DESIGN VALIDATION PROCEDURE FOR API 16C PRODUCT

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DESIGN VALIDATION PROCEDURE FOR API 16C PRODUCT

1.0 Application

This procedure shall address the design validation procedures for the API 16C products. The performance requirements shall apply to all products being manufactured and delivered for service, whereas the design validation procedures shall be imposed on designs of products and on designs resulting from changes. Validation testing specified in this annex shall be performed on prototypes or production models.

Reference to room temperature shall be a temperature between 40 °F and 120 °F (4.4 °C and 48.9 °C).

2.0 REFERENCE DOCUMENTS

2.1 *Specification for well head and Tree Equipment, API 6A, 21st Edition.*

2.2 *Specification for Drill-through Equipment, API 16A, 4th Edition.*

2.3 *Specification for Choke and Kill Equipment API 16C 2nd Edition, March 2015*

3 Product Changes

3.1 Design Changes

A design that undergoes a substantive change shall require design validation. A substantive change shall be a change identified by the manufacturer that affects the performance of the product in the intended service condition.

Prototype equipment (or first article) and fixtures used to qualify designs using these validation procedures shall be representative of production models in terms of design, production dimensions/tolerances, intended manufacturing processes, deflections, and materials. If a product design undergoes any changes in fit-form-function or material, the manufacturer shall document the impact of such changes on the performance of the product.

NOTE 1 A change in material may not require retesting if the suitability of the new material can be substantiated by other means.

NOTE 2 Fit, when defined as the geometric relationship between parts, includes the tolerance criteria used during the design of a part and mating parts. Fit, when defined as a state of being adjusted to, or shaped for, includes the tolerance criteria used during the design of a seal and its mating parts.

Equipment should be qualified with the minimal lubricants required for assembly unless the lubricants can be replenished when the equipment is in service or is provided for service in a sealed chamber. The actual dimensions of equipment subjected to validation test shall be within

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the allowable range for dimensions specified for normal production equipment. Worst-case conditions for dimensional tolerances should be addressed by the manufacturer, considering concerns such as sealing and mechanical functioning.

3.2 Metallic Materials

The standard test fluid compatibility shall be documented by testing or reference to established documentation confirming compatibility.

3.3 Nonmetallic Seals

Substantive changes to the original documented design configuration of nonmetallic seals resulting in new design shall undergo design validation in accordance with the testing on nonmetallic seals.

NOTE A change in nonmetallic materials may not require new design validation if the suitability of the new material can be substantiated by other means.

4 Conformance

All products evaluated in design validation tests shall conform with the applicable design requirements of this specification.

5 Product Validation Testing

5.1 Testing Product

Design validation testing shall be conducted on full-size products or fixtures that represent the specified dimensions for the relevant components of the end-product being verified, unless otherwise specified in this annex.

5.2 Product Dimensions

The actual dimensions of equipment subjected to design validation testing shall be within the allowable tolerance range for dimensions specified for normal production equipment. Worst-case conditions for dimensional tolerances should be addressed by the manufacturer, considering concerns such as sealing and mechanical functioning.

5.3 External Paint or Coatings

The product used in any pressure test shall be free of paint or other coatings that would impede leak detection and/or leak observation.

5.4 Maintenance Procedures During Validation

Greasing or lubricating the valves shall not be performed following a failed pressure test in order to continue testing.

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The replacement of parts shall not be allowed during validation procedures, unless specifically noted in this annex.

6 General Acceptance Criteria

6.1 General

Validation testing of the applicable product shall include all the testing requirements of this procedure.

6.2 Design Validation

6.2.1 General

Design validation procedures shall be applied to designs and design changes of products and assemblies. Validation testing shall be performed on prototypes or production models to verify that the performance requirements specified for pressure, temperature, load mechanical cycles, and standard test fluids are met in the product design.

6.2.2 Scaling

Scaling of size and pressure ratings may be used to verify the members of a product family in conformance with the requirements and limitations of this section.

6.2.2.1 Product Family

A product family shall conform to the following design requirements:

a) Configuration: The design principles of physical configuration and functional operation are the same.

b) Design stress levels: The design stress levels in relation to material mechanical properties are based on the same criteria.

6.2.2.2 Limitations of Scaling

Validation by scaling shall be subject to the following limitations.

6.2.2.2.1 Validation by Pressure Rating

The test product may be used to qualify products of the same family having equal or less pressure rating.

6.2.2.2.2 Validation by Size

Testing of one size of a product family shall verify products one nominal size larger and one nominal size smaller than the tested size, with the exception of flexible choke and kill lines. Testing of two sizes shall also verify nominal sizes between the two sizes tested.

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6.2.2.2.3 Determination of Choke Nominal Size for Validation

The choke nominal size shall be defined as the size of the maximum orifice that can be used in that choke body (orifice sizes smaller than the nominal size do not require testing).

NOTE Choke nominal sizes are in one-inch increments.

6.2.2.2.4 Determination of Other End Connector Nominal Sizes

The nominal size of other end connectors shall be defined as the nominal end connector size and lowest rated working pressure.

6.2.2.3 Validation by Temperature Rating

The temperature range validated by the test product shall validate temperature classifications that fall entirely within that range.

6.2.2.4 Validation by Standard Test Fluid

Test products validated by the standard test fluid design validation shall validate the same product family and material properties as the test product.

6.3 Acceptance Criteria

6.3.1 Structural Integrity

The product tested shall not permanently deform to the extent that any other performance requirement is not met.

6.3.2 Standard Test Fluid Compatibility

6.3.2.1 Metallic Materials

The standard test fluid compatibility of metallic materials shall be documented by testing or reference to established documentation conforming compatibility.

6.3.2.2 Nonmetallic Seals

The acceptance criteria for the standard test fluid compatibility of nonmetallic seals shall be documented in compliance with the requirements of this code and shall be in conformance with the manufacturer's specifications. 10.3.3 Post-test Examination

6.3.2.3 Post-test Examination

The tested prototype shall be disassembled and inspected. All relevant items should be photographed. The examination shall include a written statement that the product and component design does not contain defects to the extent that any performance requirement is not met.

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6.4 Hydrostatic Testing

6.4.1 Testing Medium

The testing medium shall be a fluid suitable for the testing temperatures. Water with or without additives, gas, hydraulic fluid, or other mixtures of fluids may be used as the testing medium. The testing medium shall be a fluid that remains in the liquid or gaseous state throughout the test.

6.4.2 Hydrostatic Testing at Room Temperature

6.4.2.1 Acceptance Criteria for Hydrostatic Testing

The hydrostatic test at a temperature between 40 °F and 120 °F (between 4 °C and 50 °C) shall be identified as passed if no visible leakage occurs during the specified pressure hold periods of the test. The pressure change observed on the pressure-measuring device during the hold period shall be less than 5 % of the test pressure or 3.45 MPa (500 psi), whichever is less.

6.5 Temperature Testing

6.5.1 Location of Temperature Measurement

Temperature shall be measured in contact with the equipment being tested within 1/2 in. (12.7 mm) of the throughbore where applicable and within 1/2 in. (12.7 mm) of the surface wetted by the retained fluid on the other equipment.

6.5.2 Application of Heating for Maximum Temperature Testing

The heating for maximum temperature tests may be applied internally in the through-bore or externally. The heating shall be applied such that the entire through-bore or equivalent wetted surface is at or above the maximum temperature.

6.5.3 Application of Cooling for Minimum Temperature Testing

The cooling for minimum temperature tests shall be applied to the entire external surface of equipment.

6.6 Hold Periods

6.6.1 Start of Hold Periods

Hold periods shall start after pressure and temperature stabilization has occurred and the equipment with a pressure-monitoring device has been isolated from the pressure source. The time specified for hold times shall be a minimum.

6.6.2 Pressure Stabilization

The timing of the test shall not start until the test pressure has been stabilized within the 0-100 PSI test range and the external assembly surfaces are dry.

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6.6.3 Temperature Stabilization

Temperature shall be considered stabilized when the rate of change is less than 1°F/min (-17.2 °C/min). The temperature shall remain at or beyond the extreme during the hold period but shall not exceed the extreme by more than 20 °F (11.1 °C).

7 Pressure and Temperature Cycles

Pressure/temperature cycles shall conform to the equipment-specific performance requirements specified in Purchase order. The maximum test pressure shall be rated working pressure as specified in Purchase order. The minimum and maximum test temperatures shall be as specified in conformance with in Purchase order.

8 Nonmetallic Seals

8.1 Design

Design of nonmetallic seals shall conform to drawing & Sara Engineering specification.

8.2 Materials

Materials for nonmetallic seals shall conform to the requirements of drawing & Sara Engineering specification

8.4 Design Validation

8.4.1 General

Nonmetallic seals exposed to well fluids, produced or injected, shall undergo the design validation procedures of this section.

8.4.2 Procedure

This procedure is intended to validate the seal performance in exposure to well fluids in conformance with Table A.1. It supports but does not replace the validation of products containing the seal. Seals shall be tested in conformance with 13.4.3 to validate their performance within the ratings for temperature, pressure, and fluid compatibility.

NOTE This procedure validates the seal performance in test fluids specified in Table A.1, and not the performance of products containing the seal

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Table A.1—Standard Test Fluid

Option	Fluid	Percentage by Volume	Remarks
Test Fluid Option A	Oil	50	Diesel #2 (ASTM D975)
	Brine water	20	Saturated salt at 60 °F (15.5 °C)
	Gas composed of — 85 % methane (CH_4); — 5 % carbon dioxide (CO_2); and — 10 % hydrogen sulfide (H_2S).	30	
Test Fluid Option B	Hydrocarbon liquid	60	Jet fuel, diesel, kerosene, etc
	Water	5	
	Gas composed of — 85 % methane (CH_4); — 5 % carbon dioxide (CO_2); and — 10 % hydrogen sulfide (H_2S).	35	
Test Fluid Option C	Hydrocarbon liquid	60	Jet fuel, diesel, kerosene, etc
	Water	5	
	Gas composed of — 10 % methane (CH_4); — 80 % carbon dioxide (CO_2); and — 10 % hydrogen sulfide (H_2S).	35	

8.4.3 Functional Performance Test of Seals (Pressure/Temperature Testing)

8.4.3.1 General

The functional performance of the seal material shall be verified by a test demonstrating the response of the seal to a sequence of steps; rated pressure, rated temperature, and hold time periods.

8.4.3.2 Test Temperature

The test temperature shall be the specified temperature for the temperature rating being validated (see 4.2.1).

8.4.3.3 Test Pressure

The rated working pressure test, at the test temperature, shall conform to purchase order. The low-pressure test shall be at 200 psi (1.4 MPa), +10 %, -0.

8.4.3.4 Test Fluid Application

The manufacturer may choose to conduct the testing described in 13.4.3 with the standard test fluid described in Table A.1 or with a fluid of choice (e.g. water, water with additives, or gas). If

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the functional performance test of the seals is conducted with the standard test fluid, successful completion of the test shall be acceptable to validate their performance within the ratings for temperature, pressure, and fluid compatibility. However, if the test is conducted with a fluid other than the standard test fluid, the manufacturer shall:

— document the test fluid used; and

— confirm seal compatibility as per the seal immersion testing specified in 13.4.4.

The standard test fluid is defined in Table A.1. The material samples shall be positioned such that they are partially exposed to both the liquid and gas phases. The hydrocarbon liquid shall be over-pressured with the gas mixture.

8.4.3.5 Test Sequence

The test procedure shall have five pressure hold periods in conformance with the following listed test steps:

1) At room temperature, apply rated working pressure, +10 %, -0. After pressure has stabilized, hold for 1 h.

2) Release test pressure to 0 psi.

3) Raise temperature to the maximum rated temperature, +10 %,-0.

4) Raise pressure to rated working pressure, +10 %, -0. After stabilizing pressure, hold for 12 h.

5) Release pressure to zero psi and allow fixture to cool to room temperature.

6) Raise temperature to the maximum rated temperature +10 %, -0.

7) Raise pressure to rated working pressure, +10 %, -0. After stabilizing, hold for 1 h.

8) Release pressure to zero psi and allow fixture to cool to room temperature.

9) Lower temperature to minimum rated temperature +0, -10 %.

10) Raise pressure to rated working pressure, +10 %, -0. After stabilizing pressure, hold for 1 h.

11) Release pressure to zero psi and allow fixture to warm to room temperature.

12) After stabilization at room temperature, raise pressure to 200 psi (1.4 MPa), +10 %, -0. After pressure stabilization, hold for 1 h.

13) Raise pressure to rated working pressure, +10 %, -0. After stabilization, hold for 1 h.

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8.4.3.6 Testing Apparatus

A seal may be tested using the procedure described above in fixtures or products that represent the specified

nominal clearances and extrusion gaps specified for the manufactured part.

8.4.3.7 Acceptance Criteria—Functional Test

Test results shall be acceptable if the following criteria are satisfied during each entire hold period:

— There shall be no visible leakage.

— Pressure shall remain within 5 % of the specified test pressure at the start of the hold period or within 500 psi

(3.45 MPa) of the specified test pressure, whichever is less.

— Pressure shall not drop below the specified test pressure

8.4.4 Immersion Testing

8.4.4.1 General

The fluid compatibility of the seal material shall be verified by a test demonstrating the response of the material to the test fluid listed in Table A.1 for immersion testing. The temperature shall be at or above the maximum rated temperature.

8.4.4.2 Temperature

The test temperature shall be either the maximum specified temperature of the rated temperature class or, if higher, the maximum rated temperature of the equipment being tested. During the exposure period, the temperature shall remain at or above the maximum rated temperature not to exceed the maximum rated temperature by more than 20 °F (11 °C).

8.4.4.3 Pressure

The test pressure, after heating to the test temperature, shall be maintained at 6.9 MPa ± 0.7 MPa (1000 psi ± 100 psi), with adjustments made as necessary.

8.4.4.4 Exposure Period

The test exposure period shall be a minimum of 160 h.

8.4.4.5 Test Fluid Application

The standard test fluid is defined in Table A.1. The seal material shall be positioned such that it is partially exposed to both the liquid and gas phases. The hydrocarbon liquid shall be over-pressured with the gas mixture.

8.4.4.6 Acceptance Criteria—Immersion Test

Test results for thermoplastics shall be acceptable if the condition of the seal material satisfies the following:

— sample volume changes equal to or less than +5 % to -1 %;

— tensile change is +/- 50 %;

— no visible dissolution, cracking, blistering or physical deformation.

Test results for elastomers shall be acceptable if the condition of the seal material satisfies the following:

— hardness: +10/-20 units (+5/-20 units when initial hardness is 90 Shore A);

— swelling: +25 % to -5 %;

— tensile strength, elongation, and 50 % E-modulus +/-50 %.

9 Design Validation of Articulated Choke and Kill Line Assembly

9.1 General

These shall not be required for every component manufactured. The dynamic ability and pressure integrity of the articulated choke and kill line assembly shall be proven by testing. Tests shall use the test fluid of Table A.1 and the temperatures in as in Purchase Order.

NOTE This section identifies validation of the design of swiveling components used in articulated choke and kill lines.

9.2 Dynamic Range Test

The tests shall be at rated working pressure on an articulated line component containing only one point of rotation.

The test shall rotate the assembly through a minimum 45° angle, in two planes, for at least 620 cycles.

9.3 Rapid Decompression Test

The assembly shall be pressurized three separate times to the rated working pressure (+0, –500 psi, [3.4 MPa], or –5 %, whichever is less) and maintained at or above rated temperature. The first pressurization shall be held for 24 h.

The second and third pressure applications shall be held for 12 hours each. After each pressurization, the assembly shall be vented at 1000 psi (6.9 MPa)/minute [+100 psi (0.7 MPa)/minute] and held for at least one hour at atmospheric pressure between pressure

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applications. For acceptance, the assembly shall have no visible leakage nor be damaged in any way affecting normal usage.

9.4 Pressure Endurance Test

The assembly shall be pressurized to rated working pressure [+0, -500 psi (3.4 MPa), or -5 %, whichever is less] and maintained at or above rated temperature and held for seven days. After exposure, the assembly shall be cooled to room temperature. The assembly shall be pressurized with water to at least the test pressure specified in rated working pressure. The test pressure shall be held for 30 minutes. For acceptance, the assembly shall have no visible leakage nor be damaged in any way affecting normal usage.

10 Design Validation of Buffer Chamber

Design validation requirements for the choke and kill manifold buffer chamber shall be satisfied by the hydrostatic test specified in *SARA/QA/DOC/698*.

11 Documentation

The manufacturer shall maintain a file on each design validation. Validation files shall contain or reference the following information, if applicable:

a) test number and revision level, or test procedure;

b) complete identification of the product being tested;

c) date of test completion;

d) test results and post-test examination conclusions;

e) model numbers and other pertinent identifying data on all other sizes, rated pressures, temperature ranges, and standard test fluid ratings of products of the same product family that are qualified by the validation of this particular product;

f) class of seal designs (static, dynamic);

g) all detailed dimensional and material specifications applicable to the tested product, including seals and non-extrusion devices;

j) all test data specified in this procedure, including actual test conditions (pressure, temperature, etc.) and observed leakages or other acceptance parameters;

k) identification of testing media used;

l) test equipment identification and calibration status;

n) letter of compliance stating that the tested equipment is in accordance with the design requirements of this standard.

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