraffin, asphaltenes, frac solids, or cement. These may include design features, operational constraints, remedial treatments, or regular maintenance requirements.

**5.3.2.9** The user/purchaser may request one of the following:

- a) a method of clearing a valve stuck by contaminants;
- b) a method of minimizing asphaltene accumulations;
- c) the supplier/manufacturer provide preventive equipment to minimize material accumulations.

Additionally, the user/purchaser may request the supplier/manufacturer to provide methods to protect the SSSV when remedial operations are performed elsewhere in the well.

### **5.3.3 Materials**

#### **5.3.3.1 General**

**5.3.3.1.1** Materials shall be documented by the supplier/manufacturer and shall be suitable for the functional specification. The supplier/manufacturer shall have documented specifications for all materials. All materials used shall conform with the supplier/manufacturer's documented specifications that include chemical and mechanical property limits.

**5.3.3.1.2** 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. This applies to metallic and nonmetallic components.

**5.3.3.1.3** Material substitutions from those materials used in a validated product are allowed without further validation testing. 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 this specification. Material substitutions require documented approval by a qualified person using the methods and practices used to accept the original material, and the supporting documentation shall be retained per 6.2.1.1. When requested, material substitutions shall be reported to the user / purchaser.

#### **5.3.3.2 Metals**

**5.3.3.2.1** The supplier/manufacturer's specifications for traceable components (see 6.4.5) shall define those characteristics critical to the performance of the material, such as the following:

- a) chemical-composition limits;
- b) heat treatment process;
- c) melt practice (for nickel and titanium based alloys);

d) mechanical-property limits as applicable:

- 1) tensile strength,
- 2) yield strength,
- 3) elongation,
- 4) hardness.

NOTE 1 For some SSSV material-component combinations such as structural load bearing or pressure-containing components, the supplier/manufacturer may require Charpy impact testing in addition to the above list of requirements.

NOTE 2 Wear resistant materials loaded primarily in compression typically do not have design requirements for yield strength, tensile strength, or elongation.

**5.3.3.2.2** The mechanical properties specified in 5.3.3.2.1 d) for traceable components shall be determined by tests conducted on a representative sample (e.g., prolongation, sacrificial casting or a separate test piece removed prior to heat treatment).

**5.3.3.2.3** The representative sample shall be from the same heat of material. For remelt materials the sample shall be from the same final remelt heat.

**5.3.3.2.4** The material sample shall undergo the same thermomechanical processing as the raw material used to manufacture the component it qualifies.

**5.3.3.2.5** When heat treatment is performed, the representative sample shall be heat treated with the component(s) that it qualifies.

**5.3.3.2.6** The mechanical property results shall be documented on an approved material test report (MTR) (see 6.4.3.1).

**5.3.3.2.7** Each welded component shall be stress relieved as specified in the supplier/manufacturer's written specifications. In addition, carbon and low-alloy steel weldments on sour service SSSV equipment shall be stress relieved in accordance with ANSI/NACE MR0175-2.

**5.3.3.2.8** Materials selected for use in mass loss corrosion or stress cracking environments shall conform to the supplier/manufacturer's documented procedure or as specified by the user/purchaser.

**5.3.3.2.9** Metallic materials used in stress cracking environments shall conform to the metallurgical requirements of ANSI/NACE MR0175 (all parts).

**5.3.3.2.10** Metallic sealing devices and seal components, with exception of the closure mechanism (see 3.1.1), shall also conform to the requirements of 5.3.3.3.1 and 5.3.3.3.2, Items a) to c).

### **5.3.3.3 Nonmetals**

#### **5.3.3.3.1 General**

The supplier/manufacturer shall have documented procedures, including acceptance criteria, for evaluation or testing of seal materials or other nonmetals to the limits for which the equipment is rated.

NOTE 1 SSSV serving as injection valves may require an evaluation of sealing properties of nonmetallics at low temperatures.

NOTE 2 The provisions of 5.3.3.3 apply to seals and sealing devices within the SSSV. API 14L contains sealing device requirements for lock mandrels used to convey a WLRSV.

### **5.3.3.3.2 Sealing System Requirements**

Sealing devices and seal components previously validated in accordance with prior editions of ISO 10432 or API 14A for the relevant range of application shall be considered as meeting the design validation requirements of this specification.

Sealing devices and seal components shall meet the following requirements.

- a) Chemical and environmental effects shall be considered for nonmetallic seal components to determine selection of the seal material.
- b) Verification or validation shall establish that the nonmetal seal component used is suitable for the specific configuration, environment and application. The evaluations or tests shall provide compatibility with the technical and functional requirements and shall address, as applicable, mechanical loads, applied pressure, temperature range, design geometry, and sealing environment.
- c) Scaling of seal component validation results shall be documented and approved by a qualified person. A validation test conducted on a seal component with a designed cross-section size shall validate all seal component bore sizes of the same design cross-section size. Limitations on scaling of nonmetallic seal components are as follows:
  - 1) the allowable variation in size for the scaled seal component shall be within  $\pm 5\%$  of the nominal cross-section thickness of the validated seal component design.
  - 2) the scaled seal component extrusion gap and tolerances shall not be greater than that allowed by the validated seal component design.
  - 3) the loading mode (including any support mechanisms) shall be identical for the scaled seal component and the validated seal component.
  - 4) the critical stress levels of metallic components surrounding the scaled nonmetallic seal component stated as a percentage of material yield, shall not exceed those of the validated seal component design at the same conditions.
  - 5) the stress calculation method(s) shall be identical for the scaled seal component and the validated seal component; and
  - 6) the seal component material specification shall be identical for the scaled seal component and the validated seal component.

NOTE See H.3.5.2 for additional scaling limitations for HPHT nonmetal seal components.

- d) If required by the user/purchaser in the functional specification, an ageing evaluation at or above the maximum rated operating temperature of the SSSV shall be conducted by the supplier/manufacturer to evaluate the cumulative effects of an environment on an elastomeric material per ISO 23936-2, Clause 7.2, or in accordance with the supplier/manufacturer's documented testing procedure. The compliant to an industry specification and agreed to by the user/purchaser. This evaluation may include the determination of an effective service life.

- e) If required by the user/purchaser in the functional specification, a rapid gas decompression evaluation shall be conducted by the supplier/manufacture on an elastomeric material per ISO 23936-2, Annex B. The acceptance criteria shall be a rating of 0 or 1 for the seal component cross section. Fluid composition, test temperatures, test pressures, and depressurization rate are to be agreed between the supplier/manufacture and user/purchaser.

#### **5.3.3.3.3 Bonding to Substrates**

**5.3.3.3.3.1** Nonmetallic seal components may be bonded to substrates for additional reinforcement or to perform other functions. If the bond of the nonmetallic to the substrate is critical to performance, the integrity of the bond shall be evaluated in the same manner as the performance of the seal component itself per the supplier/manufacture's defined methods and acceptance criteria.

**5.3.3.3.3.2** Substrate metals shall conform to the requirements for metallic components; nonmetallic substrates shall conform to the requirements of 5.3.3.3.4.

NOTE ASTM D429 provides methods for adhesion testing.

#### **5.3.3.3.4 Nonmetallic Components**

The supplier/manufacture shall have written specifications for nonmetallic components that shall include handling, packaging, storage, and labelling requirements, including the cure date for elastomers, batch number, material identification, and shelf life appropriate to each material, and shall define those characteristics critical to the performance of the material, such as the following:

- a) material type;
- b) mechanical properties, as a minimum:
  - 1) tensile strength (at break),
  - 2) elongation (at break),
  - 3) tensile modulus (at 50 % or 100 %, as applicable) (elastomers only);
- c) compression set (elastomers only);
- d) durometer hardness;
- e) specific gravity;
- f) yield strength (thermoplastics only);
- g) elongation at yield (thermoplastics only);
- h) Young's modulus (thermoplastics only).

### **5.4 Design Verification**

#### **5.4.1 General**

**5.4.1.1** Design verification shall be performed using documented procedures to verify that each SSSV and secondary tool design meets the supplier/manufacture's technical specifications and shall include

activities such as design reviews, design calculations, physical tests, comparison with similar designs, and historical records of defined operating conditions.

**5.4.1.2** Verification results shall be reviewed and approved by a qualified person and records of the review shall become a portion of the design documentation (see 6.2).

## **5.4.2 Design Assumptions**

**5.4.2.1** The supplier/manufacturer shall have a design margin for each component or assembly.

**5.4.2.1** The performance of the component or product shall be established based upon the component or systems minimum material condition, minimum allowable yield strength at the maximum rated operating temperatures (including temperature cycles) and maximum operational stresses.

## **5.4.3 Design Analysis**

### **5.4.3.1 General**

**5.4.3.1.1** The equipment shall be analyzed to determine the performance limits.

**5.4.3.1.2** The performance limits of the assembly shall be determined by the component of the design with the lowest design margin.

**5.4.3.1.3** The design shall consider all operational loading conditions defined in the functional specification as well as all functional test loads (Annex C).

**5.4.3.1.4** One of the design analysis methods in 5.4.3.2 shall be used to determine the maximum state of stress of a component.

### **5.4.3.2 Design Analysis Methods**

#### **5.4.3.2.1 Distortion Energy Theory**

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

**NOTE** The distortion energy theory predicts a combined stress that will exceed the material's minimum yield strength; this is also commonly known as von Mises stress. This theory determines a combined stress at a point from the given principal stresses. The von Mises stress predicts failure when the total amount of distortion in a differential cube of material is equivalent to the distortion experienced by the same cube when loaded by a uniaxial force to the yield point.

**5.4.3.2.1.2** Rules for the consideration of discontinuities and stress concentrations are beyond the scope of this method and this specification. However, the basic pressure-vessel wall thickness may be sized by combining triaxial stresses based on hydrostatic test pressure and limited by the following criterion:

$$S_E \leq S_Y$$

where:

$S_E$  is the maximum allowable equivalent stress at the most highly stressed distance into the pressure vessel wall, computed by the distortion energy theory method;

$S_Y$  is the material-specified minimum yield strength.

#### **5.4.3.2.2 Triaxial Yield Equations**

API 5C3, Annex A, provides equations that may be used to derive the triaxial yield of a cylinder.

#### **5.4.3.2.3 Finite Element Analysis**

**5.4.3.2.3.1** Finite element analysis (FEA) is a design verification methodology that may be utilized to predict equipment performance for complex geometry and/or complex loading where conventional verification methodologies are considered incomplete by the design engineer. FEA shall include the following information (as applicable) to enable verification of the results:

- a) description of the numerical method used, including name and version of computer software;
- b) geometry details:
  - 1) computer-aided design (CAD) format,
  - 2) simplified model for symmetry or full 3D model,
  - 3) element type,
  - 4) part dimensions that result in the highest state of stress;
- c) loading conditions:
  - 1) type (pressure, force, moment),
  - 2) magnitude and system of units,
  - 3) region of application (point, surface);
- d) boundary conditions:
  - 1) symmetry planes,
  - 2) spatial or displacement constraints,
  - 3) contacts (rigid, frictionless);
- e) material properties at temperature:
  - 1) modulus of elasticity;
  - 2) Poisson's ratio;
  - 3) yield strength;
  - 4) tensile strength;
  - 5) material nonlinearity model (true stress, true strain curve; cyclic true stress, true strain curve);
- f) numerical analysis procedure:
  - 1) static,

- 2) dynamic,
- 3) buckling,
- 4) harmonic,
- 5) fatigue,
- 6) fracture,
- 7) geometrically linear or nonlinear;
- g) graphical display of results:
  - 1) stress contour plot,
  - 2) deformation plot;
- h) validation of numerical model:
  - 1) mesh sensitivity review,
  - 2) comparison with experimental data or analytical calculation;
- i) summary report:
  - 1) numerical analysis results, showing the acceptance criteria utilized to meet the design requirements,
  - 2) evidence of review and verification by a qualified person other than the individual who created the original design.

**5.4.3.2.3.2** The FEA study shall be documented and electronically archived such that the study can be reevaluated at a later date. The data to archive shall include inputs, outputs, and a summary report of the FEA study.

#### **5.4.3.3 Computational Fluid Dynamics**

**5.4.3.3.1** Computational fluid dynamics (CFD) is a design verification methodology that may be utilized to predict SSSV equipment performance under flowing conditions, such as erosion, slam closure, or flow assurance considerations.

CFD shall include the following information (as applicable) to enable verification of the results:

- a) description, name, and version of computer software;
- b) geometry details:
  - 1) CAD format,
  - 2) simplified model with reduced features, symmetrical 2D model, full 3D model,
  - 3) model dimensions.

- c) boundary conditions:
  - 1) inlet and outlet geometry, diameter, length,
  - 2) symmetry planes,
  - 3) inlet or outlet mass flow rate or velocity,
  - 4) static pressure, backpressure, etc.
- d) fluid model and properties at simulated temperature:
  - 1) laminar, turbulent (K-epsilon, shear-stress transport, etc.),
  - 2) nominal viscosity for Newtonian fluid or viscosity model for non-Newtonian fluid,
  - 3) compressibility,
  - 4) single or multiphase flow,
  - 5) density.
- e) numerical analysis procedure:
  - 1) steady state,
  - 2) dynamic or transient,
  - 3) erosion estimation,
  - 4) heat transfer.
- f) graphical display of results:
  - 1) velocity (contour plot, vector map),
  - 2) pressure change contour plot,
  - 3) streamlines of flow patterns and recirculation,
  - 4) areas of interest (identification of fast-impinging velocities and impact angle, vortices).
- g) validation of numerical model:
  - 1) mesh sensitivity review,
  - 2) convergence of iterative calculations,
  - 3) comparison with experimental data.
- h) summary report:
  - 1) numerical analysis results, showing the acceptance criteria utilized to meet the design requirements,

- 2) evidence of review and verification by a qualified person other than the individual who created the original design.

5.4.3.3.2 The CFD study shall be documented and electronically archived such that the study could be re-evaluated at a later date. The data to archive shall include the input files (problem files), output files (result files), and a summary report of the CFD study.

#### **5.4.4 Rated Performance Envelope**

A rated performance envelope as specified in Annex M shall be prepared for TRSVs validated to V1 or V1-H. For other validation grades, a rated performance envelope shall be prepared when requested in the functional specification.

#### **5.4.5 Insert SSSV Considerations**

For TRSVs with insert valve capability, the supplier/manufacturer shall conduct an analysis of the maximum control line pressure capability when communication is established between the primary and insert valves.

NOTE API 14B contains information regarding insert SSSV.

### **5.5 Design Validation**

#### **5.5.1 General**

**5.5.1.1** The objectives of the validation testing requirements of this subsection are to qualify SSSV equipment for specific validation grades. SSSV equipment of each size, type, and model shall be validated in accordance with the requirements for the specific validation grade per Annex B or Annex N and this subsection.

NOTE The validation testing requirements in this specification are not represented as well conditions.

**5.5.1.2** Successful completion of the validation testing process shall qualify SSSVs of the same size, type, and model as the tested SSSV.

**5.5.1.3** When the SSSV includes a landing nipple or a landing nipple profile, the supplier/manufacturer shall identify the size, type, and model of compatible mating lock mandrel(s) and maintain design validation records of successful validation testing of the lock mandrel(s) and landing nipple or profile combinations used in the SSSV.

**5.5.1.4** Validation of SSSVs with a landing nipple or landing nipple profile shall meet the requirements of API 14L validation grade V2 or V1 (lock mandrels only) as specified by the user/purchaser.

**5.5.1.5** The identification and ratings of the lock mandrel/landing nipple combinations shall be documented in the lock mandrel operations manual.

**5.5.1.6** When the SSSV includes a landing nipple or a landing nipple profile supplied by another supplier/manufacturer, proof of validation shall be provided in the form of a certificate of conformance (COC) approved by a qualified person.

NOTE Previous editions of API 14A used the terminology design verification in lieu of design validation.

**5.5.1.7** With mutual consent between the test agency and the supplier/manufacturer, higher flow rates than those stipulated in Annex B or Annex N may be applied and used for all flow tests.

**5.5.1.8** Products qualified to higher grades of design validation shall be considered qualified for the lower grades of design validation in accordance with Table 3.

**Table 3—Design Validation Grade Coverage**

| Validation Grade | Grades Covered                            |
|------------------|---|
| V1-HR            | V1-HR, V1-H, V1-R, V1, V2-R, V2, V3-R, V3 |
| V1-R             | V1-R, V1, V2-R, V2, V3-R, V3              |
| V2-R             | V2-R, V2, V3-R, V3                        |
| V3-R             | V3-R, V3                                  |
| V1-H             | V1-H, V1, V2, V3                          |
| V1               | V1, V2, V3                                |
| V2               | V2, V3                                    |
| V3               | V3  |

## **5.5.2 Validation Grade V3**

5.5.2.1 Validation grade V3 SCSSVs shall pass the test agency-conducted tests specified in Table N.1 and the supplier/manufacturer-specified tests in Annex D. The Alternative Validation Test (N.1) shall have a validation test date prior to the effective date of this specification.

5.5.2.2 Validation grade V3 SSCSVs shall pass the test agency conducted tests specified Table N.17 and the supplier/ manufacturer-specified tests in Annex D. The Alternative Validation Test (N.15) shall have a validation test date prior to the effective date of this specification.

5.5.2.3 The body joints in a V3 TRSV shall be evaluated to verify that the body joints meet the functional and performance requirements. The evaluation may include design analysis, testing, or history of successful use in the field under conditions that meet or exceed the current functional and performance requirements.

## **5.5.3 Validation Grade V3-R**

5.5.3.1 Validation grade V3-R SCSSVs shall pass the test agency conducted tests specified in Table B.1 and the supplier/manufacture specified tests in Annex D

5.5.3.2 Validation grade V3-R SSCSVs shall pass the test agency conducted tests specified in Table B.17.

**5.5.3.3** Validation grade V3-R SSISVs shall pass the test agency-conducted tests specified in Table B.25 and the supplier/manufacture specified tests in Annex D.

**5.5.3.1** The body joints in a V3-R TRSV shall be evaluated to verify that the body joints meet the functional and performance requirements. The evaluation may include design analysis, testing, or history of successful use in the field under conditions that meet or exceed the current functional and performance requirements.

#### **5.5.4 Validation Grade V2**

**5.5.4.1** Validation grade V2 SCSSVs shall pass the test agency-conducted tests specified in Table B.1 and Table B.2 and the supplier/manufacture specified tests in Annex D.

**5.5.4.2** Validation grade V2 SSCSVs shall pass the test agency-conducted tests specified in Table B.17 and Table B.18.

**5.5.4.3** The body joints in a V2 TRSV shall be evaluated to verify that the body joints meet the functional and performance requirements. The evaluation may include design analysis, testing, or history of successful use in the field under conditions that meet or exceed the current functional and performance requirements.

**5.5.4.4** Validation grade V2 does not apply to SSISVs.

#### **5.5.5 Validation Grade V1**

**5.5.5.1** Validation grade V1 SCSSVs shall pass the tests specified in Annex G.

**5.5.5.2** The body joints in a V1 TRSV shall be evaluated to verify that the body joints meet the functional and performance requirements. The evaluation may include design analysis, testing, or history of successful use in the field under conditions that meets or exceeds the current functional and performance requirements.

**5.5.5.3** Validation grade V1 does not apply to SSCSVs or SSISVs.

#### **5.5.6 Additional Validation Testing**

**5.5.6.1** Additional validation testing selected by the user/purchaser shall be performed according to requirements of the applicable annexes (see 4.9.3) and 5.5.13. In Annex D and Annex L, the validation testing may be performed using fixtures that have equivalent fits, clearances, and loads as the affected portion of the SSSV.

**5.5.6.2** The performance of informative annex testing when selected by the user/purchaser or supplier/manufacture can be combined or embedded into other validation testing or performed as standalone testing, except these additional tests may not be combined with the testing requirements of Annex B or Annex N.

**5.5.6.3** Where the informative annexes are combined and/or embedded with other validation testing procedures, the additions shall not cause any of the test steps or acceptance criteria to be reduced in scope or intent; the criteria may be made more stringent.

**5.5.6.4** The additional testing shall be conducted in a sequence that does not invalidate the results of the Annex D, Annex G, or Annex H tests when performed without the additions. The new testing procedures, their justifications and the testing results shall be approved by a qualified person and become a portion of the product's design documentation.

#### **5.5.7 User/Purchaser Specified Validation Testing**

If the functional specification requires performance capabilities that are not validated by testing per this specification, the supplier/manufacture shall conduct the validation tests in conformance with the requirements of 5.5.13.

**NOTE** User/purchaser specified validation testing may include items such as erosion testing, debris tolerance, vibration testing, or cement-through capability.

### **5.5.8 Secondary Tool Validation**

Secondary tools and systems designs shall be validated to their rated limits in conformance with to the requirements of Annex F.

### **5.5.9 Special Feature Validation**

**5.5.9.1** The supplier/manufacture shall identify, in design documentation, all special features included in the product design that are not validated by design validation testing per this specification.

**5.5.9.2** Special features shall be validated by the supplier/manufacture to their rated limits to documented procedures including acceptance criteria and with the design validation records approved by a qualified person other than the individual who created the original design.

**5.5.9.3** Special feature validation may include test results, operational histories, and evaluations.

**5.5.9.4** Special feature validation for V1 SSSV shall be by validation testing (see G.6).

**5.5.9.5** The supplier/manufacture's design validation records shall include the design requirements, test procedures, test results, or evaluations of special features.

**5.5.9.6** The supplier/manufacture shall identify those special features that shall be included in the functional testing.

### **5.5.10 Validation of Alternate Technologies**

SSSVs with alternate technologies shall undergo design validation in conformance with 5.10.2.

### **5.5.11 Validation Test performed by a Test Agency (see Annex B or Annex N)**

#### **5.5.11.1 General**

**5.5.11.1.1** Prior to shipping the SSSV to the test agency, the supplier/manufacture shall functionally test the SSSV in conformance with Annex C.

**5.5.11.1.2** Any repairs to the SSSV after passing the functional test shall require a repeat of the functional test.

**5.5.11.1.3** The supplier/manufacture shall provide the test agency with an SSSV of the latest design revision, one operating manual, records of functional testing, and associated documentation for each size, type, and model for the design validation level and working pressure desired in the validation test.

**5.5.11.1.4** The supplier/manufacture shall furnish any equipment not furnished by the test agency to accommodate installation of a particular SSSV in the test facility or to accomplish the validation test.

**5.5.11.1.5** If a particular SSSV has design or operational features that are incompatible with the test facility and test procedures required by this specification, the supplier/manufacture shall advise the test agency as to the nature of the incompatibility and shall request and fully describe on the test application, or attachments thereto, any equipment or procedures required to test the SSSV.

**5.5.11.1.6** Responsibility for furnishing, installing, and testing this equipment shall be by agreement between the test agency and the supplier/manufacture.

**5.5.11.1.7** The supplier/manufacturer shall identify the proposed revised test steps/conditions and technically justify the revision(s) as no less stringent than the original test requirements.

**5.5.11.1.8** The supplier/manufacturer shall include the justification of any changes to the validation tests in the product's design documentation.

**5.5.11.1.9** The supplier/manufacturer and test agency shall be responsible for assuring that such equipment or procedures are not less stringent than this specification.

**5.5.11.1.10** If alternate technology is used in SSSVs (see 5.10) the supplier/manufacturer shall present a schematic and an example of the system for the operation of the test valve.

**5.5.11.1.11** Documentation of alternative technology design and quality parameters shall be provided to satisfy all operational, testing, repeatability, and safety controls for conformance to the requirements of this specification and the requirements of the test agency.

#### **5.5.11.2 Validation Test Application**

The supplier/manufacturer shall supply a validation test application to the test agency with the following information as applicable:

- a) identification of product supplier/manufacturer (company name, location/address, pertinent department, contact name and phone numbers, etc.);
- b) if retest, reference to previous test number;
- c) the test application shall include a statement verifying a successful functional test and all hardware supplied for the test;
- d) environmental controls requirements;
- e) equipment identification requirements:
  - 1) equipment type: SCSSV, SSCSV, SSISV, etc.,
  - 2) TRSV or wireline-retrievable safety valve (WRSV),
  - 3) model designation or other identification by supplier/manufacturer,
  - 4) unique serial number,
  - 5) nominal tubing size,
  - 6) RWP,
  - 7) end connection type,
  - 8) test section length,
  - 9) drift bar identifier and dimensions,
  - 10) drift sleeve identifier and dimensions (if WRSV).

- 11) additionally, for SCSSV equipment:
  - i) minimum specified ID,
  - ii) maximum specified OD (for WRSV),
  - iii) maximum hydraulic control line pressure (greater than valve bore pressure and/or absolute maximum),
  - iv) maximum unequalized opening pressure;
- 12) maximum gas pressure-relieving (bleed-down) rate,
- 13) additionally, for SSCSV equipment, the closing parameters (fluid velocity, pressure, design closing flow rate, etc. as appropriate),
- 14) additionally, for SSISV equipment, the opening parameters (fluid velocity, pressure differential, etc. as appropriate),
- 15) additionally for alternate technologies (see 5.10):
  - i) control system requirements and limitations,
  - ii) operations for activation or position controls,
  - iii) retained system pressures and limitations including safety precautions.
- f) The following procedures and special requirements shall be stated:
  - 1) validation level to be tested,
  - 2) nonstandard equipment required for testing,
  - 3) deviations to the test facility procedures.

#### **5.5.11.3 Post Test Requirements**

**5.5.11.3.1** In the case of validation test nonconformance, the supplier/manufacturer shall be responsible for determining the cause of the nonconformance.

**5.5.11.3.2** The test agency shall cooperate with the supplier/manufacturer to determine whether the nonconformance was product or test agency related.

**5.5.11.3.3** If the nonconformance is determined to be product-related, the nonconformance becomes a test failure; if the nonconformance is determined to be test agency related, the supplier/manufacturer and test agency shall determine a course of action on the validation test process for the specific valve that is not less stringent than the validation testing requirements of this specification.

**5.5.11.3.4** The test agency shall document the testing nonconformance on the test data forms.

**5.5.11.3.5** If a particular size, type, and model of SSSV fails the validation test, that SSSV and any other SSSV of the same basic design and materials of construction shall not be submitted for retest until the supplier/manufacturer has determined and documented the justification for retest.

**5.5.11.3.6** The supplier/manufacture shall conduct this analysis and document the results, including any corrective action taken. Such information need not be submitted to the test agency, and shall be placed in the supplier/manufacture's validation test file for that SSSV before the SSSV is submitted for retest.

**5.5.11.3.7** If an SSSV fails the validation test and is subsequently repaired, it shall be functionally tested prior to resubmitting for validation testing.

**5.5.11.3.8** The supplier/manufacture shall maintain design validation records on each validation test including any retests that may have been required to qualify SSSV equipment. These records shall be retained by the supplier/manufacture for a period of 20 years after such SSSV equipment is discontinued from the supplier/manufacture's product line.

**5.5.11.3.9** Pre-test and post-test dimensional verification of functionally critical dimensions defined by the supplier/manufacture shall be conducted and documented by the supplier/manufacture. Dimensions shall meet established acceptance criteria.

#### **5.5.12 Test Agency Requirements**

Test agencies shall meet the requirements of Annex A.

#### **5.5.13 Validation Testing Performed by a Supplier/Manufacturer**

##### **5.5.13.1 General**

Validation tests conducted by the supplier/manufacture to the requirements of 4.9.3 or Annexes D, F, G, H, I, J, K, or L shall meet the requirements of 5.5.13. Each product tested shall pass all requirements within the limits specified, to the defined acceptance criteria, and with documentation and approval of the results.

##### **5.5.13.2 Personnel**

Preparation, testing, and approval of results shall be conducted by qualified personnel.

##### **5.5.13.3 Procedures**

The supplier/manufacture shall develop procedures for conducting the validation tests.

##### **5.5.13.4 Measuring and Monitoring Equipment**

**5.5.13.4.1** Measuring and monitoring equipment used during the validation process shall be calibrated in accordance with the requirements of 6.4.6.2.

**5.5.13.4.2** All pressures are defined as gauge unless otherwise specified and shall be recorded on time-based equipment.

##### **5.5.13.5 Test Report**

A test report shall be prepared and approved by qualified personnel and shall be retained as part of the design validation records for the product (see 6.2.1.2). The report shall indicate the following information as a minimum:

- a) a description of the tested item which may include size, type, model, part number, and serial number;
- b) test facility name and location;
- c) date(s) of validation testing conducted;
- d) procedures used;
- e) records demonstrating conformance to the established procedures including acceptance criteria;

NOTE Records may be electronic or hardcopy.

- f) additional information required by the applicable annex describing the testing;
- g) summary of results including a discussion whether or not the test was successful;
- h) approvals and date of the report.

## **5.6 Equipment Performance Ratings**

**5.6.1** The supplier/manufacturer shall determine and state the equipment-specific performance ratings on the shipping report as required by 6.2.2.2. Where a rated performance envelope is requested or required, the supplier/manufacturer shall provide the rated performance envelope per Annex M.

**5.6.2** For secondary tools and special features, the supplier/manufacturer shall determine and state the specific performance ratings in the operating manual.

## **5.7 Design Changes**

### **5.7.1 Evaluation**

**5.7.1.1** The supplier/manufacturer shall evaluate design changes to determine whether they are substantive (see 3.1.41) or non-substantive; this evaluation shall include as a minimum:

- a) stress levels of the replaced or changed components or subassemblies relative to the base design;
- b) interchangeability of the changed components or subassemblies relative to the base design;
- c) functional or operational changes including interaction with secondary and contingency tools.

**5.7.1.2** Design changes shall conform to the design assumptions (see 5.4.2) and design analysis (see 5.4.3) methods that were applied to the base component or assembly and shall be compliant to requirements of 5.3.2 and 5.4.

**5.7.1.3** Evaluation results and justifications as a non substantive design change shall be approved by a qualified person (see 3.1.27) other than the person performing them, and records of the results shall become a portion of the design documentation (see 6.2.1.2).

### **5.7.2 Substantive Design Change**

**5.7.2.1** All design changes shall be documented and reviewed against the design verification and design validation to determine if the change is a substantive design change (see 3.1.41). A design that undergoes a

substantive design change becomes a new design requiring design verification (see 5.4) and design validation (see 5.5); however, scaling is allowed in accordance with 5.8.

**5.7.2.2** Design validation for changes to components or subassemblies may be done by validation testing 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.

**5.7.2.3** 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.

### **5.7.3 Design Changes Requiring User/Purchaser Notification**

If the supplier/manufacturer determines that a substantive design change to the SSSV and/or secondary tool reduces the specified performance of the product or has a negative impact on the operation of existing SSSVs or secondary tools, the supplier/manufacturer shall supply written notification to the user/purchaser. This notification shall include a summary of performance changes and recommended disposition of all affected equipment.

## **5.8 Design Validation by Scaling for SSSVs**

### **5.8.1 General**

Scaling may be used to validate SSSVs of the same nominal size, type, and model by reference to a successfully validation tested product (base design) in accordance with the requirements and limitations of 5.8.2 and 5.8.3.

NOTE 1 For validation grade V1-H SSSV, refer to H.3.5 for additional scaling requirements.

NOTE 2 For secondary tools, refer to Annex F for scaling requirements and limitations.

### **5.8.2 Evaluation of Scaled Design**

#### **5.8.2.1 Establish Design Margin**

**5.8.2.1.1** The supplier/manufacturer shall identify the critically stressed components of the base design and establish the minimum design margins within those components at the maximum rated conditions and the specific mode of stress.

**5.8.2.1.2** All design considerations and design margins applied to the base design and its components shall be applied to a scaled design.

**5.8.2.1.3** The supplier/manufacturer shall identify the functionally equivalent components between the two designs.

**5.8.2.1.4** The supplier/manufacturer shall establish the minimum design margins in the functionally 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.

#### **5.8.2.2 Design Margin Comparison**

**5.8.2.2.1** The evaluation of the scaled design shall include comparison of the calculated minimum design margins and these margins shall not be less than minimum design margins of the functionally equivalent components of the base design.

**5.8.2.2.2** The mode of stress and same method of calculation(s)/evaluation(s) shall be applied to the identified components of both product designs.

**5.8.2.2.3** 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 verify that it will meet the requirements of the validation test.

### **5.8.2.3 Documentation**

Documentation of the design scaling activities, including design verification, evaluation and justification, shall be included in the product's design documentation (see 6.2.1.2).

### **5.8.3 Limitations of Scaling**

Scaling is allowed to validate a product with the following limitations:

- a) scaling shall not be used to validate products with higher RWP or a temperature range that exceeds upper and lower limits of the base design;
- b) the RWP shall not be derated by more than 50 % of the base design;
- c) the scaled valve shall not have more dynamic leak paths in either the closure mechanism or control system integral to the SSSV than the base design;
- d) A valve with equalizing features shall not be scaled from a valve with non-equalizing features.

NOTE For limitations on scaling of nonmetallic materials, see 5.3.3.3.2.

## **5.9 Functional Test**

Equipment shall be designed to meet the requirements of the functional test (see 6.5). The supplier/manufacturer shall identify those special features that shall be included in the functional testing.

## **5.10 Alternate Technologies**

### **5.10.1 General**

**5.10.1.1** The following requirements apply to all SSSVs with operating technologies other than a single direct hydraulic operating control system integral to the SSSV and without integral pressure assist mechanisms.

NOTE Alternate-technology SSSVs include designs such as but not limited to pressure charged systems, multiple hydraulic systems, indirect connection of the operator to the closure opening device, electric/electronically operated/induced activators, and control systems that include electrical and electronic signaling systems.

**5.10.1.2** Alternate-technology designs shall conform to the requirements included in Sections 4, 5, 6, 7, and 8 and Annexes B and C of this specification. The performance of the validation requirements of the validation grade (see Table 1) and any additional testing (see Table 2) shall be completed to the defined acceptance criteria.

### **5.10.2 Design Validation**

**5.10.2.1** Alternate-technology SSSV designs shall undergo validation testing, as specified for the selected design validation grade.

**5.10.2.2** Non-through-bore SSSV designs may be exempted from the internal drifting requirements when a suitable method to evaluate the closure mechanism full opening is specified in the supplier/manufacture's procedures.

**5.10.2.3** Alternate-technology SSSV actuation systems shall demonstrate repeatability of operations requirements. Operations shall conform to measurable criteria as a replacement for the measurement and review of the conventional operating pressure traces defined in the validation testing procedures.

**5.10.2.4** Alternate-technology SSSV actuation systems shall conform to supplier/manufacture defined integrity (other than hydraulic, such as electromagnetic signal interference) evaluations that demonstrate the system's response at the points defined in the validation testing procedures. Integrity validation of the actuation system shall be performed to measurable criteria as a replacement for the hydraulic control Alternate pressure evaluations in the validation testing procedures.

**5.10.2.5** Supplier/manufacture procedures that include acceptance criteria shall be prepared and conformed to during the validation testing.

### **5.10.3 Operating Manual**

The supplier/manufacture shall provide an operating manual that includes the following information as a minimum, in addition to the applicable requirements of 6.2.2.3:

- a) the full operational capabilities of the SSSV, required for validation testing and when it is installed;
- b) the control system capabilities and criteria required to facilitate those operations;
- c) the means provided to identify the fully open and fully closed positions of the SSSV;
- d) the requirements for monitoring the status of the installed SSSV;
- e) all special skills/tools/products necessary for the installation and performance of the SSSV, ;
- f) the necessary technical requirements for the control conduit, conduit connections, supporting clamps, special skills, and training required to install and/or operate the SSSV in the validation testing and permanent installation environments.

### **5.10.4 Functional Test Requirements**

Functional testing of SSSVs with alternate technology shall be performed to the requirements of 6.5. Variations to the functional test requirements shall be limited to those defined in 5.10.2 as they are applied to the functional testing.

### **5.10.5 Reports**

**5.10.5.1** Test reports shall conform to section 5.5.13.5 and include the implemented procedure for variations, justifications, and correlations to the conventional hydraulic operating acceptance criteria.

**5.10.5.2** Alternative technologies may rely on a non-hydraulic signal for operation.

## **5.11 Design Assessment**

**5.11.1** The supplier/manufacture shall conduct a final design assessment to assure that the ASV, SSSV and/or secondary tools are suitable for the intended application and functional requirements. The assessment shall include as a minimum:

- a) review of functional requirements,
- b) review of technical specifications,
- c) review of design verification activities,
- d) review of design validation records (including any evaluation for scaling and special feature validation if applicable),
- e) review of design outputs and bill of materials.

**5.11.2** The design assessment shall be conducted by individuals other than the individual who created the original design.

**5.11.2** Copies of, or reference to, the actual design validation records shall be maintained in records of the design assessment. Records of the design assessment shall be maintained with the design documentation.

## **6 Supplier/Manufacturer Requirements**

### **6.1 General**

This section contains the detailed requirements for the manufacture of SSSVs and secondary tools.

### **6.2 Documentation and Data Control**

#### **6.2.1 Retained Documentation**

##### **6.2.1.1 General**

**6.2.1.1.1** The supplier/manufacture shall establish and maintain documented procedures to control all documents and data that relate to the requirements of this specification.

**6.2.1.1.2** These documents and data shall be legible and maintained to demonstrate conformance to specified requirements.

**6.2.1.1.3** All documents and data shall be retained in facilities that provide an environment that prevents damage, deterioration, or loss. Documents and data may be in the form of any type of media, such as hard copy or electronic media.

**6.2.1.1.4** All documents and data shall be available and auditable by the user/purchaser; they shall be available within one week of request.

**6.2.1.1.5** Documentation shall be retained for a minimum of 20 years from the date of manufacture—this requirement applies to products manufactured after the effective publication date of this standard.

**NOTE** Previous editions of this specification contained requirements to maintain documentation for five years.

### **6.2.1.2 Design Documentation**

Design criteria, design verification, and design validation records for each size, type, and model, and the information listed below, shall be maintained for 20 years after the date of last manufacture of any scaled product and/or the base design:

- a) functional and technical specifications;
- b) one complete set of drawings, specifications and standards;
- c) instructions providing methods for the assembly and disassembly of the equipment;
- d) operating manual for the SSSV and any required secondary tools;
- e) records of the functional test of the SSSV;
- f) records of design verification;
- g) records of design changes;
- h) design validation records shall contain sufficient documentation to identify and permit retrieval of:
  - all drawings and specifications applicable at the time of manufacture;
  - all applications for validation tests or retests;
  - all design and/or material modifications, or other justification for retest, of SSSV equipment that did not pass any validation test;
  - data that confirms successful completion of each required validation test.
  - documentation of any scaling activities (see 5.8).

### **6.2.2 Supplied Documentation**

#### **6.2.2.1 General**

SSSVs shall be delivered with a supplier/manufacture's shipping report and an operating manual. Where a rated performance envelope is requested or required, the supplier/manufacture shall provide the rated performance envelope that conforms to Annex M.

#### **6.2.2.2 SSSV Shipping Report Contents**

##### **6.2.2.2.1** The SSSV shipping report shall contain the following information.

- a) Manufacturer's data:
  - manufacturer's name and manufacturing address;
  - manufacturer's part number;
  - equipment (name) type and model;

- serial number;
  - nominal size;
  - validation grade.
- b) SSSV rated performance limits:
- RWP;
  - maximum rated operating temperature;
  - minimum rated operating temperature;
  - secondary feature operation pressure; maximum; if applicable.
- c) SSSV validation information:
- validation test agency;
  - validation test number;
  - date of report (month/day/year);
  - validation by scaling or test.
- d) SSSV functional test summary:
- opening pressure with zero pressure in test section: maximum and minimum; if applicable;
  - closing pressure with zero pressure in test section: maximum and minimum; if applicable;
  - performed by: (printed name and signature); date: (month/day/year).
- e) Statement of compliance to user/purchaser specified requirements; if applicable.
- f) Inspected by: (printed name and signature); month/day/year.

**6.2.2.1.2** Additionally; the shipping report shall contain the following when applicable:

- a) SCSSV rated performance limits:
- control chamber pressure; maximum (at maximum operating temp);
  - full open pressure at zero tubing pressure; maximum;
  - closing pressure at zero tubing pressure; minimum;
  - unequalized opening pressure differential; maximum.

b) TRSV calculated performance limits (for V1-H; V1; V2; and V3 TRSV):

- internal yield pressure (valve open; ends open; maximum rated operating temperature; exclusive of end connections; no applied loads);
- collapse pressure; minimum (at ambient temperature);
- collapse pressure; minimum (at maximum rated operating temperature);
- tensile strength (at maximum internal pressure and ambient temperature);
- tensile strength (at maximum internal pressure and maximum rated operating temperature);
- tensile strength (without pressure at ambient temperature);
- tensile strength (without pressure at maximum rated operating temperature).

c) For SSCSV valves:

- orifice size;
- setting spring;
- number of spacers to be used;
- pressure charge.

d) For SSISV valves:

- minimum full open injection rate or velocity (velocity-type); or injection pressure (tubing-pressure-type);
- maximum recommended injection rate or velocity;
- full closed injection pressure (tubing-pressure-type).

### **6.2.2.3 SSSV Operating Manual Contents**

The SSSV operating manual shall contain the following information.

- a) size, type, and model;
- b) validation grade;
- c) operating data as follows:
  - RWP;
  - operating temperature range;
  - internal yield pressure;

- collapse pressure (applies to tubing-retrievable SSSV equipment at maximum rated operating temperature);
  - tensile load strength (applies to tubing-retrievable SSSV equipment at maximum rated operating temperature);
  - rated performance envelope, if specified by the user/purchaser (see example in Annex M).
- d) Dimensional data necessary for installation and operation.
- e) Dimensions of drift bar and drift sleeve, if applicable.
- f) Calculations as follows:
- SCSSVs—calculation procedures used to determine maximum fail-safe setting depths, where applicable;
  - SSCSVs—orifice coefficients, spring force, optimum operating range of pressure differential for velocity-type valves, etc.;
  - SSISVs—calculation procedures used to determine maximum fail-safe setting depths (tubing-pressure-type).
- g) Drawings and illustrations;
- h) Parts list with all necessary information for reordering, including supplier/manufacturer's contact information;
- i) Specific details of functional testing should be included if the test apparatus or procedures are significantly different than those included in this specification;
- j) Installation instructions;
- k) Retrieving instructions;
- l) Inspection and testing procedures;
- m) Troubleshooting and maintenance procedures;
- n) Repair limitations.

**NOTE** Repair limitations can include limits established on allowable wear of components, number of allowable repair cycles, type and extent of component replacements, or number of thread make/break cycles.

- o) Redress disassembling and reassembling requirements.
- p) Special feature operations and limitations.
- q) Secondary tool operations (see 6.2.2.4).
- r) Gas bleed rate if applicable.
- s) Storage requirements to prevent damage caused by, for example, atmospheric conditions, handling, debris, radiation, etc.
- t) Shelf life, if applicable.
- u) Operating requirements as follows:
  - SCSSVs—opening and closing procedures with opening and closing pressures;
  - SSCSVs—opening and closing procedures that shall include recommendations to avoid unintended closures and throttling,
  - SSISVs—opening and closing procedures with minimum opening and maximum recommended flow rate or velocity,
  - equalizing procedure, including maximum recommended unequalized opening pressure;
- v) For alternate technologies, see 5.10.3 for additional requirements.
- w) Landing nipple profile, if applicable (see 5.5.1).

#### **6.2.2.4 Secondary Tool Operating Manual Contents**

The secondary tool operating manual shall be available and contain the following information:

- a) An abstract of the tool and its operation including identifying information.
- b) Drawings and illustrations.
- c) Operating instructions.
- d) Troubleshooting guide.
- e) Assembly and disassembly requirements including any hand or service tools, or equipment required.
- f) Repair and redress requirements that should contain the redress kit part number including a list of consumable parts.
- g) Storage requirements to prevent damage caused by, for example, atmospheric conditions, handling, debris, radiation, etc.
- h) Shelf life, if applicable.

### **6.3 Product Identification**

6.3.1 SSSV equipment furnished to this specification shall be permanently identified in accordance with the supplier/manufacturer's written specifications. Identification shall include the following:

- a) manufacturer's name or trademark;
- b) manufacturer's size and model;
- c) manufacturer's part number;
- d) unique identifying serial number;
- e) RWP;
- f) minimum ID (TRSV only);
- g) validation grade;
- h) orifices for velocity-type SSCSVs shall be identified by the orifice diameter;
- i) whether the SSSV has been repaired if applicable (see 7.1).

6.3.2 Secondary tools furnished to this specification shall be permanently identified in accordance with the supplier/manufacture's written specifications. Identification shall include the following:

- a) manufacturer's name or trademark;
- b) manufacturer's size and model;
- c) manufacturer's part number;
- d) unique identifying serial number.

### **6.4 Quality Control**

#### **6.4.1 General**

This section provides minimum quality control requirements to meet this specification. All quality control work shall be controlled by documented instructions that include acceptance criteria.

#### **6.4.2 Sampling for Nonmetals**

Sampling procedures and the basis for acceptance or rejection of a batch lot shall be in accordance with ISO 2859-1 or ANSI/ASME Z 1.4, general inspection level II at a 2.5 AQL for O-rings and a 1.5 AQL for other seal components until a documented variation history can be established. Sampling procedures shall then be established based on the documented variation history.

### **6.4.3 Raw Material**

#### **6.4.3.1 Material Certifications**

Raw material used in the manufacture of components shall require the following:

- a) COC stating that the raw material meets the supplier/manufacturer's documented specifications;
- b) MTR so that the supplier/manufacturer can verify that each batch of raw material meets their documented specifications.

MTRs provided by the material sub-supplier, or the supplier/manufacturer are acceptable documentation of mechanical properties. MTRs shall be legible and reproducible and shall be an original or direct copy of a document unaltered as issued by its source. MTRs shall contain records of mechanical property testing showing conformance to the supplier/manufacturer's specifications and shall be approved by a qualified person.

#### **6.4.3.2 Mechanical and Physical Properties**

##### **6.4.3.2.1 Nonmetals**

Mechanical properties required by the material specification shall be validated by test conducted on a material sample produced from the same batch of material. 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-elastomeric polymers 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 or 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 appropriate.

##### **6.4.3.3 Metals**

**6.4.3.3.1** When included on the specification, mechanical properties, including acceptance criteria, shall be determined by the specifications listed in Table 4 or by an equivalent international standard.

**Table 4—Mechanical Properties**

| Parameter               | Specification   |
|-------------------------|---|
| Tensile Strength        | ISO 6892-1 or ASTM 370  |
| Yield Strength          | ISO 6892-1 or ASTM 370  |
| Elongation              | ASTM A370   |
| Hardness                | ASTM E10, ASTM E18, ISO 6506-1, ISO 6508-1, ASTM E384 or ISO 6507-1 |
| Charpy impact toughness | ASTM A370   |

**6.4.3.3.2** Hardness conversion to other measurement units shall be in accordance with ASTM E140, with the exceptions noted in NACE MR0175 for materials that are intended for use in wells where corrosive agents can possibly be expected to cause stress cracking. Supplier/manufacturer may establish documented correlations for individual materials.

NOTE For the purposes of these provisions, NACE MR0175/ISO 15156-1-2-3 is equivalent to ISO 15156 (all parts).

#### **6.4.3.4 Thermal Treatments of Metallics**

##### **6.4.3.4.1 General**

**6.4.3.4.1.1** Heat treatment of raw material and production parts shall be performed according to documented procedures with heat treating equipment that has been calibrated and surveyed per 6.4.6.1.

**6.4.3.4.1.2** If heat treatment is performed by a subcontractor, the subcontractor shall provide a COC to the supplier/manufacturer stating that the heat treatment meets the supplier's/manufacturer's documented specifications. If heat treatment is performed by the supplier/manufacturer, heat treatment shall conform with the supplier's/manufacturer's documented specifications.

Each heat in a batch of material that is heat treated shall be tested for conformance to each of the mechanical

**6.4.3.4.1.3** properties specified in 5.3.3.2.1.

NOTE Heat treatment includes operations such as normalizing, austenitize/quenching, tempering, solution annealing, annealing, or aging.

**6.4.3.4.1.4** After stress relieving, only hardness testing per section 6.4.3.3 is required to confirm conformance with the hardness requirements of the supplier/manufacturer's specifications.

##### **6.4.3.4.2 Furnace Instrumentation**

The requirements for furnace instrumentation are as follows:

- automatic controlling and recording instruments shall be used;
- thermocouples shall be located in the furnace working zone(s) and protected from furnace atmospheres;
- controlling and recording instruments used for the heat treatment processes shall be accurate to  $\pm 1$  % of their full-scale range.

#### **6.4.4 Processes That Require Validation**

##### **6.4.4.1 Coatings and Surface Treatments**

The application of coatings and surface treatments shall be controlled using documented procedures, acceptance criteria, and qualified personnel.

##### **6.4.4.2 Welding and Brazing**

Welding including overlays and brazing shall conform to the following:

- a) welding and brazing procedure and personnel qualification shall be in accordance with ASME *BPVC* Section IX or equivalent;
- b) weld materials and practices not listed in the ASME *BPVC* Section IX shall be applied using weld procedures qualified in accordance with the methods of ASME *BPVC* Section IX or equivalent;
- c) welding of parts for sour service shall meet the requirements of NACE MR0175.

##### **6.4.4.3 Heat Treatment**

Heat treatment shall be controlled using documented procedures, acceptance criteria, qualified personnel, and equipment in conformance with 6.4.3.4 and 6.4.6.1.

##### **6.4.4.4 Non-destructive Examination**

Nondestructive examination (NDE) shall be controlled using documented procedures, acceptance criteria, qualified personnel, and equipment as follows:

- a) radiographic, see 6.4.7.3;
- b) ultrasonic, see 6.4.7.4;
- c) magnetic particle, see 6.4.7.5;
- d) liquid penetrant, see 6.4.7.6.

NOTE API 20D contains requirements for the design, development, and qualification of NDE methods used in the manufacture of equipment.

##### **6.4.4.5 Certifications**

For processes performed at an external subcontractor, the following documentation shall be maintained:

- a) a COC stating the materials and/or processes meet the supplier/manufacturer's documented specifications;
- b) records indicating that the materials or processes meet the supplier/manufacturer's requirements.

##### **6.4.4.6 Process Changes**

Changes to processes for coatings and overlays, welding and brazing, heat treatment, and NDE that could affect the results of the process shall require revalidation of the process. If the change to the process results

in a substantive design change (see 3.1.41) to the product, the process change shall be evaluated as a design change according to 5.7.

#### **6.4.5 Traceability**

All components, weldments, subassemblies, and assemblies necessary for the performance of the product to meet the design acceptance criteria (DAC) (see 3.1.8) shall be traceable except for the following:

- a) orifices (beans) for SSCSVs;
- b) fasteners that do not affect the DAC.

NOTE Fasteners include items such as nuts, bolts, set screws, and spacers.

Traceability shall be in accordance with the supplier/manufacturer's documented procedures. All assemblies, components (including seal components), weldments and subassemblies of equipment supplied shall be traceable to a job lot and an MTR. Components and weldments shall also have their included heat(s) or batch lot(s) identified. All components and weldments in a multiheat or multibatch lot shall be rejected if any heat or batch does not conform with the supplier/manufacturer's requirements.

Traceability for equipment is considered sufficient if the equipment meets the requirements of this specification when it leaves the supplier/manufacturer's facility.

#### **6.4.6 Calibration Systems**

##### **6.4.6.1 Heat-Treat Furnace Calibration**

**6.4.6.1.1** Each furnace shall have been surveyed within one year prior to heat treating operations. Batch-type and continuous-type heat treating furnaces shall be calibrated in accordance with SAE AMS 2750 or another internationally recognized standard.

**6.4.6.1.2** Temperature-controlling and temperature-recording instruments shall be calibrated at least once every three months until a documented calibration history can be established; calibration intervals shall then be established based on repeatability, degree of usage, and documented calibration history.

**6.4.6.1.3** Equipment used to calibrate the production equipment shall possess an accuracy of  $\pm 0.25$  % of full-scale range.

##### **6.4.6.2 Measuring/Testing Equipment Calibration**

**6.4.6.2.1** Measuring and testing equipment used for acceptance shall be identified, inspected, calibrated, and adjusted at specific intervals in accordance with documented specifications, ISO/IEC 17025, and this specification. Measuring and testing equipment shall be used within the calibrated range.

Starting calibration interval for measuring and testing equipment calibration should be included in the Supplier/Manufacturers documented procedures.

**6.4.6.2.2** Pressure measuring devices shall:

- a) be readable to  $\pm 0.5$  % or smaller of full-scale range;
- b) be calibrated to maintain  $\pm 2$  % accuracy of full-scale range.
- c) for spring operated pressure devices, they shall only be used between 25% and 75% of their full scale value.

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

**6.4.6.2.4** Pressure-measuring devices shall be calibrated with a master pressure-measuring device or a deadweight 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.

#### **6.4.7 Nondestructive Examination**

##### **6.4.7.1 General Requirements**

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

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

**6.4.7.1.1** All springs used for primary closure of an SSSV shall be magnetic particle or liquid penetrant inspected for surface defects to verify conformance with the supplier/manufacturer's written specifications.

**6.4.7.1.2** All pressure-containing welds shall be magnetic particle or liquid penetrant inspected for surface defects and shall be volumetrically inspected by radiographic or ultrasonic techniques to verify conformance with the supplier/manufacturer's written specifications. Final NDE shall be performed after all welding, postweld heat treatment, and applicable machining operations on welded areas.

**6.4.7.1.3** All pressure-containing castings and forgings shall be magnetic particle or liquid penetrant inspected for surface defects, after final machining and shall be volumetrically inspected by radiographic or ultrasonic techniques after heat treat to verify conformance with the supplier/manufacturer's written specifications.

**6.4.7.1.4** The durometer hardness of O-rings or other elastomeric seal components shall be determined in accordance with ISO 48 or ASTM D 2240. Sampling shall meet the requirements of 6.4.2.

NOTE For the purposes of these provisions, ASTM D1415 is equivalent to ISO 48.

##### **6.4.7.2 Personnel Qualifications**

**6.4.7.2.1** Personnel performing NDE evaluations and interpretations shall be qualified in accordance with ISO 9712, to at least Level II, or equivalent.

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

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

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

**6.4.7.2.3** All other personnel performing inspection for acceptance shall be qualified in accordance with documented requirements.

### **6.4.7.3 Radiographic Inspections**

#### **6.4.7.3.1 Radiographic Inspection of Weldments**

Radiographic inspection of weldments shall be carried out as follows:

- a) method: in accordance with ASTM E94;
- b) acceptance criteria: in accordance with ASME BPVC Section VIII, Division 1, UW-51.

#### **6.4.7.3.2 Radiographic Inspection of Castings**

Radiographic inspection of castings shall be carried out as follows:

- a) method: in accordance with ASTM E94;
- b) acceptance criteria:
  - 1) in accordance with ASTM E186,
  - 2) in accordance with ASTM E280,
  - 3) in accordance with ASTM E446.

The maximum defect severity levels for Items 1), 2), and 3) are given in Table 5.

**Table 5—Maximum Defect Severity Levels for Castings**

| Defect Category   | Maximum Defect Severity Level |
|---|-------------------------------|
| A   | 3                             |
| B   | 2                             |
| C (all types)   | 2                             |
| D   | None acceptable               |
| E   | None acceptable               |
| F   | None acceptable               |
| G   | None acceptable               |
| NOTE The defect categories, types, and severity levels are defined in ASTM E186, ASTM E280, and ASTM E446, as applicable. |                               |

#### **6.4.7.3.3 Radiographic Inspection of Forgings**

Radiographic inspection of forgings shall be carried out as follows:

- a) method: in accordance with ASTM E94;

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

- 1) any type of crack or lap,
- 2) any other elongated indication with length of indication =  $L$ , and wall thickness of part =  $t$ , as follows:
  - $L > 6.4 \text{ mm } (1/4 \text{ in.})$  for  $t \leq 19 \text{ mm } (3/4 \text{ in.})$ ,
  - $L > t/3$  for  $19 \text{ mm} < t \leq 57.2 \text{ mm } (3/4 \text{ in.} < t \leq 2 \text{ } 1/4 \text{ in.})$ ,
  - $L > 19 \text{ mm } (3/4 \text{ in.})$  for  $t > 57.2 \text{ mm } (2 \text{ } 1/4 \text{ in.})$ .
- 3) any group of indications in a line that have an aggregate length greater than  $t$  in a length of  $12t$ .

#### **6.4.7.4 Ultrasonic Inspections**

##### **6.4.7.4.1 Ultrasonic Inspection of Weldments**

Ultrasonic inspection of weldments shall be carried out as follows:

- a) method: in accordance with ASME BPVC Section V, Article 5;
- b) acceptance criteria:
  - 1) indications characterized as cracks, lack of fusion, or incomplete penetration are unacceptable regardless of length.
  - 2) other imperfections are unacceptable if the indications exceed the reference level amplitude and have lengths that exceed the following criteria:
    - $L > 6.4 \text{ mm } (1/4 \text{ in.})$  for  $t \leq 19 \text{ mm } (3/4 \text{ in.})$ ,
    - $L > t/3$  for  $19 \text{ mm} < t \leq 57.2 \text{ mm } (3/4 \text{ in.} < t \leq 2 \text{ } 1/4 \text{ in.})$ ,
    - $L > 19 \text{ mm } (3/4 \text{ in.})$  for  $t > 57.2 \text{ mm } (2 \text{ } 1/4 \text{ in.})$ ;

where:

$t$  is the thickness of the weld excluding any allowable reinforcement.

For a butt weld joining two members having different thicknesses at the weld,  $t$  is the thinner of these two thicknesses. If a full penetration weld includes a fillet weld, the thickness of the throat of the fillet shall be included in  $t$ .

##### **6.4.7.4.2 Ultrasonic Inspection of Castings**

Ultrasonic inspection of castings shall be carried out as follows:

- a) method: in accordance with ASTM E127 and ASTM A609;
- b) acceptance criteria: in accordance with ASTM A609 at an ultrasonic testing quality level 1, minimum.

#### **6.4.7.4.3 Ultrasonic Inspection of Forgings and Wrought Products**

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

- a) method: in accordance with ASTM E127 and ASTM A388;
- b) any of the following calibration methods:
  - 1) back reflection technique: the instrument shall be set so that the first back reflection is  $75\% \pm 5\%$  of the screen height when the transducer is placed on an indication-free area of the forging or wrought product,
  - 2) flat bottom hole technique: the distance amplitude curve shall be based on a 3.2 mm ( $1/8$  in.) flat bottom hole for thicknesses up to and including 101.6 mm (4 in.) and a 6.4 mm ( $1/4$  in.) flat bottom hole for thicknesses greater than 101.6 mm (4 in.),
  - 3) angle beam technique: the distance amplitude curve shall be based on a notch of a depth equal to the lesser of 9.5 mm ( $3/8$  in.) or 3 % of the nominal section thickness [9.5 mm ( $3/8$  in.) maximum], a length of approximately 25.4 mm (1 in.) and a width no greater than twice its depth.
- c) acceptance criteria: any of the following forging or wrought product defects shall be basis for rejection:
  - 1) back reflection technique: indications greater than 50 % of the referenced back reflection accompanied by a complete loss of back reflection,
  - 2) flat bottom hole technique: indications equal to or larger than the indications observed from the calibration flat bottom hole,
  - 3) angle beam technique: amplitude of the discontinuities exceeding those of the reference notch.

#### **6.4.7.5 Magnetic Particle Inspections—Wet Magnetic Particle Examination**

Wet magnetic particle examination shall be carried out as follows:

- c) method: in accordance with ISO 13665 or ASTM E709;
- d) indications shall be described as one of the following:
  - 1) relevant indication: only those indications with major dimensions greater than 1.6 mm ( $1/16$  in.) shall be considered relevant whereas inherent indications not associated with a surface rupture (i.e., magnetic permeability variations, nonmetallic stringers, etc.) shall be considered nonrelevant,
  - 2) linear indication: any indication in which the length is equal to or greater than three times its width,
  - 3) rounded indication: any indication which is circular or elliptical in which the length is less than three times its width;
- e) acceptance criteria:
  - 1) any relevant indication greater than or equal to 4.8 mm ( $3/16$  in.) shall be considered unacceptable,

- 2) no relevant linear indications shall be allowed for weldments,
- 3) no more than 10 relevant indications shall be present in any 39 cm<sup>2</sup> (6 in.<sup>2</sup>) area,
- 4) four or more rounded relevant indications in a line separated by less than 1.6 mm (1/16 in.) shall be considered unacceptable.

#### **6.4.7.6 Liquid Penetrant (Dye) Inspection**

Liquid penetrant inspection shall be carried out as follows:

- f) method: in accordance with ASTM E165;
- g) acceptance criteria:
  - 1) no relevant linear indications;
  - 2) no relevant rounded indications greater than 5 mm (3/16 in.)
  - 3) no more than four or more relevant rounded indications in a line separated by 1.5 mm (1/16 in.) or less (edge to edge).

#### **6.4.7.7 Visual Inspections**

**6.4.7.7.1** The supplier/manufacturer shall have documented procedures, including acceptance criteria, for visual inspection of all accessible surfaces for defects and damage before assembly of the equipment.

**6.4.7.7.2** Visual inspection of O-rings shall be in accordance with ISO 3601-3, Grade S. Other seal components shall be visually inspected in accordance with the supplier/manufacturer's documented specifications. Sampling shall meet the requirements of 6.4.2.

NOTE For the purposes of this provision, MIL STD 413 is equivalent to ISO 3601-3.

#### **6.4.7.8 Component Dimensional Inspection**

**6.4.7.8.1** All dimensions on all traceable metallic components shall be dimensionally inspected. Inspection shall be performed during or after the manufacture of the components but prior to assembly, unless assembly is required for proper measurement. Nonconformances shall be dispositioned per 6.4.8.

**6.4.7.8.2** Dimensional tolerances of elastomeric O-rings shall be in accordance with ISO 3601-1. Other seal components shall meet dimensional tolerances of the supplier/manufacturer's written specifications and/or the seal vendor inspection drawings. Sampling shall meet the requirements of 6.4.2.

NOTE For the purposes of this provision, SAE AS568B is equivalent to ISO 3601-1.

**6.4.7.8.3** All API tapered-thread tolerances, inspection requirements, gauging, gauging practice, gauge calibration, and gauge certification shall be in accordance with API 5B.

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

#### **6.4.8 Manufacturing Nonconformities**

**6.4.8.1** The manufacturer shall establish, maintain, and conform to documented procedures that prevent the unintended installation or use of an assembly or component that does not conform to specified requirements. This control shall provide requirements for identification, documentation, evaluation, segregation (when applicable), and disposition of nonconforming assemblies or components.

**6.4.8.2** Responsibility for review and authority for disposition of nonconforming assemblies or components shall be defined in procedures established by the supplier/manufacturer. Nonconforming assemblies or components disposition may include but are not limited to:

- reworked to meet the specified requirements,
- accepted with or without repair by concession, or
- rejected and scrapped.

**6.4.8.3** Use-as-is, repaired, and/or reworked assemblies or components shall be inspected in accordance with the supplier/manufacturer's technical specifications and the requirements of this specification. Weld repair shall be restricted to the weld only.

#### **6.4.9 Subsupplier Controls**

**6.4.9.1** The supplier/manufacturer shall purchase goods and services from approved subsuppliers who shall be part of the supplier/manufacturer's Approved Vendors List.

**6.4.9.2** The process of approving a subsupplier shall be per the supplier/manufacturer's documented procedure.

### **6.5 Functional Testing**

**6.5.1** SSSV functional testing shall be performed on each new SSSV manufactured in accordance with Annex C. Results of the functional test shall be traceable to the valve tested and shall be retained in accordance with 6.2.1.

**6.5.2** If a particular SSSV has design or operational features that are incompatible with the requirements of Annex C, the supplier/manufacturer shall document the incompatibility and shall identify the proposed revised test steps/conditions and technically justify the revision(s) as no less stringent than the original test requirements. The supplier/manufacturer shall include the justification of any changes to the functional test in the product's design documentation.

**6.5.3** If the user/purchaser specifies alternative requirements for closure mechanism leakage, the requirements provided in the functional specification or those specified in Annex E shall be applied.

**6.5.4** Each secondary tool manufactured shall be tested in accordance with the supplier/manufacturers written procedure.

### **6.6 Failure Reporting and Analysis**

**6.6.1** Failure reports provided by the user/purchaser as defined in API 14B shall be processed according to the following requirements. The supplier/manufacturer shall have documented procedures that define the actions required.

**6.6.2** Notification of the receipt of a failure report shall be provided to the submitting user/purchaser contact within 30 calendar days of the documented receipt at the supplier/manufacturer. This notification shall include any data collection requests that the supplier/manufacturer needs to perform an effective evaluation and a projected completion date of the evaluation. Should the requested data or equipment not be provided as requested, the failure report shall be classified as inactive 30 calendar days after the notification has been provided to the user/purchaser.

**6.6.3** Following receipt of the requested data and equipment to be analyzed, reasonable efforts shall be implemented to complete the evaluations in a timely manner that meets the prevailing business need. The evaluation report shall be provided to the user/purchaser within 15 calendar days after completion of the evaluation. This evaluation shall include the actions required of the user/purchaser to mitigate reoccurrence of the identified problem and suggested measures to extend the product's operating life, when appropriate. The supplier/manufacturer shall make necessary design changes (see 5.7) that result from the failure analysis on all affected equipment. If the required or suggested actions apply to similar products, they shall be referenced in the evaluation and affected users/purchasers shall be notified.

**6.6.4** Evaluations and any subsequent notifications prepared in response to a failure report shall be documented and available for three years after the date of preparation.

## **7 Repair/Redress**

### **7.1 Repair**

**7.1.1** Repair operations for SSSVs and secondary tools shall include the return of the product to a condition meeting all requirements stated in this specification or the edition of this specification in effect at the time of original manufacture.

**7.1.2** The supplier/manufacturer that performs the repairs shall keep records of the repair including any parts replaced and the results of functional testing per Annex C.

**7.1.3** Repaired products shall be permanently marked according to documented procedures (see 6.3.1).

NOTE Creation of a new or altered design by replacing parts on an existing design is not a repair.

### **7.2 Redress**

Redress operations for SSSVs and secondary tools shall be performed in conformance with API 14B.

## **8 Storage and Preparation for Transport**

**8.1** Equipment shall be stored in conformance with the written specifications of the equipment supplier/manufacturer to prevent damage caused by, for example, atmospheric conditions, handling, debris, UV radiation, etc. prior to transport.

**8.2** Equipment shall be packaged for transport per the written specifications of the equipment supplier/manufacturer to prevent normal handling loads and contamination from harming the equipment. These specifications shall address the protection of external seal components, sealing surfaces, exposed threaded connections, access port(s) sealing, and contamination from fluids and debris.

**8.3** Material provided as protection for transport shall be clearly identified for removal prior to equipment use.

NOTE For storage after transport (e.g., caused by atmospheric conditions, handling, debris, radiation, etc.), see the operating manual.

## **Annex A (normative)**

### **Test Agency Requirements**

#### **A.1 General**

**A.1.1** The test agency shall be an independent third party, meeting the requirements of this annex, and have the ability to perform the tests of Annex B or Annex N to conduct validation tests.

**A.1.2** Any variation from the validation test requirements of this specification shall be noted on the test application and recorded on the validation test data

**A.1.3** The test agency shall conduct validation tests as specified on the supplier/manufacture's test application in 5.5.11.2 and record the results of the validation test as specified in B.23.

**A.1.4** The test agency shall supply a copy of the validation test report to the supplier/manufacture within 30 days of the completion of the test.

**A.1.5** Test agencies performing validation testing shall have a quality management system (QMS) that conforms to a recognized quality management standard such as API Q1 or ISO 9001.

**A.1.6** The test agency shall provide, upon written request, current documentation to supplier/manufacture or user/purchaser. This shall include the following, as a minimum:

- a) description of the facility, including any limitations on the size, length, mass, type, pressure rating, temperature rating, and validation grade of SSSV that may be tested;
- b) test procedures and forms used at the facility for each type and validation grade of SSSV;
- c) calibration records;
- c) any limitations on the accessibility of the facility (such limitations shall not preclude reasonable access to the facility for inspection by supplier/manufacturers;
- d) any limitations on the receipt of proprietary information.

**A.1.7** The test agency shall within seven days provide a response to the test application requestor, if applicable, stating any rejection of the requirements therein. A test application may be declined if the data are incomplete, inaccurate, or self-conflicting. Any declined applications shall detail the specific provisions causing rejection.

#### **A.2 Test Facility Requirements**

**A.2.1** The components of the test facility systems shall have a capacity and pressure rating as required by the size and/or RWP of the SSSV to be tested.

**A.2.2** Measuring and monitoring equipment used during the validation process shall be calibrated in accordance with the requirements of 6.4.6.2.

**A.2.3** The control pressure system components should, as a minimum, consist of the following:

- a) hydraulic-fluid reservoir with a filtered vent;
- b) accumulator;
- c) hydraulic pump;
- d) control system to operate the pump;
- e) pressure-relief capability to protect the system.

**A.2.4** There shall be provision for the supply of nitrogen gas to conduct the required nitrogen leak test and a gas flow meter to indicate the leakage rate.

A gas reservoir with a gas release device and instrumentation to measure the test parameters shall be provided.

The test facility should, as a minimum, consist of the items listed below:

- a) flow piping, which shall be at least 50.8 mm (2 in.) nominal diameter;
- b) freshwater tank;
- c) sand slurry tank;
- d) Marsh funnel, required timer, and graduated beaker;
- e) centrifuge with basic sediment and water sample tubes;
- f) circulation pumps;
- g) flow meter;
- h) pressure measurement systems;
- i) data acquisition equipment to simultaneously record the required pressure and flow data and the corresponding elapsed time,
- j) backpressure regulator;
- k) propane system;
- l) high-pressure water pump and accumulator system.

NOTE API MPMS Ch. 10.4 provides guidance on sand measurement.

### **A.3 Validation Test Reports**

Test reports completed by a test agency conforming to this specification shall be traceable to the equipment tested and shall include the following:

- a) general information (date, location, supplier/manufacturer, model, serial number, size, rating, etc.);

- b) summary of test results (see B.23);
- c) observed data;
- d) test conditions (limits required by the standard);
- e) identification of test methods and/or procedures;
- f) supporting data (log sheets, etc.);
- g) graphical presentation of operating pressure traces;
- h) identification of instruments involved in the testing;
- i) copy of validation test application from 5.5.11.2;
- j) the content of the data requirements of Annex B or Annex N, as applicable;
- k) certificate of compliance in accordance with a national or internationally recognized standard such as ISO/IEC 17050;
- l) time-based testing data, as requested.

#### **A.4 Test Agency Records**

Unless otherwise specified in the appropriate referenced standard(s), the test agency shall keep the following records for 20 years from test dates:

- a) test data indicating conformance to the test requirements<sup>6</sup>;
- b) test reports<sup>6</sup>;
- c) measuring and test equipment calibration data<sup>6</sup>;
- d) testing nonconformance reports;
- e) test agency audit and corrective-action records;
- f) personnel qualification records;
- g) test procedures<sup>6</sup>;
- h) valid test applications<sup>6</sup>;
- i) certification of compliance.

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<sup>6</sup> Records required by A.4 that are included in A.3 and therefore in A.4 b) are not required to be duplicated.

## Annex B (normative)

### Validation Testing Requirements

#### B.1 General

**B.1.1** To validate the SSSV design, all steps of this validation-testing procedure shall be completed successfully within the limits specified and, in the order, shown.

**B.1.2** The SSSV shall be oriented vertically for all tests.

**B.1.3** Validation testing shall be discontinued if the valve fails to perform within the limits specified for any step, except when such failures are determined to be a result of actions by the test agency or a failure within the test facility. The basis for discontinuing the test and any unusual conditions observed at or prior to the time of discontinuance shall be noted on the test data form by the test agency.

**B.1.4** If a SSSV fails the validation test, evaluation shall be performed prior to repeating the test (see 5.5.11.3).

**B.1.5** All pressures are defined as gauge pressure unless otherwise specified and shall be recorded on time-based equipment.

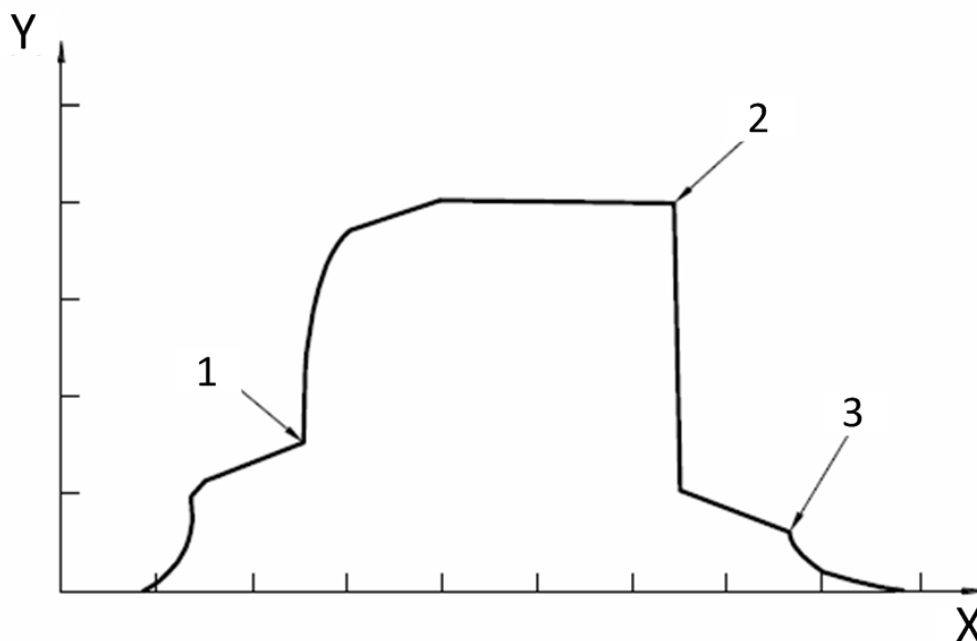
**B.1.6** Prior to any liquid pressure test, purge with test liquid to remove air.

**B.1.7** Unless otherwise specified, gas pressure-relieving (bleed-down) operations should be performed at a maximum rate of 0.7 MPa/min (100 psi/min) at pressures less than 10.3 MPa (1500 psi). The supplier/manufacture may specify gas pressure-relieving (bleed-down) operations.

**B.1.8** The supplier/manufacture shall provide characteristic operational profiles that shall contain the defined open and closing points for the SCSSVs being tested.

**NOTE** Figure B.1 illustrates a characteristic pressure versus time plot for opening and closing hydraulic control pressures with hydraulic fluid being applied at a metered rate.

**B.1.9** During validation testing of hydraulically operated SCSSVs, control line fluid metering may be used to provide a readable hydraulic control line pressure trace.



**Key**

X time, with hydraulic control pressure applied or released at a metered rate, increasing to the right

Y hydraulic pressure, increasing upward

1 SCSSV becomes fully open.

2 hydraulic system pressure-released

3 SCSSV becomes fully closed.

**Figure B.1—Example of Characteristic Hydraulic Control Pressure Curve for SCSSVs**

**B.1.10** When validation testing of SSSV sizes is not covered in Tables B.4, B.13, B.16, and B.23, the flow rate values may be interpolated or extrapolated by a ratio of the square of the diameter versus the parameter involved.

**B.1.11** The test section shall completely enclose a wireline-retrievable SSSV. Tubing-retrievable SSSVs shall be an integral part of the test section. The test section shall be rated to at least the RWP of the SSSV.

**B.1.12** The test section ends; length and hydraulic control connections shall be compatible with the test agency's facility.

**B.1.13** Each data form shall be signed and dated by the person(s) conducting the test. The form containing the data specified in B.23 shall be signed and dated by the test agency's designated approval authority.

## **B.2 Validation Test Procedure—Surface-controlled Subsurface Safety Valve**

**B.2.1** To validate an SCSSV to the requirements of validation Grade V3, the test agency shall complete the steps detailed in Table B.1.

**NOTE** For validation requirements of alternate technologies, see 5.10.2.

**Table B.1—Test Agency SCSSV V3 Steps**

| <b>Step</b>  | <b>Procedure</b>   |
|--|--|
| 1)   | Verify that the model and serial numbers appearing on the test valve are in agreement with the supplier/manufacture's application.                                       |
| 2)   | Perform the SCSSV gas flow test (see B.3).   |
| 3)   | Open the test SCSSV. Record the full open hydraulic control pressure.  |
| 4)   | Fill the SCSSV with water and circulate water to displace gas out of the test section. Once gas has been displaced from the test section, discontinue water circulation. |
| 5)   | Close the SCSSV. Record the full closed hydraulic control pressure.  |
| 6)   | Perform the liquid leakage test (see B.5).   |
| 7)   | Perform the unequalized opening test (see B.6).  |
| 8)   | Perform the operating-pressure test (see B.7).   |
| 9)   | Perform the propane test (see B.8).  |
| 10)  | Perform the nitrogen leakage test (see B.9).   |
| 11)  | Repeat the operating-pressure test (see B.7).  |
| 12)  | Perform the SCSSV V3 water flow test (see B.10).   |
| 13)  | Repeat steps 10) to 12) four additional times.   |
| 14)  | Perform the liquid leakage test (see B.5).   |
| 15)  | Perform the controlled-temperature test (see B.11).  |
| 16)  | If the SCSSV is to be tested to validation grade V2, omit the drift test in step 17) and proceed with tests described in B.2.2.  |
| 17)  | Perform the drift test (see B.4).  |
| 18)  | If the SCSSV has performed within the limits specified, it has passed the validation test.   |
| 19)  | Summarize the validation test data as specified in B.23.   |
| NOTE The requirements of this table are substantially the same as the requirements of Class 1 testing in the 9th, 10th, and 11th editions. |  |

**B.2.2** To validate an SCSSV to the requirements of validation Grade V2, the test agency shall complete the steps detailed in Table B.1 plus the additional steps specified in Table B.2. If at any point in the V2 test the valve fails, and it is desired to retain V3 qualification, the drift test (Step 17 of Table B.1) shall be performed to confirm V3 validation.

**Table B.2—Test Agency SCSSV V2 Steps**

| <b>Step</b> | <b>Procedure</b>   |
|-------------|--|
| 1)          | Verify that the SCSSV has already completed and passed the applicable requirements of Table B.1, Steps 1) to 15).  |
| 2)          | Fill the SCSSV with slurry per B.12, Steps 1) to 6) and circulate the slurry through the SCSSV for 5 min $\pm$ 1 min per Table B.16.   |
| 3)          | Perform the operating-pressure test (see B.7).   |
| 4)          | Perform the V2 slurry flow test (see B.12). V2 slurry flow testing shall be performed in a continuous manner with no interruptions longer than 2 h.  |
| 5)          | Perform the nitrogen leakage test (see B.9). In the event an SCSSV fails nitrogen testing after close-against-flow with a leakage of less than 15 scf/min, the test may be restarted one time in total at Step 3) for first flow. The SCSSV shall pass seven consecutive V2 test Steps 2) to 4) to complete validation. The restart of the test shall be initiated without any auxiliary evaluations performed on the SCSSV. |
| 6)          | Repeat Steps 3) to 5) six additional times. The slurry may be allowed to stagnate in the test section overnight with the test valve in the open position.  |
| 7)          | Perform the liquid leakage test (see B.5).   |
| 8)          | Perform the drift test (see B.4).  |
| 9)          | If the SCSSV has performed within the limits specified, it has passed the validation test.   |
| 10)         | Summarize the validation test data as specified in B.23.   |
|             |  |

### B.3 Gas Flow Test—Surface-controlled Subsurface Safety Valve

The gas flow test shall be performed in conformance with Table B.3.

**Table B.3—SCSSV Gas Flow Test**

| Step | Procedure and Acceptance Criteria  | Data to Be Recorded  |
|------|--|--|
| 1)   | Record test data as specified.   | — validation test number<br>— date   |
| 2)   | Install the test valve in the gas flow test stand. The test medium shall be nitrogen.  |  |
| 3)   | Set the control line resistance to the appropriate setting shown in Table B.4.<br>The test flow rates shall be maintained within – 5 % and +15 % of the nominal value given in Table B.4 or between $-(0.01 \times 10^6) \text{ m}^3$ and $+(0.04 \times 10^6) \text{ m}^3/\text{d}$ [ $-(0.5 \times 10^6) \text{ scf}$ and $+(1.5 \times 10^6) \text{ scf}$ per day], whichever is greater.<br>The low control line resistance test shall be performed with a hydraulic control line having an inside diameter of at least 9.6 mm (0.38 in.) and a maximum total length of 7.6 m (25 ft).<br>The configuration for the high control line resistance test shall consist of the control line used for the low-resistance configuration plus a square-edge orifice having an inside diameter of $0.5 \text{ mm} \pm 0.05 \text{ mm}$ (0.020 in. $\pm$ 0.002 in.) and a length of $25.4 \text{ mm} \pm 2.5 \text{ mm}$ (1.0 in. $\pm$ 0.1 in.). The restrictor shall be placed on the far end of the 7.6 m (25ft) low resistance line away from the valve.<br>Additional control line resistance may be specified by the user/purchaser for the high control line resistance tests. | e)   |
| 4)   | Open and close the SCSSV.  | — hydraulic opening pressure at zero bore pressure<br>— hydraulic closing pressure at zero bore pressure |
| 5)   | Provide a gas flow at a test rate in accordance with Table B.4.  |  |
| 6)   | Increase the gas pressure in the system to between 13.8 MPa (2000 psi) and 17.3 MPa (2500 psi).  |  |
| 7)   | Open the SCSSV. Record the full open control pressure.   | — hydraulic opening pressure at 13.8 MPa to 17.2 MPa (2000 psi to 2500 psi) bore pressure                |
| 8)   | Establish and maintain the gas flow rate indicated in Table B.4, and then close the SCSSV. With mutual consent between the supplier/manufacture and test agency, higher flow rates than those stipulated in Table B.4 may be used.<br><b>Acceptance Criteria:</b> The SCSSV shall shut off a minimum of 95 % of the specified flow in 5.0 s or less after the hydraulic control pressure reaches zero, or if any body joint leakage (tubing-retrievable only) is detected, the SCSSV fails the test.   | — gas flow rate<br>— time to close<br>— test passed? (yes or no)   |
| 9)   | Bleed the valve bore downstream pressure to zero. Adjust the test valve upstream bore pressure to $8.3 \text{ MPa} \pm 0.4 \text{ MPa}$ (1200 psi $\pm$ 60 psi).   | — valve bore upstream test pressure (measured)   |

|     |  |  |
|-----|--|--|
|     | <b>Acceptance criteria:</b> If the leakage rate is greater than 0.14 m <sup>3</sup> /min (5 scf/min), or if any body leakage (tubing-retrievable only) is detected, the SCSSV fails. | <ul style="list-style-type: none"> <li>— leakage rate</li> <li>— body leakage detected? (yes or no)</li> <li>— test passed? (yes or no)</li> </ul> |
| 10) | Bleed all pressure to zero. Repeat Steps 3) to 9) until all four closure tests specified in Table B.4 are successfully completed or until the SCSSV fails.                           | <ul style="list-style-type: none"> <li>— test passed? (yes or no)</li> <li>— conducted by: (printed name and signature)</li> <li>— date</li> </ul> |

**Table B.4—SCSSV Gas Flow Rates**

| Nominal Tubing or Casing Size <sup>a</sup><br>mm (in.) | Gas Flow Rate and Control Line Resistances for Each Valve Closure Test                       |  |  |  |
|--|--|--|--|--|
|  | Low Resistance   |  | High Resistance  |  |
|  | Test No. 1<br>Flow Rate<br>m <sup>3</sup> /d × 10 <sup>6</sup><br>(scf/d × 10 <sup>6</sup> ) | Test No. 2<br>Flow Rate<br>m <sup>3</sup> /d × 10 <sup>6</sup><br>(scf/d × 10 <sup>6</sup> ) | Test No. 3<br>Flow Rate<br>m <sup>3</sup> /d × 10 <sup>6</sup><br>(scf/d × 10 <sup>6</sup> ) | Test No. 4<br>Flow Rate<br>m <sup>3</sup> /d × 10 <sup>6</sup><br>(scf/d × 10 <sup>6</sup> ) |
| 60.3 (2 3/8)   | 0.14 (5.1)   | 0.22 (7.7)   | 0.07 (2.6)   | 0.14 (5.1)   |
| 73.0 (2 7/8)   | 0.23 (8.0)   | 0.34 (12.0)  | 0.11 (4.0)   | 0.23 (8.0)   |
| 88.9 (3 1/2)   | 0.33 (11.5)  | 0.49 (17.3)  | 0.16 (5.8)   | 0.33 (11.5)  |
| 101.6 (4)  | 0.44 (15.7)  | 0.67 (23.6)  | 0.22 (7.9)   | 0.44 (15.7)  |
| 114.3 (4 1/2)  | 0.58 (20.5)  | 0.87 (30.8)  | 0.29 (10.3)  | 0.58 (20.5)  |
| 127.0 (5)  | 0.73 (25.9)  | 1.10 (38.9)  | 0.37 (13.0)  | 0.73 (25.9)  |
| 139.7 (5 1/2)  | 0.91 (32.0)  | 1.36 (48.0)  | 0.45 (16.0)  | 0.91 (32.0)  |
| 168.3 (6 5/8)  | 1.42 (50.2)  | 2.14 (75.4)  | 0.71 (25.2)  | 1.42 (50.2)  |
| 177.8 (7)  | 1.79 (63.1)  | 2.68 (94.7)  | 0.89 (31.6)  | 1.79 (63.1)  |
| 219.1 (8 5/8)  | 2.31 (81.6)  | 3.47 (122.4)   | 1.16 (40.8)  | 2.31 (81.6)  |
| 244.5 (9 5/8)  | 2.89 (102.0)   | 4.33 (153.1)   | 1.45 (51.1)  | 2.89 (102.0)   |

<sup>a</sup> The supplier/manufacturer establishing sizes not covered by this table may interpolate or extrapolate, assuming the circulation rate depends on the square of the nominal size.

## **B.4 Drift Test—Surface-controlled Subsurface Safety Valve**

### **B.4.1 General**

**B.4.1.1** The supplier/manufacture shall provide the test agency with a drift sleeve (for WRSVs) and/or drift bar (for TRSVs and WRSVs) that is appropriate for detecting variations in the valve's dimensions. Each drift bar/sleeve shall be permanently marked with a unique identifier. Drift bar dimensions (provided by the supplier/manufacture) and unique identifier shall be recorded along with the minimum specified ID of the test valve (TRSVs and WRSVs) or maximum specified OD of the test valve (WRSVs).

**B.4.1.2** Drift bars' OD shall not be smaller than the valve's specified minimum ID, less 0.75 mm (0.030 in.); drift sleeves' ID shall not be larger than the valve's specified maximum OD plus 0.75 mm (0.030 in.) and shall have a circular cross section at the recorded drift dimensions.

**B.4.1.3** Each drift bar shall be of a length designated as appropriate to verify that the product provides no restriction to the passage of tools for the full length of the product and shall be a minimum length of four times the specified inside diameter of the product, or 610 mm (24 in.), whichever is greater.

**B.4.1.4** Each drift sleeve shall be of a length designated as appropriate to verify that the product can be received into its intended internal profile and shall be a minimum length of two times the specified outside diameter of the product.

### **B.4.2 Drift Test—Tubing-retrievable SSSV**

The TRSV drift test shall be performed in conformance with Table B.5

**Table B.5—TRSV Drift Test**

| <b>Step</b> | <b>Procedure and Acceptance Criteria</b>   | <b>Data to Be Recorded</b>  |
|-------------|--|---|
| 1)          | Record test data as specified.   | <ul style="list-style-type: none"> <li>— validation test number</li> <li>— date</li> <li>— minimum inside diameter of the test valve</li> <li>Drift information: <ul style="list-style-type: none"> <li>— drift bar outside diameter</li> <li>— drift length</li> <li>— unique identifier of drift bar</li> </ul> </li> </ul> |
| 2)          | Open and close the test valve, recording the full open hydraulic control pressure.   | <ul style="list-style-type: none"> <li>— full open hydraulic control pressure</li> <li>— full closed hydraulic control pressure</li> </ul>  |
| 3)          | Orient the test valve so that the valve is vertical, upside down, and in the open position. The test valve may be opened prior to repositioning.   |   |
| 4)          | Pass the drift bar completely through the test valve in a manner that does not cause the test valve's closure mechanism to be closed. The drift bar shall be aided by a force no greater than that of gravity while being passed down and back through the test valve. | <ul style="list-style-type: none"> <li>— drift pass? (yes or no)</li> <li>— conducted by: (printed name and signature)</li> <li>— date</li> </ul>   |

|  |  |  |
|--|--|--|
|  | <b>Acceptance criteria:</b> If the drift bar does not pass freely completely through the test valve, the test valve fails. |  |
|--|--|--|

### B.4.3 Drift Test—Wireline-retrievable SSSV

The WRSV drift test shall be performed in conformance with Table B.6

**Table B.6—WRSV Drift Test**

| Step | Procedure and Acceptance Criteria  | Data to Be Recorded  |
|------|--|--|
| 1)   | Record test data as specified.   | <ul style="list-style-type: none"> <li>— validation test number</li> <li>— date</li> <li>— minimum inside diameter and maximum outside diameter of test valve</li> </ul> Drift information: <ul style="list-style-type: none"> <li>— drift bar outside diameter and drift sleeve inside diameter</li> <li>— drift length (bar and sleeve)</li> <li>— unique identifier of drift bar</li> </ul> |
| 2)   | Open the WRSV, recording the full open hydraulic control pressure. Orient the WRSV so that the valve bore is vertical, upside down, and in the open position.  | — full open hydraulic control pressure   |
| 3)   | Pass the drift bar completely through the WRSV in a manner that does not cause the WRSV's closure mechanism to be closed. The drift bar shall be aided by a force no greater than that of gravity while being passed down and back through the WRSV.<br><br><b>Acceptance criteria:</b> If the drift bar does not pass freely completely through the WRSV, the WRSV fails.   | — drift pass? (yes or no)  |
| 4)   | Pass the drift sleeve over the entire length, except for the seal components, of the WRSV in a manner that does not cause the WRSV's closure mechanism to be moved.<br><br>NOTE If control line or control sleeve is in place, a partial drift of the lower valve can be accomplished here.<br><br>Close the WRSV and record the closing pressures. If a partial OD drift has been accomplished, pass the drift sleeve over the remaining length of the WRSV. The drift sleeve shall be aided by a force no greater than that of gravity while being passed down and back over the WRSV.<br><br><b>Acceptance criteria:</b> If the drift sleeve does not freely pass completely over the WRSV, except for the seal components, the WRSV fails. | <ul style="list-style-type: none"> <li>— drift pass? (yes or no)</li> <li>— conducted by: (printed name and signature)</li> <li>— date</li> </ul>  |

## B.5 Liquid Leakage Test—Subsurface Safety Valve

The SSSV liquid leakage test shall be performed in conformance with Table B.7.

**Table B.7—SSSV Liquid Leakage Test**

| Step | Procedure and Acceptance Criteria   | Data to Be Recorded   |
|------|---|---|
| 1)   | Record test data as specified.  | <ul style="list-style-type: none"> <li>— validation test number</li> <li>— date</li> </ul>  |
| 2)   | Verify that the SSSV is in the closed position with only liquid above and below the valve.  |   |
| 3)   | Apply water pressure below the SSSV closure mechanism at 100 % of the RWP (allowable range of 95 % to 100 %) of the valve. Record the SSSV bore pressure and the time at which pressure was applied to the valve.   | <ul style="list-style-type: none"> <li>— valve bore test pressure</li> <li>— time at which test pressure is applied</li> </ul>  |
| 4)   | <p>Wait for a minimum of 3 min after applying water pressure below the SSSV closure mechanism before beginning collection of water leakage through the closure mechanism.</p> <p>Continuously collect water leakage for a period of 5 min. Calculate and record the average leakage rate per minute.</p> <p><b>Acceptance criteria:</b> If the average leakage rate during the collection period exceeds 10 cm<sup>3</sup>/min (0.6 in.<sup>3</sup>/min) of water, or if external body leakage is detected (tubing-retrievable only), the test valve fails.</p> | <ul style="list-style-type: none"> <li>— time at start of leakage test</li> <li>— time at end of leakage test</li> <li>— average leakage rate at test pressure</li> <li>— body leakage detected (TRSV only)? (yes or no),</li> <li>— test step passed? (yes or no)</li> <li>— conducted by: (printed name and signature)</li> <li>— date</li> </ul> |

## B.6 Unequalized Opening Test—Surface-controlled Subsurface Safety Valve

The SCSSV unequalized opening test shall be performed in conformance with Table B.8.

**Table B.8—Unequalized Opening Test—SCSSV**

| Step | Procedure and Acceptance Criteria  | Data to Be Recorded  |
|------|--|--|
| 1)   | Record test data as specified.   | <ul style="list-style-type: none"> <li>— validation test number</li> <li>— date</li> <li>— manufacturer's maximum recommended unequalized opening pressure (from operating manual)</li> </ul>  |
| 2)   | Establish water pressure upstream of the SCSSV closure mechanism at the maximum supplier/manufacturer-specified opening-pressure differential.   | <ul style="list-style-type: none"> <li>— test start time</li> <li>— test completion time</li> <li>— valve bore upstream test pressure (measured)</li> </ul>  |
| 3)   | <p>Open the SCSSV closure mechanism against specified pressure as recommended in the test valve-operating manual.</p> <p><b>Acceptance criteria:</b> the SCSSV closure mechanism shall open against the specified pressure. If the SCSSV closure mechanism does not open the test fails.</p> | <ul style="list-style-type: none"> <li>— equalizing test pressure (measured)</li> <li>— full open hydraulic control pressure (measured)</li> <li>— test passed? (yes or no)</li> <li>— conducted by: (printed name and signature)</li> <li>— date</li> </ul> |

## B.7 Operating-pressure Test—Surface-controlled Subsurface Safety Valve

The SCSSV operating pressure test shall be performed in conformance with Table B.9.

**Table B.9—Operating-pressure Test—SCSSV**

| Step | Procedure and Acceptance Criteria  | Data to Be Recorded  |
|------|--|--|
| 1)   | Record test data as specified.   | — validation test number<br>— date   |
| 2)   | Apply pressure of 25 % of the RWP (allowable range of 20 % to 30 % of RWP) of the SCSSV to the entire test section. Record the SCSSV bore pressure (base pressure).  | — test valve bore pressure (base pressure)   |
| 3)   | <p>Close and open SCSSV five times while maintaining the test section pressure recorded in Step 2) within the specified range.</p> <p><b>NOTE</b> The test section pressure can increase as the valve is opened and then can decrease as the valve is closed due to the differential volume of the hydraulic operating piston.</p> <p>For tubing-pressure-sensitive valves, the full open/full closed hydraulic control pressures shall be adjusted based on the change of the test section pressure at the time of control pressure measurement. The adjusted control pressure is determined by adding/subtracting the actual control pressure with the difference between the base pressure and the actual test section pressure recorded at the time of each opening/closing pressure measurement.</p> <p><b>Acceptance criteria:</b> If the five adjusted hydraulic control pressures (or actual control pressures for tubing-pressure-insensitive valves) do not repeat within <math>\pm 10</math> % of their average, or <math>\pm 0.7</math> MPa (<math>\pm 100</math> psi), whichever is greater, or if any body leakage (tubing-retrievable only) is detected, the SCSSV fails.</p> | <p>For each of 5 operating cycles:</p> <ul style="list-style-type: none"> <li>— full open hydraulic control pressure and test section pressure</li> <li>— full closed hydraulic control pressure and test section pressure</li> </ul> <p>Calculated values:</p> <ul style="list-style-type: none"> <li>— adjusted hydraulic control pressure—full closed</li> <li>— average of adjusted hydraulic control pressure—full closed</li> <li>— adjusted hydraulic control pressure—full open</li> <li>— average of adjusted hydraulic control pressure—full open</li> <li>— test passed? (yes or no)</li> <li>— conducted by: (printed name and signature)</li> </ul> |
| 4)   | Repeat Steps 2) and 3) at 75 % of the RWP (allowable range of 70 % to 80 % of RWP).  |  |

## B.8 Propane Test—Surface-controlled Subsurface Safety Valve

The SSSV propane test shall be performed in conformance Table B.10.

**Table B.10—Propane Test—SSSV**

| Step | Procedure and Acceptance Criteria | Data to Be Recorded                |
|------|-----------------------------------|------------------------------------|
| 1)   | Record test data as specified.    | — validation test number<br>— date |

| Step | Procedure and Acceptance Criteria   | Data to Be Recorded   |
|------|---|---|
| 2)   | Open the test valve. Displace liquid out of the test section with nitrogen at a downstream location and bleed the nitrogen pressure to zero.  |   |
| 3)   | <p>Cycle the SSSV closed and open three times. Leave the SSSV open. Record the full closed and full open hydraulic control pressures.</p> <p><b>Acceptance criteria:</b> If the three hydraulic control pressures do not repeat within <math>\pm 10\%</math> of their averages or <math>\pm 0.7</math> MPa (100 psi), whichever is greater, the SSSV fails.</p>   | <p>For each of the open/close cycles at zero test valve bore pressure:</p> <ul style="list-style-type: none"> <li>— full closed hydraulic control pressure</li> <li>— full open hydraulic control pressure</li> </ul> <p>Calculate the following values for the set of operating cycles just completed:</p> <ul style="list-style-type: none"> <li>— average hydraulic control pressure—full closed</li> <li>— average hydraulic control pressure—full open</li> </ul>  |
| 4)   | Transfer propane to the test section until the test section pressure reaches $2.8 \text{ MPa} \pm 0.14 \text{ MPa}$ ( $400 \text{ psi} \pm 20 \text{ psi}$ ).   |   |
| 5)   | Open the downstream vent valve until liquid propane is expelled, close the propane vent valve and adjust the pressure to $2.8 \text{ MPa} \pm 0.14 \text{ MPa}$ ( $400 \text{ psi} \pm 20 \text{ psi}$ ). Record the test valve bore pressure.  | — test valve bore pressure (base pressure)  |
| 6)   | <p>Close and open the SSSV three times, leaving the SSSV in each position (opened or closed) for a minimum of 15 min. Record the full open and full closed hydraulic control pressures.</p> <p><b>NOTE</b> The test section pressure can increase as the valve is opened and then can decrease as the valve is closed due to the differential volume of the hydraulic operating piston.</p> <p>For tubing-pressure-sensitive valves, the full open/full closed hydraulic control pressures shall be adjusted based on the change of the test section pressure at the time of control pressure measurement. The adjusted control pressure is determined by adding/subtracting the actual control pressure with the difference between the base pressure and the actual test section pressure recorded at the time of each opening/closing pressure measurement.</p> <p><b>Acceptance criteria:</b> If the three adjusted hydraulic control pressures (or actual control pressures for tubing-pressure-insensitive valves) do not repeat within <math>\pm 10\%</math> of their average, or <math>\pm 0.7</math> MPa (<math>\pm 100</math> psi), whichever is greater, or if any body leakage (tubing-retrievable only) is detected, the test valve fails.</p> | <ul style="list-style-type: none"> <li>— time at valve closure,</li> <li>— full closed hydraulic control pressure</li> <li>— time at valve opening,</li> <li>— full open hydraulic control pressure</li> </ul> <p>Calculate the following values for the set of operating cycles just completed:</p> <ul style="list-style-type: none"> <li>— adjusted hydraulic control pressure—full closed</li> <li>— adjusted hydraulic control pressure—full open</li> <li>— body leakage detected (TRSV only)? (yes or no)</li> </ul> |
| 7)   | Leave the SSSV in the open position in propane for an additional 2 h, minimum. Record the start and completion times and the valve bore pressure at the end of the 2-h interval.  | <ul style="list-style-type: none"> <li>— time at start of soak period</li> <li>— time at end of soak period</li> <li>— valve bore pressure at end of 2-h interval</li> </ul>  |
| 8)   | Bleed the section pressure to zero.   |   |
| 9)   | Purge the test section with nitrogen.   |   |
| 10)  | Close the SSSV and record the full closed hydraulic control pressure.   | — the last full closed hydraulic control pressure   |

| Step | Procedure and Acceptance Criteria | Data to Be Recorded  |
|------|-----------------------------------|--|
|      |                                   | at the end of the propane test<br>— test passed? (yes or no)<br>— conducted by: (printed name and signature)<br>— date |

## B.9 Nitrogen Leakage Test—Subsurface Safety Valve

The SSSV nitrogen leakage test shall be performed in conformance with Table B.11.

**Table B.11—Nitrogen Leakage Test—SSSV**

| Step | Procedure and Acceptance Criteria   | Data to Be Recorded  |
|------|---|--|
| 1)   | Record test data as specified.  | — validation test number   |
| 2)   | Apply 1.4 MPa $\pm$ 0.07 MPa (200 psi $\pm$ 10 psi) nitrogen pressure below the closure mechanism. Wait a minimum of 1 min, then measure any nitrogen leakage through the closure mechanism.<br><br><b>Acceptance criteria:</b> If the leakage rate is greater than 0.14 m <sup>3</sup> /min (5 scf/min), or if any body leakage (tubing-retrievable only) is detected, the test valve fails. | — date<br>— SSSV bore pressure<br>— time at start of measuring period<br>— time at completion of measuring period<br>— measured gas leakage rate<br>— body leakage detected (TRSV only)? (yes or no) |
| 3)   | Repeat Step 2) at 25 % of the RWP (allowable range of 20 % to 30 % of RWP) of the SSSV.   | — SSSV bore pressure<br>— time at start of measuring period<br>— time at completion of measuring period<br>— measured gas leakage rate<br>— body leakage detected (TRSV only)? (yes or no)           |
| 4)   | Bleed the pressure upstream of the SSSV to zero.  | f)   |
| 5)   | Open the SSSV. Record the full open hydraulic control pressure.   | — full open hydraulic control pressure<br>— test passed? (yes or no)<br>— conducted by: (printed name and signature)<br>— date   |

## B.10 Grade V3 Water Flow Test—Surface-controlled Subsurface Safety Valve

For Grade V3 SCSSVs, the water flow test shall be performed in conformance with Table B.12.

**Table B.12—V3 Water Flow Test—SCSSV**

| Step | Procedure and Acceptance Criteria  | Data to Be Recorded   |
|------|--|---|
| 1)   | Record test data as specified.   | Validation test number  |
| 2)   | Circulate freshwater through the system while bypassing the SCSSV until gas has been displaced from the system.  | g)  |
| 3)   | Set the control line resistance to the appropriate setting shown in Table B.13 for the test being conducted. For low resistance, there is no specified restriction. The configuration for the high control line resistance test shall consist of the low-resistance configuration plus a square-edge orifice having an inside diameter of 0.5 mm $\pm$ 0.05 mm (0.020 in. $\pm$ 0.002 in.) and a length of 25.4 mm $\pm$ 2.5 mm (1.0 in. $\pm$ 0.1 in.). | h)  |
| 4)   | Adjust the water flow rate through the SCSSV to obtain a stable flow at the value specified in Table B.13. With mutual consent between the supplier/manufacturer and test agency, higher flow rates than those stipulated in the table may be used. Pass water through the SCSSV at the specified rate for a minimum of 5 min.   | For each iteration of the test:<br>— date of test<br>— time at start of circulation through test valve  |
| 5)   | Close the SCSSV against the flow. Record the full closed hydraulic control pressure and the water flow rate through the SCSSV at the time closure was initiated.<br><br><b>Acceptance criteria:</b> The SCSSV shall shut off a minimum of 95 % of the specified flow at the first closure attempt in 15.0 s or less after the hydraulic control pressure reaches zero, or the test valve fails.  | — time at valve closure<br>— water flow rate immediately before valve closure<br>— full closed hydraulic control pressure<br>— flow 15 s after hydraulic control pressure reaches zero<br>— time to close |
| 6)   | Open the test valve.   | Full-open hydraulic control pressure  |
| 7)   | Repeat Steps 2) through 6) until the four freshwater closure rates and two control line resistances specified in Table B.13 have been completed or the SCSSV fails.  | — test passed? (yes or no)<br>— conducted by: (printed name and signature)<br>— date  |

**Table B.13—SCSSV Liquid Flow Rates**

| Nominal Tubing or Casing Size <sup>a</sup><br>mm (in.) | Circulation Rate<br>m <sup>3</sup> /d (b/d)<br>( $\pm$ 10 %) |                              |
|--|--|------------------------------|
|  | Low-resistance Control Line                                  | High-resistance Control Line |

|  | Medium Flow Rate | High Flow Rate | Low Flow Rate | Medium Flow Rate |
|--|------------------|----------------|---------------|------------------|
| 60.3 (2 <sup>3</sup> / <sub>8</sub> )  | 159 (1000)       | 238 (1500)     | 79 (500)      | 159 (1000)       |
| 73.0 (2 <sup>7</sup> / <sub>8</sub> )  | 248 (1560)       | 372 (2340)     | 124 (780)     | 248 (1560)       |
| 88.9 (3 <sup>1</sup> / <sub>2</sub> )  | 356 (2240)       | 534 (3360)     | 178 (1120)    | 356 (2240)       |
| 101.6 (4)  | 477 (3000)       | 715 (4500)     | 238 (1500)    | 477 (3000)       |
| 114.3 (4 <sup>1</sup> / <sub>2</sub> )   | 610 (3840)       | 915 (5760)     | 305 (1920)    | 610 (3840)       |
| 127.0 (5)  | 772 (4860)       | 1159 (7290)    | 386 (2430)    | 772 (4860)       |
| 139.7 (5 <sup>1</sup> / <sub>2</sub> )   | 954 (6000)       | 1431 (9000)    | 477 (3000)    | 954 (6000)       |
| 168.3 (6 <sup>5</sup> / <sub>8</sub> )   | 1494 (9398)      | 2242 (14,098)  | 747 (4699)    | 1494 (9398)      |
| 177.8 (7)  | 1869 (11,760)    | 2804 (17,640)  | 935 (5880)    | 1869 (11,760)    |
| 219.1 (8 <sup>5</sup> / <sub>8</sub> )   | 2418 (15,205)    | 3627 (22,808)  | 1209 (7603)   | 2418 (15,205)    |
| 244.5 (9 <sup>5</sup> / <sub>8</sub> )   | 3021 (19,000)    | 4532 (25,801)  | 1511 (9501)   | 3021 (19,000)    |
| <sup>a</sup> The supplier/manufacturer established sizes not covered by this table may interpolate or extrapolate, assuming the circulation rate is dependent on the square of the nominal size. |                  |                |               |                  |

## B.11 Controlled-temperature Test—Surface-controlled Subsurface Safety Valve

The SCSSV controlled-temperature test shall be performed in conformance with Table B.14.

**Table B.14—Controlled-temperature Test—SCSSV**

| Step | Procedure and Acceptance Criteria  | Data to Be Recorded   |
|------|--|---|
| 1)   | Record test data as specified.   | — validation test number  |
| 2)   | Install the SCSSV in the controlled-temperature test stand. Temperature measurements shall be taken in the area of the control line entry port of the SCSSV.   | i)  |
| 3)   | Allow the SCSSV to reach a stable temperature of 38 °C ± 3 °C (100 °F ± 5 °F).   | j)  |
| 4)   | Apply nitrogen gas pressure of 25 % of the RWP (allowable range of 20 % to 30 % of RWP) of the SCSSV. Allow the temperature at the SCSSV to stabilize.   | — initial SCSSV valve bore pressure (base pressure)<br>— temperature at stabilization   |
| 5)   | Cycle the SCSSV 10 times while maintaining the specified SCSSV temperature and pressure recorded in Step 4) within the specified ranges.<br><br>NOTE The test section pressure can increase as the valve is opened and then can decrease as the valve is closed due to the differential volume of the hydraulic operating piston.<br><br>For tubing-pressure-sensitive valves, the full open/full closed hydraulic control pressures shall be adjusted based on the change of the test section | k) For each operating cycle:<br><br>— test temperature<br>— full open hydraulic control pressure (and actual test section pressure) |

| Step | Procedure and Acceptance Criteria   | Data to Be Recorded  |
|------|---|--|
|      | <p>pressure at the time of control pressure measurement. The adjusted control pressure is determined by adding/subtracting the actual control pressure with the difference between the base pressure and the actual test section pressure recorded at the time of each opening/closing pressure measurement.</p> <p><b>Acceptance criteria:</b> If the 10 adjusted hydraulic control pressures (or actual control pressures for tubing-pressure-insensitive valves) do not repeat within <math>\pm 10\%</math> of their average, or <math>\pm 0.7</math> MPa (<math>\pm 100</math> psi), whichever is greater, or if any body leakage (tubing-retrievable only) is detected, the SCSSV fails.</p> | <ul style="list-style-type: none"> <li>— full closed hydraulic control pressure (and actual test section pressure)</li> </ul> <p>Calculate the following:</p> <ul style="list-style-type: none"> <li>— adjusted hydraulic control pressure; fully closed</li> <li>— average of adjusted hydraulic control pressure; fully closed</li> <li>— adjusted hydraulic control pressure; fully open</li> <li>— average of adjusted hydraulic control pressure; fully open</li> </ul> |
| 6)   | Connect an empty tube from the SCSSV hydraulic control line port to a container filled with water at atmospheric pressure and ambient temperature. Position the tube so any gas bubbles from the hydraulic control line port can be observed.   |  |
| 7)   | <p>With the SCSSV bore filled with nitrogen gas at the specified temperature and pressure, wait a minimum of 3 min (and up to a maximum of 10 min if specified by the supplier/manufacturer) and then observe for gas bubble leakage continuously for a minimum of 5 min.</p> <p><b>Acceptance criteria:</b> If more than 1 bubble from the control line is observed during the observation period, one restart of the observation period shall commence. If any bubbles from the control line are observed during the second observation period or if body leakage (tubing-retrievable only) is detected at any time during the entire test, the SCSSV fails.</p>                                | <ul style="list-style-type: none"> <li>— temperature</li> <li>— time at start of stabilization period</li> <li>— time at end of stabilization period</li> <li>— time at start of monitoring period</li> <li>— time at end of monitoring period</li> <li>— leak detected? (yes or no)</li> <li>— body leakage detected (TRSV only)? (yes or no)</li> </ul>  |
| 8)   | Repeat Steps 4) to 7) using a SCSSV bore pressure of 75 % of the RWP (allowable range of 70 % to 80 % of RWP) of the SCSSV.   | — data required by Steps 4) through 7)   |
| 9)   | <p>Bleed nitrogen pressure above the closure mechanism to zero. Adjust and stabilize the pressure below the closure mechanism to 75 % of the RWP (allowable range of 70 % to 80 % of RWP) of the SCSSV. Wait a minimum of 1 min, then measure any nitrogen leakage across the closure mechanism.</p> <p><b>Acceptance criteria:</b> If the leakage rate is greater than <math>0.14 \text{ m}^3/\text{min}</math> (5 scf/min), or if any body leakage (tubing-retrievable only) is detected, the SCSSV fails.</p>  | <ul style="list-style-type: none"> <li>— time at which the bore pressure above the closure mechanism is reduced to zero</li> <li>— valve bore pressure below the closure mechanism</li> <li>— time at start of measurement period,</li> <li>— time at completion of measurement period</li> <li>— leakage rate</li> <li>— test passed? (yes or no)</li> <li>— conducted by: (printed name and signature)</li> <li>— date</li> </ul>  |

| Step | Procedure and Acceptance Criteria   | Data to Be Recorded  |
|------|---|--|
| 10)  | Repeat Steps 3) to 9) using a stabilized temperature of $82^{\circ}\text{C} \pm 3^{\circ}\text{C}$ ( $180^{\circ}\text{F} \pm 5^{\circ}\text{F}$ ). | — data required by Steps 3) through 9)   |
| 11)  | Bleed all pressure to zero. Allow the SCSSV to cool. Remove the SCSSV from the controlled-temperature test stand.                                   | — test passed? (yes or no)<br>— conducted by: (printed name and signature)<br>— date |

## B.12 Grade V2 Slurry Flow Test—Surface-controlled Subsurface Safety Valve

For Grade V2 SCSSVs, the slurry flow test shall be performed in conformance with Table B.15.

**Table B.15— Grade V2 Slurry Flow Test—SCSSV**

| Step | Procedure and Acceptance Criteria   | Data to Be Recorded   |
|------|---|---|
| 1)   | Record test data as specified.  | — validation test number  |
| 2)   | Prepare a slurry consisting of sand and viscosified water.  |   |
| 3)   | Determine the sand content of the slurry in accordance with API MPMS Ch. 10.4. Adjust the sand content to $2\% \pm 0.5\%$ by adding $150\text{ }\mu\text{m}$ to $180\text{ }\mu\text{m}$ (100 U.S. mesh to 80 U.S. mesh) sand or by diluting the slurry with freshwater.  |   |
| 4)   | Determine the viscosity of the slurry sample in accordance with API 13B-1 with a Marsh funnel. Adjust the viscosity to $70\text{ s} \pm 5\text{ s}$ by adding a viscosifier or diluting the slurry with freshwater.<br><br>NOTE For the purposes of these provisions, ISO 10414-1 is equivalent to API 13B-1.   | — sand concentration (%) at start of circulation period<br>— slurry viscosity at start of circulation period<br>— time at start of slurry circulation through valve                             |
| 5)   | The viscosity and sand content requirements specified above shall be met before proceeding.   |   |
| 6)   | Adjust the slurry circulation rate to the value specified in Table B.16.  | — date of test<br>— flow rate at start of circulation period  |
| 7)   | Circulate the slurry through the SCSSV at the specified rate for a minimum of 1 h and then close the SCSSV against the specified rate.<br><br><b>Acceptance criteria:</b> The SCSSV shall shut off a minimum of 95 % of the specified flow at the first closure attempt in 15.0 s or less after the hydraulic control pressure reaches zero or the SCSSV fails. | — time at valve closure (against slurry flow)<br>— slurry flow rate<br>— full closed hydraulic control pressure<br>— flow 15 s after hydraulic control pressure reaches zero<br>— time to close |
| 8)   | At the completion of the flow period, measure the sand content of the slurry and the slurry viscosity.  | — sand concentration (%) at completion of circulation period  |

|  |  |  |
|--|--|--|
|  |  | <ul style="list-style-type: none"> <li>— slurry viscosity at completion of circulation period</li> <li>— test passed? (yes or no)</li> <li>— conducted by: (printed name and signature)</li> <li>— date</li> </ul> |
|--|--|--|

**Table B.16—Grade V2 Liquid Flow Rates**

| Nominal Tubing or Casing Size <sup>a</sup><br>mm (in.)   | Circulation Rate<br>m <sup>3</sup> /d (B/d)<br>(±10 %) |
|--|--|
| 60.3 (2 3/8)   | 79 (500)   |
| 73.0 (2 7/8)   | 124 (780)  |
| 88.9 (3 1/2)   | 178 (1120)   |
| 101.6 (4)  | 238 (1500)   |
| 114.3 (4 1/2)  | 305 (1920)   |
| 127.0 (5)  | 386 (2430)   |
| 139.7 (5 1/2)  | 477 (3000)   |
| 168.3 (6 5/8)  | 747 (4699)   |
| 177.8 (7)  | 935 (5880)   |
| 219.1 (8 5/8)  | 1209 (7603)  |
| 244.5 (9 5/8)  | 1511 (9501)  |
| <sup>a</sup> The supplier/manufacturer established sizes not covered by this specification may interpolate or extrapolate, assuming the circulation rate is dependent on the square of the nominal size. |  |

## B.13 Validation Test Procedure—Subsurface-controlled Subsurface Safety Valve

B.13.1 To validate an SSCSV to the requirements of validation Grade V3, the test agency shall complete the steps detailed in Table B.17.

**Table B.17—Test Agency SSCSV Grade V3 Steps**

| Step | Procedure and Acceptance Criteria  |
|------|--|
| 1)   | Verify that the model and serial numbers appearing on the SSCSV assembly are in agreement with the supplier/manufacture's application.   |
| 2)   | Perform the SSCSV gas closure test (B.14). For velocity-type SSCSVs, use the gas flow test stand to conduct the test.  |
| 3)   | Perform the initial liquid closure test (B.15) using water as the test medium.   |
| 4)   | Perform the liquid leakage test (B.5).   |
| 5)   | Perform the propane test (B.16).   |
| 6)   | Perform the nitrogen leakage test (B.9), omitting Step 5).   |
| 7)   | Perform the SSCSV V3 liquid flow test (B.17).  |
| 8)   | Repeat Step 6) and Step 7) 14 additional times.<br><b>Acceptance criteria:</b> The closing flow rate for velocity-type SSCSVs or the closing pressure for tubing-pressure-type SSCSVs shall repeat within $\pm 15\%$ of the closing flow rate or pressure of Step 3) above, or the valve fails the test. |
| 9)   | Perform the liquid leakage test (see B.5).   |
| 10)  | If the SSCSV has performed within the limits specified, it has passed the validation test.   |
| 11)  | Summarize the validation test data as specified in B.23.   |

B.13.2 To validate an SSCSV to the requirements of validation grade V2, the test agency shall complete the additional steps detailed in Table B.18.

**Table B.18—Test Agency SSCSV V2 Steps**

| Step | Procedure and Acceptance Criteria   |
|------|---|
| 1)   | Verify that the SSCSV has already completed and passed the applicable requirements of Table B.17, Steps 1) to 9).   |
| 2)   | Perform the nitrogen leakage test (see B.9), omitting Step 5).  |
| 3)   | Perform the V2 slurry flow test (see B.18).   |
| 4)   | Repeat Step 2) and Step 3) six additional times.<br><b>Acceptance criteria:</b> The closing flow rate for a velocity-type SSCSV or the closing pressure for a tubing-pressure-type SSCSV shall repeat within $\pm 15\%$ of the closing flow rate or pressure of Step 3) above or the test valve fails the test. |
| 5)   | Perform the liquid leakage test (see B.5).  |
| 6)   | If the SSCSV has performed within the limits specified, it has passed the validation test.  |
| 7)   | Summarize the validation test data as specified in B.23.  |

## B.14 Gas Closure Test—Subsurface-controlled Subsurface Safety Valve

The SSCSV gas closure test shall be performed in conformance with Table B.19.

**Table B.19—Gas Closure Test—SSCSV**

| Step | Procedure and Acceptance Criteria  | Data to Be Recorded   |
|------|--|---|
| 1)   | Record test data as specified.   | — validation test number  |
| 2)   | Increase gas pressure in the system to between 13.8 MPa (2000 psi) and 17.3 MPa (2500 psi).  | — test start time   |
| 3)   | <p>Close the test valve as follows.</p> <p>For velocity-type SSCSVs—Increase the gas flow rate through the test valve until the test valve closes.</p> <p><b>Acceptance criteria:</b> The test valve shall close at a flow rate of at least <math>\pm 25\%</math> of the design closing flow rate indicated in the test application (see 5.5.11.2) in 30 s or less from the time this flow rate is achieved, or the test valve fails the test.</p> <p>For tubing-pressure-type SSCSVs—Adjust the gas pressure downstream of the test valve to verify that the test valve is open. Decrease the downstream pressure until the test valve closes.</p> <p><b>Acceptance criteria:</b> The test valve shall close at a downstream pressure of at least 75 % of the design closing pressure indicated in the test application (see 5.5.11.2). The minimum allowable downstream pressure is 0.35 MPa (50 psi). The test valve shall close in 30 s or less from the time this minimum pressure is achieved, or the test valve fails the test.</p> | <p>l) For velocity-type SSCSVs:</p> <ul style="list-style-type: none"> <li>— initial test valve upstream pressure</li> <li>— closing flow rate (gas)</li> <li>— differential closing pressure</li> </ul> <p>Calculate:</p> <ul style="list-style-type: none"> <li>— maximum closing rate</li> <li>— minimum closing rate</li> </ul> <p>For tubing-pressure-type SSCSVs:</p> <ul style="list-style-type: none"> <li>— initial test valve downstream pressure</li> <li>— downstream closing pressure</li> <li>— design closing pressure</li> </ul> <p>Calculate:</p> <ul style="list-style-type: none"> <li>— maximum closing rate</li> <li>— minimum closing rate</li> <li>— test passed? (yes or no)</li> </ul> |
| 4)   | <p>Bleed the valve bore downstream pressure to zero. Adjust the test valve bore upstream pressure to 8.3 MPa (1200 psi) <math>\pm 5\%</math>. Wait a minimum of 1 min, then measure any gas leakage through the closure mechanism.</p> <p><b>Acceptance criteria:</b> If the leakage rate is greater than 0.14 m<sup>3</sup>/min (5 scf/min), the test valve fails.</p>  | <ul style="list-style-type: none"> <li>— test valve bore pressure</li> <li>— leakage rate</li> <li>— test completion time</li> <li>— test passed? (yes or no)</li> <li>— conducted by: (printed name and signature)</li> <li>— date</li> </ul>  |
| 5)   | Bleed all pressure to zero.  |   |

## B.15 Liquid Closure Test—Subsurface-controlled Subsurface Safety Valve

The liquid closure test shall be performed in conformance with Table B.20.

**Table B.20—Liquid Closure Test—SSCSV**

| Step | Procedure and Acceptance Criteria   | Data to Be Recorded  |
|------|---|--|
| 1)   | Record test data as specified.  | <ul style="list-style-type: none"> <li>— validation test number</li> <li>— test stand (or apparatus) identification</li> </ul>   |
| 2)   | Circulate liquid through the system while bypassing the test valve until gas has been displaced from the system.  | <ul style="list-style-type: none"> <li>— test start time</li> </ul>  |
| 3)   | Adjust the circulation rate through the test valve to obtain a flow at the rate specified in Table B.23.  | m)   |
| 4)   | <p>Close the test valve as follows.</p> <p>For velocity-type SSCSVs—Adjust the pressure downstream of the test valve to between 0.35 MPa and 0.38 MPa (50 psi and 55 psi). Increase the circulation rate through the valve until the valve closes. The circulation rate shall be increased such that the pressure downstream of the test valve can be maintained between 0.35 MPa and 0.38 MPa (50 psi and 55 psi).</p> <p><b>Acceptance criteria:</b> The test valve shall close at a flow rate of at least <math>\pm 25\%</math> of the design closing flow rate indicated on the test application (see 5.5.11.2) in 30 s or less from the time this flow rate is achieved, or the test valve fails the test.</p> <p>For tubing-pressure-type SSCSVs—Decrease the downstream pressure until the test valve closes.</p> <p><b>Acceptance criteria:</b> The test valve shall close at a downstream pressure of at least 75 % of the design closing pressure indicated in the test application (see 5.5.11.2). The minimum allowable downstream pressure shall be 0.35 MPa (50 psi). The valve shall close in 30 s or less from the time this pressure minimum is achieved, or the valve fails the test.</p> | <p>For velocity-type SSCSVs:</p> <ul style="list-style-type: none"> <li>— initial test valve downstream pressure</li> <li>— closing flow rate (water)</li> <li>— differential closing pressure</li> <li>— design closing flow rate (liquid)</li> <li>— maximum closing rate: <math>125\% \times \text{design closing rate (liquid)}</math></li> <li>— minimum closing rate: <math>75\% \times \text{design closing rate (liquid)}</math></li> </ul> <p>For tubing-pressure-type SSCSVs:</p> <ul style="list-style-type: none"> <li>— initial test valve downstream pressure</li> <li>— downstream closing pressure</li> <li>— maximum closing rate: <math>125\% \times \text{design closing rate (liquid)}</math></li> <li>— minimum closing rate: <math>75\% \times \text{design closing rate (liquid)}</math></li> <li>— test completion time</li> </ul> <p>For all SSCSVs:</p> <ul style="list-style-type: none"> <li>— date</li> <li>— test passed? (yes or no)</li> <li>— conducted by: (printed name and signature)</li> <li>— date</li> </ul> |

## **B.16 Propane Test—Subsurface-controlled Subsurface Safety Valve**

For SSCSVs, the propane test shall be performed in conformance with Table B.21.

**Table B.21—Propane Test—SSCSV**

| Step | Procedure and Acceptance Criteria  | Data to Be Recorded  |
|------|--|--|
| 1)   | Record test data as specified.   | — validation test number<br>— date   |
| 2)   | Open the test valve. Displace liquid out of the test section with nitrogen at a downstream location and bleed the nitrogen pressure to zero.   |  |
| 3)   | Transfer propane to the test section until the test section pressure reaches $2.8 \text{ MPa} \pm 0.14 \text{ MPa}$ ( $400 \text{ psi} \pm 20 \text{ psi}$ ).  |  |
| 4)   | Open the downstream vent valve until liquid propane is expelled, close the propane vent valve, and adjust the pressure to $2.8 \text{ MPa} \pm 0.14 \text{ MPa}$ ( $400 \text{ psi} \pm 20 \text{ psi}$ ). Record the test valve bore pressure.  | — test valve bore pressure (base pressure)   |
| 5)   | Leave the SSSV in the open position in propane for an additional 2 h, minimum. Record the start and completion times and the valve bore pressure at the end of the 2-h interval.   | — time at start of soak period<br>— time at end of soak period<br>— valve bore pressure at end of 2-h interval |
| 6)   | Bleed the section pressure to zero.  |  |
| 7)   | Purge the test section with nitrogen.  |  |
| 8)   | Conduct the liquid closure test (B.15), using water as the test medium.<br><br><b>Acceptance criteria:</b> The closing flow rate for a velocity-type SSSCV or the closing pressure for a tubing-pressure-type SSSCV shall repeat within $\pm 15\%$ of the closing flow rate or pressure of Step 3) or the test valve fails the test. | — per Table B.20   |

## **B.17 V3 Liquid Flow Test—Subsurface-controlled Subsurface Safety Valve**

For Grade V3 SSSCVs, the liquid flow test shall be performed in conformance with Table B.22.

**Table B.22—V3 Liquid Flow Test—SSCSV**

| Step | Procedure and Acceptance Criteria   | Data to Be Recorded                     |
|------|---|---|
| 1)   | Record test data as specified.  | — validation test number                |
| 2)   | Circulate water through the system while bypassing the SSSCV until gas has been displaced from the system.  |   |
| 3)   | Adjust the water circulation rate through the SSSCV to obtain a flow rate at the value specified in Table B.23. Circulate water through the SSSCV at the specified rate for a minimum of 1 h. | — test start time<br>— circulation rate |
| 4)   | Close the SSSCV as follows.   | For velocity-type SSSCVs:               |

|  |   |   |
|--|---|---|
|  | <p>For velocity-type SSCSVs—Adjust the pressure downstream of the SSCSV to between 0.35 MPa and 0.38 MPa (50 psi and 55 psi). Increase the circulation rate through the valve until the valve closes.</p> <p><b>Acceptance criteria:</b> The SSCSV shall close at a flow rate of at least <math>\pm 25</math> % of the design closing flow rate indicated in the test application (see 5.5.11.2) in 30 s or less from the time this flow rate is achieved, or the SSCSV fails the test.</p> <p>For tubing-pressure-type SSCSVs—Decrease the downstream pressure until the SSCSV closes.</p> <p><b>Acceptance criteria:</b> The SSCSV shall close at a downstream pressure of at least 75 % of the design closing pressure indicated in the test application (see 5.5.11.2). The minimum allowable downstream pressure shall be 0.35 MPa (50 psi). The valve shall close in 30 s or less from the time this pressure minimum is achieved, or the valve fails the test.</p> | <ul style="list-style-type: none"> <li>— +15 % of closing flow rate</li> <li>— -15 % of closing flow rate</li> <li>— initial downstream pressure</li> <li>— water flow rate at closure</li> <li>— differential pressure across valve at closure</li> </ul> <p>For tubing-pressure-type SSCSVs:</p> <ul style="list-style-type: none"> <li>— +15 % of downstream closing pressure</li> <li>— -15 % of downstream closing pressure</li> <li>— initial downstream pressure</li> <li>— downstream pressure at closure</li> </ul> <p>For all SSCSVs:</p> <ul style="list-style-type: none"> <li>— time at valve closure</li> <li>— test completion time</li> <li>— test passed? (yes or no)</li> <li>— conducted by: (printed name and signature)</li> <li>— date</li> </ul> |
|--|---|---|

**Table B.23—SSCSV Liquid Flow Rates**

| Nominal Tubing or Casing Size <sup>a</sup><br>mm (in.) | Circulation Rate<br>m <sup>3</sup> /d (B/d)<br>( $\pm 10$ %) |
|--|--|
| 60.3 (2 <sup>3</sup> / <sub>8</sub> )                  | 79 (500)   |
| 73.0 (2 <sup>7</sup> / <sub>8</sub> )                  | 124 (780)  |
| 88.9 (3 <sup>1</sup> / <sub>2</sub> )                  | 178 (1120)   |
| 101.6 (4)  | 238 (1500)   |
| 114.3 (4 <sup>1</sup> / <sub>2</sub> )                 | 305 (1920)   |

|  |             |
|--|-------------|
| 127.0 (5)  | 386 (2430)  |
| 139.7 (5 1/2)  | 477 (3000)  |
| 168.3 (6 5/8)  | 747 (4699)  |
| 177.8 (7)  | 935 (5880)  |
| 219.1 (8 5/8)  | 1209 (7603) |
| 244.5 (9 5/8)  | 1511 (9501) |
| <sup>a</sup> The supplier/manufacturer establishing sizes not covered by this specification may interpolate or extrapolate, assuming the circulation rate depends on the square of the nominal size. |             |

## B.18 Grade V2 Slurry Flow Test—Subsurface-controlled Subsurface Safety Valve

For Grade V2 SSCSVs, the slurry flow test shall be performed in conformance with the steps detailed in Table B.24. Slurry flow testing shall be performed in a continuous manner with no interruptions exceeding two hours duration.

**Table B.24—V2 Slurry Flow Test—SSCSV**

| Step | Procedure and Acceptance Criteria   | Data to Be Recorded   |
|------|---|---|
| 1)   | Record test data as specified.  | — validation test number  |
| 2)   | Prepare a slurry consisting of 150 µm to 180 µm (100 U.S. mesh to 80 U.S. mesh) sand and viscosified water.   |   |
| 3)   | Determine the sand content of the slurry in accordance with API MPMS Ch. 10.4. Adjust the sand content to 2 % ± 0.5 % by adding 150 µm to 180 µm (100 U.S. mesh to 80 U.S. mesh) sand or by diluting the slurry with water.   | — sand concentration (%) at start of circulation period   |
| 4)   | Determine the viscosity of the slurry sample in accordance with API 13B-1 with a Marsh funnel. Adjust the viscosity to 70 s ± 5 s by adding a viscosifier or diluting the slurry with freshwater.<br><br>NOTE For the purposes of these provisions, ISO 10414-1 is equivalent to API 13B-1. | — slurry viscosity at start of circulation period   |
| 5)   | The viscosity and sand content requirements specified above shall be met before proceeding.   |   |
| 6)   | Adjust the slurry circulation rate to the value specified in Table B.23.  | — date of test<br>— time at start of slurry circulation through valve<br>— flow rate at start of circulation period |
| 7)   | Circulate slurry through the SSCSV at the specified rate for a minimum of 1 h.  |   |
| 8)   | Close the SSCSV as follows.   | For velocity-type SSCSVs:   |

| Step | Procedure and Acceptance Criteria   | Data to Be Recorded  |
|------|---|--|
|      | <p>For velocity-type SSCSVs—Adjust the pressure downstream of the SSCSV to between 0.35 MPa and 0.38 MPa (50 psi and 55 psi). Increase the circulation rate through the valve until the valve closes.</p> <p><b>Acceptance criteria:</b> The SSCSV shall close at a flow rate of at least <math>\pm 25\%</math> of the design closing flow rate indicated in 5.5.11.2 in 30 s or less from the time this flow rate is achieved, or the test valve fails the test.</p> <p>For tubing-pressure-type SSCSVs—Decrease the downstream pressure until the test valve closes.</p> <p><b>Acceptance criteria:</b> The SSCSV shall close at a downstream pressure of at least 75 % of the design closing pressure indicated in 5.5.11.2. The minimum allowable downstream pressure shall be 0.35 MPa (50 psi). The valve shall close in 30 s or less from the time this pressure minimum is achieved, or the valve fails the test.</p> | <ul style="list-style-type: none"> <li>— initial downstream pressure</li> <li>— slurry flow rate at closure</li> <li>— differential pressure across valve at closure</li> <li>— +15 % of closing flow rate</li> <li>— -15 % of closing flow rate</li> <li>— initial downstream pressure</li> </ul> <p>For tubing-pressure-type SSCSVs:</p> <ul style="list-style-type: none"> <li>— initial downstream pressure</li> <li>— downstream pressure at closure</li> <li>— +15 % of downstream closing pressure recorded</li> <li>— -15 % of downstream closing pressure</li> </ul> <p>For all SSCSVs:</p> <ul style="list-style-type: none"> <li>— time at valve closure against slurry flow</li> <li>— sand concentration (%) at completion</li> <li>— slurry viscosity at completion of circulation period</li> <li>— date</li> <li>— test passed? (yes or no)</li> <li>— conducted by: (printed name and signature)</li> <li>— date</li> </ul> |

## B.19 Validation Test Procedure—Subsurface Injection Safety Valve

To validate an SSISV to the requirements of validation Grade V3, the test agency shall complete the steps detailed in Table B.25.

**Table B.25—Test Agency SSISV Grade V3 Steps**

| Step | Procedure and Acceptance Criteria   |
|------|---|
| 1)   | Verify that the model and serial numbers appearing on the SSISV assembly are in agreement with the supplier/manufacturer's application. |
| 2)   | Perform the SSISV gas injection test (B.20). For velocity-type SSISVs, use the gas flow test stand to conduct the test.                 |
| 3)   | Perform the liquid injection test (B.21).   |
| 4)   | Perform the liquid leakage test (B.5).  |

|     |   |
|-----|---|
| 5)  | Perform the nitrogen leakage test (B.9), omitting Step 5).  |
| 6)  | Perform the SSISV V3 liquid flow test (B.22).   |
| 7)  | Repeat Step 5) and Step 6) 14 additional times.   |
| 8)  | Perform the liquid leakage test (B.5).  |
| 9)  | <p>Prepare the SSISV for drift tests, as applicable; if the SSISV fails the drift test, it fails the validation test.</p> <ol style="list-style-type: none"> <li>1) Drift the interior, if applicable, of the SSISV assembly with the supplier/manufacturer's specified drift bar, per the supplier/manufacturer's procedure.</li> <li>2) When required by the functional specification, drift the exterior of wireline-retrievable SSISVs with the supplier/manufacturer's specified drift sleeve, per the supplier/manufacturer's procedure. Repeat the drift test in the opposite direction.</li> </ol> <p>Acceptance criteria: The force applied to move the drift bar shall not be greater than the weight of the drift bar.</p> |
| 10) | If the SSISV has performed within the limits specified, it has passed the validation test.  |
| 11) | Summarize the validation test data as specified in B.23.  |

## **B.20 Gas Injection Test—Subsurface Injection Safety Valve**

For SSISVs, the gas injection test shall be performed in conformance with Table B.26.

**Table B.26—Gas Injection Test—SSISV**

| Step | Procedure and Acceptance Criteria  | Data to Be Recorded   |
|------|--|---|
| 1)   | Record test data as specified. The test medium shall be nitrogen.  | Validation test number  |
| 2)   | <p>Open the test valve as follows.</p> <p>For velocity-type SSISVs—Increase the gas flow rate through the test valve to the supplier/manufacturer's minimum recommended full open gas injection rate or velocity. Once the minimum rate is achieved, maintain flow for a minimum of 5 seconds.</p> <p>For tubing-pressure-type SSISVs—Increase the gas pressure in the system to the supplier/manufacturer's recommended hold-open pressure.</p> | <p>— Test start time</p> <p>For velocity-type SSISVs:</p> <p>— opening flow rate or velocity</p> <p>For tubing-pressure-type SSISVs:</p> <p>— opening pressure</p>                        |
| 3)   | <p>Close the test valve as follows.</p> <p>For velocity-type SSISVs—Decrease the gas flow rate through the test valve to zero.</p> <p>For tubing-pressure-type SSISVs—Bleed the valve bore pressure to zero.</p>   |   |
| 4)   | <p>Adjust the test valve pressure below the closure mechanism to 8.3 MPa (1200 psi) <math>\pm</math> 5 %. Wait a minimum of 1 min, then measure any gas leakage through the closure mechanism.</p> <p><b>Acceptance criteria:</b> If the leakage rate is greater than 0.14 m<sup>3</sup>/min (5 scf/min), or if any body leakage (tubing-retrievable only) is detected, the test valve fails.</p>  | <p>— Test valve bore pressure</p> <p>— Leakage rate</p> <p>— Test completion time</p> <p>— Test passed? (yes or no)</p> <p>— Conducted by: (printed name and signature)</p> <p>— Date</p> |
| 5)   | Bleed all pressure to zero.  |   |

## B.21 Liquid Injection Test—Subsurface Injection Safety Valve

For SSISVs, the liquid injection test shall be performed in conformance with Table B.27.

**Table B.27—Liquid Injection Test—SSISV**

| Step | Procedure and Acceptance Criteria  | Data to Be Recorded   |
|------|--|---|
| 1)   | Record test data as specified.   | — Validation test number<br>— Test stand (or apparatus) identification  |
| 2)   | Circulate liquid through the system while bypassing the test valve until gas has been displaced from the system.   |   |
| 3)   | Open the test valve as follows.<br><br>For velocity-type SSISVs—Increase the liquid flow rate through the test valve to the supplier/manufacture’s minimum recommended full open liquid injection rate or velocity.<br><br>For tubing-pressure-type SSISVs—Increase the pressure in the system to the supplier/manufacture’s recommended hold-open pressure. | — test start time<br><br>For velocity-type SSISVs:<br>— opening flow rate or velocity<br><br>For tubing-pressure-type SSISVs:<br>— opening pressure |
| 4)   | Close the test valve as follows.<br><br>For velocity-type SSISVs—Decrease the liquid flow rate through the test valve to zero.<br><br>For tubing-pressure-type SSISVs—Bleed the valve bore pressure to zero.   |   |

## B.22 V3 Liquid Flow Test—Subsurface Injection Safety Valve

For grade V3 SSISVs, the liquid flow test shall be performed in conformance with Table B.28.

**Table B.28—V3 Liquid Flow Test—SSISV**

| Step | Procedure and Acceptance Criteria  | Data to Be Recorded   |
|------|--|---|
| 1)   | Record test data as specified.   | Validation test number  |
| 2)   | Circulate water through the system while bypassing the SSISV until gas has been displaced from the system.   |   |
| 3)   | Open the test valve as follows.<br><br>For velocity-type SSISVs—Increase the liquid flow rate through the test valve to the supplier/manufacture’s minimum recommended full open liquid injection rate or velocity.<br><br>For tubing-pressure-type SSISVs—Increase the pressure in the system to the supplier/manufacture’s recommended hold-open pressure. | Test start time<br><br>For velocity-type SSISVs:<br>— opening flow rate or velocity<br><br>For tubing-pressure-type SSISVs:<br>— opening pressure |
| 4)   | While maintaining the SSISV in the open position, increase the flow rate to the supplier/manufacture’s maximum recommended flow rate or velocity.  | — circulation rate  |

|    |  |  |
|----|--|--|
|    | Circulate water through the SSISV at the specified rate for a minimum of 1 h.  |  |
| 5) | Close the test valve as follows.<br>For velocity-type SSISVs—Decrease the liquid flow rate through the test valve to zero.<br>For tubing-pressure-type SSISVs—Bleed the valve bore pressure to zero. |  |

## **B.23 Validation Test Summary**

The following shall be recorded in the summary report as per the requirements of A.3.b:

- a) identification of test agency (company/facility name, location/address, etc.);
- b) identification of product supplier/manufacture (company name, location/address, etc.);
- c) date of validation test and date of report;
- d) validation test number (provided by test facility);
- e) equipment type: SCSSV, SSCSV, etc.;
- f) model designation or other identification by supplier/manufacture;
- g) product number with unique serial number;
- h) nominal tubing size;
- i) RWP;
- j) validation level tested;
- k) validation level passed;
- l) if valve failed the test, step at which the failure occurred and the reason for failure;
- m) remarks (describing any nonspecified equipment or procedures requested by valve supplier/manufacture, unusual conditions observed during test, etc.);
- n) test approved by: (test agency approval authority) and date.

## Annex C (normative)

### Functional Testing Requirements

#### C.1 General

**C.1.1** All steps of this procedure shall be completed successfully within the limits specified and, in the order, shown. The test facility shall be equipped with instrumentation to display and record information required by the test procedure.

**C.1.2** Functional testing shall be discontinued if the valve fails to perform within the limits specified for any step. The basis for discontinuing the test, and any unusual conditions observed at or prior to the time of discontinuance, shall be noted on the test data form.

**C.1.3** Testing may be resumed from the last successfully completed step when it is determined the cause of the failure is the result of a failure within the test facility.

**C.1.4** All pressures are defined as gauge unless otherwise specified and shall be recorded on time-based equipment.

**C.1.5** Prior to any liquid pressure test, purge with test liquid to remove air.

**C.1.6** Unless otherwise specified, gas pressure-relieving (bleed-down) operations should be performed at a maximum rate of 0.7 MPa/min (100 psi/min) at pressures less than 10.3 MPa (1500 psi). The supplier/manufacturer may specify gas pressure-relieving (bleed-down) operations.

**C.1.7** During functional testing of hydraulically operated SSSVs, control line fluid metering may be used to provide a readable hydraulic control line pressure trace.

**C.1.8** The test section shall completely enclose a wireline-retrievable SSSV. Tubing-retrievable SSSVs shall be an integral part of the test section. The test section shall be rated to at least the maximum test pressure.

**C.1.9** During all functional tests the SSSV shall be positioned essentially vertically.

**C.1.10** All test measurement for final acceptance shall be measured with calibrated devices and recorded (see 6.4.6).

**C.1.11** Drift bars and drift sleeves used for the drift portion of the functional test shall meet the criteria of Section B.4.

#### C.2 Functional Test—Surface-controlled Subsurface Safety Valve

##### C.2.1 Test Facility

**C.2.1.1** The supplier/manufacturer shall identify a test facility that allows testing to be completed per the requirements of this annex.

**C.2.1.2** Functional testing may be done in the manufacturer's facility (in-house) or outsourced to a qualified facility. An outside test facility shall be an approved vendor of the manufacturer and shall meet all applicable requirements of this specification, including qualification of inspection and test personnel.

## **C.2.2 Functional Test Procedure—Surface-controlled Subsurface Safety Valve**

The functional test of SCSSVs shall be performed in conformance with Table C.1.

**Table C.1—Functional Test Procedure—SCSSV**

| <b>Step</b> | <b>Procedure and Acceptance Criteria</b>  | <b>Data to Be Recorded</b>  |
|-------------|---|---|
| 1)          | Record the valve identification information.  | <ul style="list-style-type: none"> <li>— valve supplier/manufacturer</li> <li>— equipment name</li> <li>— SSSV type and size</li> <li>— manufacturer's part number</li> <li>— unique serial number</li> <li>— working pressure rating</li> </ul>  |
| 2)          | Place the SCSSV in a fixture capable of retaining and sealing the valve.  |   |
| 3)          | <p>Open the SCSSV with zero pressure in the test section. Adjust and stabilize the hydraulic control pressure to the supplier/manufacturer's recommended hold-open pressure. Isolate the hydraulic control pressure from the source. Monitor for a minimum of 5 min.</p> <p><b>Acceptance criteria:</b> If a loss greater than 5 % of the applied pressure is detected after stabilization, the SCSSV fails the functional test.</p>  | <ul style="list-style-type: none"> <li>— start time at pressure</li> <li>— end time at pressure</li> <li>— beginning control pressure</li> <li>— ending control pressure</li> <li>— calculated pressure loss over minimum of 5 min</li> <li>— test passed? (yes or no)</li> </ul>   |
| 4)          | <p>Close and open the SCSSV five times with zero pressure in the test section.</p> <p><b>Acceptance criteria:</b> Each control pressure shall repeat within <math>\pm 5</math> % of the average pressure of the five valve operating cycles as well as falling within the supplier/manufacturer's specified control pressure tolerance. If each pressure is not within these the limits, the SCSSV fails the functional test.</p>   | <p>For each of 5 operating cycles:</p> <ul style="list-style-type: none"> <li>— full open hydraulic control pressure</li> <li>— full closed hydraulic control pressure</li> </ul> <p>Calculated average of 5 operating cycles:</p> <ul style="list-style-type: none"> <li>— full open hydraulic control pressure</li> <li>— full closed hydraulic control pressure</li> <li>— test passed? (yes or no)</li> </ul> |
| 5)          | <p>Fill the test section with water or another suitable liquid to displace air from the test section, and proceed as follows.</p> <p>For wireline-retrievable SCSSVs—Close the SCSSV. Adjust and stabilize the pressure across the entire test section to 150 % of the RWP (allowable range of 145 % to 155 % of the RWP) for SCSSVs up to 69 MPa (10,000 psi) RWP. For SCSSVs with rating working pressures in excess of 69 MPa (10,000 psi), the test pressure shall be the RWP plus a minimum of</p> | <p>First iteration:</p> <ul style="list-style-type: none"> <li>— start time at pressure</li> <li>— end time at pressure</li> <li>— beginning section pressure</li> <li>— ending section pressure</li> </ul>   |

| Step | Procedure and Acceptance Criteria   | Data to Be Recorded  |
|------|---|--|
|      | <p>34.5 MPa (5000 psi). Hold the pressure for a minimum of 5 min. Reduce the pressure in the test section to zero. Repeat the test once.</p> <p>NOTE For V1-H rated SSSV, see H.4.2 for the minimum allowable test pressure for this step.</p> <p><b>Acceptance criteria:</b> The SCSSV fails the functional test if leakage is detected through the hydraulic control port(s).</p> <p>For tubing-retrievable SCSSVs—Close the SCSSV. Thoroughly dry the test valve exterior. Adjust and stabilize the pressure in the entire test section to 150 % of the RWP (allowable range of 145 % to 155 % of the RWP) for SCSSVs up to 69 MPa (10,000 psi) RWP of the SCSSV. For SCSSVs with rating working pressures in excess of 69 MPa (10,000 psi), the test pressure shall be the RWP plus a minimum of 34.5 MPa (5000 psi). Hold the pressure a minimum of 5 min. Reduce the pressure in the test section to zero. Repeat the test once.</p> <p>NOTE For V1-H rated SSSV, see H.4.2 for the minimum allowable test pressure for this step.</p> <p><b>Acceptance criteria:</b> The SCSSV fails the functional test if leakage is detected on the exterior or through the hydraulic control line port(s).</p>   | <ul style="list-style-type: none"> <li>— leakage within 5 min? (yes or no)</li> <li>— test passed? (yes or no)</li> </ul> <p>Second iteration:</p> <ul style="list-style-type: none"> <li>— start time at pressure</li> <li>— end time at pressure</li> <li>— beginning section pressure</li> <li>— ending section pressure</li> <li>— leakage within 5 min? (yes or no)</li> <li>— test passed? (yes or no)</li> </ul>  |
| 6)   | Open and close the SCSSV with zero pressure in the test section and record the full open and full closed hydraulic control pressures. Open the SCSSV.   | <ul style="list-style-type: none"> <li>— full open hydraulic control pressure</li> <li>— full closed hydraulic control pressure</li> </ul>   |
| 7)   | <p>Apply pressure of 50 % of the SCSSV's RWP (allowable range of 45 % to 55 % of RWP) of the test valve to the entire test section. Close and open test valve five times while maintaining the test section pressure within the specified range.</p> <p>NOTE The test section pressure can increase as the valve is opened and then can decrease as the valve is closed due to the differential volume of the hydraulic operating piston.</p> <p>For tubing-pressure-sensitive valves, the full open/full closed hydraulic control pressures shall be adjusted based on the change of the test section pressure at the time of control pressure measurement. The adjusted control pressure is determined by adding/subtracting the actual control pressure with the difference between the base pressure and the actual test section pressure recorded at the time of each opening/closing pressure measurement.</p> <p><b>Acceptance criteria:</b> If the five adjusted hydraulic control pressures (or actual control pressures for tubing-pressure-insensitive valves) do not repeat within <math>\pm 10</math> % of their average, or <math>\pm 0.7</math> MPa (<math>\pm 100</math> psi), whichever is greater, or if any body leakage (tubing-retrievable only) is detected, the SCSSV fails.</p> | <p>For each iteration of the operating pressure test:</p> <ul style="list-style-type: none"> <li>— initial SCSSV valve bore pressure (base pressure) at 50 % of RWP</li> <li>— full open hydraulic control pressure and actual test section pressure</li> <li>— full closed hydraulic control pressure and actual test section pressure</li> </ul> <p>Calculate and record the following values:</p> <ul style="list-style-type: none"> <li>— adjusted fully closed hydraulic control pressure</li> <li>— average of adjusted fully closed hydraulic control pressure</li> <li>— adjusted fully open hydraulic control pressure</li> <li>— average of adjusted fully open hydraulic control pressure</li> <li>— repeatability test passed (yes or no)</li> <li>— TRSV body leakage detected (yes or no)</li> </ul> |

| Step | Procedure and Acceptance Criteria   | Data to Be Recorded   |
|------|---|---|
| 8)   | Adjust and stabilize the test section pressure to 100 % of the RWP (allowable range of 95 % to 105 % of RWP) of the SCSSV. Close the SCSSV. Bleed the hydraulic control pressure to zero.   | <ul style="list-style-type: none"> <li>— test section pressure</li> <li>— full closed hydraulic control pressure</li> </ul>   |
| 9)   | Adjust and stabilize the test section pressure to 100 % of the RWP (allowable range of 95 % to 105 % of RWP) of the SCSSV. Monitor for leakage at hydraulic control line ports(s) for a minimum of 5 min.<br><b>Acceptance criteria:</b> If any leakage is detected, the SCSSV fails the functional test.   | <ul style="list-style-type: none"> <li>— test section pressure</li> <li>— start time at pressure</li> <li>— end time at pressure</li> <li>— control port leakage within 5 min? (yes or no)</li> <li>— test passed? (yes or no)</li> </ul>   |
| 10)  | Bleed the pressure above the SCSSV closure mechanism to zero. Adjust and stabilize the pressure below the closure mechanism to 100 % of the RWP (allowable range of 95 % to 105 % of RWP) of the SCSSV. Measure liquid leakage for a minimum of 5 min.<br><b>Acceptance criteria:</b> If the leakage rate exceeds 10 cm <sup>3</sup> /min (0.6 in. <sup>3</sup> /min), the SCSSV fails the functional test.   | <ul style="list-style-type: none"> <li>— pressure below closing mechanism</li> <li>— start time at pressure</li> <li>— end time at pressure</li> <li>— measured leakage</li> <li>— test passed? (yes or no)</li> </ul>  |
| 11)  | Remove the liquid from the test section.  |   |
| 12)  | Open the SCSSV. Record the full open hydraulic control pressure.  | <ul style="list-style-type: none"> <li>— full open hydraulic control pressure</li> </ul>  |
| 13)  | Adjust and stabilize the pressure in the entire test section with gas to 1.4 MPa ± 0.07 MPa (200 psi ± 10 psi). Close the SCSSV. Bleed the hydraulic control pressure to zero. Adjust and stabilize the test section pressure with gas to 1.4 MPa ± 0.07 MPa (200 psi ± 10 psi). Monitor for gas leakage at the hydraulic control port(s) for a minimum of 5 min.<br><b>Acceptance criteria:</b> If any leakage is detected, the SCSSV fails the functional test. | <ul style="list-style-type: none"> <li>— test section pressure</li> <li>— start time at pressure</li> <li>— end time at pressure</li> <li>— full closed hydraulic control pressure</li> <li>— control port leakage within 5 min? (yes or no)</li> <li>— test passed? (yes or no)</li> </ul> |
| 14)  | Bleed the pressure above the SCSSV's closure mechanism to zero. Adjust and stabilize the pressure below the SCSSV's closure mechanism to 1.4 MPa ± 0.07 MPa (200 psi ± 10 psi) with gas. Measure the leakage rate for a minimum of 5 min.<br><b>Acceptance criteria:</b> If the leakage rate exceeds 0.14 m <sup>3</sup> /min (5 scf/min), the SCSSV fails the functional test.   | <ul style="list-style-type: none"> <li>— pressure below closure mechanism</li> <li>— start time at pressure</li> <li>— end time at pressure</li> <li>— measured leakage</li> <li>— test passed? (yes or no)</li> </ul>  |
| 15)  | Repeat Steps 13) and 14) with 8.3 MPa ± 0.41 MPa (1200 psi ± 60 psi) instead of 1.4 MPa ± 0.07 MPa (200 psi ± 10 psi).  |   |
| 16)  | Bleed all pressures to zero.  |   |
| 17)  | Open and close the SCSSV two times.   | <p>For each of 2 operating cycles:</p> <ul style="list-style-type: none"> <li>— full open hydraulic control pressure</li> <li>— full closed hydraulic control pressure</li> </ul>   |

| Step | Procedure and Acceptance Criteria   | Data to Be Recorded   |
|------|---|---|
| 18)  | <p>Prepare the SCSSV for drift tests; If the SCSSV fails the drift test, it fails the functional test. Open the SCSSV, then, proceed as follows.</p> <ol style="list-style-type: none"> <li>1) Drift the interior of the SCSSV assembly with the supplier/manufacture's specified drift bar. Pass the drift bar completely through the test valve from top to bottom. Repeat the drift test in the opposite direction.</li> <li>2) Drift the exterior of wireline-retrievable SCSSVs with the supplier/manufacture's specified drift sleeve. Repeat the drift test in the opposite direction.</li> <li>3) When required by the functional specification, drift the exterior of the SSSV with the supplier/manufacture's specified drift sleeve. Repeat the drift test in the opposite direction.</li> </ol> <p><b>Acceptance criteria:</b> The force applied to move the drift bar shall not be greater than the weight of the drift bar.</p> | <ul style="list-style-type: none"> <li>— drift bar/sleeve unique identifier</li> <li>— drift bar/sleeve size</li> <li>— internal/external drift test passed? (yes or no)</li> </ul> |
| 19)  | <p>Special features unique to a supplier/manufacture's SCSSV shall be tested in accordance with the supplier/manufacture's operating manual. Failure to meet the requirements of these tests fails the SCSSV. These tests can be incorporated in the existing sequence of functional tests. Such special-feature test procedures, the sequence, acceptance criteria, and the results shall be fully described in the test report.</p>   | <ul style="list-style-type: none"> <li>— data required by supplier/manufacture's procedures</li> <li>— special features test passed? (yes or no)</li> </ul>                         |
| 20)  | <p>If the SCSSV performs within the limits of the functional test, it passes the functional test. Attach all recorded data to the supplier/manufacture's test form.</p>   | <ul style="list-style-type: none"> <li>— test date</li> <li>— person performing test printed name</li> <li>— person performing test signature</li> </ul>                            |

### C.3 Functional Test—Subsurface-controlled Subsurface Safety Valve

#### C.3.1 Test Facility

**C.3.1.1** The supplier/manufacture shall identify a have a test facility that allows testing to be completed per the requirements of this annex.

**C.3.1.2** Functional testing may be done in the manufacture's facility (in-house) or outsourced to a qualified facility. An outside test facility shall be an approved vendor of the manufacture and shall meet all applicable requirements of this specification, including qualification of inspection and test personnel.

#### C.3.2 Functional Test Procedure—Velocity-type Subsurface-controlled Subsurface Safety Valve

The functional test of velocity-type SSCSVs shall be performed in conformance with Table C.2.

**Table C.2—Functional Test Procedure—Velocity-type SSCSV**

| Step | Procedure and Acceptance Criteria   | Data to Be Recorded   |
|------|---|---|
| 1)   | Record valve identification information.  | <ul style="list-style-type: none"> <li>— valve supplier/manufacturer</li> <li>— equipment name</li> <li>— SSSV type and size</li> <li>— manufacturer's part number</li> <li>— serial number</li> <li>— safety valve lock, serial number, and size (as applicable)</li> <li>— working pressure rating</li> </ul>   |
| 2)   | <p>Initiate a flow against a minimum backpressure of 0.35 MPa (50 psi). Check the operation of the recorders for the flow rate, upstream pressure and downstream pressure. Increase flow rate until the SSCSV closes.</p> <p><b>Acceptance criteria:</b> If the closing rate and pressure differential are not within <math>\pm 5\%</math> of the supplier/manufacturer's specified values, the SSCSV fails the functional test.</p>  | <ul style="list-style-type: none"> <li>— initial flow rate</li> <li>— initial upstream pressure</li> <li>— initial downstream pressure</li> <li>— flow rate at moment of SSCSV closing</li> <li>— upstream pressure at moment of SSCSV closing</li> <li>— downstream pressure at moment of SSCSV closing</li> <li>— test passed? (yes or no)</li> </ul> |
| 3)   | <p>Adjust and stabilize the pressure upstream of the SSCSV to <math>100\% \pm 5\%</math> of the RWP. Hold the upstream pressure for a minimum of 5 min and measure the leakage rate.</p> <p><b>Acceptance criteria:</b> If the leakage rate exceeds <math>10 \text{ cm}^3/\text{min}</math> (<math>0.6 \text{ in.}^3/\text{min}</math>), the SSCSV fails the functional test.</p>   | <ul style="list-style-type: none"> <li>— start time at pressure</li> <li>— end time at pressure</li> <li>— upstream pressure</li> <li>— liquid leakage rate</li> <li>— test passed? (yes or no)</li> </ul>  |
| 4)   | <p>Bleed the pressure from below the SSCSV to a value 0.7 MPa (100 psi) greater than the differential closing pressure. Adjust the gas pressure to a value <math>1.4 \text{ MPa} \pm 0.07 \text{ MPa}</math> (<math>200 \text{ psi} \pm 10 \text{ psi}</math>) greater than the differential closing pressure. Measure the gas leakage rate for 5 min.</p> <p><b>Acceptance criteria:</b> If the leakage rate exceeds <math>0.14 \text{ m}^3/\text{min}</math> (<math>5 \text{ scf/min}</math>), the SSCSV fails the functional test.</p> | <ul style="list-style-type: none"> <li>— start time at pressure</li> <li>— end time at pressure</li> <li>— upstream pressure</li> <li>— gas leakage rate</li> <li>— test passed? (yes or no)</li> </ul>   |
| 5)   | Bleed all pressures to zero.  |   |
| 6)   | <p>Prepare the SSCSV for a drift test. Drift the exterior of a wireline-type SSCSV with the drift sleeve.</p> <p><b>Acceptance criteria:</b> If the SSCSV does not pass through the drift sleeve, it fails the functional test.</p>   | <ul style="list-style-type: none"> <li>— drift bar/sleeve unique identifier</li> <li>— drift bar/sleeve size</li> <li>— external drift test passed? (yes or no)</li> </ul>  |

| Step | Procedure and Acceptance Criteria  | Data to Be Recorded  |
|------|--|--|
| 7)   | If the SSCSV performs within the limits of the functional test, it has passed the functional test. Attach all recorded data to the supplier/manufacture's test form. | <ul style="list-style-type: none"> <li>— test date</li> <li>— person performing test (printed name)</li> <li>— person performing test (signature)</li> </ul> |

### C.3.3 Functional Test Procedure—Tubing-pressure-type Subsurface-controlled Subsurface Safety Valve

The functional test of tubing-pressure-type SSCSVs shall be performed in conformance with Table C.3.

**Table C.3—Functional Test Procedure—Tubing-Pressure-type SSCSV**

| Step | Procedure and Acceptance Criteria  | Data to Be Recorded   |
|------|--|---|
| 1)   | Record the valve identification information.   | <ul style="list-style-type: none"> <li>— valve supplier/manufacture</li> <li>— equipment name</li> <li>— SSCSV type and size</li> <li>— manufacturer's part number</li> <li>— serial number</li> <li>— safety valve lock, serial number, and size (as applicable)</li> <li>— RWP</li> </ul> |
| 2)   | Adjust the flow rate in accordance with Table B.16. Reduce the downstream pressure until the SSCSV closes.<br><b>Acceptance criteria:</b> If the downstream pressure at closure is not within $\pm 5\%$ of the supplier/manufacture's specified pressure or 0.7 MPa (100 psi), whichever is larger, the SSCSV fails the functional test.             | <ul style="list-style-type: none"> <li>— liquid flow rate</li> <li>— flow rate at moment of SSCSV closing</li> <li>— downstream pressure at moment of SSCSV closing</li> <li>— test passed? (yes or no)</li> </ul>  |
| 3)   | Bleed the downstream pressure to zero.   | n)  |
| 4)   | Adjust and stabilize the pressure upstream of the SSCSV to $100\% \pm 5\%$ of the RWP of the SSCSV. Hold the upstream pressure for a minimum of 5 min and measure the leakage rate.<br><b>Acceptance criteria:</b> If the leakage rate exceeds $10 \text{ cm}^3/\text{min}$ ( $0.6 \text{ in.}^3/\text{min}$ ), the SSCSV fails the functional test. | <ul style="list-style-type: none"> <li>— start time at pressure</li> <li>— end time at pressure</li> <li>— upstream pressure</li> <li>— liquid leakage rate</li> <li>— test passed? (yes or no)</li> </ul>  |
| 5)   | Bleed the upstream pressure from the SSCSV to a value 0.7 MPa (100 psi) greater than the closing pressure.   | o)  |

| Step | Procedure and Acceptance Criteria  | Data to Be Recorded   |
|------|--|---|
| 6)   | Adjust the upstream pressure with gas to a value $1.4 \text{ MPa} \pm 0.07 \text{ MPa}$ ( $200 \text{ psi} \pm 10 \text{ psi}$ ) greater than the closing pressure. Measure the gas leakage rate for 5 min.<br><br><b>Acceptance criteria:</b> If the leakage rate exceeds $0.14 \text{ m}^3/\text{min}$ ( $5 \text{ scf/min}$ ), the SSCSV fails the functional test. | <ul style="list-style-type: none"> <li>— start time at pressure</li> <li>— end time at pressure</li> <li>— upstream pressure</li> <li>— gas leakage rate</li> <li>— test passed? (yes or no)</li> </ul> |
| 7)   | Bleed all pressures to zero.   | p)  |
| 8)   | Prepare the SSCSV for a drift test. Drift the exterior of wireline-type SSCSVs with a drift sleeve.<br><br><b>Acceptance criteria:</b> If the SSCSV does not pass through the drift sleeve, it fails the functional test.  | <ul style="list-style-type: none"> <li>— drift bar/sleeve unique identifier</li> <li>— drift bar/sleeve size</li> <li>— external drift test passed? (yes or no)</li> </ul>                              |
| 9)   | If the SSCSV performs within the limits of the functional test, it has passed the test. Attach all recorded data to the supplier/manufacture's test form.  | <ul style="list-style-type: none"> <li>— test date</li> <li>— person performing test (printed name)</li> <li>— person performing test (signature)</li> </ul>  |

## C.4 Functional Test—Subsurface Injection Safety Valve

### C.4.1 Test Facility

The supplier/manufacture shall identify a test facility that allows testing to be completed per the requirements of this annex.

Functional testing may be done in the supplier/manufacture's facility (in-house) or outsourced to a qualified facility. An outside test facility shall be an approved vendor of the supplier/manufacture and shall meet all applicable requirements of this specification, including qualification of inspection and test personnel.

**NOTE** For steps involving flow and leakage measurement across the SSISV closure mechanism, the upstream and downstream locations are transposed for SSISVs as compared to SCSSVs and SSCSVs.

### C.4.2 Functional Test Procedure—Subsurface Injection Safety Valve

The functional test of SSISVs shall be performed in conformance with Table C.4.

**Table C.4—Functional Test Procedure—SSISV**

| Step | Procedure and Acceptance Criteria            | Data to Be Recorded   |
|------|--|---|
| 1)   | Record the valve identification information. | <ul style="list-style-type: none"> <li>— valve supplier/manufacture</li> <li>— equipment name</li> <li>— SSSV type and size</li> <li>— manufacturer's part number</li> <li>— serial number</li> </ul> |

| Step | Procedure and Acceptance Criteria   | Data to Be Recorded  |
|------|---|--|
|      |   | <ul style="list-style-type: none"> <li>— safety valve lock, serial number, and size (as applicable)</li> <li>— RWP</li> </ul>  |
| 2)   | <p>Fill SSISV with water, displace air, and open the SSISV as follows:</p> <p>For velocity-type SSISVs—Increase the liquid flow rate or velocity, or the upstream-to-downstream differential pressure.</p> <p>For tubing-pressure-type SSISVs—Increase the liquid pressure in the system to the supplier/manufacturer's recommended hold-open pressure.</p>   | <ul style="list-style-type: none"> <li>— test start time</li> </ul> <p>For velocity-type SSISVs:</p> <ul style="list-style-type: none"> <li>— opening flow rate, velocity, or differential pressure</li> </ul> <p>For tubing-pressure-type SSISVs:</p> <ul style="list-style-type: none"> <li>— opening pressure</li> </ul>  |
| 3)   | <p>Close the SSISV as follows.</p> <p>For velocity-type SSISVs—Decrease the liquid flow rate through the test valve to zero or bleed the upstream-to-downstream differential pressure to zero.</p> <p>For tubing-pressure-type SSISVs—Bleed the valve bore liquid pressure to zero.</p>   | q)   |
| 4)   | Repeat Step 2) and Step 3) four additional times.   | r)   |
| 5)   | <p>Displace air from the test section and proceed as follows.</p> <p>For TRSVs, thoroughly dry the test valve exterior. Adjust and stabilize the pressure in the entire test section to 150 % of the RWP (allowable range of 145 % to 155 % of the RWP) for SSISVs up to 69 MPa (10,000 psi) RWP of the SSISV. For SSISVs with rating working pressures in excess of 69 MPa (10,000 psi), the test pressure shall be the RWP plus a minimum of 34.5 MPa (5000 psi). Hold the pressure for a minimum of 5 min. Reduce the pressure in the test section to zero. Repeat the test once.</p> <p><b>Acceptance criteria:</b> The SSISV fails the functional test if leakage is detected on the exterior or through any external control port(s).</p> | <p>First iteration:</p> <ul style="list-style-type: none"> <li>— start time at pressure</li> <li>— end time at pressure</li> <li>— beginning section pressure</li> <li>— ending section pressure</li> <li>— leakage within 5 min? (yes or no)</li> <li>— test passed? (yes or no)</li> </ul> <p>Second iteration:</p> <ul style="list-style-type: none"> <li>— start time at pressure</li> <li>— end time at pressure</li> <li>— beginning section pressure</li> <li>— ending section pressure</li> <li>— leakage within 5 min? (yes or no)</li> <li>— test passed? (yes or no)</li> </ul> |
| 6)   | Bleed all pressure to zero.   | s)   |
| 7)   | <p>Adjust and stabilize the test section pressure to 100 % of the RWP (allowable range of 95 % to 105 % of RWP) of the SSISV. Monitor for leakage for a minimum of 5 min.</p> <p><b>Acceptance criteria:</b> If any leakage is detected, the SSISV fails the functional test.</p>   | <ul style="list-style-type: none"> <li>— test section pressure</li> <li>— start time at pressure</li> <li>— end time at pressure</li> <li>— external leakage within 5 min? (yes or no)</li> <li>— test passed? (yes or no)</li> </ul>  |

| Step | Procedure and Acceptance Criteria  | Data to Be Recorded   |
|------|--|---|
| 8)   | Bleed the pressure above the SSISV closure mechanism to zero. Adjust and stabilize the pressure below the closure mechanism to 100 % of the RWP (allowable range of 95 % to 105 % of RWP) of the SSISV. Measure liquid leakage for a minimum of 5 min.<br><br><b>Acceptance criteria:</b> If the leakage rate exceeds 10 cm <sup>3</sup> /min (0.6 in. <sup>3</sup> /min), the SSISV fails the functional test.  | <ul style="list-style-type: none"> <li>— pressure below closing mechanism</li> <li>— start time at pressure</li> <li>— end time at pressure</li> <li>— measured leakage</li> <li>— test passed? (yes or no)</li> </ul>                |
| 9)   | Remove the liquid from the test section.   | t)  |
| 10)  | Adjust and stabilize the pressure in the entire test section with gas to 1.4 MPa ± 0.07 MPa (200 psi ± 10 psi). Monitor for gas leakage for a minimum of 5 min.<br><br><b>Acceptance criteria:</b> If any leakage is detected from the valve exterior, the SSISV fails the functional test.  | <ul style="list-style-type: none"> <li>— test section pressure</li> <li>— start time at pressure</li> <li>— end time at pressure</li> <li>— external leakage within 5 min? (yes or no)</li> <li>— test passed? (yes or no)</li> </ul> |
| 11)  | Bleed the pressure above the SSISV's closure mechanism to zero. Adjust and stabilize the pressure below the SSISV's closure mechanism to 1.4 MPa ± 0.07 MPa (200 psi ± 10 psi) with gas. Measure the leakage rate for a minimum of 5 min.<br><br><b>Acceptance criteria:</b> If the leakage rate exceeds 0.14 m <sup>3</sup> /min (5 scf/min), the SSISV fails the functional test.  | <ul style="list-style-type: none"> <li>— pressure below closure mechanism</li> <li>— start time at pressure</li> <li>— end time at pressure</li> <li>— measured leakage</li> <li>— test passed? (yes or no)</li> </ul>                |
| 12)  | Repeat Steps 10) and 11) with 8.3 MPa ± 0.41 MPa (1200 psi ± 60 psi) instead of 1.4 MPa ± 0.07 MPa (200 psi ± 10 psi).   | u)  |
| 13)  | Bleed all pressures to zero.   | v)  |
| 14)  | Prepare the SSISV for drift tests, as applicable; if the SSISV fails the drift test, it fails the functional test.<br><br>1) Drift the interior, if applicable, of the SSISV assembly with the supplier/manufacturer's specified drift bar, per the supplier/manufacturer's procedure.<br><br>2) When required by the functional specification, drift the exterior of wireline-retrievable SSISVs with the supplier/manufacturer's specified drift sleeve, per the supplier/manufacturer's procedure. Repeat the drift test in the opposite direction.<br><br><b>Acceptance criteria:</b> The force applied to move the drift bar shall not be greater than the weight of the drift bar. | <ul style="list-style-type: none"> <li>— drift bar/sleeve unique identifier</li> <li>— drift bar/sleeve size</li> <li>— internal/external drift test passed? (yes or no)</li> </ul>   |
| 15)  | Special features unique to a supplier/manufacturer's SSISV shall be tested in accordance with the supplier/manufacturer's operating manual. Failure to meet the requirements of these tests fails the SSISV. These tests can be incorporated in the existing sequence of functional tests. Such special-feature test procedures, the sequence, acceptance criteria, and the results shall be fully described in the test report.   | <ul style="list-style-type: none"> <li>— data required by supplier/manufacturer's procedures</li> <li>— special features test passed? (yes or no)</li> </ul>  |
| 16)  | If the SSISV performs within the limits of the functional test, it passes the functional test. Attach all recorded data to the supplier/manufacturer's test form.  | <ul style="list-style-type: none"> <li>— test date</li> <li>— person performing test (printed name)</li> <li>— person performing test (signature)</li> </ul>  |

## **Annex D (normative)**

### **Supplier/Manufacturer Validation Testing Requirements for Grades V2 and V3**

#### **D.1 General**

**D.1.1** This annex contains the additional validation requirements for SSSVs to conform to the requirements of validation Grade V2 or V3.

**D.1.2** To meet the applicable validation grade, all tests described in this annex shall be completed per the supplier/manufacturer's written procedures.

**D.1.3** Each individual test shall be completed without any repair or redress of the test valve or fixture; repair and redress between individual tests is allowed. Products failing one or more of the tests may be retested to meet the requirements of that test or tests.

**D.1.4** Validation testing per this annex shall meet the requirements of 5.5.13.

#### **D.2 Temperature Cycle Test**

##### **D.2.1 General**

The purpose of the temperature cycle test is to validate the dynamic seal system that operates the SCSSV closure mechanism.

##### **D.2.2 Requirements**

**D.2.2.1** The test shall be conducted on a SCSSV or a test fixture that replicates all applicable dimensions and loading conditions of the dynamic seal system of the SCSSV.

**D.2.2.2** The test shall include multiple cycles and shall be conducted at minimum and maximum rated operating temperatures and at the maximum rated operating pressure of the dynamic seal systems.

**D.2.2.3** The supplier/manufacturer shall record the hydraulic control line leakage, as applicable.

##### **D.2.3 Acceptance Criteria**

The acceptance criteria shall be as specified in the supplier/manufacturer's documented procedure.

##### **D.2.4 Test Results and Records**

Records of the test shall be available for review by the user/purchaser upon request to the supplier/manufacturer and shall consist of the following information:

- number of operating cycles and the temperature at which the cycles occurred;
- the fluid in the test section;
- control line fluid, if applicable;
- test pressures applied;
- flow rates applied, if applicable.

### **D.3 Differential Opening Testing**

#### **D.3.1 General**

**D.3.1.1** The purpose of the differential opening test is to evaluate the effects of slam open operation on an SSSV closure mechanism as well as determining the maximum differential pressure for opening a non-self-equalizing valve.

**D.3.1.2** When the rated differential opening pressure is zero, this test may be excluded.

#### **D.3.2 Requirements**

**D.3.2.1** Establish pressure upstream of the SSSV closure mechanism at the maximum supplier/manufacture specified opening pressure differential.

**D.3.2.2** Open the SSSV closure mechanism against maximum recommended unequalized opening pressure as recommended in the test valve-operating manual.

**D.3.2.3** A minimum of 5 slam open cycles shall be completed.

#### **D.3.3 Acceptance Criteria**

The acceptance criteria shall be as specified in the supplier/manufacture's documented procedure.

#### **D.3.4 Test results and Records**

Records of the test shall be available for review by the user/purchaser upon request to the supplier/manufacture and shall consist of the following information:

- number of slam open cycles completed,
- equalizing test pressure and the associated hydraulic control pressure,
- repeatability within supplier/manufacture defined limits of equalizing test pressure,
- repeatability within supplier/manufacture defined limits of associated hydraulic control pressure,
- test fluid used.

## **D.4 Self-equalizing Test (when applicable)**

### **D.4.1 General**

The purpose of the equalization mechanism endurance test is to evaluate the endurance, operation, and sealing performance of a self-equalizing mechanism.

### **D.4.2 Requirements**

The test shall include multiple cycles at the maximum differential pressure rating of the equalization system.

### **D.4.3 Acceptance Criteria**

The acceptance criteria shall be per the supplier/manufacture's documented procedure.

### **D.4.4 Test Results and Records**

Records of the test shall be available for review by the user/purchaser upon request to the supplier/manufacture and shall consist of the following information:

- number of equalization cycles completed,
- equalizing test pressure and the associated hydraulic control pressure,
- repeatability within supplier/manufacture's defined limits of equalizing test pressure,
- repeatability within supplier/manufacture's defined limits of associated hydraulic control pressure,
- leakage across the equalization mechanism,
- temperatures at which the equalization cycles were conducted,
- the fluid in the test section.

## **Annex E (Normative)**

### **Alternative Requirement for Closure Mechanism Minimal Leakage**

#### **E.1 General**

Minimal leakage rate applies only to the functional test. If a minimal leakage requirement is specifically requested by user/purchaser, the supplier/manufacture shall adhere to E.2 and E.3.

#### **E.2 Gas Leakage Test Requirements**

If the leakage rate exceeds 14.2 dm<sup>3</sup>/min (0.5 scfm), the SSSV fails the functional test.

#### **E.3 Liquid Leakage Test Requirements**

If the leakage rate exceeds 1 cm<sup>3</sup>/min (0.034 fl oz/min), the SSSV fails the functional test.

## **Annex F (normative)**

### **Design Validation Requirements for Secondary Tools**

#### **F.1 General**

This annex describes the design validation and scaling limitations that shall be followed when creating new designs from previously validated designs of secondary tools. Functional requirements and the remainder of technical specifications for secondary tools are addressed in Sections 4 and 5, respectively. Manufacturing requirements for secondary tools are addressed in Section 6.

#### **F.2 Design Validation**

##### **F.2.1 General**

Design validation shall be accomplished by evaluation or by testing.

##### **F.2.2 Validation by Evaluation**

Design validation by evaluation shall be conducted according to the supplier/manufacturer's procedures and acceptance criteria. The evaluation shall be documented, approved by a qualified person(s), and, as a minimum, shall include:

- a) design verifications, including assembly processes, body integrity, operational capability, and drift testing; or
- b) objective evidence of successful performance of a minimum of three uses of the same size, type, and model of each; or
- c) combinations of Items a) and b).

##### **F.2.3 Validation by Testing**

###### **F.2.3.1 General**

Validation testing per this annex shall meet the requirements of 5.5.13.

###### **F.2.3.2 Testing During Previous SSSV Validation**

Any secondary tool that has had all of its operating capabilities successfully validated to their rated limits in the performance of SSSV validation testing per Annexes B, D, G, H, I, J, K, or L (design validation of the primary product) shall be considered meeting the requirements of this annex. Operating capabilities that have not been validated during SSSV validation testing shall be evaluated to the requirements of this annex.

### **F.2.3.3 Product-specific Testing**

#### **F.2.3.4 General**

**F.2.3.4.1** Redress and/or repair to the tested tool during the testing process are not allowed; a redress and/or repair shall require a restart of the validation testing.

**F.2.3.4.2** Design validation by testing shall be done with the entire SSSV or with a fixture with the equivalent fits, clearances, and loads as the affected portion of the SSSV.

**F.2.3.4.3** During validation testing of hydraulically operated tools, control fluid metering may be used to provide readable control signals where necessary.

**F.2.3.4.4** Validation testing shall be discontinued if the tool fails to perform within the limits specified for any step, except when such failures are determined to be a result of a failure within the test facility that does not affect the validity of the test.

#### **F.2.3.5 Assembly Evaluation**

**F.2.3.5.1** Assembly processing shall follow the supplier/manufacturer's documented procedures, including fluids, lubricants, in situ tests, and methods.

**F.2.3.5.2** Any variance from the requirements shall be documented and corrected prior to initiating the testing process.

**F.2.3.5.3** Each component of the test product shall be traceable to its unique material and processing records.

**F.2.3.5.4** Each supplier/manufacturer-specified critically stressed component shall be dimensionally inspected before the evaluation process, as specified in the supplier/manufacturer's documented methods and acceptance criteria.

#### **F.2.3.6 Secondary Tool Design Validation**

**F.2.3.6.1** Each secondary tool design shall be tested to its rated limits and operational capabilities as specified by the supplier/manufacturer.

**F.2.3.6.2** If multiple products of the identical design are required due to design limitations to complete the testing defined (such as single-use products), each shall be identified within the applicable test and the compiled test report shall indicate all the products used for that purpose.

#### **F.2.3.7 Acceptance Criteria**

The secondary tool shall perform to the supplier/manufacturer specified acceptance criteria. Failure to do so requires a restart of the set of evaluations/tests after corrections are completed.

#### **F.2.3.8 Post-testing Evaluations**

**F.2.3.8.1** The secondary tool shall be disassembled after the testing and each component visually inspected to verify its condition.

**F.2.3.8.2** Dimensional inspection of critically stressed components and dynamic surfaces shall be completed. Any damage or deformation shall be documented in the validation test report (see 5.5.13.5).

## **F.3 Scaling of Validation Results**

### **F.3.1 Limitations of Scaling**

**F.3.1.1** Scaling shall not be used to cover secondary tools with higher pressure ratings, a temperature range that exceeds upper and lower limits of the base design, or a higher axial load rating than the base design that has been validated.

**F.3.1.2** If a rated performance envelope was generated for the base design, the scaled design rated performance envelope shall fall completely within the base rated performance envelope.

**F.3.1.3** The scaled design secondary tool shall not have more leak paths than the base design.

**F.3.1.4** For secondary tools that apply to validation grade V1-H SSSV, refer to H.3.5 for additional scaling requirements.

### **F.3.2 Evaluation of Scaling**

A scaled design of secondary tools shall be evaluated according to the requirements of 5.8.2.

## Annex G (normative)

### Validation Grade V1 Requirements

#### G.1 General

**G.1.1** This annex contains the validation requirements for SCSSVs meeting the requirements of validation grade V1.

**G.1.2** The SCSSV shall have passed the functional test specified in Annex C prior to commencement of any tests in this annex.

**G.1.3** To meet the V1 validation grade, all tests described in this annex shall be completed in conformance with the acceptance criteria. These validation tests may be conducted in any order.

**G.1.4** Each individual test shall be completed without repair or redress of the test valve.

**G.1.5** Repair and redress between individual tests is allowed, but a functional test specified in Annex C shall be performed prior to commencement of any additional tests.

**G.1.6** Products failing one or more of the tests may be retested to meet the requirements of that test or tests; however, substantive design changes (see 5.7.2) to any component of a SSSV shall require that all the Annex G validation test(s) are repeated.

**G.1.7** To conform to the requirements of this annex, each SCSSV tested shall pass all requirements within the limits specified and within the supplier/manufacture's rated performance limits.

**G.1.8** The supplier/manufacture shall maintain design validation records on each validation test including any retests that may have been required to qualify SSSV equipment. These records shall be retained by the supplier/manufacture for a period of 20 years after such SSSV equipment is discontinued from the supplier/manufacture's product line.

**G.1.9** Pre-test and post-test dimensional verification of functionally critical dimensions defined by the supplier/manufacture shall be conducted and documented by the supplier/manufacture. Dimensions shall meet established acceptance criteria.

**G.1.10** Unless otherwise specified, gas pressure-relieving (bleed-down) operations should be performed at a maximum rate of 0.7 MPa/min (100 psi/min) at pressures less than 10.3 MPa (1500 psi). The supplier/manufacture may specify gas pressure-relieving (bleed-down) operations.

**G.1.11** The SCSSV shall be oriented vertically for all tests unless specified otherwise by the user/purchaser and noted in the validation test report.

**G.1.12** Validation testing per this annex shall meet the requirements of 5.5.13.

#### G.2 Validation Testing at a Test Agency

The validation tests in Table B.1 and Table B.2 shall be completed on the SCSSV.

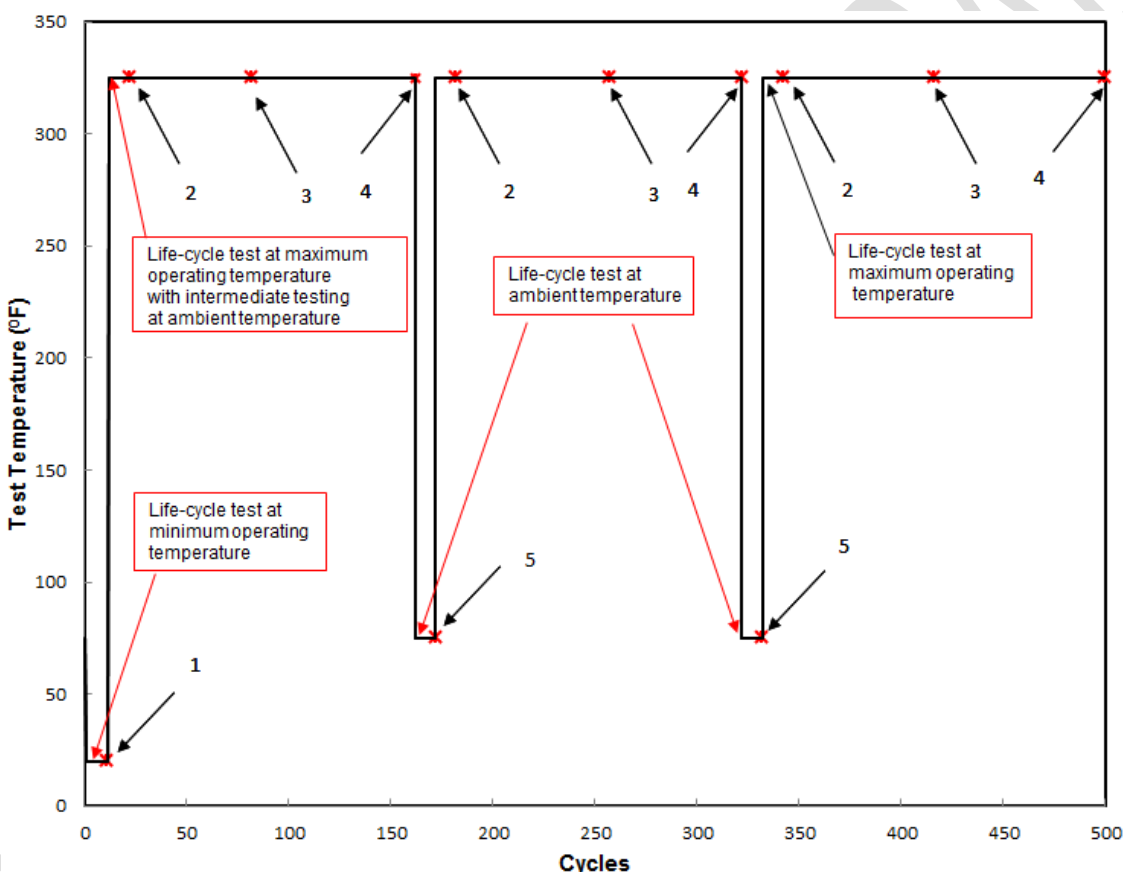
## G.3 Operating Life Testing

### G.3.1 General

**G.3.1.1** The purpose of the operating life test is to simulate the expected operating life performance of a SSSV considering all phases, including functional testing and well production conditions such as rig deck testing, normal operations at depth including well decline, operations during workover, and injection activities if applicable.

**G.3.1.2** The number of cycles defining operating life expectations shall be a minimum of 500 operating cycles, or more if specified by the user/purchaser.

**G.3.1.3** An example of an operating life cycle test profile with each step labelled is illustrated in Figure G.1.



**Key:**

X-axis = number of operating cycles      Y-axis = test temperature

- 1 Repeatability evaluation of 10 operating cycles at end of minimum rated operating temperature cycling
- 2 Repeatability evaluation of 10 operating cycles at start of the maximum rated temperature cycling
- 3 Repeatability evaluation of 10 operating cycles at midpoint of the maximum rated temperature cycling
- 4 Repeatability evaluation of 10 operating cycles at end of the maximum rated temperature cycling
- 5 Repeatability evaluation of 10 operating cycles at end of the ambient temperature cycling

**Figure G.1—Example of an Operating Life Test Profile**

## G.3.2 Requirements

The following shall be performed when conducting operating life testing on a SSSV.

- a) The SSSV to be tested shall be assembled and prepared for the test per the supplier/manufacturer's specifications.
- o) The operating life test shall be performed in the order defined in G.3.3.
- p) All tests shall be conducted using nitrogen gas as the test medium.

## G.3.3 Procedure

### G.3.3.1 Operating Life Test at Minimum Rated Operating Temperature

The operating life test shall be performed in conformance with the steps detailed in Table G.1.

**Table G.1—Operating Life Test at Minimum Rated Operating Temperature**

| Step | Procedure Step and Acceptance Criteria  | Data to Be Recorded  |
|------|---|--|
| 1)   | Install the SSSV into an appropriate test stand.  | — manufacturer, brand name, and type (oil-based, water based) of control fluid used for all cycles   |
| 2)   | Cool the SSSV to the minimum rated operating temperature.   | — the temperature when the minimum rated operating temperature is reached and has stabilized   |
| 3)   | <p>Perform a minimum of 10 operating cycles at or below the minimum rated operating temperature while at or above the RWP in the test section.</p> <p>For tubing-pressure-sensitive valves, the full open/full closed hydraulic control pressures shall be adjusted based on the change of the test section pressure at the time of control pressure measurement. The adjusted control pressure is determined by adding/subtracting the actual control pressure with the difference between the base pressure and the actual test section pressure recorded at the time of each opening/closing pressure measurement.</p> <p><b>Acceptance criteria:</b> If the 10 adjusted hydraulic control pressures (or actual control pressures for tubing-pressure-insensitive valves) do not repeat within <math>\pm 10\%</math> of their average, or <math>\pm 0.7</math> MPa (<math>\pm 100</math> psi), whichever is greater, or if any body leakage (tubing-retrievable only) is detected, the test valve fails.</p> | <p>A repeatability evaluation shall be conducted on 10 operating cycles at the end of these cycles as follows.</p> <p>For each of the last 10 operating cycle:</p> <ul style="list-style-type: none"> <li>— full open hydraulic control pressure and maximum applied hydraulic control pressure</li> <li>— test section pressure</li> <li>— full closed hydraulic control pressure</li> <li>— test section pressure</li> </ul> <p>Calculate the following:</p> <ul style="list-style-type: none"> <li>— adjusted hydraulic control pressure; fully closed</li> </ul> |

| Step | Procedure Step and Acceptance Criteria  | Data to Be Recorded   |
|------|---|---|
|      |   | <ul style="list-style-type: none"> <li>— average of adjusted hydraulic control pressure; fully closed</li> <li>— adjusted hydraulic control pressure; fully open</li> <li>— average of adjusted hydraulic control pressure; fully open</li> <li>— test passed? (yes or no)</li> </ul>             |
| 4)   | <p>Bleed the pressure above the SCSSV's closure mechanism to zero. Adjust and stabilize the pressure below the SCSSV's closure mechanism to 1.4 MPa <math>\pm</math> 0.07 MPa (200 psi <math>\pm</math> 10 psi). Measure the leakage rate for a minimum of 5 min.</p> <p><b>Acceptance criteria:</b> If the leakage rate exceeds 0.43 m<sup>3</sup>/min (15 scf/min), the test valve fails the operating life test.</p> | <ul style="list-style-type: none"> <li>— pressure below closure mechanism</li> <li>— start time at pressure</li> <li>— end time at pressure</li> <li>— measured leakage</li> <li>— test passed? (yes or no)</li> <li>— Record the total number of operating cycles ran if more than 10</li> </ul> |

### G.3.3.2 Operating Life Test at Maximum Rated Operating Temperature with Intermediate Ambient Temperature Testing

A minimum of 300 cycles or 60 % of the total specified operating cycles at the maximum rated operating temperature shall be performed, including a minimum of 10 operating cycles at ambient temperature at the approximate midpoint in accordance with Table G.2.

**Table G.2—Operating Life Test at Maximum Rated Operating Temperature with Intermediate Testing at Ambient Temperature**

| Step | Procedure Step and Acceptance Criteria   | Data to Be Recorded   |
|------|--|---|
| 1)   | Heat the SSSV to the maximum rated operating temperature and stabilize at or above the maximum rated operating temperature. Maintain the maximum rated operating temperature until the end of Step 3).   | — temperature   |
| 2)   | <p>Perform a minimum of 150 cycles or 30 % of the total specified operating cycles at or above the maximum rated operating temperature and at or above the RWP in the test section.</p> <p>For tubing-pressure-sensitive valves, the full open/full closed hydraulic control pressures shall be adjusted based on the change of the test section pressure at the time of control pressure measurement. The adjusted control pressure is determined by adding/subtracting the actual control pressure with the difference between the base pressure and the actual test section pressure recorded at the time of each opening/closing pressure measurement.</p> <p><b>Acceptance criteria:</b> If the 10 adjusted hydraulic control pressures (or actual control pressures for tubing-pressure-insensitive valves) do not repeat within</p> | <p>A repeatability evaluation shall be conducted on 10 operating cycles at the start, midpoint, and end of these cycles as follows.</p> <p>For each of these 10 operating cycles:</p> <ul style="list-style-type: none"> <li>— full open hydraulic control pressure and maximum applied hydraulic control pressure</li> </ul> |

| Step | Procedure Step and Acceptance Criteria  | Data to Be Recorded   |
|------|---|---|
|      | ±10 % of their average, or ±0.7 MPa (±100 psi), whichever is greater, the test valve fails.   | <ul style="list-style-type: none"> <li>— test section pressure</li> <li>— full closed hydraulic control pressure</li> <li>— test section pressure</li> </ul> <p>Calculate the following:</p> <ul style="list-style-type: none"> <li>— adjusted hydraulic control pressure; fully closed</li> <li>— average of adjusted hydraulic control pressure; fully closed</li> <li>— adjusted hydraulic control pressure; fully open</li> <li>— average of adjusted hydraulic control pressure; fully open</li> <li>— test passed? (yes or no)</li> </ul> |
| 3)   | <p>Bleed the pressure above the SCSSV's closure mechanism to zero. Adjust and stabilize the pressure below the SCSSV's closure mechanism to 1.4 MPa ± 0.07 MPa (200 psi ± 10 psi). Measure the leakage rate for a minimum of 5 min.</p> <p><b>Acceptance criteria:</b> If the leakage rate exceeds 0.43 m<sup>3</sup>/min (15 scf/min), the test valve fails the operating life test.</p>   | <ul style="list-style-type: none"> <li>— pressure below closure mechanism</li> <li>— start time at pressure</li> <li>— end time at pressure</li> <li>— measured leakage</li> <li>— test passed? (yes or no)</li> <li>— record the number of the operating cycle at the conclusion of each evaluation period at the start, midpoint, and end.</li> <li>— test passed? (yes or no)</li> </ul>   |
| 4)   | Cool the SSSV to the ambient temperature  | <ul style="list-style-type: none"> <li>— temperature</li> </ul>   |
| 5)   | <p>Perform a minimum of 10 operating cycles at or above the RWP in the test section, at the approximate midpoint of the total number of operating cycles. For tubing-pressure-sensitive valves, the full open/full closed hydraulic control pressures shall be adjusted based on the change of the test section pressure at the time of control pressure measurement. The adjusted control pressure is determined by adding/subtracting the actual control pressure with the difference between the base pressure and the actual test section pressure recorded at the time of each opening/closing pressure measurement.</p> <p><b>Acceptance criteria:</b> If the 10 adjusted hydraulic control pressures (or actual control pressures for tubing-pressure-insensitive valves) do not repeat within ±10 % of their average, or ±0.7 MPa (±100 psi), whichever is greater, the test valve fails.</p> | <p>For each operating cycle:</p> <ul style="list-style-type: none"> <li>— full open hydraulic control pressure and maximum applied hydraulic control pressure</li> <li>— test section pressure,</li> <li>— full closed hydraulic control pressure</li> <li>— test section pressure</li> </ul> <p>Calculate the following:</p> <ul style="list-style-type: none"> <li>— adjusted hydraulic control pressure; fully closed</li> </ul>   |

| Step | Procedure Step and Acceptance Criteria   | Data to Be Recorded   |
|------|--|---|
|      |  | <ul style="list-style-type: none"> <li>— average of adjusted hydraulic control pressure; fully closed</li> <li>— adjusted hydraulic control pressure; fully open</li> <li>— average of adjusted hydraulic control pressure; fully open</li> <li>— test passed? (yes or no)</li> </ul>   |
| 6)   | Heat the SSSV to the maximum rated operating temperature and stabilize at or above the maximum rated operating temperature. Maintain the maximum rated operating temperature until the end of Step 8).   | <ul style="list-style-type: none"> <li>— temperature</li> </ul>   |
| 7)   | <p>Perform a minimum of 150 cycles or 30 % of the total specified operating cycles at or above the maximum rated operating temperature and at or above the RWP in the test section.</p> <p>For tubing-pressure-sensitive valves, the full open/full closed hydraulic control pressures shall be adjusted based on the change of the test section pressure at the time of control pressure measurement. The adjusted control pressure is determined by adding/subtracting the actual control pressure with the difference between the base pressure and the actual test section pressure recorded at the time of each opening/closing pressure measurement.</p> <p><b>Acceptance criteria:</b> If the 10 adjusted hydraulic control pressures (or actual control pressures for tubing-pressure-insensitive valves) do not repeat within <math>\pm 10</math> % of their average, or <math>\pm 0.7</math> MPa (<math>\pm 100</math> psi), whichever is greater, the test valve fails.</p> | <p>A repeatability evaluation shall be conducted on 10 operating cycles at the start, midpoint, and end of these cycles as follows.</p> <p>For each of the 10 operating cycles:</p> <ul style="list-style-type: none"> <li>— full open hydraulic control pressure and maximum applied hydraulic control pressure</li> <li>— test section pressure,</li> <li>— full closed hydraulic control pressure</li> <li>— test section pressure</li> </ul> <p>Calculate the following:</p> <ul style="list-style-type: none"> <li>— adjusted hydraulic control pressure; fully closed</li> <li>— average of adjusted hydraulic control pressure; fully closed</li> <li>— adjusted hydraulic control pressure; fully open</li> <li>— average of adjusted hydraulic control pressure; fully open</li> <li>— test passed? (yes or no)</li> </ul> |
| 8)   | <p>Bleed the pressure above the SCSSV's closure mechanism to zero. Adjust and stabilize the pressure below the SCSSV's closure mechanism to <math>1.4 \text{ MPa} \pm 0.07 \text{ MPa}</math> (<math>200 \text{ psi} \pm 10 \text{ psi}</math>). Measure the leakage rate for a minimum of 5 min.</p> <p><b>Acceptance criteria:</b> If the leakage rate exceeds <math>0.43 \text{ m}^3/\text{min}</math> (<math>15 \text{ scf}/\text{min}</math>), the test valve fails the operating life test.</p>  | <ul style="list-style-type: none"> <li>— pressure below closure mechanism</li> <li>— start time at pressure</li> <li>— end time at pressure</li> <li>— measured leakage</li> <li>— test passed? (yes or no)</li> </ul>  |

| Step | Procedure Step and Acceptance Criteria | Data to Be Recorded  |
|------|--|--|
|      |  | — record the number of the operating cycle at the conclusion of each evaluation period at the start, midpoint, and end |

### G.3.3.3 Operating Cycle Test at Ambient Temperature

A minimum of 10 operating cycles at ambient temperature shall be performed in accordance with Table G.2, Steps 4) to 5), immediately after completing the requirements of Table G.2.

### G.3.3.4 Operating Cycle Test at Maximum Rated Operating Temperature

The remaining operating cycle tests shall be completed per Table G.3 at the maximum rated temperature.

**Table G.3—Operating Cycle Test at Maximum Operating Temperature**

| Step | Procedure Step and Acceptance Criteria  | Data to Be Recorded  |
|------|---|--|
| 1)   | Heat the SSSV to the maximum rated operating temperature and stabilize at or above the maximum rated operating temperature. Maintain the maximum rated operating temperature until the end of Step 3).  | — temperature  |
| 2)   | <p>Perform the balance of the operating cycle tests at or above the RWP in the test section.</p> <p>For tubing-pressure-sensitive valves, the full open/full closed hydraulic control pressures shall be adjusted based on the change of the test section pressure at the time of control pressure measurement. The adjusted control pressure is determined by adding/subtracting the actual control pressure with the difference between the base pressure and the actual test section pressure recorded at the time of each opening/closing pressure measurement.</p> <p><b>Acceptance criteria:</b> If the 10 adjusted hydraulic control pressures (or actual control pressures for tubing-pressure-insensitive valves) do not repeat within <math>\pm 10\%</math> of their average, or <math>\pm 0.7</math> MPa (<math>\pm 100</math> psi), whichever is greater, the test valve fails.</p> | <p>A repeatability evaluation shall be conducted on 10 operating cycles at the start, midpoint, and end of these cycles as follows.</p> <p>For each of the 10 operating cycles:</p> <ul style="list-style-type: none"> <li>— full open hydraulic control pressure and maximum applied hydraulic control pressure</li> <li>— test section pressure</li> <li>— full closed hydraulic control pressure</li> <li>— test section pressure</li> </ul> <p>Calculate the following:</p> <ul style="list-style-type: none"> <li>— adjusted hydraulic control pressure; fully closed</li> <li>— average of adjusted hydraulic control pressure; fully closed</li> <li>— adjusted hydraulic control pressure; fully open</li> <li>— average of adjusted hydraulic control pressure; fully open</li> <li>— test passed? (yes or no)</li> </ul> |

|    |  |   |
|----|--|---|
| 3) | <p>Bleed the pressure above the SCSSV's closure mechanism to zero. Adjust and stabilize the pressure below the SCSSV's closure mechanism to 1.4 MPa <math>\pm</math> 0.07 MPa (200 psi <math>\pm</math> 10 psi). Measure the leakage rate for a minimum of 5 min.</p> <p><b>Acceptance criteria:</b> If the leakage rate exceeds 0.43 m<sup>3</sup>/min (15 scf/min), the test valve fails the test.</p> | <ul style="list-style-type: none"> <li>— pressure below closure mechanism</li> <li>— start time at pressure</li> <li>— end time at pressure</li> <li>— measured leakage</li> <li>— test passed? (yes or no)</li> <li>— record the total number of operating cycles ran</li> </ul> |
|----|--|---|

### G.3.3.5 Operating Life Test Hydraulic Chamber Evaluation at Ambient Temperature

The hydraulic chamber operating life test shall be performed in accordance with Table G.4.

**Table G.4—Hydraulic Control Line Chamber Evaluation**

| Step | Procedure Step and Acceptance Criteria  | Data to Be Recorded  |
|------|---|--|
| 1)   | Cool the SSSV to ambient temp.  | — temperature  |
| 2)   | Apply nitrogen gas pressure of 25 % of the RWP in the test section (allowable range of 20 % to 30 % of RWP) of the SCSSV.   | <ul style="list-style-type: none"> <li>— SSSV stabilized test temperature</li> <li>— initial SSSV valve bore pressure (base pressure)</li> </ul>   |
| 3)   | <p>Cycle the SCSSV 10 times.</p> <p><b>NOTE</b> The test section pressure can increase as the valve is opened and then can decrease as the valve is closed due to the differential volume of the hydraulic operating piston.</p> <p>For tubing-pressure-sensitive valves, the full open/full closed hydraulic control pressures shall be adjusted based on the change of the test section pressure at the time of control pressure measurement. The adjusted control pressure is determined by adding/subtracting the actual control pressure with the difference between the base pressure and the actual test section pressure recorded at the time of each opening/closing pressure measurement.</p> <p><b>Acceptance criteria:</b> If the 10 adjusted hydraulic control pressures (or actual control pressures for tubing-pressure-insensitive valves) do not repeat within <math>\pm 10</math> % of their average, or <math>\pm 0.7</math> MPa (<math>\pm 100</math> psi), whichever is greater, the test valve fails.</p> | <p>For each operating cycle:</p> <ul style="list-style-type: none"> <li>— full open hydraulic control pressure (and actual test section pressure)</li> <li>— full closed hydraulic control pressure (and actual test section pressure)</li> </ul> <p>Calculate the following:</p> <ul style="list-style-type: none"> <li>— adjusted hydraulic control pressure; fully closed</li> <li>— average of adjusted hydraulic control pressure; fully closed</li> <li>— adjusted hydraulic control pressure; fully open</li> <li>— average of adjusted hydraulic control pressure; fully open</li> </ul> |
| 4)   | Connect an empty tube from the SCSSV hydraulic control line port to a container filled with water at atmospheric pressure and ambient temperature. Position the tube so any gas bubbles from the hydraulic control line port can be observed.   | w)   |
| 5)   | With the SCSSV bore filled with nitrogen gas at ambient temperature and specified pressure, wait a minimum of 3 min (and up to a maximum of 10 min if specified by the supplier/manufacturer) and then observe for gas bubble leakage continuously for a minimum of 5 min.  | <ul style="list-style-type: none"> <li>— time at start of 3-min waiting period</li> <li>— time at end of 3-min waiting period</li> </ul>   |

| Step | Procedure Step and Acceptance Criteria  | Data to Be Recorded   |
|------|---|---|
|      | <b>Acceptance criteria:</b> If more than 5 bubbles are observed during the observation period, the test valve fails.  | <ul style="list-style-type: none"> <li>— time at start of 5-min waiting period</li> <li>— time at end of 5-min waiting period</li> <li>— leak detected? (yes or no)</li> </ul>  |
| 6)   | Repeat Steps 2) through 5) using a SCSSV test section pressure of 75 % of the RWP (allowable range of 70 % to 80 % of RWP) of the SCSSV.  | x)  |
| 7)   | Bleed the test section pressure to zero pressure using supplier/manufacture's procedures.   | y)  |
| 8)   | <p>Open the SCSSV with zero pressure in the test section. Adjust and stabilize the hydraulic control pressure to at least the minimum supplier/manufacture's recommended hold-open pressure. Isolate the hydraulic control pressure from the source. Monitor for a minimum of 5 min.</p> <p><b>Acceptance criteria:</b> If a loss of the hydraulic control line pressure greater than 5 % of the applied pressure is detected after stabilization, the test valve fails the test.</p> | <ul style="list-style-type: none"> <li>— start time at pressure</li> <li>— end time at pressure</li> <li>— beginning control pressure</li> <li>— ending control pressure</li> <li>— calculated pressure loss over minimum of 5 min</li> <li>— test passed? (yes or no)</li> </ul> |

## G.4 Differential Opening Testing

### G.4.1 General

**G.4.1.1** The purpose of the differential opening test is to evaluate the effects of slam open operation on an SSSV closure mechanism as well as determining the maximum differential pressure for opening a non-self-equalizing valve.

**G.4.1.2** All tests shall be conducted using nitrogen gas as the test medium.

**G.4.1.3** If a self-equalizing valve successfully completes Section G.5 testing with nitrogen as the test medium, it satisfies the requirements of the differential opening test.

### G.4.2 Procedure

**Table G.5—Closure Mechanism Differential Slam Open Test**

| Step | Procedure Step and Acceptance Criteria   | Data to Be Recorded  |
|------|--|--|
| 1)   | Identify components of the SSSV that are affected by rapid slam open occurrences.  | — measure and record the relevant dimensions of those identified components prior to commencing the test |
| 2)   | Assemble the SSSV per defined procedures.  |  |
| 3)   | Install the SSSV into an appropriate test stand with adequate upstream volume. Use a 1/4-in. OD control line with a minimum length of 304.8 m (1000 ft) or an equivalent volume. | Manufacturer, brand name, and type (oil-based, water based) of control fluid used for all cycles         |

| Step | Procedure Step and Acceptance Criteria   | Data to Be Recorded   |
|------|--|---|
| 4)   | Open and close the SSSV five times with zero pressure in the test section.   | For each of 5 operating cycles:<br>— full open hydraulic control pressure and maximum applied hydraulic control pressure<br>— full closed hydraulic control pressure<br><br>Calculated average of 5 operating cycles:<br>— full open hydraulic control pressure<br>— full closed hydraulic control pressure |
| 5)   | With the SSSV closed, apply 1.4 MPa $\pm$ 0.07 MPa (200 psi $\pm$ 10 psi) nitrogen pressure upstream of the SSSV. Wait a minimum of 1 min, then measure any nitrogen leakage through the closure mechanism.<br><br><b>Acceptance criteria:</b> If the leakage rate is greater than 0.14 m <sup>3</sup> /min (5 scf/min), the test valve fails. | — SSSV test section pressure<br>— time at start of waiting period<br>— time at completion of waiting period<br>— measured gas leakage rate<br>— test passed? (yes or no)  |
| 6)   | Increase pressure to 100 % $\pm$ 5 % of the RWP of the SSSV. Wait a minimum of 1 min, then measure any nitrogen leakage through the closure mechanism.<br><br><b>Acceptance criteria:</b> If the leakage rate is greater than 0.14 m <sup>3</sup> /min (5 scf/min), the test valve fails.  | — SSSV test section pressure<br>— time at start of waiting period<br>— time at completion of waiting period<br>— measured gas leakage rate<br>— test passed? (yes or no)  |
| 7)   | Maintain 100 % $\pm$ 5 % of the RWP upstream of the SSSV while maintaining downstream pressure at zero.  | Valve upstream test pressure (measured)   |
| 8)   | Apply the maximum rated hydraulic control pressure to the SSSV hydraulic system.   | Applied hydraulic control pressure (measured)   |
| 9)   | For nonequalizing SSSV—Apply pressure to the downstream of the closure mechanism until the closure mechanism rapidly opens.<br><br>For self-equalizing SSSV—Allow the valve to equalize across the closure mechanism until the closure mechanism rapidly opens.  | For nonequalizing valve:<br>— downstream test pressure at which the valve opens (measured)<br><br>For self-equalizing valve:<br>— valve upstream test pressure (measured) prior to valve opening<br>— downstream test pressure at which the valve opens (measured)  |
| 10)  | Repeat Steps 7) through 9), four more times for a total of five operating cycles.  |   |

| Step | Procedure Step and Acceptance Criteria  | Data to Be Recorded  |
|------|---|--|
| 11)  | <p>Verify proper valve operation by performing a minimum of five operating cycles with zero pressure in the test section and compare to the average control pressures calculated in Step 4).</p> <p><b>Acceptance criteria:</b> Compare the average of the full open hydraulic control pressure calculated in this step to the average of the full open hydraulic control pressure calculated in Step 4). The allowable deviation between the averages is 10 %.</p> | <p>For each of 5 operating cycles:</p> <ul style="list-style-type: none"> <li>— full open hydraulic control pressure and maximum applied hydraulic control pressure</li> <li>— full closed hydraulic control pressure</li> </ul> <p>Calculated average of 5 operating cycles:</p> <ul style="list-style-type: none"> <li>— full open hydraulic control pressure</li> <li>— full closed hydraulic control pressure</li> <li>— test passed? (yes or no)</li> </ul> |
| 12)  | <p>Apply <math>1.4 \text{ MPa} \pm 0.07 \text{ MPa}</math> (<math>200 \text{ psi} \pm 10 \text{ psi}</math>) pressure upstream of the SSSV. Wait a minimum of 1 min, then measure any leakage through the closure mechanism.</p> <p><b>Acceptance criteria:</b> If the leakage rate is greater than <math>0.14 \text{ m}^3/\text{min}</math> (<math>5 \text{ scf/min}</math>), the test valve fails.</p>  | <ul style="list-style-type: none"> <li>— SSSV test section pressure</li> <li>— Time at start of waiting period</li> <li>— Time at completion of waiting period</li> <li>— Measured gas leakage rate</li> <li>— Test passed? (yes or no)</li> </ul>   |
| 13)  | <p>Apply <math>100 \% \pm 5 \%</math> of the RWP of the SSSV. Wait a minimum of 1 min, then measure any nitrogen leakage through the closure mechanism.</p> <p><b>Acceptance criteria:</b> If the leakage rate is greater than <math>0.14 \text{ m}^3/\text{min}</math> (<math>5 \text{ scf/min}</math>), the test valve fails.</p>   | <ul style="list-style-type: none"> <li>— SSSV test section pressure</li> <li>— Time at start of waiting period</li> <li>— Time at completion of waiting period</li> <li>— Measured gas leakage rate</li> <li>— Test passed? (yes or no)</li> </ul>   |
| 14)  | <p>Disassemble and inspect the SSSV. An evaluation shall be performed if the leakage rates in Steps 12) and 13) significantly increase from the initial leakage rates reported in Steps 5) and 6), respectively.</p>  | <ul style="list-style-type: none"> <li>— Repeat the measurements carried out in Step 1)</li> <li>— Any abnormal wear, distortion or deformation, or other damage shall be recorded</li> </ul>  |

## G.5 Equalization Mechanism Endurance Testing

**G.5.1** The purpose of the equalization mechanism endurance test is to evaluate the endurance, operation, and sealing performance of a SSSV self-equalizing mechanism when opened repeatedly against maximum unequalized opening pressure differential. This testing shall be performed per Table G.6.

**G.5.2** This test shall be conducted using the supplier/manufacturer's specified fluid as the test medium unless otherwise specified.

**G.5.3** If this test is completed with nitrogen as the test medium, it satisfies the requirements of the differential opening test.

**Table G.6—Equalization Mechanism Endurance Test**

| Step | Procedure Step and Acceptance Criteria  | Data to Be Recorded   |
|------|---|---|
| 1)   | Identify components of the SSSV that are affected by multiple equalization cycles.  | Measure and record the relevant dimensions of those identified components prior to commencing the test  |
| 2)   | Assemble the SSSV per defined procedures.   |   |
| 3)   | Install the SSSV into an appropriate test stand with adequate upstream volume and fill with supplier/manufacture's specified fluid. Use a 1/4-in. OD control line with a minimum length of 304.8 m (1000 ft) or an equivalent volume.   | <ul style="list-style-type: none"> <li>— Manufacturer, brand name, and type (oil-based, water based) of control fluid used for all cycles</li> <li>— Test fluid</li> </ul>  |
| 4)   | Heat the SSSV to the maximum rated operating temperature and stabilize at or above the maximum rated operating temperature. Maintain the maximum rated operating temperature until the end of Step 14).   | temperature   |
| 5)   | Open and close the SSSV five times with zero pressure in the test section.  | For each of 5 operating cycles: <ul style="list-style-type: none"> <li>— full open hydraulic control pressure</li> <li>— full closed hydraulic control pressure</li> </ul> Calculated average of 5 operating cycles: <ul style="list-style-type: none"> <li>— full open hydraulic control pressure</li> <li>— full closed hydraulic control pressure</li> </ul>   |
| 6)   | With the SSSV closed, apply 1.4 MPa $\pm$ 0.07 MPa (200 psi $\pm$ 10 psi) nitrogen pressure upstream of the SSSV. Wait a minimum of 1 min, then measure any nitrogen leakage through the closure mechanism.<br><br><b>Acceptance criteria:</b> If the leakage rate is greater than 0.14 m <sup>3</sup> /min (5 scf/min), the test valve fails.          | <ul style="list-style-type: none"> <li>— SSSV test section pressure</li> <li>— Time at start of waiting period</li> <li>— Time at completion of waiting period</li> <li>— Measured gas leakage rate</li> <li>— Test passed? (yes or no)</li> </ul>  |
| 7)   | With the SSSV closed, apply 100 % $\pm$ 5 % of the RWP upstream of the SSSV while maintaining downstream pressure at zero. Wait a minimum of 1 min, then measure any nitrogen leakage through the closure mechanism.<br><br><b>Acceptance criteria:</b> If the leakage rate is greater than 0.14 m <sup>3</sup> /min (5 scf/min), the test valve fails. | <ul style="list-style-type: none"> <li>— SSSV test section pressure</li> <li>— Time at start of waiting period</li> <li>— Time at completion of waiting period</li> <li>— Measured gas leakage rate</li> <li>— Test passed? (yes or no) valve bore upstream test pressure (measured)</li> <li>— Time at start of waiting period</li> <li>— Time at completion of waiting period</li> <li>— Measured gas leakage rate</li> </ul> |

| Step | Procedure Step and Acceptance Criteria  | Data to Be Recorded  |
|------|---|--|
|      |   | — Test passed? (yes or no)   |
| 8)   | If required, establish pressure upstream of the SSSV closure mechanism at the maximum supplier/manufacture specified unequalized opening pressure differential.   | — differential pressure across the closure mechanism   |
| 9)   | Open the SSSV.  | Hydraulic control pressure at equalization (measured)  |
| 10)  | Close the SSSV and apply 100 % $\pm$ 5 % of the RWP upstream below the shut closure mechanism, maintain downstream pressure at zero.  | z)   |
| 11)  | Repeat Steps 8) through 10), a total of 20 operating cycles.<br>On the 20th cycle, omit Step 10) and bleed the test section pressure to zero.   | aa)  |
| 12)  | Close and open the SSSV with zero pressure in the test section.<br><b>Acceptance criteria:</b> The full closed and full open hydraulic control pressures from the last cycle shall be within the supplier/manufacture's ratings. If the pressures are out of tolerance the test valve fails the test.   | — Full open hydraulic control pressure<br>— Full closed hydraulic control pressure<br>— Test passed? (yes or no)   |
| 13)  | Close the SSSV and apply 1.4 MPa $\pm$ 0.07 MPa (200 psi $\pm$ 10 psi) nitrogen pressure upstream of the SSSV. Wait a minimum of 1 min, then measure any nitrogen leakage through the closure mechanism.<br><b>Acceptance criteria:</b> If the leakage rate is greater than 0.14 m <sup>3</sup> /min (5 scf/min), the test valve fails.             | — SSSV test section pressure<br>— Time at start of waiting period<br>— Time at completion of waiting period<br>— Measured gas leakage rate<br>— Test passed? (yes or no)   |
| 14)  | With the SSSV closed, apply 100 % $\pm$ 5 % of the RWP upstream of the SSSV while maintaining downstream pressure at zero. Wait a minimum of 1 min, then measure any nitrogen leakage through the closure mechanism.<br><b>Acceptance criteria:</b> If the leakage rate is greater than 0.14 m <sup>3</sup> /min (5 scf/min), the test valve fails. | — SSSV test section pressure<br>— Time at start of waiting period<br>— Time at completion of waiting period<br>— Measured gas leakage rate<br>— Test passed? (yes or no)<br>— Valve bore upstream test pressure (measured)<br>— Time at start of waiting period<br>— Time at completion of waiting period<br>— Measured gas leakage rate<br>— Test passed? (yes or no) |
| 15)  | Disassemble and inspect the SSSV. An evaluation shall be performed if the leakage rates in Steps 13) and 14) significantly increase from the initial leakage rates reported in Steps 6) and 7), respectively.   | — repeat the measurements carried out in Step 1)<br>— any abnormal wear, distortion or deformation, or other damage shall be recorded  |

## **G.6 Special Feature Validation**

Special features in V1 SSSV shall be validated by testing as specified by the supplier/manufacture to the rated limits.

## **G.7 SSSV Electronics Qualification (where applicable)**

Electronics shall be validated per API 17F, Section 9.2.3 by the supplier/manufacture to their rated limits to documented procedures including acceptance criteria and with the results approved by a qualified person other than the person responsible for the design.

NOTE      API 17F, Annex F describes other tests for electronically operated subsea equipment.

## **Annex H** **(normative)**

### **Verification and Validation Requirements for High-pressure, High-temperature Environment**

#### **H.1 General**

**H.1.1** This annex defines the additional verification and validation requirements that shall be followed in designing and manufacturing V1-H rated SSSV and was developed using the suggested guidelines of API 1PER15K-1. This annex applies to equipment with a working pressure rating greater than 103.4 MPa (15,000 psig) or a temperature rating greater than 176.7 °C (350 °F) or when specified by the user/purchaser.

**H.1.2** The requirements of this annex are in addition to Sections 1 through 8 in this specification.

#### **H.2 Functional Specification—Environmental Conditions**

In addition to Section 4, the user/purchaser should provide:

- maximum flowing temperature at the SSSV setting depth;
- shut in static temperature at the SSSV setting depth;
- as applicable, the duration that the SSSV will operate at each temperature;
- as applicable, the expected well life data to be utilized in fatigue screening/analysis.

#### **H.3 Technical Specification**

##### **H.3.1 General**

**H.3.1.1** The supplier/manufacture shall prepare and provide to the user/purchaser the technical specification that responds to the requirements defined in the functional specification.

**H.3.1.2** The user/purchaser should review the technical specifications and confirm to the supplier/manufacture that the SSSV meets the requirements of their functional specification. Records of the review should be provided to the supplier/manufacture.

**H.3.1.3** If corrosion or corrosion/erosion allowances are included in the design, the design verification and validation shall consider those allowances.

## **H.3.2 Materials**

### **H.3.2.1 Metals**

#### **H.3.2.2 Temperature Effects**

For design purposes, the supplier/manufacturer shall utilize temperature derated yield strength (see 5.3.2.5); in addition, the testing shall be conducted in accordance with ASTM E21 for yield strength. The test material samples shall be taken from production heat(s) representative of those to be used for the intended components and shall be removed from midwall or midradius unless the equipment supplier/manufacturer determines that a more appropriate testing location is required. Alternate testing locations may be selected due to a component's highest stress location or, for cold worked material, lowest strength location due to material anisotropy.

#### **H.3.2.3 Environmental Effects**

For V1-H rated SSSVs, the compatibility of metals with well fluids specified by the user/purchaser in the functional specification shall be evaluated and documented by a qualified person. Such evaluation may come from the supplier/manufacturer, user/purchaser or other technical resource.

#### **H.3.2.4 Other Requirements**

**H.3.2.4.1** Castings **shall** be qualified and compliant to the CSL 4 requirements of API 20A.

**H.3.2.4.2** Structural components used for pressure-containing/controlling components or components integral to the tubing string shall not contain welds other than inlay or overlay welds (i.e., deposits of corrosion resistant alloy or hard facing).

**H.3.2.4.3** Welding procedures and welders/welding operators shall be qualified in accordance with applicable internationally recognized standards such as ASME BPVC Section IX. In addition, welds for sour service shall be qualified in accordance with ANSI/NACE MR0175 (ISO 15156).

**H.3.2.4.4** Components that require postweld heat treatment after welding shall be hardness tested to confirm acceptable base material hardness per the supplier/manufacturer's material specification.

**H.3.2.4.5** Welds shall be subjected to require final surface NDE (see 6.4.7.5 or 6.4.7.6), after all heat treatment and machining.

#### **H.3.2.5 Nonmetals**

#### **H.3.2.6 Functional Requirements**

**H.3.2.6.1** The user/purchaser should provide the following additional information required for the selection of nonmetals as applicable:

- completion fluid composition: bromides (Zn, Ca, Na), formates (Cs, K, Na), chlorides (K, Ca, Na), acetates (Cs);
- mud type (oil-based, water-based, pseudo-oil-based) and mud density (s.g),
- aromatic solvents (type/amount);
- inhibitor treatments (type, concentration, and pH);

- hydraulic control line fluid.

**H.3.2.6.2** In cases where the user/purchaser has access to historical data and/or research that are applicable to the functional specification, the user/purchaser should state to the supplier/manufacture which material(s) has the ability to perform as required within a similar environment.

### **H.3.2.7 Compound Selection**

**H.3.2.7.1** The supplier/manufacture shall have a documented procedure that provides for the selection of nonmetallic material type and specific compounds by qualified personnel. The documented procedure(s) shall, as a minimum, include:

- functional requirements;
- technical specifications;
- operational parameters;
- environmental conditions;
- compound availability;
- material type and compound use history;
- geometric component design;
- required service life;
- required approvals of material type and compound selection;
- required documentation of material type and compound selection.

**H.3.2.7.2** The material type and specific compound shall be selected in accordance with the supplier/manufacture's procedure. Records of material type and compound selection shall become a portion of the design documentation of the product (see 6.2). If the user/purchaser provides a material selection, 5.3.3.1 shall also apply.

### **H.3.2.8 Elastomeric Compound Assessment**

**H.3.2.8.1** The supplier shall conduct compound assessment testing per documented procedures containing acceptance criteria as follows:

- a) When required by the functional specification, rapid gas decompression (RGD) testing shall be conducted by the supplier/manufacture on an elastomeric material per ISO 23936-2, Annex B with an acceptance criterion of 0 or 1 for the component cross section. Unless agreed otherwise between the supplier/manufacture and the user/purchaser, testing parameters shall be:
  - fluid composition;
  - test temperature: 212 °F (±5 °F) [100 °C (±2 °C)];
  - test pressure: 2176 psi (+145 psi, -73 psi) [15 MPa (+1, -0.5 MPa)];

— depressurization rate: 290 psi/min ( $\pm 29$  psi/min) [2 MPa/min ( $\pm 0.2$  MPa/min)];

- b) Ageing testing shall be conducted by the supplier/manufacturer on an elastomeric compound per ISO 23936-2, Clause 7.2. This evaluation shall include the determination of an effective service life. The service temperature shall meet or exceed the maximum rated operating temperature of the SSSV.

**H.3.2.8.2** Records of RGD testing, ageing testing, and final compound approval shall be included in the design documentation of the product (see 6.2).

NOTE 1 RGD and ageing testing alone can be insufficient to determine the service life or performance of a molded component. Additional testing such as thermal cycling, pressure reversals, dynamic sealing, static sealing, rotary motion, or combinations of these may be required.

NOTE 2 The test parameters of ageing testing per ISO 23936-2 require agreement between the user/purchaser and the supplier/manufacturer for test fluid(s), test temperatures, test pressures, test times, and specimen shape.

### **H.3.2.9 Product Specification**

**H.3.2.9.1** In addition to the specification requirements of 5.3.3.3, the supplier/manufacturer shall establish requirements and acceptance criteria for all elastomers and thermoplastic components using the following parameters determined per the applicable specification listed in Table H.1.

**Table H.1—Nonmetal Material Additional Specification Requirements**

| Parameter <sup>a</sup>  | Specification                      |
|---|------------------------------------|
| Component dimension   | Dimensioned and toleranced drawing |
| Density   | ASTM D792, ASTM D297               |
| <sup>a</sup> The specification shall specify whether the parameters are measured on a production sample or an actual component. |                                    |

**H.3.2.9.2** For elastomeric materials, the supplier/manufacturer's specification shall include requirements and acceptance criteria for the following parameters determined per the applicable

**specification or internationally recognized equivalent listed in Table H.2. Table H.2—Elastomeric Material Additional Specification Requirements**

| Parameter <sup>a</sup>   | Specification           |
|--|-------------------------|
| Tensile strength   | ASTM D1414 or ASTM D412 |
| Tensile modulus  | ASTM D1414 or ASTM D412 |
| Elongation   | ASTM D1414 or ASTM D412 |
| Compression set  | ASTM D 395              |
| Tear resistance  | ISO 34-2 or ASTM D624   |
| Low temperature limit of brittleness   | ISO 812                 |
| Low temperature stiffening/flexibility   | ISO 1432                |
| <sup>a</sup> The specification shall detail whether the parameters are measured on a production sample or an actual component. |                         |

For thermoplastic materials, the supplier/manufacturer's specification shall include requirements and acceptance criteria for the following parameters determined per the applicable specification or internationally recognized equivalent listed in Table H.3.

**Table H.3—Thermoplastic Material Additional Specification Requirements**

| Parameter <sup>a</sup>   | Specification      |
|--|--------------------|
| Tensile strength (at either break or yield as applicable)  | ASTM D638 or D1708 |
| Elongation (at either break or yield as applicable) <sup>b</sup>   | ASTM D638 or D1708 |
| Modulus of elasticity <sup>b</sup>   | ASTM D638          |
| Flexural modulus   | ASTM D790          |
| Creep failure as applicable  | ASTM D2990         |
| <sup>a</sup> The specification shall detail whether the parameters are measured on a production sample or an actual component. |                    |
| <sup>b</sup> Modulus of elasticity and yield properties are only required for materials tested to ASTM D638.                   |                    |

#### **H.3.2.10 Process Specification**

The supplier/manufacture shall develop and/or receive from the subsupplier of nonmetal components a process specification that details the controls necessary for the production of the nonmetal item to meet the supplier/manufacture's specifications.

#### **H.3.2.11 Component Validation**

To validate a nonmetal component to this specification, the following shall be performed.

- a) First-article component and/or sample(s) inspections per the supplier/manufacture's specification, documented procedures, and acceptance criteria.
- b) Nondestructive inspections to validate that the component conforms to the supplier/manufacture's specification(s) and dimensional requirements.
- c) Destructive inspections to validate the component or sample conforms to the supplier/manufacture's specification(s) and dimensional requirements if required.
- d) Where the SSSV product validation does not encompass all loading scenarios, perform component validation testing to assure component suitability for use at SSSV limits of loading(s) and maximum/minimum operating temperatures.
- e) Test results shall be documented and approved by a qualified person. Records of first article inspection, nondestructive inspections, destructive inspections, component validation testing, and final component/supplier approval shall become a portion of the design documentation of the product (see 6.2).

#### **H.3.2.12 Bond Strength Validation**

**H.3.2.12.1** If the component design requires the elastomer or thermoplastic to be bonded to a substrate, the adhesive force required for component performance shall be defined and tested with a bond peel test.

**H.3.2.12.2** The bond peel test shall conform to the requirements of ASTM D429, or an equivalent supplier/manufacture referenced testing program that includes measured acceptance criteria.

**H.3.2.12.3** A minimum of three representative sample components shall be evaluated and all tested samples shall meet or exceed the defined acceptance criteria.

**H.3.2.12.4** Production bonding processes shall be periodically evaluated to documented procedures by qualified persons.

#### **H.3.2.13 Other Materials**

Nonmetallic materials and components that are not manufactured or supplied under the controls of conventional elastomeric or polymeric materials in H.3.2.2 shall have a documented material specification and the necessary controls of the material to verify conformance to requirements. These requirements apply to the nonmetallic materials and components utilized within each SSSV device validated to the requirements of this specification, including but not limited to

- circuit boards;
- electronic/electrical connections;

- wire(s);
- electrical/electronic components;
- batteries;
- sensors;
- ceramic components of all types;
- fluids, lubricants;
- carbon fiber components;
- rupture discs;
- frangible components.

### **H.3.3 Design Verification**

**H.3.3.1** The user/purchaser should determine the maximum anticipated shut-in tubing pressure (SITP) at the SSSV.

**H.3.3.2** The user/purchaser should specify the RWP to be greater than the SITP.

**H.3.3.3** The SSSV shall conform to the requirements of 5.4 and the following additional requirements.

- a) For all metallic components integral to the tubing string and closure mechanism, an elastic-plastic FEA shall be performed using ASME BPVC Section VIII, Division 2 Paragraph 5.2.4 or ASME BPVC Section VIII, Division 3, KD 231.2, using the supplier/manufacturer documented design margins and load factors. These FEA methods require a true stress, true strain curve developed using ASME BPVC Section VIII, Division 2, Annex 3.D or Section VIII, Division 3, Paragraph KD-231.4 or the true stress, true strain data may be obtained via piecewise linear fit of the test data per ASTM E21 for elevated temperature, ASTM A370/E8 for room temperature.
- b) Localized stress discontinuities and localized yielding shall be evaluated by a qualified person to determine if the design is acceptable or if additional analysis is required.
- c) When FEA has identified plastic strain in excess of 0.2 %, a ratcheting analysis shall be performed per ASME BPVC Section VIII, Division 3, Paragraph KD-234 or ASME BPVC Section VIII, Division 2, Paragraph 5.5.7.
- d) A fatigue screening shall be performed using ASME BPVC Section VIII, Division 2 Paragraph 5.2.4 or ASME BPVC Section VIII, Division per ASME BPVC Section VIII, Division 2, Paragraph 5.5.2. If the design exhibits fatigue sensitivity, conduct a fatigue analysis per API 579/ASME FFS-1 using a safety factor of 2 on anticipated operating life.

**NOTE** Load cases to be used in the fatigue screening are provided in the functional specification.

- f) The supplier/manufacturer shall perform combined loading analysis and generate the rated performance envelope (see Annex M).

### **H.3.4 Design Validation**

#### **H.3.4.1 Validation Testing**

To validate a SSSV to validation grade V1-H, the following testing shall be performed: All the validation grade V1 tests per Annex G, a combined load operational test per Annex J at maximum rated operating temperature and a dynamic seal system test per Annex L.

The supplier/manufacture shall conduct a review to determine if validation testing per this annex sufficiently validates the design, for the functional requirements in the intended application, including any electronics used in the design of the SSSV. If it does not, a failure modes and effects analysis (FMEA) shall be conducted per the requirements of a national or international standard or a documented supplier/manufacture procedure to determine any additional validation testing which may be required. Any validation testing identified as a result of the FMEA shall be performed.

NOTE FMEA methodology is described in the following standards:

- API 1PER15K-1;
- SAE ARP 5580;
- IEC 60812;
- SAE J1739;
- AIAG FMEA-4;
- ISO TS 16949.

#### **H.3.4.2 Post-validation Test Analysis**

A complete surface NDE shall be successfully performed per 6.4.7.5 or 6.4.7.6 on critically stressed components after completion of the combined load operational test.

### **H.3.5 Scaling of HPHT Rated SSSV**

#### **H.3.5.1 Scaling of Metals**

The analysis and selection of the scaled material shall follow the same process and functional approvals as the validated product (see 5.8). In addition, a materials engineer, metallurgist or a qualified person with corrosion and material training shall review material selection for acceptance. The user/purchaser should review and accept the scaled material selection.

#### **H.3.5.2 Scaling of Nonmetal Seal Components**

Scaling of nonmetal component validation test results shall be documented and approved by a qualified person. In addition to 5.3.3.3.2 c), the following additional limitations on scaling of nonmetallic seal components shall be followed:

- a) the compound of construction shall be identical for the scaled seal component and the validated seal component and,
- b) deflections in the scaled design shall not create an extrusion gap greater than the validated design.

## **H.4 Supplier/Manufacturer Requirements**

### **H.4.1 Metals Verification**

**H.4.1.1** The yield strength for components or parts that are integral to the tubing string and the closure mechanism shall be documented by the supplier/manufacturer at maximum rated operating temperature per ASTM E21.

**H.4.1.2** The representative sample part shall be approved by a qualified person and shall represent the section of the component or part from which material properties are to be established.

**H.4.1.3** The test specimen shall come from midwall or midradius except for cold-worked alloys, in which case the testing location shall be selected based on material anisotropy or highest stress location.

**H.4.1.4** The modulus of elasticity shall be established for maximum rated operating temperature.

### **H.4.2 Functional Test Requirements**

The functional test pressure used in Annex C shall be a minimum of 1.25 times RWP.

### **H.4.3 Quality plan**

**H.4.3.1** When requested by the user/purchaser, the supplier/manufacturer shall prepare and the user/purchaser should approve, in writing, a quality plan conforming to the guidelines of ISO 10005 and 6.4 for each order placed.

**H.4.3.2** Changes to the approved quality plan shall be further approved by the same process as used for the original plan. The quality plan shall become a part of the retained documentation (see 6.2.1).

### **H.4.4 Final Design Review**

The supplier/manufacturer and the user/purchaser should conduct a final design review to assure that the SSSVs and secondary tools are suitable for the applicable HPHT environment.

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## **Annex I (informative)**

### **Extended Sand Endurance Testing**

#### **I.1 General**

**I.1.1** This annex contains additional requirements for SCSSVs when specifically requested by the user/purchaser. If this test was successfully performed and documented on the same size, type, model, and design to the requirements defined herein, it can be considered as fulfilling the requirements of this annex.

**I.1.2** To meet the requirements of this annex, testing shall be completed in conformance with the acceptance criteria and shall be completed without any repair or redress of the test valve.

**I.1.3** All gas tests shall be conducted using nitrogen gas as the test medium.

**I.1.4** Unless otherwise specified, gas pressure-relieving (bleed-down) operations should be performed at a maximum rate of 0.7 MPa/min (100 psi/min) at pressures less than 10.3 MPa (1500 psi). The supplier/manufacturer may specify gas pressure-relieving (bleed-down) operations.

**I.1.5** The SCSSV shall be oriented vertically for all tests unless specified otherwise by the user/purchaser.

**I.1.6** The SCSSV shall have passed the functional test specified in Annex C prior to commencement of any tests in this annex.

**I.1.7** Substantive design changes to any component of a SCSSV shall require that the affected validation test(s) are repeated.

**I.1.8** Validation testing per this annex shall meet the requirements of 5.5.13.

#### **I.2 Test Requirements**

##### **I.2.1 General**

The purpose of the extended sand endurance test is to validate the SCSSV closure mechanism functionality and its ability to seal in the presence of sand, to the user/purchaser specified operating cycles.

##### **I.2.2 Procedure**

**I.2.2.1** The user/purchaser may specify the following test parameters:

- number of operating cycles;
- operating temperature.

**I.2.2.2** If either, or both of the parameters in I.2.2.1 are not specified by the user/purchaser, the following parameters shall be used:

- the number of operating cycles shall be 240 cycles;
- the test shall be conducted at ambient temperature.

**I.2.2.3** Test shutdowns that involve circulating pump(s) to be stopped, shall be recorded; the test may be resumed after the sand concentration is established per Step 9) and have the following restart requirements:

- planned test shutdowns shall only be performed upon completion of a step in its entirety;
- unplanned test shutdowns shall require testing to be resumed from the end of the last successfully completed step.

**I.2.2.4** The supplier/manufacture shall conduct the extended sand endurance test shall be performed per Table I.1:

**Table I.1—Extended Sand Endurance Test**

| Step | Procedure Step and Acceptance Criteria  | Data to Be Recorded   |
|------|---|---|
| 1)   | Record test data as specified.  | <ul style="list-style-type: none"> <li>— date</li> <li>— location</li> <li>— test stand (or apparatus) identification</li> </ul>  |
| 2)   | <p>Open and close the SCSSV five times with zero pressure in the test section.</p> <p><b>Acceptance criteria:</b> Each control pressure shall repeat within <math>\pm 5\%</math> of the average pressure of the five valve operating cycles as well as falling within the supplier/manufacture's specified control pressure tolerance. If each pressure is not within these the limits, the test valve fails.</p>   | <p>For each of 5 operating cycles:</p> <ul style="list-style-type: none"> <li>— full open hydraulic control pressure</li> <li>— full closed hydraulic control pressure</li> </ul> <p>Calculated average of 5 operating cycles:</p> <ul style="list-style-type: none"> <li>— full open hydraulic control pressure</li> <li>— full closed hydraulic control pressure</li> <li>— test passed? (yes or no)</li> </ul> |
| 3)   | <p>Close the SCSSV and apply <math>1.4 \text{ MPa} \pm 0.07 \text{ MPa}</math> (<math>200 \text{ psi} \pm 10 \text{ psi}</math>) nitrogen pressure upstream of the SCSSV. Wait a minimum of 1 min, then measure any nitrogen leakage through the closure mechanism.</p> <p><b>Acceptance criteria:</b> If the leakage rate is greater than <math>0.14 \text{ m}^3/\text{min}</math> (<math>5 \text{ scf/min}</math>), or if any body joint leakage (tubing-retrievable only) is detected, the test valve fails.</p> | <ul style="list-style-type: none"> <li>— SCSSV bore pressure</li> <li>— time at start of waiting period</li> <li>— time at completion of waiting period</li> <li>— measured gas leakage rate body leakage detected (TRSV only)? (yes or no)</li> </ul>  |
| 4)   | <p>Repeat Step 3) at 25 % of the RWP (allowable range of 20 % to 30 % of RWP) of the SSSV.</p> <p><b>Acceptance criteria:</b> If the leakage rate is greater than <math>0.14 \text{ m}^3/\text{min}</math> (<math>5 \text{ scf/min}</math>), or if any body joint leakage (tubing-retrievable only) is detected, the test valve fails.</p>  | <ul style="list-style-type: none"> <li>— SCSSV bore pressure</li> <li>— time at start of waiting period</li> <li>— time at completion of waiting period</li> <li>— measured gas leakage rate</li> <li>— body leakage detected (TRSV only)? (yes or no)</li> </ul>   |
| 5)   | Bleed the pressure upstream of the SCSSV to zero.   | bb)   |

| Step | Procedure Step and Acceptance Criteria   | Data to Be Recorded  |
|------|--|--|
| 6)   | Apply water pressure upstream of the SCSSV closure mechanism at 100 % of the RWP (allowable range of 95 % to 100 %) of the valve. Record the SCSSV bore pressure and the time at which pressure was applied to the valve.  | <ul style="list-style-type: none"> <li>— valve bore test pressure</li> <li>— time at which test pressure is applied</li> </ul>   |
| 7)   | <p>Wait for a minimum of 3 min after applying water pressure upstream of the SCSSV closure mechanism before beginning collection of water leakage from the downstream bleed valve.</p> <p>Continuously collect water leakage for a period of 5 min. Calculate and record the average leakage rate per minute.</p> <p><b>Acceptance criteria:</b> If the average leakage rate during the collection period exceeds 10 cm<sup>3</sup>/min (0.6 in.<sup>3</sup>/min) of water, or if external body leakage is detected (tubing-retrievable only), the test valve fails.</p> | <ul style="list-style-type: none"> <li>— time at start of leakage test</li> <li>— time at end of leakage test</li> <li>— average leakage rate at test pressure</li> <li>— body leakage detected (TRSV only)? (yes or no),</li> <li>— test step passed? (yes or no)</li> </ul>                          |
| 8)   | Prepare a mixture consisting of sand and water.  | cc)  |
| 9)   | Determine sand content using a bulk measurement ratio. Adjust sand content to 2 % (1.5 % to 2.5 % acceptable) by volume by adding approximately equal quantities by volume of 140/200, 200/270, and 270/325 U.S. mesh sand or diluting mixture with freshwater.  | <ul style="list-style-type: none"> <li>— sand concentration (%) at start of circulation period</li> </ul>  |
| 10)  | Heat the fluid to the user/purchaser specified operating temperature or a minimum of ambient if not specified.   | <ul style="list-style-type: none"> <li>— record the temperature when the specified operating temperature is reached and has stabilized, if applicable</li> </ul>   |
| 11)  | Adjust the mixture circulation rate to a minimum of 2.1 m/s (7 ft/s) calculated at the minimum internal diameter of the SCSSV.   | <ul style="list-style-type: none"> <li>— time at start of mixture circulation through valve</li> <li>— flow rate at start of circulation period</li> </ul>   |
| 12)  | Open the SCSSV and circulate the mixture through the SCSSV at the specified rate for a minimum of 2 h unless otherwise specified by the user/purchaser, and then close the SCSSV against the specified rate.   | <ul style="list-style-type: none"> <li>— time at valve closure (against mixture flow)</li> <li>— mixture flow rate</li> <li>— full closed hydraulic control pressure</li> <li>— flow 15 s after hydraulic control pressure reaches zero</li> <li>— time to close</li> </ul>                            |
| 13)  | <p>With no applied pressure in the test section, open and close the SCSSV a total of 10 % of specified operating cycles.</p> <p>Circulate the mixture through the SCSSV at the specified rate for a minimum of 5 min every 5 cycles.</p>   | <p>For a minimum of the last 10 cycles record:</p> <ul style="list-style-type: none"> <li>— start to open hydraulic control pressure</li> <li>— full open hydraulic control pressure</li> <li>— start to close hydraulic control pressure</li> <li>— full closed hydraulic control pressure</li> </ul> |

| Step | Procedure Step and Acceptance Criteria   | Data to Be Recorded  |
|------|--|--|
| 14)  | Apply water pressure upstream of the SCSSV closure mechanism at 100 % of the RWP (allowable range of 95 % to 100 %) of the valve. Record the SCSSV bore pressure and the time at which pressure was applied to the valve.  | <ul style="list-style-type: none"> <li>— valve bore test pressure</li> <li>— time at which test pressure is applied</li> <li>— time at start of leakage test</li> <li>— time at end of leakage test</li> </ul> |
| 15)  | Wait for a minimum of 3 min after applying water pressure upstream of the SCSSV closure mechanism before beginning collection of water leakage from the downstream bleed valve.<br>Continuously collect water leakage for a period of 5 min. Calculate and record the average leakage rate per minute.<br><b>Acceptance criteria:</b> If the average leakage rate during the collection period exceeds 400 cm <sup>3</sup> /min (24.4 in. <sup>3</sup> /min) or if external body leakage is detected (tubing-retrievable only), the test valve fails.  | <ul style="list-style-type: none"> <li>— average leakage rate at test pressure</li> <li>— body leakage detected (TRSV only)? (yes or no)</li> <li>— test step passed? (yes or no)</li> </ul>                   |
| 16)  | Repeat Steps 9) to 15) one time for a total 20 % cumulative of the specified operating cycles.   | dd)  |
| 17)  | Open the SCSSV, and circulate the mixture through the SCSSV at the specified rate [Step 11)] for a minimum of 15 min.  | <ul style="list-style-type: none"> <li>— time at start of mixture circulation through valve</li> <li>— flow rate at start of circulation period</li> </ul>   |
| 18)  | Determine sand content of mixture by filling two oil gauger's 100 ml (6.1 in. <sup>3</sup> ) sample tubes with mixture samples. Centrifuge with oil gauger's centrifuge according to API MPMS Ch. 10.4. The use of solvents and temperature controls are not required. Adjust sand content to 2 % (1.5 % to 2.5 % acceptable) by adding approximately equal quantities by volume of 140/200, 200/270, and 270/325 U.S. mesh sand or diluting mixture with freshwater.  | <ul style="list-style-type: none"> <li>— sand concentration (%) at start of circulation period</li> </ul>  |
| 19)  | Stop circulation and let the mixture settle for 15 min (maintain SCSSV in the open position).  | <ul style="list-style-type: none"> <li>— time at start of mixture settling</li> <li>— time at end of mixture settling</li> </ul>   |
| 20)  | Close and open the SCSSV a total of 5 % of specified operating cycles.<br>NOTE Upon completion of this step the first time, 25 % of the specified operating cycles will have been performed.   | For a minimum of the last 10 cycles record: <ul style="list-style-type: none"> <li>— full open hydraulic control pressure</li> <li>— full closed hydraulic control pressure</li> </ul>                         |
| 21)  | With the valve closed, apply water pressure upstream of the SCSSV closure mechanism at 100 % of the RWP (allowable range of 95 % to 100 %) of the valve. Record the SCSSV bore pressure and the time at which pressure was applied to the valve.   | <ul style="list-style-type: none"> <li>— valve bore test pressure</li> <li>— time at which test pressure is applied</li> <li>— time at start of leakage test</li> <li>— time at end of leakage test</li> </ul> |
| 22)  | Wait for a minimum of 3 min after applying water pressure upstream of the SCSSV closure mechanism before beginning collection of water leakage from the downstream bleed valve.<br>Continuously collect water leakage for a period of 5 min. Calculate and record the average leakage rate per minute.<br><b>Acceptance criteria:</b> If the average leakage rate during the collection period exceeds 400 cm <sup>3</sup> /min (24.4 in. <sup>3</sup> /min), or if external body leakage is detected (tubing-retrievable only), the test valve fails. | <ul style="list-style-type: none"> <li>— average leakage rate at test pressure</li> <li>— body leakage detected (TRSV only)? (yes or no)</li> <li>— test step passed? (yes or no)</li> </ul>                   |

| Step | Procedure Step and Acceptance Criteria  | Data to Be Recorded   |
|------|---|---|
| 23)  | Repeat Steps 12) to 22) three more times for a total of 100 % of the specified operating cycles.  | ee)   |
| 24)  | Determine sand content of mixture by filling two oil gauger's 100 ml sample tubes with mixture samples. Centrifuge with oil gauger's centrifuge according to API MPMS Ch. 10.4. The use of solvents and temperature controls are not required.  | — sand concentration (%) at end of test   |
| 25)  | Cool the SCSSV down to ambient temperature, open the SCSSV and evacuate all water (mixture) from the SCSSV.   | ff)   |
| 26)  | Apply $1.4 \text{ MPa} \pm 0.07 \text{ MPa}$ ( $200 \text{ psi} \pm 10 \text{ psi}$ ) nitrogen pressure upstream of the SCSSV. Wait a minimum of 1 min, then measure any nitrogen leakage through the closure mechanism.<br><br><b>Acceptance criteria:</b> If the leakage rate is greater than $0.43 \text{ m}^3/\text{min}$ (15 scf/min), or if any body joint leakage (tubing-retrievable only) is detected, the test valve fails. | — date<br>— SCSSV bore pressure<br>— time at start of waiting period<br>— time at completion of waiting period<br>— measured gas leakage rate<br>— body leakage detected (TRSV only)? (yes or no) |
| 27)  | Repeat Step 26) at 25 % of the RWP (allowable range of 20 % to 30 % of RWP) of the SSSV.<br><br><b>Acceptance criteria:</b> If the leakage rate is greater than $0.43 \text{ m}^3/\text{min}$ (15 scf/min), or if any body joint leakage (tubing-retrievable only) is detected, the test valve fails.   | — SCSSV bore pressure<br>— time at start of waiting period<br>— time at completion of waiting period<br>— measured gas leakage rate<br>— body leakage detected (TRSV only)? (yes or no)           |
| 28)  | Bleed the pressure upstream of the SCSSV to zero.   | gg)   |
| 29)  | Disassemble the SSSV and document sand intrusion with pictures (before cleaning)  | — document with photographs all open/close mechanism parts before cleaning  |

### I.3 Test Report

In addition to the requirements of 5.5.13.5, the following shall be included in the report:

- a discussion of the repeatability of the leakage through the closure mechanism;
- a discussion of the repeatability of the opening and closing pressures;
- the data gathered in Step 29).

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## Annex J (informative)

### Combined Loads Operational Test

#### J.1 General

**J.1.1** This annex contains additional requirements for TRSVs when specifically requested by the user/purchaser. If a particular test was completed on the same size, type, model, and design to the requirements defined herein and previously passed and documented to those requirements, the test can be counted as fulfilling the requirements of this annex.

**J.1.2** To perform this test, a closed end rated performance envelope shall be generated. This envelope will be similar to the ends open rated performance envelope specified in Annex M and generated using the same analysis criteria, except that end conditions will be fully closed rather than ends open. Alternately, the supplier/manufacturer may choose to perform an ends-open test to an ends-open rated performance envelope if fixturing design allows it.

**NOTE** In combined load testing, the total axial load is the sum of the load frame axial load plus the pressure-induced axial load if any.

**J.1.1** To meet the requirements of this annex, all tests described shall be completed in conformance with the acceptance criteria and shall be completed without any repair or redress of the test valve.

**J.1.1** The SSSV shall have passed the functional test specified in Annex C prior to commencement of any tests in this annex.

**J.1.1** Validation testing per this annex shall meet the requirements of 5.5.13.

#### J.2 Test Requirements

##### J.2.1 General

The purpose of the combined loads operational test is to validate the closed end rated performance envelope at 100 % of envelope ratings.

##### J.2.2 Procedure

The supplier/manufacturer shall conduct the combined loads operational test per Table J.1 and the following requirements:

- a) use a liquid test medium of water, with or without additives, or hydraulic oil. The density shall be less than 1100 kg/m<sup>3</sup> (68.67 lb/ft<sup>3</sup>) and the liquid shall be visibly free from particulate matter or other material that can plug a small leak;
- b) at maximum rated operating temperature or at an ambient temperature where the design loads are increased by a factor equivalent to the inverse of the temperature derating factor:

$$L_A = L_T \cdot (1/Y_f) \text{ where } L_A = \text{Test load(s) at ambient temperature,}$$
$$L_T = \text{Calculated load(s) at maximum rated temperature, and}$$

$Y_f$  = Material derating factor at maximum rated temperature.

- c) the tested envelope shall contain the test points to be evaluated, which may represent load cases for a specific user/purchaser application and shall contain the limits of the SSSV calculated closed end rated performance envelope:
  - 1) all intersection points of the of the envelope shall be tested;
  - 2) the maximum tension load without internal or external pressure shall be tested;
  - 3) the maximum compressive load without internal or external pressure shall be tested;
  - 4) the maximum internal and external pressure without axial load shall be tested;
  - 5) a minimum of one point in each quadrant shall be tested;
  - 6) additional points may be tested per the supplier/manufacturer's documented procedure and/or specific user/purchaser specification.
- d) for each test point, the following shall be defined:
  - 1) internal pressure and test medium;
  - 2) external pressure and test medium;
  - 3) tensile load;
  - 4) compressive load;
  - 5) temperature;
  - 6) applied control line hydraulic pressure;
  - 7) bending load if applicable;
  - 8) torsion if applicable;
  - 9) length of evaluation period for each test point;
  - 10) any operational activity performed (open/close cycle, closure mechanism leak check).
- e) define the order in which the test points will be evaluated and the method of progressing from one test point to the next.

**Table J.1—Combined Loads Operational Test**

| Step | Procedure Step and Acceptance Criteria   | Data to Be Recorded   |
|------|--|---|
| 1)   | Record the SSSV data.  | <ul style="list-style-type: none"> <li>— RWP</li> <li>— operating temperature, maximum</li> <li>— actual material yield strength of each component that will be subjected to internal or external pressure or to tensile or compressive axial load</li> </ul>   |
| 2)   | Install the SSSV in the combined load test frame.  | hh)   |
| 3)   | Open and close the SSSV five times with zero pressure in the test section.   | <p>For each of 5 operating cycles:</p> <ul style="list-style-type: none"> <li>— full open hydraulic control pressure</li> <li>— full closed hydraulic control pressure</li> </ul> <p>Calculated average of 5 operating cycles:</p> <ul style="list-style-type: none"> <li>— full open hydraulic control pressure</li> <li>— full closed hydraulic control pressure</li> </ul> |
| 4)   | <p>Apply pressure and axial load as required by each test point, in the order defined in the supplier/manufacture's test procedure. Open and close the SSSV at each test point.</p> <p><b>Acceptance criteria:</b> If the full open and full closed hydraulic control pressures at each test point is not within the supplier/manufacture's test procedure or if any external body leakage or if leakage is detected through the hydraulic control port(s), the SSSV fails the test.</p> | <ul style="list-style-type: none"> <li>— pressure</li> <li>— axial load</li> <li>— temperature</li> </ul> <p>For each of the open/close cycles, record the following:</p> <ul style="list-style-type: none"> <li>— full closed hydraulic control pressure</li> <li>— full open hydraulic control pressure</li> </ul>  |
| 5)   | <p>Open and close the SSSV five times with zero pressure in the test section.</p> <p><b>Acceptance criteria:</b> If the average of the five hydraulic control pressures do not repeat within <math>\pm 10\%</math>, or <math>\pm 0.7</math> MPa (<math>\pm 100</math> psi), whichever is greater, of the value calculated in Step 3) above the SSSV fails the test.</p>  | <p>For each of 5 operating cycles:</p> <ul style="list-style-type: none"> <li>— full open hydraulic control pressure</li> <li>— full closed hydraulic control pressure</li> </ul> <p>Calculated average of 5 operating cycles:</p> <ul style="list-style-type: none"> <li>— full open hydraulic control pressure</li> <li>— full closed hydraulic control pressure</li> </ul> |
| 6)   | Disassemble the SSSV and visually inspect all the components of the SSSV.  | <ul style="list-style-type: none"> <li>— any abnormal wear, distortion or deformation,</li> </ul>   |

|  |  |                                   |
|--|--|-----------------------------------|
|  |  | or other damage shall be recorded |
|--|--|-----------------------------------|

### **J.3 Test Report**

In addition to the test report information required by 5.5.13.5, the following shall be included in the report:

- a) metallurgy and yield strength of relevant components;
- b) the order in which the test points were evaluated and the sequence of progression from one test point to the next;
- c) input data and output data for the closed end rated performance envelope;
- d) closed end rated performance envelope;
- e) the results of Step 6) in Table J.1.

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## **Annex K (informative)**

### **Gas Slam Closure Testing**

#### **K.1 General**

**K.1.1** This annex contains additional requirements for SSSVs when specifically requested by the user/purchaser. If a particular test was completed on the same size, type, model and design to the requirements defined herein and previously passed and documented to those requirements, the test can be counted as fulfilling the requirements of this annex.

**K.1.2** To meet the requirements of this annex, all tests described shall be completed in conformance with the acceptance criteria and shall be completed without any repair or redress of the test valve.

**K.1.3** Unless otherwise specified, gas pressure-relieving (bleed-down) operations should be performed at a maximum rate of 0.7 MPa/min (100 psi/min) at pressures less than 10.3 MPa (1500 psi). The supplier/manufacture may specify gas pressure-relieving (bleed-down) operations.

**K.1.4** The SCSSV shall be oriented vertically for all tests unless specified otherwise by the user/purchaser.

**K.1.5** Validation testing per this annex shall meet the requirements of 5.5.13.

#### **K.2 Test Requirements**

##### **K.2.1 General**

**K.2.1.1** The purpose of the gas slam closure testing is to validate unique closure situations of intensity and includes multiple slam closures at the velocities stipulated.

**K.2.1.2** The testing velocities shall be calculated based on the minimum I.D. of the valve, temperature, and flowing pressure.

##### **K.2.2 Procedure**

Conduct the gas slam closure test per Table K.1. Steps 2), 3), 4), and 14) shall be performed by the supplier/manufacture; all other steps may be performed by the supplier/manufacture or outsourced to a test facility.

**Table K.1—Gas Slam Closure Test**

| Step | Procedure Step and Acceptance Criteria  | Data to Be Recorded   |
|------|---|---|
| 1)   | Record the SSSV data.   | <ul style="list-style-type: none"> <li>— RWP</li> <li>— operating temperature, maximum</li> <li>— operating temperature, minimum</li> </ul>   |
| 2)   | Identify and dimensionally measure components of the SSSV that are affected by gas slam closure occurrences.  | — component dimensions  |
| 3)   | Assemble the SSSV per defined procedures.   | ii)   |
| 4)   | Perform the functional test per Annex C.  | jj)   |
| 5)   | Install the test valve in the gas flow test stand using a hydraulic control line to operate the SSSV.<br><br>NOTE A control line with an ID of 9.6 mm (0.38 in.) and a length of 7.6 m (25 ft) provides minimal resistance and simulates a fast slam closure. | <ul style="list-style-type: none"> <li>— date</li> <li>— location</li> <li>— length and internal diameter of the control line used to operate the SSSV</li> <li>— manufacturer, brand name, and type (oil-based, water based) of control fluid used for all cycles</li> </ul>   |
| 6)   | Open and close the SSSV five times with zero pressure in the test section.  | For each of 5 operating cycles: <ul style="list-style-type: none"> <li>— full open hydraulic control pressure</li> <li>— full closed hydraulic control pressure</li> </ul> Calculated average of 5 operating cycles: <ul style="list-style-type: none"> <li>— full open hydraulic control pressure</li> <li>— full closed hydraulic control pressure</li> </ul> |
| 7)   | Apply sufficient hydraulic pressure to maintain the SSSV in the fully open position under flowing gas conditions.   | — hydraulic opening pressure  |
| 8)   | Flow gas through the SSSV at 18.3 m/s (60 ft/s).<br><br>When the flow reaches the target velocity $\pm 10\%$ , release hydraulic pressure and allow the SSSV to close.  | <ul style="list-style-type: none"> <li>— velocity</li> <li>— flowing temperature</li> <li>— bore pressure</li> <li>— gas properties (density, pressure, temperature, composition)</li> <li>— time to close</li> </ul>   |
| 9)   | Apply maximum test facility allowable pressure or 8.3 MPa $\pm$ 0.4 MPa (1200 psi $\pm$ 60 psi) gas pressure upstream of the SSSV, whichever is lower. Wait a minimum of 1 min, then measure any gas leakage through the closure mechanism.                   | <ul style="list-style-type: none"> <li>— SSSV bore pressure</li> <li>— time at start of waiting period</li> </ul>   |

| Step | Procedure Step and Acceptance Criteria   | Data to Be Recorded  |
|------|--|--|
|      | <b>Acceptance criteria:</b> If the leakage rate is greater than 0.43 m <sup>3</sup> /min (15 scf/min), or if any body leakage (tubing-retrievable only) is detected, the test valve fails.   | <ul style="list-style-type: none"> <li>— time at completion of waiting period</li> <li>— measured gas leakage rate</li> <li>— body leakage detected (TRSV only)? (yes or no)</li> </ul>  |
| 10)  | Apply 1.4 MPa ± 0.07 MPa (200 psi ± 10 psi) gas pressure upstream of the SSSV. Wait a minimum of 1 min, then measure any gas leakage through the closure mechanism.<br><br><b>Acceptance criteria:</b> If the leakage rate is greater than 0.43 m <sup>3</sup> /min (15 scf/min), or if any body leakage (tubing-retrievable only) is detected, the test valve fails.  | <ul style="list-style-type: none"> <li>— SSSV bore pressure</li> <li>— time at start of waiting period</li> <li>— time at completion of waiting period</li> <li>— measured gas leakage rate</li> <li>— body leakage detected (TRSV only)? (yes or no)</li> </ul> |
| 11)  | Repeat Steps 7) through 10) one additional time at 24.4 m/s (80 ft/s) and one additional time at 30.5 m/s (100 ft/s).  | — record the average hydraulic control pressures   |
| 12)  | Repeat Steps 7) to 11) using the control line used for Step 5) plus a square-edge orifice having an inside diameter of 0.5 mm ± 0.05 mm (0.020 in. ± 0.002 in.) and a length of 25.4 mm ± 2.5 mm (1.0 in. ± 0.1 in.) or equivalent. The restrictor shall be placed on the far end of the 7.6 m (25ft) low resistance line away from the valve.<br><br>Additional control line resistance may be specified by the user/purchaser. | — record the control line configuration used   |
| 13)  | Repeat the drift test per Table C.1, Step 18)  | kk)  |
| 14)  | Disassemble the SSSV and dimensionally inspect all the components identified and measured in Step 2) and visually inspect all other components of the SSSV.  | <ul style="list-style-type: none"> <li>— component dimensions</li> <li>— abnormal wear, distortion or deformation, or other damage</li> </ul>  |

### K.3 Test Report

In addition to the requirements of 5.5.13.5, the following shall be included in a report created by the supplier/manufacturer:

- a discussion of the repeatability of the leakage through the closure mechanism;
- a discussion of the repeatability of the opening and closing pressures;
- results of dimensional and visual inspection of all the components initially identified and measured in Table K.1, Step 2) and Step 14);
- a discussion regarding the continued operability of the SSSV.

## **Annex L (Normative)**

### **Dynamic Seal System Test**

#### **L.1 General**

**L.1.1** This annex contains additional requirements for SCSSVs when specifically requested by the user/purchaser. If a particular test was completed on the same size, type, model, and design to the requirements defined herein and previously passed and documented to those requirements, the test can be counted as fulfilling the requirements of this annex.

**L.1.2** To meet the requirements of this annex, all tests described shall be completed in conformance with the acceptance criteria and shall be completed without any repair or redress of the test valve or fixture.

**L.1.3** All gas tests shall be conducted using nitrogen gas as the test medium.

**L.1.4** Unless otherwise specified, gas pressure-relieving (bleed-down) operations should be performed at a maximum rate of 0.7 MPa/min (100 psi/min) at pressures less than 10.3 MPa (1500 psi). The supplier/manufacturer may specify gas pressure-relieving (bleed-down) operations.

**L.1.5** A dynamic seal system that has successfully passed dynamic seal system testing shall be considered as validated for use in any SCSSV with equivalent or lower operating loads in the piston and seal components, within the limits of the maximum pressure, and minimum and maximum temperatures to which it was tested.

**L.1.6** Substantive design changes to any component of the dynamic seal system of a SCSSV shall require that the Annex L test be repeated.

**L.1.7** Validation testing per this Annex shall meet the requirements of 5.5.13.

#### **L.2 Test Requirements**

##### **L.2.1 General**

The purpose of the dynamic seal system test is to validate a SCSSV's dynamic seal system's ability to hold hydraulic control line pressure and internal gas pressure under low- and high-pressure gas conditions at the minimum temperature and SCSSV's maximum rated operating temperatures with the static seal components disabled:

- the test seal components shall be of identical design to the dynamic seal system undergoing validation within the requirements of 5.3.3.3.5;
- piston bore diameter and surface finish shall meet the dimensions and tolerance requirements of the dynamic seal system undergoing validation;
- if a fixture is used, the loads on the piston and seal components shall be equal to or greater than that of the dynamic seal system that requires validation;
- hydraulic control line fluid shall be rated for test temperatures in the control section;

- the piston shall be mechanically held in a position where the up-stop and down-stop static seal components are not engaged during testing.

## L.2.2 Procedure

The supplier/matrixufacturer shall conduct the dynamic seal system test per Table L.1.

**Table L.1—Dynamic Seal System Testing**

| Step | Procedure Step and Acceptance Criteria   | Data to Be Recorded  |
|------|--|--|
| 1)   | Record the SCSSV or fixture data.  | <ul style="list-style-type: none"> <li>— RWP</li> <li>— operating temperature, maximum</li> <li>— operating temperature, ambient</li> </ul>  |
| 2)   | Install the SCSSV or fixture in the test stand. The test medium shall be nitrogen.   | <ul style="list-style-type: none"> <li>— manufacturer, brand name, and type (oil-based, water based) of control fluid used for all cycles</li> </ul>   |
| 3)   | Heat the SCSSV or fixture to the maximum rated operating temperature and stabilize at or above the maximum rated operating temperature. Maintain the maximum rated operating temperature for 6 h until the end of Step 4).   | <ul style="list-style-type: none"> <li>— temperature</li> </ul>  |
| 4)   | Open and close the SCSSV or fixture 100 times with zero pressure in the test section while using the maximum applied hydraulic control pressure.   | For the final 10 operating cycles: <ul style="list-style-type: none"> <li>— maximum applied hydraulic control pressure</li> </ul>  |
| 5)   | Cool the SCSSV or fixture to the minimum rated operating temperature.  | <ul style="list-style-type: none"> <li>— temperature</li> </ul>  |
| 6)   | Connect an empty tube from the SCSSV hydraulic control line port to a container filled with water at atmospheric pressure and ambient temperature or lower. Position the tube so any gas bubbles from the hydraulic control line port can be observed.   | II)  |
| 7)   | With the closure mechanism closed, fill the SCSSV bore with nitrogen gas at the ambient temperature or lower and 0.3 MPa $\pm$ 0.03 MPa (50 psi $\pm$ 5 psi) pressure, wait a minimum of 3 min (and up to a maximum of 10 mins if specified by the supplier/matrixufacturer) and then observe for gas bubble leakage continuously for a minimum of 5 min.<br><br><b>Acceptance criteria:</b> If more than 1 bubble from the control line is observed during the observation period, one restart of the observation period shall commence. If more than 1 bubble from the control line is observed during the second observation period is detected at any time during the entire test, the test fails. | <ul style="list-style-type: none"> <li>— time at start of 3-min waiting period</li> <li>— time at end of 3-min waiting period</li> <li>— time at start of 5-min observation period</li> <li>— time at end of 5-min observation period</li> <li>— leak detected? (yes or no)</li> </ul> |
| 8)   | Fill the SCSSV bore with nitrogen gas at the ambient temperature or lower and 100 % +0 %/–5 % of the RWP, wait a minimum of 3 min (and up to a maximum of 10 mins if specified by the supplier/matrixufacturer) and then observe for gas bubble leakage continuously for a minimum of 5 min.<br><br><b>Acceptance criteria:</b> If more than 1 bubble from the control line is observed during the observation period, one restart of the observation period shall commence. If more than 1 bubble from the control line is observed during the second observation period is detected at any time during the entire test, the test fails.  | <ul style="list-style-type: none"> <li>— time at start of 3-min waiting period</li> <li>— time at end of 3-min waiting period</li> <li>— time at start of 5-min observation period</li> <li>— time at end of 5-min observation period</li> <li>— leak detected? (yes or no)</li> </ul> |

|    |   |  |
|----|---|--|
| 9) | Disassemble the SCSSV or test fixture and visually inspect all the components of the dynamic seal system. | — any abnormal wear, distortion or deformation, or other damage shall be recorded. |
|----|---|--|

TASK GROUP DRAFT

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## Annex M (Normative)

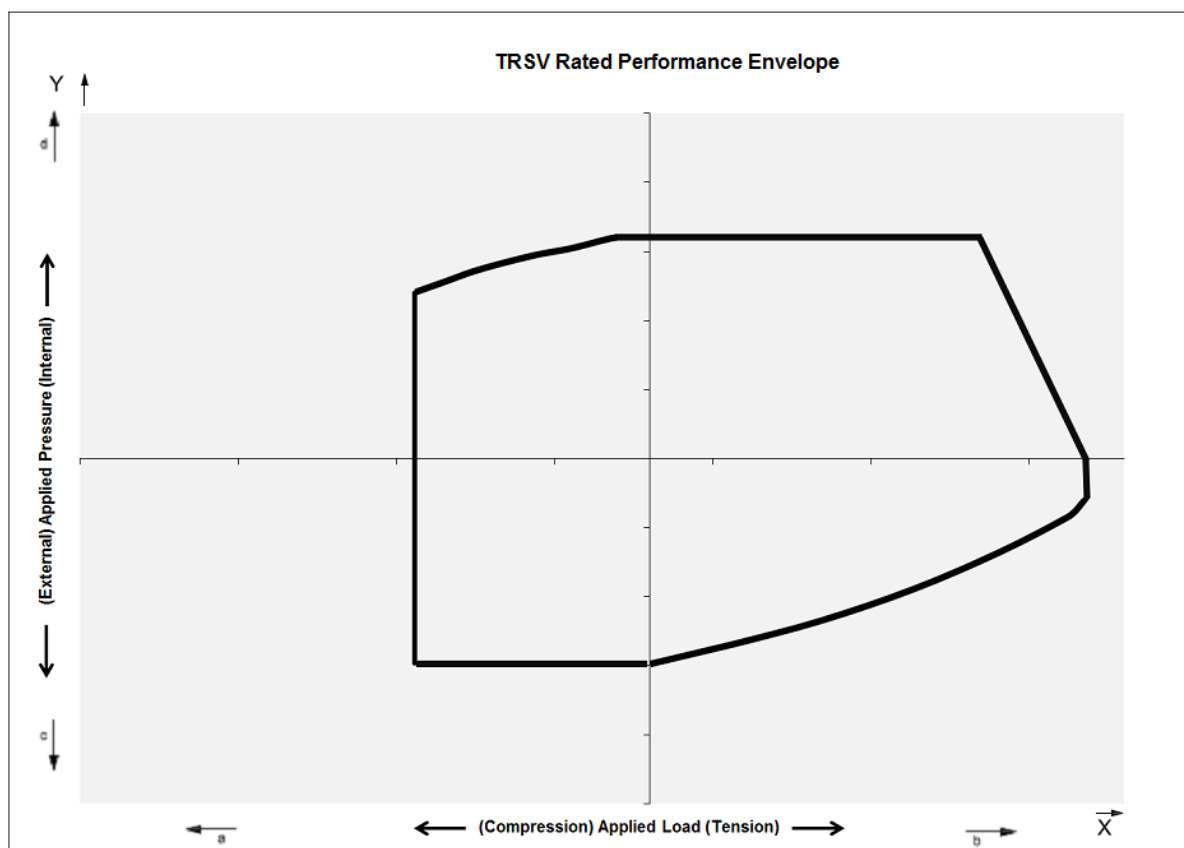
## Rated Performance Envelope

## M.1 Rated Performance Envelope Documentation

**M.1.1** The rated performance envelope is for a TRSV with no insert SSSV installed. It shall illustrate the combined effects of pressure, temperature, and applied axial loads on the body of the TRSV including the body joints.

NOTE This annex does not provide for rated performance envelopes for a non-tubing-mounted SSSV and ASVs.

**M.1.2** An example envelope is illustrated in Figure M.1 below. The lines forming the boundary of the envelope shall define the rated performance values of the SSSV.



## Key

X axial load

Y pressure

- a Compression.
- b Tension.
- c External pressure only.
- d Internal pressure only.

**Figure M.1—Rated Performance Envelope Example**

## **M.2 Rated Performance Envelope Requirements**

Rated performance envelopes shall meet the criteria below.

- The boundary of the envelope represents the supplier/manufacture's maximum operational limits for the TRSV at maximum rated operating temperature.
- The ratings of end connections shall not be included.
- The envelope shall be in the ends open condition with the closure mechanism equalized.
- Nominal tubing OD and nominal tubing bore ID shall be used for calculating pressure-induced loads.
- The axial load shall be on the X axis.
- Pressure shall be on the Y axis.
- More than one graph may be displayed on the envelope if a legend is included for explanation.
- The product(s) covered by the envelope shall be specified on the envelope.

## **M.3 Rated Performance Envelopes for Nontraditional SSSVs**

**M.3.1** For TRSVs for which a two-dimensional rated performance envelope cannot be created, a table of combined load and pressure limits shall be provided. This table may be a combination of supplier/manufacture data and user/purchaser supplied load and pressure combinations verified by FEA and/or testing.

**M.3.1** The content of this table shall be in agreement between supplier/manufacture and user/purchaser.

## **M.4 TRSV with an Insert SSSV, Rated Performance Envelopes**

For TRSVs with an insert SSSV installed, specific application parameters are required to create a rated performance envelope or a table of combined load and pressure limits. The supplier/manufacture shall provide the TRSV envelope or table upon request from the user/purchaser based on the specific application parameters.

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## Annex N (normative)

### Alternative Validation Test Requirements

#### N.1 General

**N.1.1** This annex shall be used when a user/purchaser specifies a SSSV product validation grade of V1-H, V1, V2, V3 from Table 1. The requirements stated in this annex shall replace the corresponding requirements in Annex B of this edition, while all other sections of this specification shall apply.

**NOTE 1** Previous editions of this specification used the designation Class 1 instead of validation Grade V3 and Class 2 instead of validation grade V2.

**NOTE 2** This annex applies to SSSV products validated by the test agency prior to the effective date of the 12th edition of this specification, January 1, 2015. Requirements for the test agency performed validation test conducted at that time are provided within this annex.

**N.1.2** A summary of the differences between the current edition Annex B and the Annex N requirements is listed in Table N.1.

**Table N.1—Difference between Annex B and Annex N**

| Test                     | Annex B Requirement   | Annex N Requirement   |
|--------------------------|---|---|
| Gas Flow Test            | B.3: The test medium shall be nitrogen.   | N.3: The test medium shall be air, nitrogen, or any other suitable gas.                                       |
| Unequalized Opening Test | B.6: Acceptance Criteria: the SCSSV closure mechanism shall open against the specified pressure. If the SCSSV closure mechanism does not open the test fails. | N.6: No explicit acceptance criteria.   |
| V3 Water Flow Test       | B.10: Four freshwater closures at two defined control line resistances.   | N.10: Three freshwater closures.  |
| V2 Nitrogen Leakage Test | B.2.2: The nitrogen leakage test is performed after the operating-pressure test and the V2 slurry flow test.  | N.2.3: The nitrogen leakage test is performed before the operating-pressure test and the V2 slurry flow test. |

**N.1.4** To validate the SSSV design, all steps of this validation testing procedure shall be completed successfully within the limits specified and, in the order, shown.

**N.1.5** Validation testing shall be discontinued if the valve fails to perform within the limits specified for any step except when such failures are determined to be a result of actions by the test agency or a failure within the test facility. The basis for discontinuing the test, and any unusual conditions observed at or prior to the time of discontinuance, shall be noted on the test data form by the test agency.

**N.1.6** All pressures are defined as gauge unless otherwise specified and shall be recorded on time-based equipment.

**N.1.7** Prior to any liquid pressure test, purge with test liquid to remove air.

**N.1.8** Gas pressure-relieving (bleed-down) operations shall be performed per the manufacturer's requirements.

**N.1.9** During validation testing of hydraulically operated SSSVs, control line fluid metering may be used to provide a readable hydraulic control line pressure trace. Refer to Figure B.1 for a characteristic pressure versus time plot for opening and closing hydraulic control pressures with hydraulic fluid being applied at a metered rate.

**N.1.10** When validation testing of SSSV sizes not covered in Tables N.2, N.3, and N.4, the flow rate values may be interpolated or extrapolated by a ratio of the square of the diameter versus the parameter involved.

**N.1.11** The test section shall completely enclose a wireline-retrievable SSSV. Tubing-retrievable SSSVs shall be an integral part of the test section. The test section shall be rated to at least the rated working pressure of the SSSV.

**N.1.12** The test section ends; length and hydraulic control connections shall be compatible with the test agency's facility.

**N.1.13** Each data form shall be signed and dated by the person(s) conducting the test. The form containing the data specified in N.18.12 shall be signed and dated by the test agency's designated approval authority.

## **N.2 Validation test procedure — SCSSV**

### **N.2.1 General**

The model and serial numbers appearing on the test valve shall be verified to confirm they are in agreement with the manufacturer's application.

### **N.2.2 Test Agency SCSSV V3 Steps**

- 1) Perform the SCSSV gas flow test (see N.3).
- 2) Open the test valve. Record the full-open hydraulic control pressure as shown in N.18.1.
- 3) Fill the test valve with water and circulate water to displace gas out of the test section. Once gas has been displaced from the test section, discontinue water circulation.
- 4) Close the test valve. Record the full-closed hydraulic control pressure as shown in N.18.1.
- 5) Perform the liquid leakage test (see N.5).
- 6) Perform the unequalized opening test (see N.6).
- 7) Perform the operating-pressure test (see N.7).
- 8) Perform the propane test (see N.8).
- 9) Perform the nitrogen leakage test (see N.9).
- 10) Repeat the operating-pressure test (see N.7).

- 11) Perform the SCSSV V3 water flow test (see N.10).
- 12) Repeat N.2.2.9 to N.2.2.11 four additional times.
- 13) Perform the liquid leakage test (see N.5).
- 14) Perform the controlled-temperature test (see N.11).
- 15) If the test valve is being qualified for validation grade V3 only, proceed to N.2.3.6.

### **N.2.3 Test Agency SSSV V2 Steps**

- 1) Perform the nitrogen leakage test (see N.9).
- 2) Perform the operating-pressure test (see N.7).
- 3) Perform the V2 slurry flow test (see N.12). V2 slurry flow testing shall be performed in a continuous manner with no interruptions longer than 2 h.
- 4) Repeat N.2.3.1 to N.2.3.3 six additional times.
- 5) Perform the liquid leakage test (see N.5).
- 6) Perform the drift test (see N.4). If at any point in the V2 test the valve fails and it is desired to have V3 validation grade, perform the V3 drift test (N.2.2.15) to confirm V3 qualification.
- 7) If the test valve has performed within the limits specified, it has passed the validation test.
- 8) Summarize the validation test data as specified in N.18.12.

### **N.3 Gas flow test — SCSSV**

- 1) Record test data as specified in N.18.2.
  - 2) Install the test valve in the gas flow test stand. The test medium shall be air, nitrogen or any other suitable gas.
  - 3) Set the control line resistance to the appropriate setting shown in Table N.2.
- The test flow rates specified in Table N.2 are based on a pressure of 13,8 MPa (2 000 psi) and a velocity of 6,10 m/s (20 ft/s) in the tubing for valve closure test 1 and test 4, a velocity of 9,15 m/s (30 ft/s) for test 2, and a velocity of 3,05 m/s (10 ft/s) for test 3.
  - The test flow rates shall be maintained within – 5 % and + 15 % of the nominal value given in Table N.2 or between  $-(0,01 \cdot 10^6)$  m<sup>3</sup> and  $+(0,04 \cdot 10^6)$  m<sup>3</sup>/d [ $-(0,5 \cdot 10^6)$  scf and  $+(1,5 \cdot 10^6)$  scf per day], whichever is greater.
  - The low control line resistance test shall be performed with a hydraulic control line having an inside diameter of at least 9,6 mm (0,38 in) and a maximum total length of 7,6 m (25 ft).
  - The configuration for the high control line resistance test shall consist of the control line used for the low-resistance configuration plus a square-edge orifice having an inside diameter of 0,5 mm  $\pm$  0,05 mm (0,020 in  $\pm$  0,002 in) and a length of 25,4 mm  $\pm$  2,5 mm (1,0 in  $\pm$  0,1 in).

**Table N.2—SCSSV Gas Flow Rates**

| Nominal tubing or casing size<br><br>mm (in) | Gas flow rate and control line resistances for each valve closure test                    |   |   |   |
|--|---|---|---|---|
|  | Low resistance  |   | High resistance   |   |
|  | Test No. 1<br>Flow rate<br>m <sup>3</sup> /d x 10 <sup>6</sup> (scf/d x 10 <sup>6</sup> ) | Test No. 2<br>Flow rate<br>m <sup>3</sup> /d x 10 <sup>6</sup> (scf/d x 10 <sup>6</sup> ) | Test No. 3<br>Flow rate<br>m <sup>3</sup> /d x 10 <sup>6</sup> (scf/d x 10 <sup>6</sup> ) | Test No. 4<br>Flow rate<br>m <sup>3</sup> /d x 10 <sup>6</sup> (scf/d x 10 <sup>6</sup> ) |
| 60.3 (2 3/8)                                 | 0.14 (5.1)  | 0.22 (7.7)  | 0.07 (2.6)  | 0.14 (5.1)  |
| 73.0 (2 7/8)                                 | 0.23 (8.0)  | 0.34 (12.0)   | 0.11 (4.0)  | 0.23 (8.0)  |
| 0.88.9 (3 1/2)                               | 0.33 (11.5)   | 0.49 (17.3)   | 0.16 (5.8)  | 0.33 (11.5)   |
| 101.6 (4)                                    | 0.44 (15.7)   | 0.67 (23.6)   | 0.22 (7.9)  | 0.44 (15.7)   |
| 114.3 (4 1/2)                                | 0.58 (20.5)   | 0.87 (30.8)   | 0.29 (10.3)   | 0.58 (20.5)   |
| 127.0 (5)                                    | 0.73 (25.9)   | 1.10 (38.9)   | 0.37 (13.0)   | 0.73 (25.9)   |
| 139.7 (5 1/2)                                | 0.91 (32.0)   | 1.36 (48.0)   | 0.45 (16.0)   | 0.91 (32.0)   |
| 165.1 (6 1/2)                                | 1.30 (46.1)   | 1.96 (69.2)   | 0.65 (23.1)   | 1.30 (46.1)   |
| 177.8 (7)                                    | 1.79 (63.1)   | 2.68 (94.7)   | 0.89 (31.6)   | 1.79 (63.1)   |

- 4) Open and close the test valve. Record the full-open and full-closed control pressures.
- 5) Close the flow control valve and bleed valve. Set the flow control valve to provide a gas flow at a test rate in accordance with Table N.3.
- 6) Increase the gas pressure in the system to between 13,8 MPa (2 000 psi) and 17,3 MPa (2 500 psi).
- 7) Open the test valve. Record the full-open control pressure.
- 8) Establish and maintain the gas flow rate indicated in Table N.2, and then close the test valve while recording the control line pressure and gas flow rate.
- 9) The test valve shall shut off a minimum of 95 % of the specified flow in 5,0 s or less after the hydraulic control pressure reaches zero, or the test valve fails the test. Record the time required by the test valve to shut off the specified flow. If the test valve fails, discontinue testing.
- 10) Bleed the valve bore downstream pressure to zero. Adjust the test valve upstream bore pressure to 8,3 MPa ± 0,4 MPa (1 200 psi ± 60 psi). Record the test valve bore upstream pressure and gas leakage rate. If leakage exceeds 0,14 m<sup>3</sup>/min (5 scf/min) of gas, the test valve fails. If the test valve fails, discontinue testing.
- 11) Bleed all pressure to zero. Repeat Step 3) to Step 10) until all four closure tests specified in Table N.2 are successfully completed or until the test valve fails.

## **N.4 Drift test — SCSSV**

### **N.4.1 General**

**N.4.1.1** The manufacturer shall provide the test agency with a drift sleeve (for WRSVs) and/or drift bar (for TRSVs and WRSVs) that is appropriate for detecting changes in the valve's dimensions. Each drift bar/sleeve shall be permanently marked with a unique identifier. Drift bar dimensions (measured) and unique identifier shall be recorded along with the minimum specified ID of the test valve (TRSVs and WRSVs) or maximum specified OD of the test valve (WRSVs).

**N.4.1.2** Drift bars shall be of no smaller OD than the valve's specified minimum ID, less 0,75 mm (0,030 in); drift sleeves shall be no larger on the ID than the valve's specified maximum OD plus 0,75 mm (0,030 in) and shall be a full round at the recorded drift dimensions.

**N.4.1.3** Each drift bar shall be of a length designated as appropriate to verify that the product provides no restriction to the passage of tools for the full length of the product and shall be a minimum length of four times the specified inside diameter of the product, or 610 mm (24 in), whichever is greater.

**N.4.1.4** Each drift sleeve shall be of a length designated as appropriate to verify that the product can be received into its intended receptacle and shall be a minimum length of two times the specified outside diameter of the product.

### **N.4.2 Drift test — TRSV**

- 1) Record test data as specified in N.18.3.
- 2) Open and close the test valve, recording the full-open hydraulic control pressure.
- 3) Orient the test valve so that the valve is vertical, upside down, and in the normal open position. The test valve may be opened prior to repositioning.
- 4) Pass the drift bar completely through the test valve in a manner that does not cause the test valve's closure mechanism to be opened. The drift bar shall be aided by a force no greater than that of gravity while being passed down and back through the test valve. If the drift bar does not pass freely completely through the test valve, the test valve fails.

### **N.4.3 Drift test — WRSV**

- 1) Record test data as specified in N.18.3.
- 2) Open the test valve, recording the full-open hydraulic control pressure. Orient the test valve so that the valve is vertical, upside down, and in the normal open position.
- 3) Pass the drift bar completely through the test valve in a manner that does not cause the test valve's closure mechanism to be opened. The drift bar shall be aided by a force no greater than that of gravity while being passed down and back through the test valve. If the drift bar does not pass freely completely through the test valve, the test valve fails.
- 4) Pass the drift sleeve over the entire length, except for the packing stack/sealing device, of the test valve in a manner that does not cause the test valve's closure mechanism to be moved.

**NOTE** If control line or control sleeve is in place, a partial drift of the lower valve can be accomplished here.

- 5) Close the test valve and record the closing pressures. If a partial OD drift has been accomplished, pass the drift sleeve over the remaining length of the test valve. The drift sleeve shall be aided by a force no greater than that of gravity while being passed down and back over the test valve. If the drift sleeve does not freely pass completely over the test valve, except for the packing stack/sealing device, the test valve fails.

## **N.5 Liquid leakage test — SSSV**

- 1) Record test data as specified in N.18.4.
- 2) Make certain that the test valve is in the closed position with only liquid above and below the valve.
- 3) Apply water pressure upstream of the test valve closure mechanism at 100 % of the rated working pressure (allowable range of 95 % to 100 %) of the valve. Record the test valve bore pressure and the time at which pressure was applied to the valve.
- 4) Wait for a minimum of 3 min after applying water pressure upstream of the test valve closure mechanism before beginning collection of water leakage from the downstream bleed valve.
- 5) Continuously collect water leakage for a period of 5 min. Record the times at which water leakage collection began and ended and the amount of water collected. Calculate and record the average leakage rate. If the average leakage rate during the collection period exceeds 10 cm<sup>3</sup>/min of water, or if external body leakage is detected (tubing-retrievable only), the test valve fails. If the test valve fails, discontinue testing.

## **N.6 Unequalized opening test — SCSSV**

- 1) Record test data as specified in N.18.5.
- 2) Establish water pressure upstream of the test valve closure mechanism at the maximum manufacturer-specified opening-pressure differential.
- 3) Open the test valve closure mechanism against pressure as recommended in the test valve-operating manual. Record the equalizing pressure and the full-open hydraulic control pressure.

## **N.7 Operating-pressure test — SCSSV**

- 1) Record test data as specified in N.18.6.
- 2) Apply pressure of 25 % of the rated working pressure (allowable range of 20 % to 30 % of rated working pressure) of the test valve to the entire test section. Record the test valve bore pressure (base pressure).
- 3) Close and open test valve five times while maintaining the test section pressure recorded in Step 2) within the specified range.

**NOTE** The test section pressure can increase as the valve is opened, and then can decrease as the valve is closed due to the differential volume of the hydraulic operating piston.

- 4) The full-open/full-closed hydraulic control pressures shall be adjusted based on the change in test section pressure at the time of control pressure measurement. The adjusted control pressure is determined by adding/subtracting the actual control pressure with the difference between the base pressure and the actual test section pressure recorded at the time of each opening/closing pressure measurement.

- 5) If the five adjusted hydraulic control pressures do not repeat within  $\pm 10\%$  of their average, or  $\pm 0,7$  MPa ( $\pm 100$  psi), whichever is greater, or if any body joint leakage (tubing-retrievable only) is detected, the test valve fails.
- 6) Repeat Steps.2) and 3) at 75 % of the rated working pressure (allowable range of 70 % to 80 % of rated working pressure).

## **N.8 Propane test — SCSSV (SSCSV as noted)**

- 1) Record test data as specified in N.18.7.
- 2) Open the test valve. Displace liquid out of the test section with nitrogen at a downstream location and bleed the nitrogen pressure to zero.
- 3) Cycle the test valve closed and open three times. Leave the test valve open. Record the full-closed and full-open hydraulic control pressures. If the three hydraulic control pressures do not repeat within  $\pm 10\%$  of their averages or  $\pm 0,7$  MPa (100 psi), whichever is greater, the test valve fails.
- 4) Transfer propane to the test section until the test section pressure reaches 2,8 MPa  $\pm 0,14$  MPa (400 psi  $\pm 20$  psi).
- 5) Open the downstream vent valve until liquid propane is expelled, close the propane vent valve, and adjust the pressure to 2,8 MPa  $\pm 0,14$  MPa (400 psi  $\pm 20$  psi). Record the test valve bore pressure.
- 6) Close and open the test valve three times, leaving the test valve in each position (opened or closed) for a minimum of 15 min. Record the full-open and full-closed hydraulic control pressures.

NOTE The test section pressure can increase as the valve is opened, and then can decrease as the valve is closed due to the differential volume of the hydraulic operating piston.

- 7) The full-open/full-closed hydraulic control pressures shall be adjusted based on the change in test section pressure at the time of control pressure measurement. The adjusted control pressure is determined by adding/subtracting the actual control pressure with the difference between the base pressure and the actual test section pressure recorded at the time of each opening/closing pressure measurement.
- 8) If the three adjusted hydraulic control pressures do not repeat within  $\pm 10\%$  of their average, or  $\pm 0,7$  MPa ( $\pm 100$  psi), whichever is greater, or if any body joint leakage (tubing-retrievable only) is detected, the test valve fails.
- 9) Leave the test valve in the open position in propane for an additional 2 h, minimum. Record the start and completion times and the valve bore pressure at the end of the 2 h interval.
- 10) Bleed the section pressure to zero.
- 11) Purge the test section with nitrogen.
- 12) Close the test valve and record the full-closed hydraulic control pressure.

## **N.9 Nitrogen leakage test — SCSSV (SSCSV as noted)**

- 1) Record test data as specified in N.18.7.

- 2) Apply 1,4 MPa  $\pm$  0,07 MPa (200 psi  $\pm$  10 psi) nitrogen pressure upstream of the test valve. Wait a minimum of 1 min, then measure any nitrogen leakage through the closure mechanism. Record the test valve bore pressure, the leakage rate and the start and completion times of the waiting period. If the leakage rate is greater than 0,14 m<sup>3</sup>/min (5 scf/min), or if any body joint leakage (tubing-retrievable only) is detected, the test valve fails.
- 3) Repeat Step 2) at 25 % of the rated working pressure (allowable range of 20 % to 30 % of rated working pressure) of the test valve.
- 4) Bleed the pressure upstream of the test valve to zero.
- 5) Open the test valve. Record the full-open hydraulic control pressure.

#### **N.10 V3 water flow test — SCSSV**

- 1) Record test data as specified in N.18.9.
- 2) Circulate fresh water through the system while bypassing the test valve until gas has been displaced from the system.
- 3) Adjust the water flow rate through the test valve to obtain a stable flow at the value specified in Table N.3. Record the time at which flow is directed through the test valve. Pass water through the test valve at the specified rate for a minimum of 5 min.

**Table N.3—SCSSV Liquid Flow Rates**

| Nominal tubing or casing size<br><br>mm (in)   | Circulation rate<br>m <sup>3</sup> /d (B/D)<br>( $\pm$ 10%) |                 |                 |            |
|--|---|-----------------|-----------------|------------|
|  | V3  |                 |                 | V2         |
|  | Test rate No. 1   | Test rate No. 2 | Test rate No. 3 |            |
| 60.3 (2 3/8)   | 79 (500)  | 159 (1000)      | 238 (1500)      | 79 (500)   |
| 73.0 (2 7/8)   | 124 (780)   | 248 (1560)      | 372 (2340)      | 124 (780)  |
| 0.88.9 (3 1/2)   | 178 (1120)  | 356 (2240)      | 534 (3360)      | 178 (1120) |
| 101.6 (4)  | 238 (1500)  | 477 (3000)      | 715 (4500)      | 238 (1500) |
| 114.3 (4 1/2)  | 305 (1920)  | 610 (3840)      | 915 (5760)      | 305 (1920) |
| 127.0 (5)  | 386 (2430)  | 772 (4860)      | 1159 (7290)     | 386 (2430) |
| 139.7 (5 1/2)  | 477 (3000)  | 954 (6000)      | 1431 (9000)     | 477 (3000) |
| 165.1 (6 1/2)  | 686 (4320)  | 1373 (8640)     | 2060 (12960)    | 686 (4320) |
| 177.8 (7)  | 935 (5880)  | 1869 (11760)    | 2804 (17640)    | 935 (5880) |
| The manufacturer establishing sizes not covered by this table may interpolate or extrapolate, assuming the circulation rate depends on the square of the nominal size. |   |                 |                 |            |

- 4) Close the test valve against the flow. Record the full-closed hydraulic control pressure and the water flow rate through the test valve at the time closure was initiated. The test valve shall shut off a minimum of 95 %

of the specified flow at the first closure attempt in 15,0 s or less after the hydraulic control pressure reaches zero, or the test valve fails. Record the time required by the test valve to shut off the specified flow.

- 5) Open the test valve. Record the full-open hydraulic control pressure.
- 6) Repeat Step 2) to Step 4) until the three fresh-water closure rates have been completed or the test valve fails.

## **N.11 Controlled-temperature test — SCSSV**

- 1) Record test data as specified in N.18.10.
- 2) Install the test valve in the controlled-temperature test stand. Temperature measurements shall be taken in the area of the control line entry port of the test valve.
- 3) Allow the test valve to reach a stable temperature of  $38\text{ }^{\circ}\text{C} \pm 3\text{ }^{\circ}\text{C}$  ( $100\text{ }^{\circ}\text{F} \pm 5\text{ }^{\circ}\text{F}$ ).
- 4) Apply nitrogen gas pressure of 25 % of the rated working pressure (allowable range of 20 % to 30 % of rated working pressure) of the test valve. Allow the temperature at the test valve to stabilize. Record the test valve temperature and the test valve bore pressure (base pressure).
- 5) Cycle the test valve ten times while maintaining the specified test valve temperature and pressure recorded in N.11.4 within the specified ranges.

NOTE The test section pressure can increase as the valve is opened, and then can decrease as the valve is closed due to the differential volume of the hydraulic operating piston.

- 6) The full-open/full-closed hydraulic control pressures shall be adjusted based on the change in test section pressure at the time of control pressure measurement. The adjusted control pressure is determined by adding/subtracting the actual control pressure with the difference between the base pressure and the actual test section pressure recorded at the time of each opening/closing pressure measurement.
- 7) If the ten adjusted hydraulic control pressures do not repeat within  $\pm 10\text{ }%$  of their average, or  $\pm 0,7\text{ MPa}$  ( $\pm 100\text{ psi}$ ), whichever is greater, or if any body joint leakage (tubing-retrievable only) is detected, the test valve fails.
- 8) Connect a tube from the test valve hydraulic control line port to a container filled with water. Position the tube so any gas bubbles from the hydraulic control line port can be observed.
- 9) With the test valve bore filled with nitrogen gas at the specified temperature and pressure, wait a minimum of 3 min and then observe for gas bubble leakage continuously for a minimum of 5 min. Record the times at which the 3 min waiting period, preceding the leakage test, begins and ends and the times at which the 5 min gas bubble leakage observation period begins and ends. If continuous leakage from the control line is observed for at least 1 min during the observation period, or if body joint leakage (tubing-retrievable only) is detected, the test valve fails.
- 10) Repeat Step 3) to Step 7) using a test valve bore pressure of 75 % of the rated working pressure (allowable range of 70 % to 80 % of rated working pressure) of the test valve.
- 11) Bleed nitrogen pressure above the closure mechanism to zero. Adjust and stabilize the pressure below the closure mechanism to 75 % of the rated working pressure (allowable range of 70 % to 80 % of rated working pressure) of the test valve. Wait a minimum of 1 min, then measure any nitrogen leakage across the closure mechanism. Record the test valve bore pressure below the closure mechanism, any leakage,

and the start and completion times of the waiting period. If the leakage rate is greater than 0,14 m<sup>3</sup>/min (5 scf/min), or if any body joint leakage (tubing-retrievable only) is detected, the test valve fails.

- 12) Repeat Step 3) to Step 8) using a stabilized temperature of 82 °C ± 3 °C (180 °F ± 5 °F).
- 13) Bleed all pressure to zero. Allow the test valve to cool. Remove the test valve from the controlled-temperature test stand.

## **N.12 V2 flow test — SCSSV**

- 1) Record test data as specified in N.18.11.
- 2) Prepare a slurry consisting of sand and viscosified water.
- 3) Determine the sand content of the slurry in accordance with the API MPMS, Chapter 10.4. Adjust the sand content to 2 % ± 0,5 % by adding 150 µm to 180 µm (100 U.S. mesh to 80 U.S. mesh) sand or by diluting the slurry with fresh water.
- 4) Determine the viscosity of the slurry sample with a Marsh funnel viscometer in accordance with ISO 10414-1. Adjust the viscosity to 70 s ± 5 s by adding a viscosifier or diluting the slurry with fresh water.

NOTE For the purposes of these provisions, API RP 13B-1 is equivalent to ISO 10414-1.

- 5) The viscosity and sand content requirements specified above shall be met before proceeding.
- 6) Adjust the slurry circulation rate to the value specified in Table N.3. Record the slurry circulation rate, sand content and slurry viscosity. Record the time at which the slurry circulation begins.
- 7) Circulate the slurry through the test valve at the specified rate for a minimum of 1 h, and then close the test valve against the specified rate.
- 8) Record the full-closed hydraulic control pressure and the slurry flow rate through the test valve at the time closure is initiated. The test valve shall shut off a minimum of 95 % of the specified flow at the first closure attempt in 15,0 s or less after the hydraulic control pressure reaches zero or the test valve fails. Record the time required for the test valve to shut off the specified flow. If the test valve fails, discontinue testing.
- 9) At the completion of the flow period, measure and record the sand content of the slurry and the slurry viscosity.

## **N.13 Validation test procedure — SSCSV**

- 1) Verify that the model and serial numbers appearing on the test valve assembly are in agreement with the manufacturer's application.
- 2) Perform the SSCSV gas closure test (N.14). For velocity-type SSCSVs, use the gas flow test stand to conduct the test.
- 3) Perform the initial liquid closure test (N.15) using water as the test medium.
- 4) Perform the liquid leakage test (N.5).
- 5) Perform the propane test (Step 8)), omitting Step 2) and Step 5). Replace Step 9) with: Conduct the liquid closure test (N.15), using water as the test medium. Record the results as specified in N.18.15. The closing

flow rate for a velocity-type SSCSV or the closing pressure for a tubing-pressure-type SSCSV shall repeat within  $\pm 15\%$  of the closing flow rate or pressure of N.13.3 or the test valve fails the test. If the test valve fails, discontinue testing.

- 6) Perform the nitrogen leakage test (N.9), omitting N.9.4. Record the results as specified in N.18.16.
- 7) Perform the SSCSV V3 flow test (N.16).
- 8) Repeat Step 6) and Step 7) fourteen additional times. The closing flow rate for velocity-type SSCSVs or the closing pressure for tubing-pressure-type SSCSVs shall repeat within  $\pm 15\%$  of the closing flow rate or pressure of Step 3), or the valve fails the test. If the test valve fails, discontinue testing.
- 9) Perform the liquid leakage test (see N.5). If the test valve is being validated to V3 requirements only, proceed to Step 14).
- 10) Perform the nitrogen leakage test (see N.9), omitting N.9.4.
- 11) Perform the V2 flow test (see N.17). V2 flow testing shall be performed in a continuous manner with no interruptions longer than 2 h.
- 12) Repeat N.13.10 and N.13.11 six additional times. The closing flow rate for a velocity-type SSCSV or the closing pressure for a tubing-pressure-type SSCSV shall repeat within  $\pm 15\%$  of the closing flow rate or pressure of N.13.3, or the test valve fails the test.
- 13) Perform the liquid leakage test (see N.5).
- 14) If the test valve has performed within the limits specified, it has passed the validation test.
- 15) Summarize the validation test data as specified in N.18.12.

#### **N.14 Gas closure test — SSCSV**

- 1) Record test data as specified in N.18.13.
- 2) Increase gas pressure in the system to between 13,8 MPa (2 000 psi) and 17,3 MPa (2 500 psi).
- 3) Close the test valve as follows.
  - a) Velocity-type SSCSVs — Increase the gas flow rate through the test valve until the test valve closes. The test valve shall close at a flow rate of at least  $\pm 25\%$  of the design closing flow rate indicated in the test application (see 5.5.11.2) in 30 s or less from the time this flow rate is achieved, or the test valve fails the test. If the test valve fails, discontinue testing. Record the initial pressure upstream of the test valve, the differential pressure across the test valve closure mechanism, and the gas flow rate through the test valve at closure.
  - b) Tubing-pressure-type SSCSVs — Adjust the gas pressure downstream of the test valve to ensure the test valve is open. Decrease the downstream pressure until the test valve closes. The test valve shall close at a downstream pressure of at least 75 % of the design closing pressure indicated in the test application (see 5.5.11.2). The minimum allowable downstream pressure is 0,35 MPa (50 psi). The test valve shall close in 30 s or less from the time this minimum pressure is achieved, or the test valve fails the test. Record the initial pressure downstream of the test valve and the pressure downstream of the test valve at closure. If the test valve fails, discontinue testing.

- 4) Bleed the valve bore downstream pressure to zero. Adjust the test valve bore upstream pressure to 8,3 MPa (1 200 psi)  $\pm$  5 %. Wait a minimum of 1 min, then measure any gas leakage through the closure mechanism. Record the test valve bore pressure, the leakage rate and the start and completion times of the waiting period. If the leakage rate is greater than 0,14 m<sup>3</sup>/min (5 scf/min), the test valve fails. If the test valve fails, discontinue testing.
- 5) Bleed all pressure to zero.

## **N.15 Liquid closure test — SSCSV**

- 1) Record test data as specified in N.18.14.
- 2) Circulate liquid through the system while bypassing the test valve until gas has been displaced from the system.
- 3) Adjust the circulation rate through the test valve to obtain a flow at the rate specified in Table N.4.

**Table N.4—SSCSSV Liquid Flow Rates**

| Nominal<br>tubing or<br>casing size<br><br>mm (in) | Circulation rate<br><br>m <sup>3</sup> /d (B/D)<br>( $\pm$ 10%) |
|--|---|
|  | <b>V3 and V2</b>  |
| 60.3 (2 3/8)                                       | 79 (500)  |
| 73.0 (2 7/8)                                       | 124 (780)   |
| 88.9 (3 1/2)                                       | 178 (1120)  |
| 101.6 (4)  | 238 (1500)  |
| 114.3 (4 1/2)                                      | 305 (1920)  |
| 127.0 (5)  | 386 (2430)  |
| 139.7 (5 1/2)                                      | 477 (3000)  |
| 165.1 (6 1/2)                                      | 686 (4320)  |
| 177.8 (7)  | 935 (5880)  |

- 4) Close the test valve as follows.
  - a) Velocity-type SSCSVs — Adjust the pressure downstream of the test valve to between 0,35 MPa and 0,38 MPa (50 psi and 55 psi). Increase the circulation rate through the valve until the valve closes. The circulation rate shall be increased such that the pressure downstream of the test valve can be maintained between 0,35 MPa and 0,38 MPa (50 psi and 55 psi). The test valve shall close at a flow rate of at least  $\pm$  25 % of the design closing flow rate indicated in the test application (see 5.5.11.2) in 30 s or less from the time this flow rate is achieved, or the test valve fails the test. If the test valve fails, discontinue testing. Record the initial pressure upstream of the test valve, the differential pressure across the valve closure mechanism and the flow rate through the valve at closure.

- c) Tubing-pressure-type SSCSVs — Decrease the downstream pressure until the test valve closes. The test valve shall close at a downstream pressure of at least 75 % of the design closing pressure indicated in the test application (see 5.5.11.2). The minimum allowable downstream pressure shall be 0,35 MPa (50 psi). The valve shall close in 30 s or less from the time this pressure minimum is achieved, or the valve fails the test. Record the initial pressure downstream of the test valve and the pressure downstream of the test valve at closure. If the test valve fails, discontinue testing.

## **N.16 V3 flow test — SSCSV**

- 1) Record test data as specified in N.18.17.
- 2) Circulate water through the system while bypassing the test valve until gas has been displaced from the system.
- 3) Adjust the water circulation rate through the test valve to obtain a flow rate at the value specified in Table N.4. Record the time at which flow is directed through the test valve and the circulation rate. Circulate water through the test valve at the specified rate for a minimum of 1 h.
- 4) Close the test valve using the liquid closure test procedure (see N.15), using water as the test medium and omitting Step 1) and Step 2) in N.15.

## **N.17 V2 flow test — SSCSV**

- 1) Record test data as specified in N.18.18.
- 2) Prepare a slurry consisting of 150 µm to 180 µm (100 U.S. mesh to 80 U.S. mesh) sand and viscosified water.
- 3) Determine the sand content of the slurry in accordance with the API MPMS, Chapter 10.4. Adjust the sand content to 2 % ± 0,5 % by adding 150 µm to 180 µm (100 U.S. mesh to 80 U.S. mesh) sand or by diluting the slurry with water.
- 4) Determine the viscosity of the slurry sample with a Marsh funnel viscometer in accordance with ISO 10414-1. Adjust the viscosity to 70 s ± 5 s by adding a viscosifier or diluting the slurry with water.

NOTE For the purposes of these provisions, API RP 13B-1 is equivalent to ISO 10414-1.

- 5) The viscosity and sand content requirements specified above shall be met before proceeding.
- 6) Adjust the slurry circulation rate to the value specified in Table N.4. Record the slurry circulation rate, sand content and slurry viscosity. Also, record the time at which the slurry circulation begins.
- 7) Circulate slurry through the test valve at the specified rate for a minimum of 1 h, and then close the test valve using the liquid closure test procedure (see N.15), using slurry as the test medium and omitting Step 1) and Step 2) in.
- 8) At the completion of the circulation period, measure and record the sand content and the slurry viscosity.

## **N.18 Data Requirements**

### **N.18.1 Initial opening and closing test — SSCSV (References N.2.2.2 and N.2.2.4)**

The following shall be recorded:

- a) validation test number;
- d) test stand (or apparatus) identification;
- e) date (month/day/year);
- f) test start time; test stop time;
- g) open and close at zero valve bore pressure:
  - 1) full-open hydraulic control pressure (measured),
  - 2) full-closed hydraulic control pressure (measured);
- h) conducted by: (printed name and signature), date: (month/day/year).

#### **N.18.2 Gas flow test — SCSSV (Reference N.3)**

The following shall be recorded:

- a) validation test number;
- b) date (month/day/year);
- c) test start time; test stop time;
- d) data to be collected/recorded for each flow test shall be as follows:
  - 1) hydraulic opening pressure at zero bore pressure,
  - 2) hydraulic closing pressure at zero bore pressure,
  - 3) hydraulic opening pressure at 13,8 MPa to 17,2 MPa (2 000 psi to 2 500 psi) bore pressure,
  - 4) closure data:
    - i) gas flow rate,
    - ii) full-closed hydraulic control pressure,
    - iii) time to close,
  - 5) nitrogen leakage data:
    - i) test pressure,
    - ii) leakage rate,
    - iii) body joint leakage detected? (yes or no);
- e) test passed? (yes or no);
- f) conducted by: (printed name and signature), date: (month/day/year).

### **N.18.3 Drift test — SCSSV (Reference N.4)**

The following shall be recorded:

- a) validation test number;
- b) drift information:
  - 1) minimum inside diameter or maximum outside diameter of test valve (specify ID or OD),
  - 2) drift bar outside diameter or drift sleeve inside diameter (specify ID or OD),
  - 3) drift length,
  - 4) unique identifier of drift bar or sleeve;
- c) for each drift test, record the following:
  - 1) date of test (month/day/year),
  - 2) full-open hydraulic control pressure (five times),
  - 3) full-closed hydraulic control pressure (five times),
  - 4) drift pass? (yes or no);
- d) conducted by: (printed name and signature), date: (month/day/year).

### **N.18.4 Liquid leakage test — SCSSV (Reference N.5)**

The following shall be recorded:

- a) validation test number;
- b) test stand (or apparatus) identification;
- c) for each iteration (N.2.2.5, N.2.2.13, and N.2.3.5) of the liquid leakage test, record the following:
  - 1) identification of the applicable test step being performed (note validation level as well),
  - 2) date of test (month/day/year),
  - 3) valve bore test pressure (nominal 100 % of rated working pressure),
  - 4) time at which test pressure is applied,
  - 5) time at start of leakage test,
  - 6) time at end of leakage test,
  - 7) average leakage rate at test pressure (100 % of rated working pressure),
  - 8) body leakage detected (TRSV only)? (yes or no),

9) test step passed? (yes or no);

d) conducted by: (printed name and signature), date: (month/day/year).

#### **N.18.5 Unequalized opening test — SCSSV (Reference N.6)**

The following shall be recorded:

- a) validation test number;
- b) test stand (or apparatus) identification;
- c) date (month/day/year);
- d) rated working pressure of SCSSV being tested;
- e) manufacturer's maximum recommended unequalized opening pressure (from operating manual);
- f) for each unequalized opening test, record the following:
  - 1) test start time; test completion time,
  - 2) valve bore upstream test pressure (measured),
  - 3) equalizing test pressure (measured),
  - 4) full-open hydraulic control pressure (measured);
- g) Test passed? (yes or no);
- h) conducted by: (printed name and signature), date: (month/day/year).

#### **N.18.6 Operating pressure test — SCSSV (reference N.7)**

The following shall be recorded:

- a) validation test number;
- b) test stand (or apparatus) identification;
- c) for each iteration (N.2.2.7, N.2.2.10, N.2.2.12, N.2.3.2, and N.2.3.4) of the operating pressure test, record the following:
  - 1) date (month/day/year),
  - 2) initial SCSSV valve bore pressure (base pressure) at 25 % of working pressure,
  - 3) full-open hydraulic control pressure (and actual test section pressure),
  - 4) full-closed hydraulic control pressure (and actual test section pressure),
  - 5) record repeated cycle results as specified by the requirement in N.7,

- 6) repeat above at 75 % of working pressure;
- d) calculate the following values:
  - 1) adjusted hydraulic control pressure — full-closed,
  - 2) average of adjusted hydraulic control pressure — full-closed,
  - 3) adjusted hydraulic control pressure — full-open,
  - 4) average of adjusted hydraulic control pressure — full-open;
- e) body leakage detected (TRSV only)? (yes or no);
- f) test passed? (yes or no);
- g) conducted by: (printed name and signature), date: (month/day/year).

#### **N.18.7 Propane test — SSSV (reference N.8)**

The following shall be recorded:

- a) validation test number;
- b) test stand (or apparatus) identification;
- c) date (month/day/year);
- d) for each of the open/close cycles at zero test valve bore pressure, record the following:
  - 1) full-closed hydraulic control pressure,
  - 2) full-open hydraulic control pressure;
- e) calculate the following values for the set of cycles just completed:
  - 1) average adjusted hydraulic control pressure - full-closed; same plus 10 %; same minus 10 %,
  - 2) average adjusted hydraulic control pressure - full-open; same plus 10 %; same minus 10 %;
- f) for each of the open/close cycles at 2,8 MPa (400 psi) test valve nominal bore pressure, record the following:
  - 1) time at valve closure,
  - 2) full-closed hydraulic control pressure,
  - 3) time at valve opening,
  - 4) full-open hydraulic control pressure;
- g) calculate the following values for the set of cycles just completed:

- 1) average adjusted hydraulic control pressure - full-closed; same plus 10 %; same minus 10 %;
  - 2) average adjusted hydraulic control pressure - full-open; same plus 10 %; same minus 10 %.
- h) for (each) propane soak period. record the following:
- 1) time at start of soak period,
  - 2) time at end of soak period,
  - 3) valve bore pressure at end of soak period;
- i) record the last full-closed hydraulic control pressure at the end of the propane test.
- j) Test passed? (yes or no);
- k) conducted by: (printed name and signature), date: (month/day/year).

#### **N.18.8 Nitrogen leakage test — SSSV (reference N.9)**

The following shall be recorded:

- a) validation test number;
- b) test stand (or apparatus) identification;
- c) for each iteration (N.2.2.9, N.2.2.12, N.2.3.1, and N.2.3.4) of the nitrogen leakage test, record the following:
  - 1) date (month/day/year),
  - 2) SCSSV bore pressure [1,33 MPa to 1,47 MPa (190 psi to 210 psi)],
  - 3) time at start of waiting period,
  - 4) time at completion of waiting period,
  - 5) measured gas leakage rate,
  - 6) body leakage detected (TRSV only)? (yes or no),
  - 7) SCSSV bore pressure [20 % to 30 % of rated working pressure (RWP)],
  - 8) full-open hydraulic control pressure,
  - 9) time at start of waiting period,
  - 10) time at completion of waiting period,
  - 11) measured gas leakage rate,
  - 12) body leakage detected (TRSV only)? (yes or no),
  - 13) test passed? (yes or no);

d) conducted by: (printed name and signature), date: (month/day/year).

#### **N.18.9 V3 flow test — SCSSV (reference N.10)**

The following shall be recorded:

- a) validation test number;
- b) test stand (or apparatus) identification;
- c) for each iteration (N.2.2.11 and N.2.2.12) of the V3 flow test, record the following:
  - 1) date of test (month/day/year),
  - 2) for each circulation flow rate record the following:
    - i) time at start of circulation through test valve,
    - ii) time at valve closure,
    - iii) water flow rate immediately before valve closure,
    - iv) full-closed hydraulic control pressure,
    - v) flow 15 s after hydraulic control pressure reaches zero,
    - vi) time to close,
    - vii) full-open hydraulic control pressure;
- d) test passed? (yes or no);
- e) conducted by: (printed name and signature), date (month/day/year).

#### **N.18.10 Controlled temperature test — SCSSV (reference N.11)**

The following shall be recorded:

- a) validation test number;
- b) test stand (or apparatus) identification;
- c) SCSSV stabilized test temperature;
- d) For each iteration (N.11.4, N.11.7, and N.11.9) of the controlled temperature test, record the following:
  - 1) date (month/day/year),
  - 2) initial SCSSV valve bore pressure (base pressure) at 25 % of working pressure at 38 °C (100 °F) and 82 °C (180 °F),
  - 3) full-open hydraulic control pressure (and actual test section pressure),

- 4) full-closed hydraulic control pressure (and actual test section pressure),
- 5) record repeated cycle results as specified by the requirements in N.11.4,
- 6) repeat above at 75 % of working pressure;
- e) Calculate the following values:
  - 1) adjusted hydraulic control pressure — fully-closed,
  - 2) average of adjusted hydraulic control pressure — fully-closed,
  - 3) adjusted hydraulic control pressure — fully-open,
  - 4) average of adjusted hydraulic control pressure — fully-open;
- f) For each control line leakage test (at specified valve temperature and pressure), record the following:
  - 1) time at start of waiting period,
  - 2) time at completion of waiting period,
  - 3) leak detected? (yes or no),
  - 4) body leakage detected (TRSV only)? (yes or no);
- g) For each closure mechanism leakage test (at specified valve temperature and pressure below the closure mechanism), record the following:
  - 1) test temperature,
  - 2) time at which the bore pressure above the closure mechanism is reduced to zero,
  - 3) valve bore pressure below the closure mechanism,
  - 4) time at start of waiting period,
  - 5) time at completion of waiting period,
  - 6) leakage rate,
- h) Test passed? (yes or no);
- i) conducted by: (printed name and signature), date: (month/day/year).

#### **N.18.11 V2 flow test — SCSSV (reference N.12)**

The following shall be recorded:

- a) validation test number;
- b) test stand (or apparatus) identification;

c) For each iteration (N.2.3.3 and N.2.3.4) of the V3 flow test, record the following:

- 1) date of test (month/day/year),
- 2) time at start of slurry circulation through valve,
- 3) flow rate at start of circulation period,
- 4) sand concentration (%) at start of circulation period,
- 5) slurry viscosity at start of circulation period,
- 6) time at valve closure (against slurry flow),
- 7) slurry flow rate,
- 8) full-closed hydraulic control pressure,
- 9) flow 15 s after hydraulic control pressure reaches zero,
- 10) time to close,
- 11) sand concentration (%) at completion of circulation period,
- 12) slurry viscosity at completion of circulation period,
- 13) test passed? (yes or no);

d) conducted by: (printed name and signature), date: (month/day/year).

#### **N.18.12 Validation test summary — SSSV (references N.2.3.8 and N.13.15)**

The following shall be recorded:

- a) identification of test agency (company/facility name, location/address, pertinent department, etc.);
- b) identification of product manufacturer (company name, location/address, pertinent department, contact name & phone numbers, etc.);
- c) date of validation test and date of report;
- d) validation test number (provided by test facility);
- e) equipment type: SCSSV, SSCSV (surface controlled vs. subsurface controlled, etc.);
- f) model designation or other identification by manufacturer;
- g) product number with unique serial number;
- h) nominal tubing size;
- i) rated working pressure;

- j) validation grade tested (V2 or V3);
- k) validation grade passed (V2 or V3);
- l) if valve failed the test, step at which the failure occurred and the reason for failure;
- m) remarks (describing any non-specified equipment or procedures requested by valve manufacturer, unusual conditions observed during test, etc.);
- n) test approved by: (test agency approval authority), date: (month/day/year).

#### **N.18.13 Gas closure test — SSCSV (reference N.14)**

The following shall be recorded:

- a) validation test number;
- b) test stand (or apparatus) identification;
- c) test start time;
- d) test completion time;
- e) date (month/day/year);
- f) for velocity-type SSCSVs:
  - 1) initial test valve upstream pressure,
  - 2) closing flow rate (gas),
  - 3) differential closing pressure,
  - 4) calculate maximum closing rate,
  - 5) calculate minimum closing rate;
- g) for tubing-pressure-type SSCSVs:
  - 1) initial test valve downstream pressure,
  - 2) downstream closing pressure,
  - 3) design closing pressure,
  - 4) calculate maximum closing rate,
  - 5) calculate minimum closing rate;
- h) nitrogen leakage data:
  - 1) test valve bore pressure,

- 2) leakage rate;
- i) test passed? (yes or no);
- j) conducted by: (printed name and signature), date: (month/day/year).

#### **N.18.14 Liquid closure test — SSCSV (reference N.15)**

The following shall be recorded:

- a) validation test number;
- b) test stand (or apparatus) number;
- c) test start time;
- d) test completion time;
- e) date (month/day/year);
- f) for velocity-type SSCSVs:
  - 1) initial test valve downstream pressure,
  - 2) closing flow rate (water),
  - 3) differential closing pressure,
  - 4) design closing flow rate (liquid),
  - 5) maximum closing rate:  $125 \% \times \text{design closing rate (liquid)}$ ,
  - 6) minimum closing rate:  $75 \% \times \text{design closing rate (liquid)}$ ;
- g) for tubing-pressure-type SSCSVs:
  - 1) initial test valve downstream pressure,
  - 2) downstream closing pressure,
  - 3) maximum closing rate:  $125 \% \times \text{design closing rate (liquid)}$ ,
  - 4) minimum closing rate:  $75 \% \times \text{design closing rate (liquid)}$ ;
- h) test passed? (yes or no);
- i) conducted by: (printed name and signature), date: (month/day/year).

#### **N.18.15 Propane test — SSCSV (reference N.13.5)**

The following shall be recorded:

- a) validation test number;

- b) test stand (or apparatus) identification;
- c) propane soak period:
  - 1) date,
  - 2) 2 h soak period:
    - i) start,
    - ii) stop;
  - 3) valve bore pressure at end of 2 h soak period;
- d) closure after propane soak:
  - 1) test start time,
  - 2) test completion time,
  - 3) date (month/day/year);
- e) for velocity-type SSCSVs:
  - 1) initial test valve downstream pressure,
  - 2) closing flow rate (water):
    - i) + 15 % of the closing flow rate recorded in N.18.14 f) 2),
    - ii) - 15 % of the closing flow rate recorded in N.18.14 f) 2);
  - 3) differential closing pressure;
- f) for tubing-pressure-type SSCSVs:
  - 1) initial test valve downstream pressure,
  - 2) downstream closing pressure:
    - i) + 15 % of the downstream closing pressure recorded in N.18.14 g) 2),
    - ii) - 15 % of the downstream closing pressure recorded in N.18.14 g) 2);
- g) test passed? (yes or no);
- h) conducted by: (printed name and signature), date: (month/day/year).

#### **N.18.16 Nitrogen leakage — SSCSV (reference N.13.6)**

The following shall be recorded:

- a) validation test number;

- b) test stand (or apparatus) identification;
- c) for each iteration of the SSCSV nitrogen leakage test (reference N.13.6 and N.13.8):
  - 1) date (month/day/year),
  - 2) valve bore test pressure [1,33 MPa to 1,47 MPa (190 psi to 210 psi)],
  - 3) time at start of waiting period,
  - 4) time at completion of waiting period,
  - 5) measured gas leakage rate,
  - 6) valve bore test pressure (20 % to 30 % RWP),
  - 7) time at start of waiting period,
  - 8) time at completion of waiting period,
  - 9) measured gas leakage rate,
  - 10) test passed? (yes or no);
- d) conducted by: (printed name and signature), date: (month/day/year).

#### **N.18.17 V3 flow test — SSCSV (reference N.16)**

The following shall be recorded:

- a) validation test number;
- b) test stand (or apparatus) identification;
- c) for velocity-type SSCSVs:
  - 1) + 15 % of closing flow rate recorded in N.18.14 f) 2),
  - 2) – 15 % of closing flow rate recorded in N.18.14 f) 2);
- d) For tubing-pressure-type SSCSVs:
  - 1) + 15 % of downstream closing pressure recorded in N.18.14 g) 2),
  - 2) – 15 % of downstream closing pressure recorded in N.18.14 g) 2);
- e) For each iteration of the SSCSV V3 flow test (reference N.13.7 and N.13.8), record the following:
  - 1) date of test (month/day/year),
  - 2) for each circulation flow rate record the following:
    - i) time at start of circulation through test valve,

- ii) flow rate at start of circulation period,
- iii) time at valve closure;
- 3) for velocity-type SSCSVs:
  - i) initial downstream pressure,
  - ii) water flow rate at closure,
  - iii) differential pressure across valve at closure;
- 4) for tubing-pressure-type SSCSVs:
  - i) initial downstream pressure,
  - ii) downstream pressure at closure;
- 5) test passed? (yes or no).
- f) conducted by: (printed name and signature), date: (month/day/year).

#### **N.18.18 V2 flow test — SSCSV (reference N.17)**

The following shall be recorded:

- a) validation test number;
- b) test stand (or apparatus) number;
- c) for velocity-type SSCSVs:
  - 1) + 15 % of closing flow rate recorded in N.18.14 f) 2),
  - 2) – 15 % of closing flow rate recorded in N.18.14 f) 2);
- d) for tubing-pressure-type SSCSVs:
  - 1) + 15 % of downstream closing pressure recorded in N.18.14 g) 2),
  - 2) – 15 % of downstream closing pressure recorded in N.18.14 g) 2);
- e) For each iteration of the SSCSV V2 flow test (reference N.13.11 and N.13.12), record the following:
  - 1) date of test (month/day/year),
  - 2) For each circulation flow rate record the following:
    - i) time at start of circulation through test valve,
    - ii) flow rate at start of circulation period,
    - iii) sand concentration (%) at start of circulation period,

- iv) slurry viscosity at start of circulation period (Marsh seconds),
- v) time at valve closure (against slurry flow);
- 3) for velocity-type SSCSVs:
  - i) initial downstream pressure,
  - ii) slurry flow rate at closure,
  - iii) differential pressure across valve at closure;
- 4) for tubing-pressure-type SSCSVs:
  - i) initial downstream pressure,
  - ii) downstream pressure at closure,
  - iii) sand concentration (%) at completion,
  - iv) slurry viscosity at completion of circulation period;
- 5) test passed? (yes or no);
- f) conducted by: (printed name and signature), date: (month/day/year).

## Annex O (normative)

### Annular Safety Valves

#### O.1 General

**O.1.1** This annex contains requirements for annular safety valves (ASVs), as defined herein. Included in these requirements are design, manufacturing, verification, validation and functional testing.

**O.1.2** For ASVs, when referencing the main body of this industry standard, the term ASV shall apply where SSSV is mentioned.

**O.1.3** The ASV shall be designed and manufactured in accordance with Sections 4 through 8 with the exception of the modifications listed in Annex O.

#### O.2 Functional Specification for ASVs

##### O.2.1 ASV Functional Characteristics

The following ASV functional characteristics shall replace 4.3 when applicable:

- a) type of ASV control;
- b) type of ASV retrieval;
- c) type of ASV closing mechanism;
- d) internal self-equalizing capability;
- e) temporary or permanent lock-open system;
- f) pump-through capability; and
- g) any redundant/independent backup operating systems.

##### O.2.2 Well Parameters

The following bullet shall be added to 4.4:

- relationship of ASV with other well devices/tubing/casing by means of a well schematic drawing, if applicable.

##### O.2.3 Operational Parameters

**O.2.3.1** The content in O.2.3.2 and O.2.3.3 shall replace 4.5.1.

**O.2.3.2** The following operational parameters shall be specified for the ASV:

- a) ASV rated working pressure (ASV RWP);
- b) rated temperature range;
- c) production parameters; and
- d) injection parameters.

**O.2.3.3** The conditions under which the ASV will operate (closure mechanism equalization and flow conditions) and the conditions under which the valve closes shall be specified, such as:

- a) loading conditions, including combined loading (pressures, tension/compression, torque, bending) and the corresponding temperature extremes anticipated to be applied to the ASV;
- b) at valve setting depth, the minimum and maximum values of the production/injection pressures and temperatures at the anticipated flow rates; and
- c) composition of the production/injection fluid (gas/oil/water) and density of each component.

## **O.2.4 Optional Parameters**

**NOTE** API 11D1 provides requirements for the functional specification and technical specification, including design, design verification and validation, materials, documentation and data control, repair, shipment, and storage of packers.

In addition to the provisions in 4.5.2, the ASV and the annular packer assembly functional characteristics shall include the following, when applicable:

- a) requirements for the validation grade of the annular packer assembly to conform to API 11D1;
- b) requirements for the ASV to be permanent or retrievable;
- c) end connections above/below the ASV;
- d) applicable information for the interface and integration with the ASV;
- e) configuration of tubing (single or multiple strings) and other lines (electrical/hydraulic) that are required to pass through or bypass the annular packer assembly;
- f) annular packer assembly differential pressure ratings;
- g) installation method, including conveyance method and setting;
- h) retrieving method; and
- i) setting and releasing pressures.

## **O.2.5 User/Purchaser Grade Selection**

**O.2.5.1** SSSV validation grades in 4.9 are not applicable to ASV's. The content in Table O.1 shall replace 4.9.

**Table O.1—ASV Validation Grades**

| <b>Validation Grade</b> | <b>Comments</b>  |
|-------------------------|--|
| V4-A                    | Validation grade V4-A shall only be used for ASVs that have been validated per manufacturer/supplier specified procedures.<br><br>The user/purchaser shall select the applicable validation grade for the annular packer assembly per the Design Validation section of the latest version of API 11D1. |
| V3-A                    | Validation grade V3-A shall only be used for ASVs that have been validated per Section O.4.<br><br>The user/purchaser shall select the applicable validation grade for the annular packer assembly per the Design Validation section of the latest version of API 11D1.                                |

**O.2.5.1** This specification does not currently address HPHT requirements for ASVs. The user/purchaser may specify additional requirements for ASVs that are intended for use in HPHT environments.

### **O.3 Technical Specification**

In addition to the criteria in 5.3.2, the following shall replace the content of 5.3.2.3:

- a) The supplier/manufacturer shall state the pressure, temperature, and axial performance ratings, control chamber pressure rating if applicable, flow area(s), and ASV RWP, excluding end connections. The design shall account for the effects of pressure containment and pressure-induced loads.
- b) Supplier/manufacturer shall determine maximum liquid and gas flow rates through the by-pass flow area.

### **O.4 Design Validation**

#### **O.4.1 General**

**O.4.1.1** The following content replaces 5.5:

- a) The objectives of the validation testing requirements of this subsection are to qualify ASV equipment. ASV equipment furnished to this specification requires validation testing to qualify each size, type, and model of ASV. The validation testing requirements in this specification are not represented as well conditions.
- b) Designs shall be validated to demonstrate that the design assumptions and design analysis methods and practices conform to the defined design requirements. The ASVs produced in accordance with this specification shall pass the validation tests required by this subsection and the functional test in O.9.
- c) Successful completion of the validation testing process shall qualify ASVs of the same size, type, and model as the tested ASV.
- d) The validation tests specified in O.4.2 and O.4.3 can be conducted in any order. Each individual test shall be completed without any repair or redress of the test valve; repair and redress between individual tests is allowed.

- e) Products failing one or more of the tests may be retested to meet the requirements of that test or tests; however, substantive design changes (see 5.7.2) to any component of an ASV shall require that all the validation test(s) are repeated.

**NOTE** An ASV consists of two functional parts: the annular flow isolation assembly and the annular packer assembly. Sections O.4.2 and O.4.3 describe the validation for each.

**O.4.1.2** If an ASV is not configured as separate sub-assemblies, the terms AFIA or annular packer assembly may be replaced with ASV in O.4.2 and O.4.3

## **O.4.2 Design Validation by Scaling**

**O.4.2.1** Design validation of AFIA by scaling shall be conducted in accordance with 5.8 by replacing RWP with ASV RWP

**O.4.2.2** Design validation of Annular Packer Assembly by scaling shall be conducted according to rules for scaling in API 11D1.

## **O.4.3 Annular Flow Isolation Assembly**

### **O.4.3.1 General**

**O.4.3.1.1** Successful completion of the validation testing process shall qualify AFIA of the same size, type, and model as the tested AFIA.

**O.4.3.1.2** The body joints (if applicable) in an AFIA shall be evaluated to ensure that the body joints meet the functional and performance requirements.

**O.4.3.1.3** The body joint evaluation may include design analysis, testing, or history of successful use in the field under conditions that meets or exceeds the current functional and performance requirements.

**O.4.3.1.4** A functional test as specified in O.9 shall be performed prior to commencement of any additional tests.

**O.4.3.1.5** Flow validation and gas flow testing may be conducted per agreement with user/purchaser.

### **O.4.3.2 Opening Differential Unloading of Closure Mechanism**

**O.4.3.2.1** An AFIA or an AFIA that contains or is a SCSSV meeting the requirements of V3, V4-2, or V4-1, in addition to an Opening Differential Test per D.3 or G.4 meet the requirements of this subsection.

**O.4.3.2.2** Validation testing of the AFIA shall be performed in accordance with Table O.2:

**O.4.3.2.3** A full ASV may be tested if specified by the supplier/manufacture. If tested together, the leakage rate of the whole system shall be considered as the leakage across the closure mechanism for the purpose of the Opening Differential Unloading of Closure Mechanism test.

**Table O.2—Opening Differential Unloading Validation Test — AFIA**

| Step | Procedure and Acceptance Criteria  | Data to Be Recorded  |
|------|--|--|
| 1)   | Record the valve identification information.   | <ul style="list-style-type: none"> <li>— Validation test number</li> <li>— Date</li> <li>— Inspection records</li> </ul> |
| 2)   | <p>With the AFIA closed, apply 1.4 MPa <math>\pm</math> 0.07 MPa (200 psi <math>\pm</math> 10 psi) nitrogen pressure below the closure mechanism. Wait a minimum of 1 min, then measure any nitrogen leakage through the closure mechanism.</p> <p><b>Acceptance criteria:</b> If the leakage rate is greater than 0.14 m<sup>3</sup>/min (5 scf/min), the test valve fails.</p> | <ul style="list-style-type: none"> <li>— Test pressure</li> <li>— Measured leakage</li> <li>— Pass / fail</li> </ul>     |
| 3)   | <p>Increase pressure to a minimum of 100 % of the differential rating of the AFIA. Wait a minimum of 1 min, then measure any nitrogen leakage through the closure mechanism.</p> <p><b>Acceptance criteria:</b> If the leakage rate is greater than 0.14 m<sup>3</sup>/min (5 scf/min), the test valve fails.</p>  | <ul style="list-style-type: none"> <li>— Test pressure</li> <li>— Measured leakage</li> <li>— Pass / fail</li> </ul>     |
| 4)   | <p>Maintain a minimum of 100 % of the differential rating of the annular flow isolation assembly below the closure mechanism while maintaining pressure above the closure mechanism at zero. Apply the maximum rated hydraulic control pressure to the annular flow isolation assembly hydraulic system.</p>   | <ul style="list-style-type: none"> <li>— Test pressure</li> <li>— Hydraulic control pressure</li> </ul>                  |
| 5)   | Apply pressure above the closure mechanism until the closure mechanism rapidly opens.  | Test pressure  |
| 6)   | Repeat steps 2 through 5 four more times for a total of five operating cycles.   | Data recorded during steps 2, 3, 4, and 5  |
| 7)   | <p>Apply 1.4 MPa <math>\pm</math> 0.07 MPa (200 psi <math>\pm</math> 10 psi) pressure below the closure mechanism. Wait a minimum of 1 min, then measure any leakage through the closure mechanism.</p> <p><b>Acceptance criteria:</b> If the leakage rate is greater than 0.14 m<sup>3</sup>/min (5 scf/min), the test valve fails</p>  | <ul style="list-style-type: none"> <li>— Test pressure</li> <li>— Measured leakage</li> <li>— Pass / fail</li> </ul>     |
| 8)   | <p>Apply a minimum of 100 % of the differential rating of the AFIA. Wait a minimum of 1 min, then measure any nitrogen leakage through the closure mechanism.</p> <p><b>Acceptance criteria:</b> If the leakage rate is greater than 0.14 m<sup>3</sup>/min (5 scf/min), the test valve fails</p>  | <ul style="list-style-type: none"> <li>— Test pressure</li> <li>— Measured leakage</li> <li>— Pass / fail</li> </ul>     |

| Step | Procedure and Acceptance Criteria   | Data to Be Recorded   |
|------|---|---|
| 9)   | <p>If applicable to the design, Prepare the AFIA for drift tests; Drift bars (and sleeves if requested) shall comply with the requirements of section B.4.1. If the AFIA fails the drift test, it fails the test. Open the AFIA, then, proceed as follows.</p> <p>a) Drift the interior of the AFIA with the supplier/manufacture's specified drift bar. Pass the drift bar completely through the test valve from top to bottom. Repeat the drift test in the opposite direction.</p> <p>b) When required by the functional specification, drift the exterior of the AFIA with the supplier/manufacture's specified drift sleeve. Repeat the drift test in the opposite direction.</p> <p><b>Acceptance criteria:</b> The force applied to move the drift bar or drift sleeve shall not be greater than the weight of the drift bar or sleeve as applicable.</p> | <ul style="list-style-type: none"> <li>— Drift bar/sleeve unique identifier</li> <li>— Drift bar/sleeve size</li> <li>— Internal/external drift test passed? (yes or no)</li> </ul> |
| 10)  | Perform post-test dimensional inspection which shall be documented as specified by the supplier/manufacture procedures and acceptance criteria.   | Inspection records  |

#### **O.4.3.3 Cyclic Temperature Validation**

A cyclic temperature validation test shall be performed per D.2 or an operating life test per G.3.

#### **O.4.3.4 Self-Equalizing Test (When Applicable)**

A self-equalizing test shall be performed per D.4 or an equalization mechanism endurance test per G.5.

### **O.4.4 Annular Packer Assembly**

**O.4.4.1** The annular packer assembly shall be validated to the requirements of API 11D1, Section 6.5 with a minimum validation Grade of V3.

**O.4.4.2** The annular packer assembly may be tested individually, or together with the annular flow isolation assembly.

**O.4.4.3** When tested separately, the interface between the two products shall be validated during the functional test per Table O.3, Step 17.

### **O.5 Design Assessment**

Design assessment for ASVs shall be performed in accordance with 5.11.

### **O.6 Equipment Performance Ratings**

**O.6.1** The supplier/manufacture shall determine and state the equipment-specific performance ratings on the shipping report as required by O.7.1. Where a rated performance envelope is requested or required, the supplier/manufacture shall provide the rated performance envelope as defined by the supplier/manufacture.

**O.6.2** For secondary tools and special features, the supplier/manufacturer shall determine and state the specific performance ratings in the operating manual.

**O.6.3** Individually validated annular isolation flow assemblies and annular packer assemblies may be assembled to form an ASV. The ASV rating(s) shall be the lowest maximum rating(s) and highest minimum rating(s) of the individual assemblies.

**NOTE** The annular isolation flow assembly and annular packer assembly validated individually can have different ratings.

## **O.7 Documentation and Data Control**

### **O.7.1 Shipping Report**

**O.7.1.1** The following shall replace the content of 6.2.2.2.

- a) Manufacturer's data:
  - 1) manufacturer's name and manufacturing address,
  - 2) manufacturer's part number,
  - 3) equipment (name) type and model,
  - 4) serial number,
  - 5) nominal size,
- b) ASV rated performance limits:
  - 1) annular flow isolation assembly rated differential pressure,
  - 2) packer isolation assembly differential pressure,
  - 3) maximum rated operating temperature,
  - 4) minimum rated operating temperature,
  - 5) secondary feature operation pressure, maximum, if applicable.
- c) ASV functional test summary:
  - 1) opening pressure with zero pressure in test section: maximum and minimum, if applicable,
  - 2) closing pressure with zero pressure in test section: maximum and minimum, if applicable,
  - 3) drift test report, if applicable,
  - 4) performed by: (printed name and signature), date: (month/day/year).
- d) Statement of compliance to user/purchaser specified requirements, if applicable;
- e) Inspected by: (printed name and signature), month/day/year.

**O.7.1.2** Additionally, the shipping report shall contain the following when applicable.

a) ASV rated performance limits:

- 1) control chamber pressure, maximum (at maximum operating temperature).
- 2) full open pressure at zero annulus pressure, maximum.
- 3) closing pressure at zero annulus pressure, minimum.
- 4) unequalized opening pressure differential from above and below (if different), maximum.
- 5) control line pressure to maintain sealing of the isolation assembly at zero annulus pressure, maximum.
- 6) pump open pressure; and
- 7) maximum injection flow rate.

b) ASV calculated performance limits:

- 1) annular flow isolation assembly internal yield pressure (at maximum rated operating temperature).
- 2) annular packer assembly internal yield pressure (at maximum rated operating temperature).
- 3) packing element differential pressure (at maximum rated operating temperature).
- 4) packing element differential pressure (at minimum rated operating temperature).
- 5) collapse pressure, minimum (at ambient temperature).
- 6) collapse pressure, minimum (at maximum rated operating temperature).
- 7) tensile strength (at maximum internal pressure and ambient temperature).
- 8) tensile strength (at maximum internal pressure and maximum rated operating temperature).
- 9) tensile strength (without pressure at ambient temperature).
- 10) tensile strength (without pressure at maximum rated operating temperature).

c) Performance envelope of the annular packer assembly.

NOTE A rated performance envelope for a packer and an annular safety valve can be different due to the

**O.7.2 Operating Manual**

The following shall replace the information in 6.2.2.3 for the ASV operating manual .

- a) Size, type, and model.
- b) Validation grade.
- c) Operating data as follows:

- 1) ASV RWP.
  - 2) operating temperature range,
  - 3) temperature cycle range if different from (2) above (ref API 11D1 4th edition 3.32)
  - 4) internal yield pressure,
  - 5) collapse pressure (applies to ASV equipment at maximum rated operating temperature),
  - 6) tensile load strength (applies to ASV equipment at maximum rated operating temperature),
  - 7) rated performance envelope, if specified by the user/purchaser (see example in Annex M).
- d) Dimensional data.
- e) Dimensions of drift bar and drift sleeve, if applicable.
- f) Calculations as follows:
- 1) calculation procedures used to determine maximum fail-safe setting depths, where applicable
  - 2) orifice coefficients, spring force, optimum operating range of pressure differential for velocity-type valves, etc., if applicable
- g) Drawings and illustrations.
- h) Parts list with all necessary information for reordering, including supplier/manufacturer's contact information.
- i) Specific details of functional testing should be included if the test apparatus or procedures are significantly different than those included in this specification.
- j) Installation instructions.
- k) Retrieving instructions.
- l) Inspection and testing procedures.
- m) Troubleshooting and maintenance procedures.
- n) Repair limitations. repair limitations may include limits established on allowable wear of components, number of allowable repair cycles, type and extent of component replacements, or number of thread make/break cycles.
- o) Redress disassembling and reassembling requirements.
- p) Special feature operations and limitations.
- q) Secondary tool operations (see 6.2.2.4).
- r) Gas bleed rate if applicable.

- s) Storage requirements to prevent damage caused by, for example, atmospheric conditions, handling, debris, UV radiation, etc.
- t) Shelf life, if applicable.
- u) Operating requirements as follows:
  - 1) opening and closing procedures with opening and closing pressure.
  - 2) opening and closing procedures that shall include recommendations to avoid unintended closures and throttling.
- v) For alternate technologies, see 5.10.3 for additional requirements replacing SSSV with ASV where applicable.
- w) Landing nipple profile, if applicable (see 5.5.1).

## **O.8 Quality Control**

### **O.8.1 General**

The provisions in O.8.2 through O.8.4 shall be in addition to those in 6.4.

### **O.8.2 Shear Device Verification**

At least one shear device per heat lot shall be sheared in accordance with the supplier/manufacture's documented procedure to verify that the shear value meets the supplier/manufacture's documented specification.

### **O.8.3 Packer Element Inspection**

In addition to 6.4.3.2.1 and 6.4.2, the following shall be performed:

- a) 100% visual and dimensional inspection per supplier's/manufacture's documented specifications;
- b) a test specimen from each batch of elastomeric packing elements shall be hardness tested in accordance with an international standard or national standard, such as ASTM D2240 or ASTM D1415.

### **O.8.4 Product Identification**

Marking and other identification shall conform to 6.3 as applicable. Replace RWP with ASV RWP in bullet 6.3.1.e)

## **O.9 Functional Testing**

**O.9.1** The provisions in O.9.2 through O.9.4 shall replace the provisions of 6.5:

**O.9.2** ASV functional testing shall be performed in accordance with Table O.2 on each ASV. Results of the functional test shall be traceable to the valve tested and retained in accordance with 6.2.1.

**O.9.3** Functional testing may be done in the manufacturer's facility (in-house) or outsourced to a qualified facility. An outside test facility shall be an approved vendor of the manufacturer and shall meet all applicable requirements of this specification, including qualification of inspection and test personnel.

**Table O.3—Functional Test Procedure—ASV**

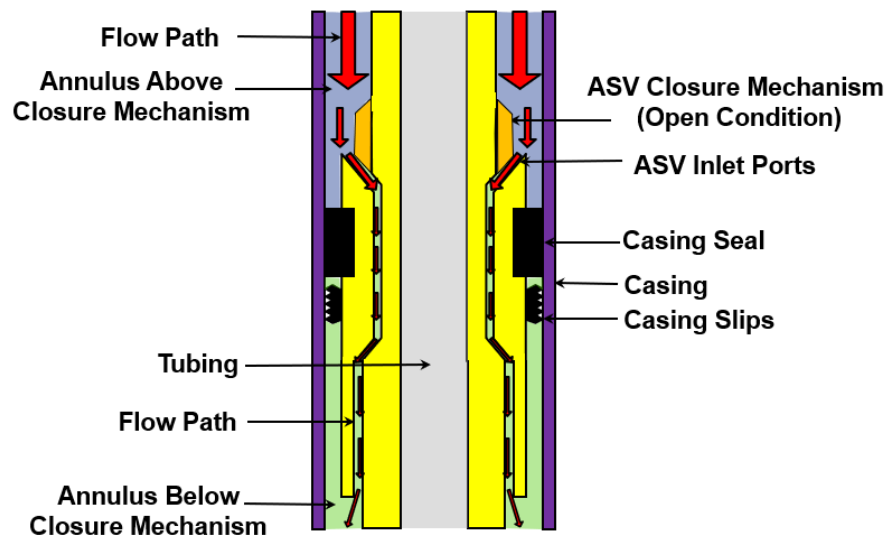
| Step | Procedure and Acceptance Criteria  | Data to Be Recorded   |
|------|--|---|
| 1)   | Record the ASV identification information.   | <ul style="list-style-type: none"> <li>— ASV supplier/manufacture</li> <li>— Equipment name</li> <li>— ASV type and size</li> <li>— Manufacturer's part number</li> <li>— Unique serial number</li> <li>— Working pressure rating</li> </ul>  |
| 2)   | Place the AFIA in a fixture capable of retaining and sealing the annular flow isolation assembly.  | Orientation of Annular Flow Isolation Assembly (horizontal or vertical)   |
| 3)   | <p>Fill the flow path<sup>a</sup> of the AFIA with water or other suitable liquid to displace air and proceed as follows.</p> <p>Close the AFIA. Thoroughly dry the accessible portions of the AFIA. Adjust and stabilize the pressure to a minimum of 100 % of the differential rating of the AFIA (allowable range of 95 % to 105 % of differential rating). Hold the pressure for a minimum of 15 min. Reduce the pressure to zero.</p> <p><b>Acceptance criteria:</b> The AFIA fails the functional test if leakage is detected on the exterior or through the hydraulic control line port(s) as applicable.</p> | <ul style="list-style-type: none"> <li>— Start time and pressure</li> <li>— End time and pressure</li> <li>— Beginning annular pressure</li> <li>— Ending annular pressure</li> <li>— Leakage within 15 min? (yes or no)</li> <li>— Test passed? (yes or no)</li> </ul>   |
| 4)   | <p>Open the AFIA with vented zero pressure in the flow path of the AFIA.</p> <p>Adjust and stabilize the hydraulic control pressure to the supplier/manufacture's recommended hold-open pressure. Isolate the hydraulic control pressure from the source. Monitor for a minimum of 5 min. <b>Acceptance criteria:</b> If a hydraulic control pressure loss greater than 5 % of the applied pressure is detected after stabilization, the AFIA fails the functional test.</p>   | <ul style="list-style-type: none"> <li>— Start time and pressure</li> <li>— End time and pressure</li> <li>— Beginning control pressure</li> <li>— Ending control pressure</li> <li>— Calculated pressure loss over minimum of 5 min</li> <li>— Test passed? (yes or no)</li> </ul>   |
| 5)   | <p>Close and open the AFIA a minimum of five times and a maximum of twenty with zero pressure in the flow path of the AFIA.</p> <p><b>Acceptance criteria:</b> Each control pressure shall repeat within <math>\pm 5</math> % of the average pressure of the total (5 to 20) AFIA operating cycles as well as falling within the supplier/manufacture's specified control pressure tolerance. If each pressure is not within these the limits, the AFIA fails the functional test.</p>   | <p>For each operating cycle:</p> <ul style="list-style-type: none"> <li>— full open hydraulic control pressure</li> <li>— full closed hydraulic control pressure</li> </ul> <p>Calculated average of total operating cycles:</p> <ul style="list-style-type: none"> <li>— full open hydraulic control pressure</li> <li>— full closed hydraulic control pressure</li> <li>— test passed? (yes or no)</li> </ul> |

| Step | Procedure and Acceptance Criteria   | Data to Be Recorded  |
|------|---|--|
| 6)   | <p>If applicable, fill the flow path of the AFIA with water or another suitable liquid to displace air, and proceed as follows.</p> <p>Apply pressure below the closure mechanism to 50% (allowable range of 45 % to 55 % of the differential rating of the AFIA. Hold the pressure a minimum of 5 min. and monitor above the closure mechanism for leakage. Reduce the pressure in the flow path of the AFIA to zero.</p> <p><b>Acceptance criteria:</b> If the leakage rate exceeds 10 cc/min (0.6 in<sup>3</sup>/min), the ASV fails the functional test.</p>  | <ul style="list-style-type: none"> <li>— Start time and pressure</li> <li>— End time and pressure</li> <li>— Beginning pressure below closure mechanism</li> <li>— Ending pressure below closure mechanism</li> <li>— Leakage?</li> <li>— Test passed? (yes or no)</li> </ul>  |
| 7)   | <p>Apply pressure of 50 % of the differential rating of the AFIA (allowable range of 45 % to 55 % of differential rating of the AFIA) to the flow path of the AFIA and verify that pressure is equalized above and below the closure mechanism. Close and open test valve five times while maintaining pressure within the specified range.</p> <p>NOTE The pressure can increase as the AFIA is opened and then can decrease as the AFIA is closed due to the differential volume of the hydraulic operating piston.</p> <p><b>Acceptance criteria:</b> If the five adjusted hydraulic control pressures (or actual control pressures for tubing-pressure-insensitive valves) do not repeat within <math>\pm 10</math> % of their average, or <math>\pm 0.7</math> MPa (<math>\pm 100</math> psi), whichever is greater the AFIA fails the test.</p> | <ul style="list-style-type: none"> <li>— AFIA flow path pressure (base pressure) at 50 % of differential rating of the AFIA</li> <li>— full open hydraulic control pressure and actual pressure in the flow path of the AFIA</li> <li>— full closed hydraulic control pressure and actual pressure in the flow path of the AFIA</li> </ul> <p>Calculate and record the following values:</p> <ul style="list-style-type: none"> <li>— adjusted fully closed hydraulic control pressure</li> <li>— average of adjusted fully closed hydraulic control pressure</li> <li>— adjusted fully open hydraulic control pressure</li> <li>— average of adjusted fully open hydraulic control pressure</li> <li>— repeatability test passed (yes or no)</li> </ul> |
| 8)   | Adjust and stabilize pressure in the flow path of the AFIA to 100 % of the differential rating of the AFIA (allowable range of 95 % to 105 % of differential rating of the AFIA). Close the AFIA.   | <ul style="list-style-type: none"> <li>— Pressure above and below AFIA</li> <li>— Full closed hydraulic control pressure</li> </ul>  |
| 9)   | <p>Bleed the pressure above the AFIA closure mechanism to zero. Adjust and stabilize the pressure below the AFIA closure mechanism to 100 % of the differential rating of the AFIA (allowable range of 95 % to 105 % of differential rating of the AFIA) . Measure liquid leakage for a minimum of 5 min.</p> <p><b>Acceptance criteria:</b> If the leakage rate exceeds 10 cm<sup>3</sup>/min (0.6 in.<sup>3</sup>/min), the ASV fails the functional test.</p>  | <ul style="list-style-type: none"> <li>— Pressure below the AFIA closure mechanism</li> <li>— Start time and pressure</li> <li>— End time and pressure</li> <li>— Measured leakage</li> <li>— Test passed? (yes or no)</li> </ul>  |
| 10)  | Bleed all pressures to zero and remove the liquid from the flow path of the AFIA.   |  |
| 11)  | Open the AFIA. Record the full open hydraulic control pressure.   | Full open hydraulic control pressure   |

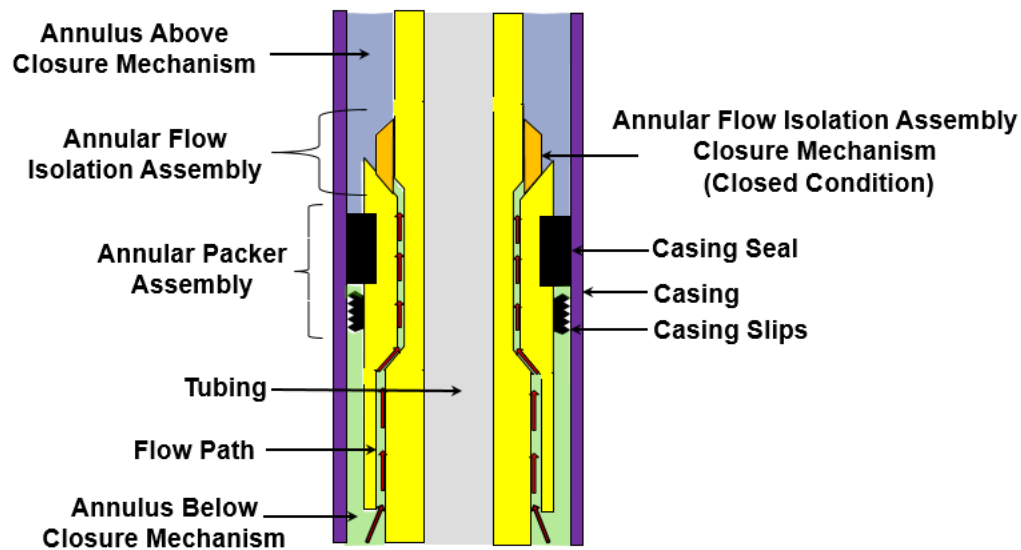
| Step | Procedure and Acceptance Criteria  | Data to Be Recorded   |
|------|--|---|
| 12)  | Adjust and stabilize the pressure above and below the AFIA closure mechanism with gas to $1.4 \text{ MPa} \pm 0.07 \text{ MPa}$ ( $200 \text{ psi} \pm 10 \text{ psi}$ ). Close the AFIA. Bleed the hydraulic control pressure to zero. Monitor for gas leakage at the hydraulic control port(s) for a minimum of 5 min.<br><br><b>Acceptance criteria:</b> If any leakage is detected, the AFIA fails the functional test.  | <ul style="list-style-type: none"> <li>— Pressure above and below the AFIA closure mechanism</li> <li>— Start time and pressure</li> <li>— End time and pressure</li> <li>— Full closed hydraulic control pressure</li> <li>— Control port leakage within 5 min? (yes or no)</li> <li>— Test passed? (yes or no)</li> </ul> |
| 13)  | Bleed the pressure above the AFIA closure mechanism to zero. Adjust and stabilize the pressure below the AFIA closure mechanism to $1.4 \text{ MPa} \pm 0.07 \text{ MPa}$ ( $200 \text{ psi} \pm 10 \text{ psi}$ ) with gas. Measure the leakage rate for a minimum of 5 min.<br><br><b>Acceptance criteria:</b> If the leakage rate exceeds $0.14 \text{ m}^3/\text{min}$ ( $5 \text{ scf}/\text{min}$ ), the AFIA fails the functional test.   | <ul style="list-style-type: none"> <li>— Pressure below the AFIA closure mechanism</li> <li>— Start time and pressure</li> <li>— End time and pressure</li> <li>— Measured leakage</li> <li>— Test passed? (yes or no)</li> </ul>   |
| 14)  | Repeat Steps 12) and 13) with $8.3 \text{ MPa} \pm 0.41 \text{ MPa}$ ( $1200 \text{ psi} \pm 60 \text{ psi}$ ) instead of $1.4 \text{ MPa} \pm 0.07 \text{ MPa}$ ( $200 \text{ psi} \pm 10 \text{ psi}$ ).   |   |
| 15)  | Bleed all pressures to zero.   |   |
| 16)  | Open and close the ASV closure mechanism two times.  | For each of 2 operating cycles: <ul style="list-style-type: none"> <li>— full open hydraulic control pressure</li> <li>— full closed hydraulic control pressure</li> </ul>  |
| 17)  | When required by O.4.3, an internal test shall be performed on the connection(s) between the AFIA and the annular packer assembly as a minimum by plugging the end connections and pressurizing the main tubing bore to a minimum of 100% of the lowest differential rating of the AFIA or annular packer assembly using liquid and hold pressure for 10 minutes.<br><br><b>Acceptance criteria:</b> The ASV fails the functional test if visible leakage is detected at the test connection(s). | <ul style="list-style-type: none"> <li>— Start time and pressure</li> <li>— End time and pressure</li> <li>— Visible leakage?</li> <li>— Test passed? (yes or no)</li> <li>— Test date</li> </ul>   |
| 18)  | Special features unique to a supplier/manufacture's ASV shall be tested in accordance with the supplier/manufacture's operating manual. Failure to meet the requirements of these tests fails the ASV. These tests can be incorporated in the existing sequence of functional tests. Such special-feature test procedures, the sequence, acceptance criteria, and the results shall be fully described in the test report.   | <ul style="list-style-type: none"> <li>— Data required by supplier/manufacture's procedures</li> <li>— Special features test passed? (yes or no)</li> </ul>   |

| Step  | Procedure and Acceptance Criteria   | Data to Be Recorded   |
|---|---|---|
| 19)   | <p>Prepare the ASV for drift tests; Drift bars (and sleeves if requested) shall comply with the requirements of section B.4.1. If the ASV fails the drift test, it fails the functional test. Open the ASV, then, proceed as follows.</p> <ol style="list-style-type: none"> <li>1) Drift the main bore of the ASV assembly with the supplier/manufacturer's specified drift bar. Pass the drift bar completely through the test valve from top to bottom. Repeat the drift test in the opposite direction.</li> <li>2) If applicable to the design, drift the interior of the AFIA with the supplier/manufacturer's specified drift bar. Pass the drift bar completely through the test valve from top to bottom. Repeat the drift test in the opposite direction.</li> <li>3) When required by the functional specification, drift the exterior of the ASV with the supplier/manufacturer's specified drift sleeve. Repeat the drift test in the opposite direction.</li> </ol> <p><b>Acceptance criteria:</b> The force applied to move the drift bar or drift sleeve shall not be greater than the weight of the drift bar or sleeve as applicable.</p> | <ul style="list-style-type: none"> <li>— Drift bar/sleeve unique identifier</li> <li>— Drift bar/sleeve size</li> <li>— Internal/external drift test passed? (yes or no)</li> </ul>       |
| 20)   | <p>If the ASV performs within the limits of the functional test, it passes the functional test. Attach all recorded data to the supplier/manufacturer's test form.</p>  | <ul style="list-style-type: none"> <li>— Test date</li> <li>— Person performing test printed name</li> <li>— Person performing test signature</li> <li>— Document test results</li> </ul> |
| If an AFIA is not configured as a sub-assembly, the term AFIA may be replaced with ASV for Steps 2) to 15).           |   |   |
| <sup>a</sup> The term flow path refers to the flow of the annular injection media in lieu of tubing production media. |   |   |

**O.9.4** Figures O.1 and O.2 shall apply to all ASV styles, casing retention and closing mechanism configurations and should be used to define areas only without prejudice to design.



**Figure O.1 — ASV in Open Condition**



**Figure O.2 — ASV in Closed Condition**

## **O.10O.10 Repair and Redress of ASVs**

### **O.10.1 Repair of ASVs**

Repair of ASVs shall be done in accordance with 7.1 by replacing Annex C with Annex O.9

### **O.10.2 Redress of ASVs**

Redress operations for SSSVs and secondary tools shall be performed per the requirements of Section 7 of API 14B, Sixth Edition, by replacing TRSV with ASV.

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