Validation of Valve Bore Sealing Mechanisms for Valves Used in Sandy Service

API STANDARD 6AV1

FOURTH EDITION – BALLOT DRAFT

Contents

(TO BE CREATED BY API EDITORS PRIOR TO PUBLICATION)

Introduction

The validation of wellhead surface safety valves (SSVs), boarding shutdown valves (BSDVs), and underwater safety valves (USVs) is an important part of determining their fitness for service. The changes incorporated with this edition of API 6AV1 include but are not limited to the following:

— 6AV1 was reworded to accommodate USVs per API 17D.

— Clarifies that the 6AV1 Sandy Service Class III test can be used for other valve bore sizes and applications other than safety valve, based on the agreement between the manufacturer and purchaser.

Validation of Safety and Shutdown Valves for Sandy Service

1 Scope

This standard identifies the design validation procedure requirements for a Service Class II or Service Class III API 6A surface safety valve (SSV), API 6A boarding shutdown valve (BSDV) or API 17D underwater safety valve (USV). Service Class II validation applies to the valve bore sealing mechanism to seal performance in the presence of hard substances such as sand. Service Class III validation adds additional requirements for the bonnet assembly sealing parts, including the stem seals.

This standard does not apply to validation of a Service Class I valve design or to validation of the actuator for actuated valves.

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 Specification 6A, *Specification for Wellhead and Tree Equipment*

API Specification 17D, *Specification for Subsea Wellhead and Tree Equipment*

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

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

3 Terms, Definitions, and Abbreviations

3.1 Terms and Definitions

For the purposes of this document, the following terms and definitions apply.

3.1.1
actuator
Mechanism for the remote or automatic operation of a valve or choke.

3.1.2
sandy service
Application where the retained fluid contains particulates such as sand.

3.1.3
substantive change
Significant modification to a product that affects its service or performance as specified or intended.

3.1.4

test agency
Independent third party that provides a test facility and administers a testing program that meets the test valve validation requirements of this standard.

3.1.5
test valve
Actuated valve that conforms to 4.4.1 or 4.4.2 of this standard.

NOTE Test valves may be prototypes or production valves.

3.1.6
validation
Confirmation, through the provision of objective evidence (data), that the requirements for a specific intended use or application have been fulfilled.

3.1.7
valve
Portion of the SSV/USV/BSDV that contains the well stream and shuts off flow when closed.

3.2 Abbreviations

For the purposes of this document, the following abbreviations apply.

bbl	barrels
BSDV	boarding shutdown valve
gpm	gallons per minute
m^3	cubic meters
m^3/min	cubic meters per minute
MPa	megapascals
PR	performance requirement
PSL	product specification level
psi	pounds per square inch (gauge)
RWP	rated working pressure
SSV	surface safety valve
USV	underwater safety valve

4 Validation

4.1 General

The application of Service Class shall be based on requirements specified in API 6A or 17D.

This standard shall be used in conjunction with the other design requirements for safety and boarding shut-down valves of the product specification, for design validation of the valve and:

- A valve bore sealing mechanism for a valve designed to Service Class II; and/or
- A valve bore sealing mechanism and valve stem seal(s) for a valve designed to Service Class III

NOTE 1 In prior editions of this standard, the term “PR2 sandy service” is equivalent to a Service Class II designation in subsequent editions.

NOTE 2 Bore sealing mechanism designs validated to previous editions of this standard can claim to meet the current edition provided records (see 4.4.7) are maintained to support this claim.

NOTE 3 The validation requirements in this standard do not claim to duplicate actual well conditions. Complete validation requirements for all classes of safety valves are contained in applicable editions of API 6A or API 17D.

4.2 Service Class II and Service Class III Valve Validation

To qualify a valve design for Service Class II or Service Class III, the manufacturer shall submit a test valve to a test agency conforming to the requirements of this standard.

For Service Class II and Service Class III designs, a substantive change to design or materials of construction of the valve bore sealing mechanism shall require revalidation of the design. In addition, for Service Class III designs, any substantive change to the valve stem seal shall require revalidation of the design.

4.3 Test Agency

4.3.1 General

The test agency shall be independent of the organization that developed the test valve design and/or manufactured the test valve. The test agency shall perform design validation that satisfies the requirements of this standard using a quality management system that conforms to an internationally recognized standard such as API Q1 or ISO 9001, and includes the following:

— a description of the facility (see 4.3.2) including any limitations on size or pressure rating of test valve that may be tested; test procedures and forms used at the facility;

— basis for determining test scheduling priorities;

— procedures for making application for test, delivery of the test valve, initial installation and checkout of the test valve, and other pertinent information;

— limitations on accessibility of the facility, although such limitations shall not preclude reasonable access to the facility for inspection by manufacturers or equipment owner;

— limitations on receipt of proprietary information;

— any other information considered pertinent by the test agency.

The documentation shall be maintained and furnished to customers upon written request.

4.3.2 Facility Requirements

4.3.2.1 Design Considerations

The test facility shall be designed to permit the validation as detailed in 5.1 and 5.2 of this standard.

NOTE An example piping arrangement and test section detail of a test facility are shown in Figure 1 and Figure 2, respectively.

4.3.2.2 Circulation System Components

The test facility shall have the following circulation system components as a minimum:

— Freshwater tank: A freshwater tank shall be provided with a minimum capacity of 5 bbl (0.8 m^3).

— Sand slurry tank and associated accessories: A cone-bottom sand slurry tank with a minimum capacity of 5 bbl (0.8 m^3) shall be provided. The tank shall be equipped with agitation as required to obtain proper slurry consistency. Sample connections shall be provided in the tank and in the return line to the tank so that representative sand content and viscosity analysis samples may be taken.

— Circulating pumps and controls: Circulating pumps with drivers and special equipment for pumping the sand slurry and freshwater at the required flow rates and pressures shall be installed. A means of flow control shall be provided.

— Circulation piping and controls: The circulation piping should be installed in an arrangement similar to that shown in Figure 1. Isolation valves should be provided as indicated in Figure 1 and Figure 2. The return piping to the sand slurry tank shall be installed in such a manner as to provide agitation to aid in preventing sand accumulation in the bottom of the tank. A device shall be installed between the circulation pumps and test section and shall be used to control test valve differential pressure to 400 psi (2.8 MPa) during the cycling test (refer to 5.1.3 and 5.2.3).

— Circulation flow meter: The circulation flow meter shall be sized so that the flow rate to be measured falls within the flow meter's calibrated measurement range. This flow meter shall provide an output signal suitable for electronic data acquisition.

— Instrumentation: Pressure measuring devices shall conform to API 6A. Measurement instrumentation shall be provided to monitor the following data at a minimum:

  a) circulation flow rate during all testing,

  b) test valve upstream test pressure during the seat test, and

  c) differential pressure across test valve during the cycle test.

— Data acquisition system: A data acquisition system shall be provided to gather electronic data from instrumentation on a time-based system.

4.3.2.3 Utility Systems

The manufacturer and test agency shall agree on the fluid media/power source required to operate the test valve and any other associated operating mechanisms.

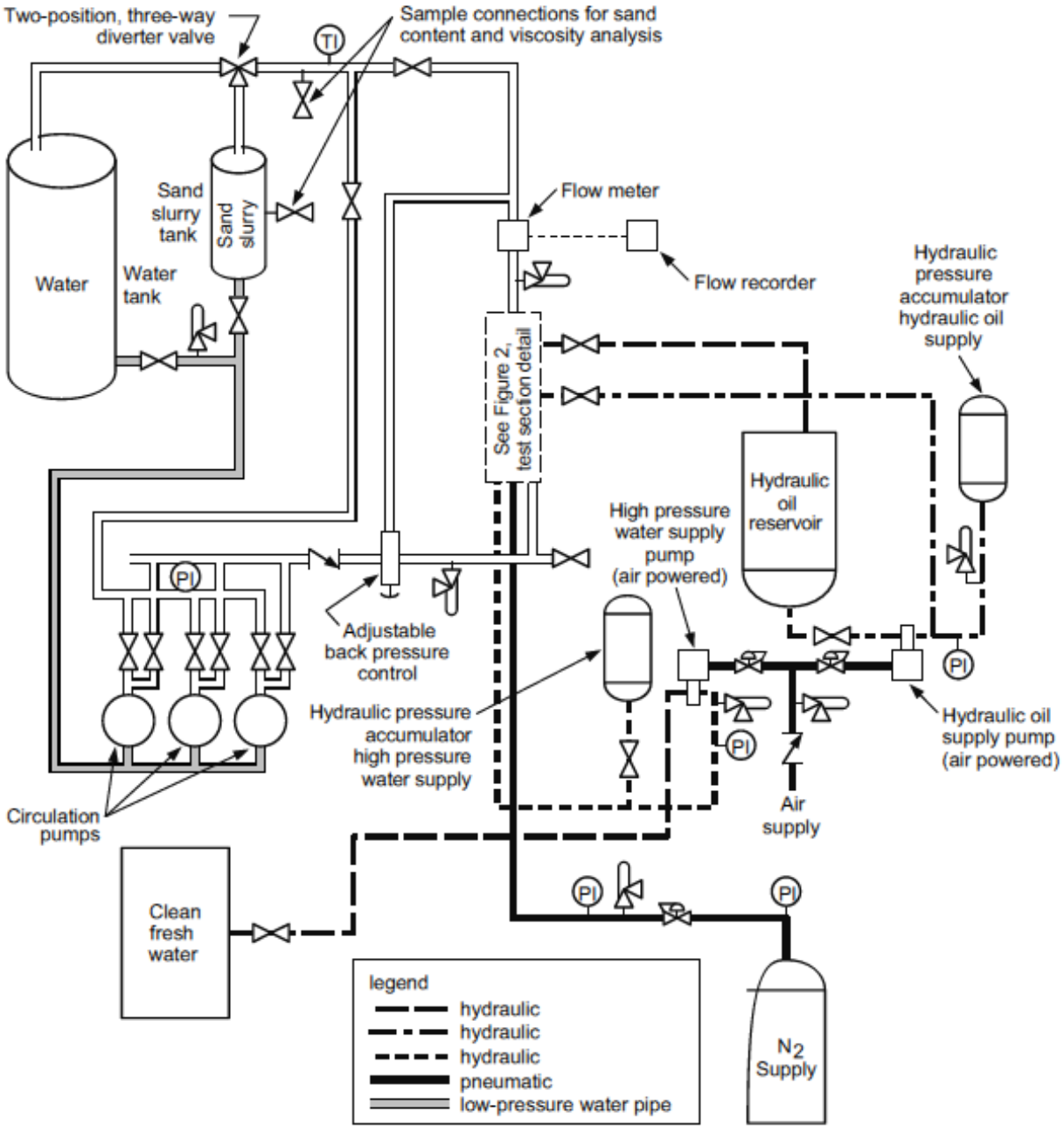

Figure 1—Example Piping Arrangement—Test Facility for Service Class II Valve Validation

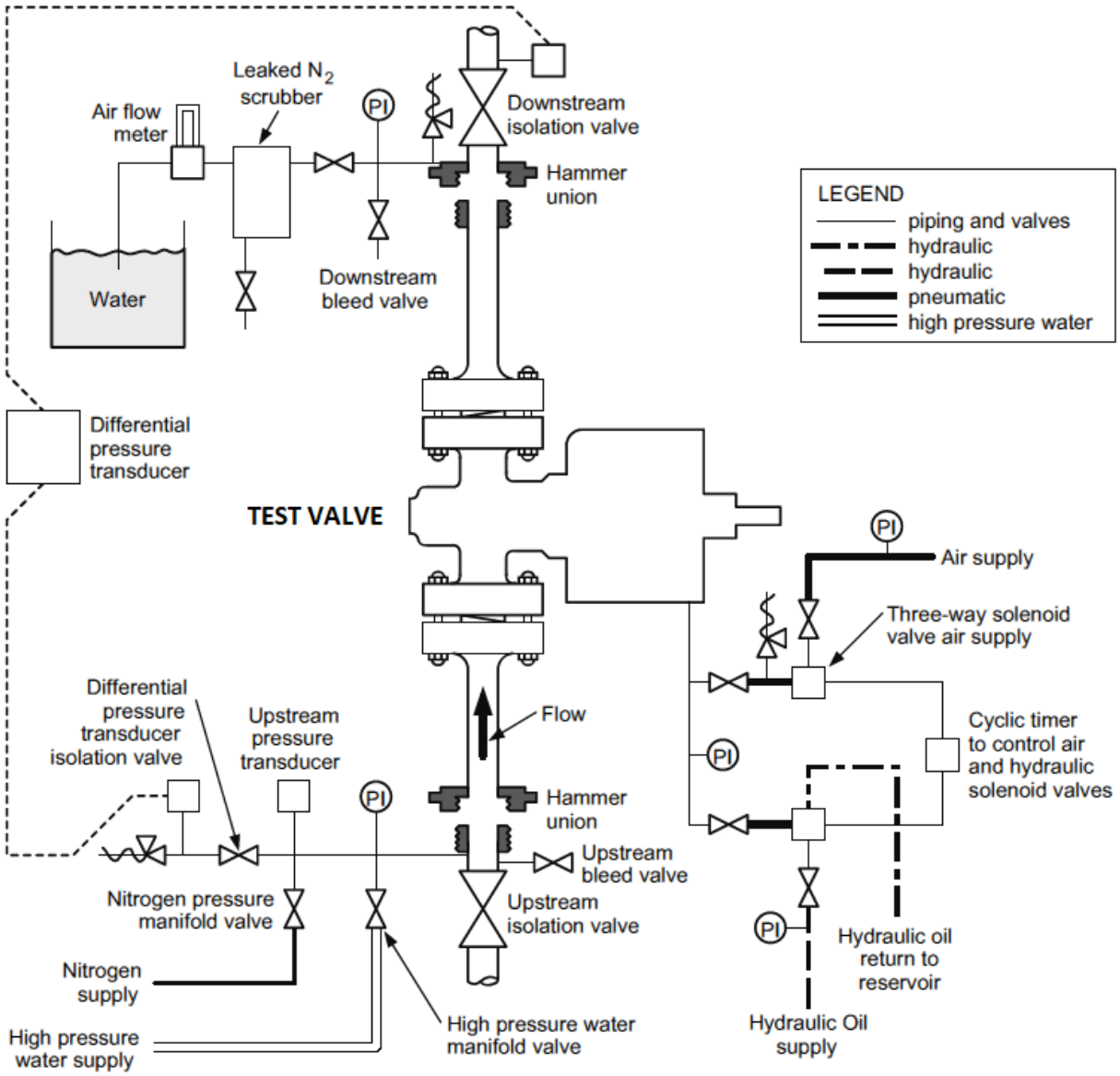

Figure 2—Example Valve Validation Section Detail

4.4 Validation Requirements

4.4.1 Service Class II Requirements for Valve

Unless otherwise noted on the valve manufacturer's application, a $2^{1}/_{16}$ in. (52 mm), 5000 psi (34.5 MPa) rated working pressure (RWP) valve shall be used for the validation.

The valve manufacturer shall provide the test agency with one test valve that meets or exceeds the requirements of API 6A or API 17D, product specification level (PSL) 2, in accordance with the data supplied with the

manufacturer's test application. The test valve shall be assembled with an actuator of the valve manufacturer's choice. The test valve shall be furnished with an operating manual.

4.4.2 Service Class III Requirements for Valve

The valve manufacturer shall provide the test agency with one test valve that meets or exceeds the requirements of API 6A or API 17D, product specification level (PSL) 2 for surface and underwater safety valves, and PSL 3 for boarding shut-down valves, in accordance with the data supplied with the manufacturer's test application. The test valve shall be assembled with an actuator of the valve manufacturer's choice. The test valve shall be furnished with an operating manual.

If the test valve is other than a $2^{1}/_{16}$ in. (52 mm), 5000 psi (34.5 MPa) RWP valve, manufacturer shall also furnish to the test agency all piping components necessary to install the test valve in the facility test loop, unless the manufacturer has made other arrangements with the test agency.

The test valve shall be equipped with a provision to monitor stem seal leakage during the testing.

4.4.3 Test Application

Submission of an application for testing to a test agency shall be a declaration by the valve manufacturer that the identified test valve is of a specific design and construction of the valve bore sealing mechanism. The application form shall include the following:

a) manufacturer's name, address, representative, and contact information;

b) designation of retest or initial test and service class of test (Service Class II or Service Class III);

c) valve data: manufacturer, model or catalog number, part number, serial number, size, RWP, end connector, and any special considerations;

d) actuator data: manufacturer, model or catalog number, part number, serial number, actuation type (pneumatic, hydraulic, other), supply pressure rating, and any special considerations.

NOTE An example of an application form is shown in Table 1.

If a test valve has design or operational features that are incompatible with the test facility and test procedures required by this standard, the manufacturer shall advise the test agency of the nature of the incompatibility and shall request and describe on the test application, or attachment thereto, any nonspecified equipment or procedures required to test the test valve. Responsibility for furnishing and installing nonspecified equipment shall be by agreement between the test agency and the manufacturer. The manufacturer shall document that such nonspecified equipment or procedures are not less stringent than requirements of this standard.

The test agency shall conduct the test as specified on the valve manufacturer's test application. Any variation from the test requirements of this standard shall be recorded in the test report generated by the test agency.

Table 1—Example Application

TEST AGENCY		VALVE ASSEMBLY MANUFACTURER	
Name		Name	
Address		Address	
Qualification Test Service Class II or Service Class III		Representative	
Retest (Y/N)		Application Date	
VALVE DATA		**ACTUATOR DATA**	
Manufacturer		Manufacturer	
Model Name		Model Name	
Part Number		Part Number	
Serial Number		Serial Number	
Type (Gate/Ball)		Type (Pneumatic/Hydraulic/Other)	
Nominal Valve Size			
Rated Working Pressure		Maximum Supply Pressure	
End Connections			
Product Specification	API 6A [ ] API 17D [ ]	Product Specification	API 6A [ ] API 17D [ ]
Special Considerations		Special Considerations	

4.4.4 Testing and Test Acceptance Criteria

Service Class II testing shall conform to 5.1.

Service Class III testing shall conform to 5.2.

The acceptance criteria shall be as follows.

— Valves shall show no visible leakage during each holding period.

For the hold period, the following shall apply:

— Monitored pressures shall not vary from the test pressure at the start of the test by more than 5 % or 3.45 MPa (500 psi), whichever is less, during the entire hold period.

— The initial test pressure shall not be greater than 5 % above the specified test pressure.

— During the entire hold period, the monitored pressure shall not drop below the specified pressure.

4.4.5 Test Reporting

The test agency shall record the results of the validation that contain the minimum data specified below:

— identification of test valve manufacturer (company name, location/address, etc.);

— if retest, reference to previous test number;

— nonstandard equipment required for testing;

— deviations to the test facility procedures;

— equipment type, model, part number, serial number, size, and RWP;

— test results:

a) dates and times at the start and end of all pressure holds and flow rates;

b) test pressures applied and notes on leakage;

c) person(s) performing the tests;

d) sand slurry flow rates;

e) sand slurry sand concentration, temperatures, and viscosities at the start and end of tests;

f) differential test pressures applied during opening/closing cycles;

g) number of opening/closing cycles completed and average cycles per minute;

h) type and frequency of preventive maintenance applied;

i) notes on any testing problems or difficulties;

j) assessment of test results (pass/fail).

NOTE Example forms are shown in Table 2 and Table 3.

Records of testing and test reports shall conform to 4.4.7

4.4.6 Assessment

All steps of the validation procedures in Section 5 shall be performed in the order and within the limits specified. The validation test shall be terminated and not continued if the test valve fails to perform within specified limits at any step of the test procedure, except when such failures are determined to be a result of actions by the test agency or malfunction or failure within the test facility. The basis for terminating the validation, and any unusual conditions observed at or prior to the time of termination, shall be noted on the test data form by the test agency; however, the manufacturer shall be responsible for determining the cause of test valve failure.

If a test valve fails to meet the requirements of this section, that valve and any other valve of the same design and construction of the valve bore sealing mechanism shall not be eligible for retesting until the valve manufacturer has determined the cause of failure, provided corrective action to minimize the likelihood of repeat failure. The cause of failure and corrective actions taken shall be documented.

4.4.7 Records

The manufacturer shall maintain test records for each valve design tested, including any retest that may have been required to qualify a valve design. The valve manufacturer shall provide the test records to the valve owner upon request. Confidentiality of the test results shall be maintained by the valve manufacturer and test agency.

The test records shall be retained by the valve manufacturer for a period of at least 10 years after valves of that design are discontinued from production by the manufacturer.

As a minimum, the records shall contain documentation to identify and permit retrieval of the following:

— test valve drawing(s) that include all manufacturing dimensions, material specifications and surface treatment of valve bore sealing mechanisms that are the basis of the manufactured valve;

— valve test application(s) (see 4.4.3)

— design and material modifications or other justification for retests of valves that did not pass any validation;

— test data specified in this standard;

— model numbers and other pertinent identifying data on all other sizes and RWP of valves of the same basic design and construction of the valve bore sealing mechanism that were qualified for Service Class II or Service Class III by the validation of the test valve.

Table 2—Example Service Class II Test Reporting Form

TEST REPORT NUMBER							
I. TEST VALVE AND ACTUATOR INFORMATION							
	Manufacturer	Model	Type	Part No.	Serial No.	Size	RWP
Valve							
Valve Design Specification				API 6A [ ] API 17D [ ]			
Actuator							
II. INITIAL VALVE SEAT SEAL TEST (Table 4)							
Performed by						Date/Time	
1) Liquid Seat Seal Test Pressure (psi)						Leaked (Y/N)	
2) Gas Seat Seal Test Pressure (psi)						Leaked (Y/N)	
III. SAND SLURRY FLOW TEST (Table 5)							
Performed by						Date/Time	
1) Circulation rate of sand slurry (gpm [m^3/min])							
2) Circulating sand slurry (% by volume of 40 to 60 US mesh sand)							
3) Viscosity determined by Marsh funnel viscometer (seconds)							
4) Slurry temperature (°F/°C)							
5) Time of sand slurry circulation (hours)							
6) Liquid Seat Seal Test Pressure (psi)						Leaked (Y/N)	
7) Gas Seat Seal Test Pressure (psi)						Leaked (Y/N)	
IV. SAND SLURRY FLOW TEST WHILE OPENING AND CLOSING VALVE (Table 6)							
Performed by						Date/Time	
1) Circulation rate of sand slurry (gpm [m^3/min])							
2) Circulating sand slurry (% by volume of 40 to 60 US mesh sand)							
3) Viscosity determined by Marsh funnel viscometer (seconds)							
4) Slurry temperature (°F/°C)							
5) Differential pressure across valve when opened (psi)							
6) Average time to complete one cycle (seconds)							
7) Number of test cycles							
8) Liquid Seat Seal Test Pressure (psi)						Leaked (Y/N)	
9) Gas Seat Seal Test Pressure (psi)						Leaked (Y/N)	
10) Type and frequency of preventive maintenance. Describe in detail							
V. VALVE PERFORMANCE TEST CERTIFICATION (to be completed by a person performing the test or by a test facility–designated certifying officer)							
Remarks—Note any testing problem or difficulties							
Valve qualified for Service **Class II (Y/N)**							
Certified by						**Date/Time**	

Table 3—Example Service Class III Test Reporting Form

TEST REPORT NUMBER							
I. TEST VALVE AND ACTUATOR INFORMATION							
	Manufacturer	Model	Type	Part No.	Serial No.	Size	RWP
Valve							
Valve Design Specification	API 6A [ ] API 17D [ ]						
Actuator							
II. INITIAL VALVE SEAT SEAL TEST (Table 7)							
Performed by						Date/Time	
1) Liquid Seat Seal Test Pressure (psi)						Leaked (Y/N)	
2) Gas Seat Seal Test Pressure (psi)						Leaked (Y/N)	
III. SAND SLURRY FLOW TEST (Table 9)							
Performed by						Date/Time	
1) Circulation rate of sand slurry (gpm [m^3/min])							
2) Circulating sand slurry (% by vol. of 20/40, 40/60, 80/100 US mesh sand)							
3) Viscosity determined by Marsh funnel viscometer (seconds)							
4) Slurry temperature (°F/°C)							
5) Time of sand slurry circulation (hours)							
6) Liquid Seat Seal Test Pressure (psi)						Leaked (Y/N)	
7) Gas Seat Seal Test Pressure (psi)						Leaked (Y/N)	
IV. SAND SLURRY FLOW TEST WHILE OPENING AND CLOSING VALVE (Table 10)							
Performed by						Date/Time	
1) Circulation rate of sand slurry (gpm [m^3/min])							
2) Circulating sand slurry (% by vol. of 20/40, 40/60, 80/100 US mesh sand)							
3) Viscosity determined by Marsh funnel viscometer (seconds)							
4) Slurry temperature (°F/°C)							
5) Differential pressure across valve when opened (psi)							
6) Average time to complete one cycle (seconds)							
7) Number of test cycles							
8) Liquid Seat Seal Test Pressure (psi)						Leaked (Y/N)	
9) Gas Seat Seal Test Pressure (psi)						Leaked (Y/N)	
10) Type and frequency of preventive maintenance. Describe in detail							
11) Number of cycles completed at last preventive maintenance operation							
V. VALVE PERFORMANCE TEST CERTIFICATION (to be completed by a person performing the test or by a test facility–designated certifying officer)							
Remarks—Note any testing problem or difficulties							
Valve qualified for Service **Class III (Y/N)**							

Certified by			Date/Time	

5 Test Procedures

5.1 Service Class II Test Procedure

5.1.1 General

Service Class II testing shall be performed, in the order specified, per requirements outlined in 5.1.2, 5.1.3, and 5.1.4.

NOTE Figure 3 summarizes the applicable testing.

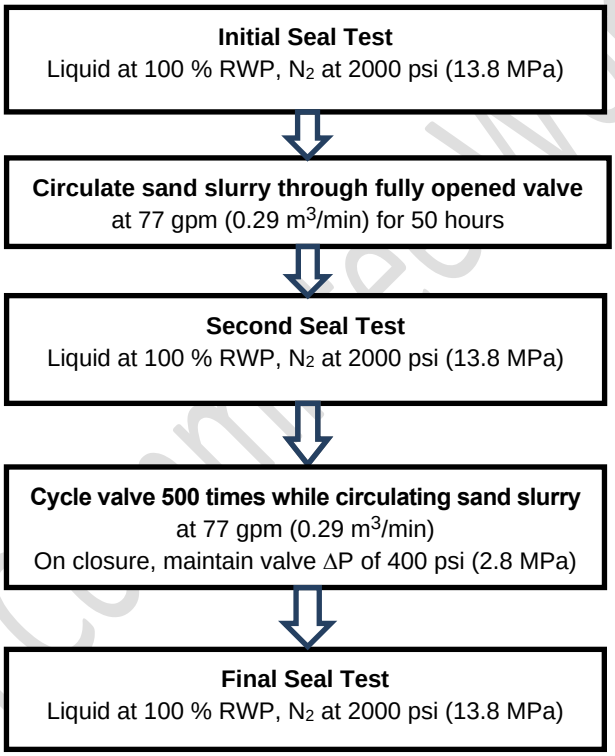

Figure 3— Service **Class II Validation Summary Flow Diagram**

5.1.2 Initial Seal Test

The initial seal test shall be performed per Table 4.

Table 4— Service Class II Initial Seal Test

Step	Procedure Step and Acceptance Criteria	Data to Be Recorded
0)	Verify the identification (model and serial number) of the test valve and actuator before starting the test.	— Valve manufacturer, model, part number, serial number, size, RWP — Actuator manufacturer, model, part number, serial number, type, supply pressure rating
1)	Install test valve in the test flow loop.	
2)	Check test valve for leakage with liquid: a) circulate freshwater at a minimum flow rate of 77 gpm (0.29 m^3/min) but no more than 90 gpm (0.34 m^3/min) for at least 10 minutes with test valve fully open; b) close test valve by releasing actuator power; c) close isolation valves upstream and downstream from test valve; d) open downstream liquid leak detection valve; e) apply water pressure upstream of the test valve equal to 100 % to 105 % of the RWP of the test valve; and f) after the pressure has stabilized within the acceptable range for 3 minutes minimum, check for test valve seat leakage from the downstream leak detection valve for a period of 5 minutes minimum. **Acceptance Criteria:** According to 4.4.4 during the 5-minute hold period.	— Validation number — Date (month/day/year) — Person performing test **Flow Period** — Test start time of flow — Flow rate — Test end time of flow **Pressure Holding** — Test start time of pressure monitoring — Test end time of pressure monitoring — Pressure at start of test — Pressure at end of test — Test passed (yes/no)
3)	Check test valve for leakage with nitrogen pressure: a) close upstream and downstream isolation valves; b) bleed all pressure and drain water on both sides of test valve (open and close test valve three times while draining water); c) close test valve; d) with bleed valve open, immerse the end of a flexible tube connected thereto in a container of water; e) apply 2000 psi (13.8 MPa) ±5 % nitrogen on upstream side of test valve; and f) after the pressure has stabilized within the acceptable range for 3 minutes minimum, check for test valve seat leakage by observing for gas bubbles for a period of 5 minutes minimum. **Acceptance Criteria:** According to 4.4.4 during the 5-minute hold period.	— Test start time of pressure monitoring — Test end time of pressure monitoring — Pressure at start of test — Pressure at end of test — Test passed (yes/no)

5.1.3 Sand Slurry Flow Test

The sand slurry flow test shall be performed per Table 5.

5.1.4 Sand Slurry Flow Test While Opening and Closing during Circulation

The sand slurry flow test while opening and closing during circulation shall be performed per Table 6.

Table 5— Service Class II Sand Slurry Flow Test

Step	Procedure Step and Acceptance Criteria	Data to Be Recorded
1)	Circulate sand slurry at a minimum flow rate of 77 gpm (0.29 m^3/min) while bypassing the test section until slurry viscosity and sand content stabilize with slurry agitator on.	— Validation number — Date (month/day/year) — Person performing test
2)	Determine sand content of slurry by filling two oil gaugers' 100 ml sample tubes with slurry sample and centrifuge with oil gaugers' centrifuge according to API *MPMS* Ch. 10.4. The use of solvents and temperature controls are not required. Adjust sand content of circulating fluid to 2 % ($1^1/_2$ % to $2^1/_2$ % acceptable) by adding 40 to 60 US mesh sand or diluting mixture with freshwater.	— Sand concentration (%)
3)	Determine viscosity of sand slurry sample with Marsh funnel viscometer according to API 13B-1. Adjust viscosity to 100 sec (120 sec maximum and 90 sec minimum) by adding polymer viscosifier or diluting mixture with freshwater.	— Slurry viscosity (sec)
4)	If dilution or strengthening was necessary in Step 3, return to procedure in Step 1.	
5)	Adjust flow rate to a minimum of 77 gpm (0.29 m^3/min).	— Flow rate at start of circulation period — Slurry viscosity (sec) — Sand concentration (%)
6)	Pump sand slurry through test valve for 25 hours (±1 hour).	— Time at start of slurry circulation through test valve — Time at end of slurry circulation through test valve
7)	Check sand content and viscosity of slurry as before in Step 2 and Step 3; adjust as required.	— Slurry viscosity (sec) — Sand concentration (%)
8)	Pump sand slurry through test valve for an additional 25 hours (±1 hour) at a minimum flow rate of 77 gpm (0.29 m^3/min). The total duration of the flow periods in Step 6 and Step 8 shall be a minimum of 50 hours.	— Time at start of slurry circulation through test valve — Flow rate at start of circulation period — Time at end of slurry circulation through test valve
9)	Check test valve for leakage with liquid: a) close test valve by releasing actuator power; b) close isolation valves upstream and downstream from test valve; c) open downstream liquid leak detection valve; d) apply water pressure upstream of the test valve equal to 100 % to 105 % of the RWP of the test valve; and e) after the pressure has stabilized within the acceptable range for 3 minutes minimum, check for test valve seat leakage from the downstream leak detection valve for a period of 5 minutes minimum. **Acceptance Criteria:** According to 4.4.4 during the 5-minute hold period.	**Pressure Holding** — Test start time of pressure monitoring — Test end time of pressure monitoring — Pressure at start of test — Pressure at end of test — Test passed (yes/no)

10)	Check test valve for leakage with nitrogen pressure: a) close upstream and downstream isolation valves; b) bleed all pressure and drain water on both sides of test valve (open and close test valve three times while draining water); c) close test valve; d) with bleed valve open, immerse the end of a flexible tube connected thereto in a container of water; e) apply 2000 psi (13.8 MPa) ±5 % nitrogen on upstream side of test valve; and f) after the pressure has stabilized within the acceptable range for 3 minutes minimum, check for test valve seat leakage by observing for gas bubbles for a period of 5 minutes minimum. **Acceptance Criteria:** According to 4.4.4. during the 5-minute hold period.	— Test start time of pressure monitoring — Test end time of pressure monitoring — Pressure at start of test — Pressure at end of test — Test passed (yes/no)

Table 6— Service **Class II Sand Slurry Flow Test While Opening and Closing during Circulation**

Step	Procedure Step and Acceptance Criteria	Data to Be Recorded
1)	Circulate sand slurry at a minimum flow rate of 77 gpm (0.29 m^3/min) while bypassing the test section until slurry viscosity and sand content stabilize with slurry agitator on.	— Validation number — Date (month/day/year) — Person performing test
2)	Determine sand content of slurry by filling two oil gaugers' 100 ml sample tubes with slurry samples. Centrifuge with oil gaugers' 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 40 to 60 US mesh sand or diluting mixture with freshwater.	— Sand concentration (%)
3)	Determine viscosity of slurry sample with Marsh funnel viscometer according to API 13B-1. Adjust viscosity to 100 sec (120 sec maximum, 90 sec minimum) by adding polymer viscosifier or diluting mixture with freshwater.	— Slurry viscosity (sec)
4)	If dilution or strengthening was performed in Step 3, return to procedure in Step 1.	
5)	Adjust flow rate to a minimum of 77 gpm (0.29 m^3/min).	— Flow rate at start of circulation period — Slurry viscosity (sec) — Sand concentration (%)
6)	Cycle test valve from fully opened to fully closed at a maximum rate of 7 cycles per minute.	
7)	Adjust choke (or equivalent) upstream from test valve to provide a differential pressure of 400 psi (2.8 MPa) ±10 % across the test valve when closed.	— Differential pressure across test valve when closed (psi)
8)	Open and close test valve a minimum of 500 cycles. During this phase of testing, normal preventive maintenance procedures, if any, as prescribed in the manufacturer's operating manual, shall be performed except that no preventive maintenance shall be allowed during the last 100 cycles of operation in the test and during Step 9 and Step 10.	— Number of cycles — Cycles per minute (nominal) — Type and frequency of maintenance performed (list)
9)	Check test valve for leakage with fresh water: a) close test valve by releasing actuator power; b) close isolation valves upstream and downstream from test valve; c) open downstream liquid leak detection valve; d) apply water pressure upstream of the test valve equal to 100 % to 105 % of the RWP of the test valve; and e) after the pressure has stabilized within the acceptable range for 3 minutes minimum, check for test valve seat leakage from the downstream leak detection valve for a period of 5 minutes minimum. **Acceptance Criteria:** According to 4.4.4 during the 5-minute hold period.	**Pressure Holding** — Test start time of pressure monitoring — Test end time of pressure monitoring — Pressure at start of test — Pressure at end of test — Test passed (yes/no)
10)	Check test valve for leakage with nitrogen pressure: a) close upstream and downstream isolation valves; b) bleed all pressure and drain water on both sides of test valve (open and close test valve three times while draining water); c) close test valve; d) with bleed valve open, immerse the end of a flexible tube connected thereto in a container of water; e) apply 2000 psi (13.8 MPa) ±5 % nitrogen on upstream side of test valve; and f) after the pressure has stabilized within the acceptable range for 3 minutes minimum, check for test valve seat leakage by observing for gas bubbles for a period of 5 minutes minimum.	— Test start time of pressure monitoring — Test end time of pressure monitoring — Pressure at start of test — Pressure at end of test — Test passed (yes/no)

	Acceptance Criteria: According to 4.4.4 during the 5-minute hold period.	

5.2 Service Class III Test Procedure

5.2.1 General

Service Class III testing shall be performed, in the order specified, per requirements outlined in 5.2.2, 5.2.3, and 5.2.4.

NOTE Figure 4 summarizes the applicable testing.

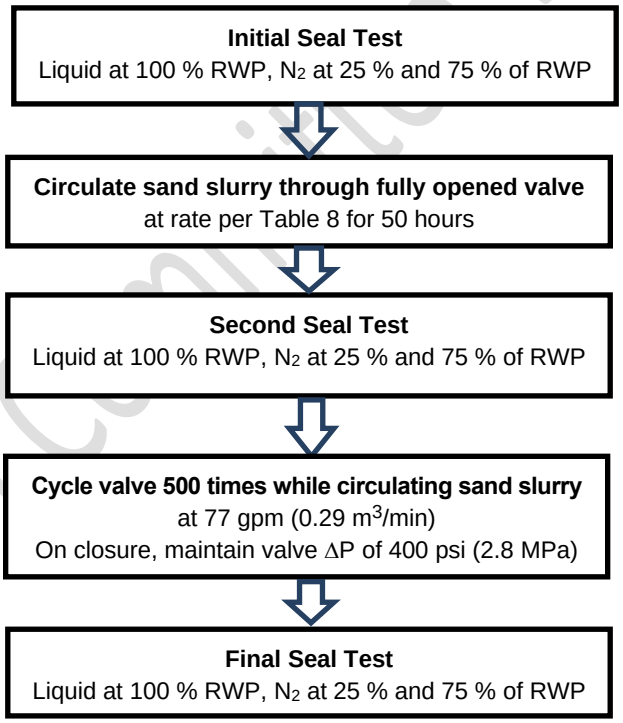

Figure 4— Service Class III Validation Summary Flow Diagram

5.2.2 Initial Seal Test

The initial seal test shall be performed per Table 7.

Table 7— Service Class III Initial Seal Test

Step	Procedure Step and Acceptance Criteria	Data to Be Recorded
0)	Verify the identification (model and serial number) of the test valve and actuator before starting the test.	— Valve manufacturer, model, part number, serial number, size, RWP — Actuator manufacturer, model, part number, serial number, type, supply pressure rating
1)	Install test valve in the test flow loop.	
2)	Check test valve for leakage with liquid: a) circulate freshwater at a minimum flow rate of 77 gpm (0.29 m^3/min) but no more than 90 gpm (0.34 m^3/min) for at least 10 minutes with test valve fully open; b) close test valve by releasing actuator power; c) close isolation valves upstream and downstream from test valve; d) open downstream liquid leak detection valve; e) apply water pressure upstream of the test valve equal to 100 % to 105 % of the RWP of the test valve; and f) after the pressure has stabilized within the specified range for 3 minutes minimum, check for test valve seat, stem seal, body, and bonnet seal leakage for a period of 5 minutes minimum. **Acceptance Criteria:** According to 4.4.4 during the 5-minute hold period.	— Validation number — Date (month/day/year) — Person performing test **Flow Period** — Test start time of flow — Flow rate — Test end time of flow **Pressure Holding** — Test start time of pressure monitoring — Test end time of pressure monitoring — Pressure at start of test — Pressure at end of test — Leakage location (if any) — Test passed (yes/no)
3)	Check test valve for leakage with nitrogen pressure: a) close upstream and downstream isolation valves; b) bleed all pressure and drain water on both sides of test valve (open and close test valve three times while draining water); c) close test valve; d) with bleed valve open, immerse the end of a flexible tube connected thereto in a container of water; e) apply 25 % of RWP ±5 % using nitrogen on upstream side of test valve; and f) after the pressure has stabilized within the specified range for 3 minutes minimum, check for test valve seat, stem seal, body, and bonnet seal leakage by observing for gas bubbles for a period of 5 minutes minimum; **Acceptance Criteria:** According to 4.4.4 during the 5-minute hold period. g) apply 75 % of RWP ±5 % using nitrogen on upstream side of test valve; and h) after the pressure has stabilized within the specified range for 3 minutes minimum, check for test valve seat stem seal, body, and bonnet seal leakage by observing for gas bubbles for a period of 5 minutes minimum. **Acceptance Criteria:** According to 4.4.4 during the 5-minute hold period.	**25 % RWP Test** — Test start time of pressure monitoring — Test end time of pressure monitoring — Pressure at start of test — Pressure at end of test — Leakage location (if any) — Test passed (yes/no) **75 % RWP Test** — Test start time of pressure monitoring — Test end time of pressure monitoring — Pressure at start of test — Pressure at end of test — Leakage location (if any) — Test passed (yes/no)

5.2.3 Sand Slurry Flow Test

5.2.3.1 Sand Slurry Composition

The sand slurry composition for the Service Class III test shall meet the following requirements:

— sand content of 1.5 % to 2.5 % by volume, and

— sand mixture shall be equal quantities by volume of 20/40, 40/60, and 80/100 US mesh sand.

5.2.3.2 Sand Slurry Flow Rate

The Service Class III sand slurry flow rate shall result in a flow velocity greater than or equal to a flow velocity of 7.4 ft/sec. Table 8 lists the minimum flow rates for common valve sizes.

Valves with bore sizes not listed in Table 8 shall be tested with the 7.4 ft/sec flow velocity.

Table 8— Service **Class III Sand Slurry Flow Rates**

Nominal Bore Size		**Slurry Flow Rate**		
in.	(mm)	gpm	bpm	(m^3/min)
$2^1/_{16}$	(52)	77	1.8	(0.29)
$2^9/_{16}$	(65)	119	2.8	(0.45)
$3^1/_{16}$	(78)	170	4.0	(0.64)
$3^1/_8$	(79)	177	4.2	(0.67)
$3^3/_{16}$	(81)	185	4.4	(0.70)
$4^1/_{16}$	(103)	299	7.1	(1.13)
$4^1/_8$	(105)	308	7.3	(1.17)
$4^1/_4$	(108)	328	7.8	(1.24)
$5^1/_8$	(130)	476	11.3	(1.80)
6	(152)	653	15.6	(2.47)
$6^1/_8$	(155)	680	16.2	(2.57)
$6^3/_8$	(162)	739	17.6	(2.80)
$6^5/_8$	(168)	795	18.9	(3.01)
$7^1/_{16}$	(179)	904	21.5	(3.42)
$7^1/_8$	(181)	920	21.9	(3.48)
9	(228)	1470	35.0	(5.56)

NOTE The 7.4 ft/sec is based on the flow rate of 77 gpm for a $2^1/_{16}$ valve size.

5.2.3.3 Test Method

The sand slurry flow test shall be performed per Table 9.

Table 9— Service Class III Sand Slurry Flow Test

Step	Procedure Step and Acceptance Criteria	Data to Be Recorded
1)	Circulate sand slurry while bypassing the test section until slurry viscosity and sand content stabilize with slurry agitator on.	— Validation number — Date (month/day/year) — Person performing test
2)	Determine sand content of slurry by filling two oil gaugers' 100 ml sample tubes with slurry sample and centrifuge with oil gaugers' centrifuge according to API *MPMS* Ch. 10.4. The use of solvents and temperature controls are not required. Adjust sand content of circulating fluid to 2 % ($1^1/_2$ % to $2^1/_2$ % acceptable) by adding sand mixture or diluting slurry with freshwater.	— Sand concentration (%)
3)	Determine viscosity of sand slurry sample with Marsh funnel viscometer according to API 13B-1. Adjust viscosity to 70 sec (75 sec maximum and 65 sec minimum) by adding polymer viscosifier or diluting slurry with freshwater.	— Slurry viscosity (sec)
4)	If dilution or strengthening was necessary in Step 3, return to procedure in Step 1.	
5)	Adjust flow rate to a minimum per Table 8 corresponding to test valve size.	— Flow rate at start of circulation period — Slurry viscosity (sec) — Sand concentration (%)
6)	Pump sand slurry through test valve for 25 hours (±1 hour).	— Time at start of slurry circulation through test valve — Time at end of slurry circulation through test valve
7)	Check sand content and viscosity of slurry as before in Step 2 and Step 3; adjust as required.	— Slurry viscosity (sec) — Sand concentration (%)
8)	Pump sand slurry through test valve for an additional 25 hours (±1 hour) at a minimum flow rate per Table 8 corresponding to test valve size. The total duration of the flow periods in Step 6 and Step 8 shall be a minimum of 50 hours.	— Time at start of slurry circulation through test valve — Flow rate at start of circulation period — Time at end of slurry circulation through test valve
9)	Check test valve for leakage with fresh water: a) close test valve by releasing actuator power; b) close isolation valves upstream and downstream from test valve; c) open downstream liquid leak detection valve; d) apply water pressure upstream of the test valve equal to 100 % to 105 % of the RWP of the test valve; and e) after the pressure has stabilized within the acceptable range for 3 minutes minimum, check for test valve seat, stem seal, body, and bonnet seal leakage for a period of 5 minutes minimum. **Acceptance Criteria:** According to 4.4.4 during the 5-minute hold period.	— Validation number — Date (month/day/year) **Pressure Holding** — Test start time of pressure monitoring — Test end time of pressure monitoring — Pressure at start of test — Pressure at end of test — Leakage location (if any) — Test passed (yes/no)

Table 9— Service **Class III Sand Slurry Flow Test** *(continued)*

Step	Procedure Step and Acceptance Criteria	Data to Be Recorded
10)	Check test valve for leakage with nitrogen pressure: a) close upstream and downstream isolation valves; b) bleed all pressure and drain water on both sides of test valve (open and close test valve three times while draining water); c) close test valve; d) with bleed valve open, immerse the end of a flexible tube connected thereto in a container of water; e) apply 25 % of RWP ±5 % using nitrogen on upstream side of test valve; and f) after the pressure has stabilized within the acceptable range for 3 minutes minimum, check for test valve seat, stem seal, body, and bonnet seal leakage by observing for gas bubbles for a period of 5 minutes minimum; **Acceptance Criteria:** According to 4.4.4 during the 5-minute hold period. g) apply 75 % of RWP ±5 % using nitrogen on upstream side of test valve; and h) after the pressure has stabilized for 3 minutes minimum, check for test valve seat, stem seal, body, and bonnet seal leakage by observing for gas bubbles for a period of 5 minutes minimum. **Acceptance Criteria:** According to 4.4.4 during the 5-minute hold period.	**25 % RWP Test** — Test start time of pressure monitoring — Test end time of pressure monitoring — Pressure at start of test — Pressure at end of test — Leakage location (if any) — Test passed (yes/no) **75 % RWP Test** — Test start time of pressure monitoring — Test end time of pressure monitoring — Pressure at start of test — Pressure at end of test — Leakage location (if any) — Test passed (yes/no)

5.2.4 Sand Slurry Flow Test While Opening and Closing during Circulation

The sand slurry flow test while opening and closing during circulation shall be performed per Table 10.

Table 10— Service **Class III Sand Slurry Flow Test While Opening and Closing during Circulation**

Step	**Procedure Step and Acceptance Criteria**	**Data to Be Recorded**
1)	Circulate sand slurry while bypassing the test section until slurry viscosity and sand content stabilize with slurry agitator on.	— Validation number — Date (month/day/year) — Person performing test
2)	Determine sand content of slurry by filling two oil gaugers' 100 ml sample tubes with slurry samples. Centrifuge with oil gaugers' 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 sand mixture or diluting slurry with freshwater.	— Sand concentration (%)
3)	Determine viscosity of slurry sample with Marsh funnel viscometer according to API 13B-1. Adjust viscosity to 70 sec (75 sec maximum, 65 sec minimum) by adding polymer viscosifier or diluting mixture with freshwater.	— Slurry viscosity (sec)
4)	If dilution or strengthening was necessary in Step 3, return to procedure in Step 1.	
5)	Adjust flow rate to a minimum of 77 gpm (0.29 m^3/min).	— Flow rate at start of circulation period — Slurry viscosity (sec) — Sand concentration (%)

6)	Cycle test valve from fully opened to fully closed at a maximum rate of 7 cycles per minute.	
7)	Adjust choke (or equivalent) upstream from test valve to provide a differential pressure of 400 psi (2.8 MPa) ±10 % across the test valve when closed.	— Differential pressure across test valve when closed (psi)

Table 10— Service **Class III Sand Slurry Flow Test While Opening and Closing during Circulation**
(continued)

Step	Procedure Step and Acceptance Criteria	Data to Be Recorded
8)	Open and close test valve a minimum of 500 cycles. During this phase of testing, normal preventive maintenance procedures, if any, as prescribed in the manufacturer's operating manual, shall be performed except that no preventive maintenance shall be allowed during the last 100 cycles of operation in the test and during Step 9 and Step 10.	— Number of cycles — Cycles per minute (nominal) — Type and frequency of maintenance performed (list)
9)	Check test valve for leakage with fresh water: a) close test valve by releasing actuator power; b) close isolation valves upstream and downstream from test valve; c) open downstream liquid leak detection valve; d) apply water pressure upstream of the test valve equal to 100 % to 105 % of the RWP of the test valve; and e) after the pressure has stabilized within the acceptable range for 3 minutes minimum, check for test valve seat, stem seal, body, and bonnet seal leakage for a period of 5 minutes minimum. **Acceptance Criteria**: According to 4.4.4 during the 5-minute hold period.	**Pressure Holding** — Test start time of pressure monitoring — Test end time of pressure monitoring — Pressure at start of test — Pressure at end of test — Leakage location (if any) — Test passed (yes/no)
10)	Check test valve for leakage with nitrogen pressure: a) close upstream and downstream isolation valves; b) bleed all pressure and drain water on both sides of test valve (open and close test valve three times while draining water); c) close test valve; d) with bleed valve open, immerse the end of a flexible tube connected thereto in a container of water; e) apply 25 % of RWP ±5 % using nitrogen on upstream side of test valve; and f) after the pressure has stabilized within the acceptable range for 3 minutes minimum, check for test valve seat, stem seal, body, and bonnet seal leakage by observing for gas bubbles for a period of 5 minutes minimum; **Acceptance Criteria:** According to 4.4.4 during the 5-minute hold period. g) apply 75 % of RWP ±5 % using nitrogen on upstream side of test valve; and h) after the pressure has stabilized for 3 minutes minimum, check for test valve seat, stem seal, body, and bonnet seal leakage by observing for gas bubbles for a period of 5 minutes minimum. **Acceptance Criteria:** According to 4.4.4 during the 5-minute hold period.	**25 % RWP Test** — Test start time of pressure monitoring — Test end time of pressure monitoring — Pressure at start of test — Pressure at end of test — Leakage location (if any) — Test passed (yes/no) **75 % RWP Test** — Test start time of pressure monitoring — Test end time of pressure monitoring — Pressure at start of test — Pressure at end of test — Leakage location (if any) — Test passed (yes/no)

6 Scaling of Test Results

6.1 General

NOTE Scaling is independent of the PSL and material class of the test valve.

6.2 Scaling of Service Class II Validation Results

Successful completion of the validation on an $2^{1}/_{16}$ in. (52 mm), 5000 psi (34.5 MPa) RWP test valve shall validate all sizes and all pressure ratings of that manufacturer's valves of the same basic design and construction of the valve bore sealing mechanism for Service Class II.

Successful completion of the validation on a size or pressure rating other than $2^{1}/_{16}$ in. (52 mm), 5000 psi (34.5 MPa) RWP test valve shall validate that size and larger for all pressure ratings of that manufacturer's valves of the same basic design and construction of the valve bore sealing mechanism for Service Class II.

Any substantive change in the design or surface treatments that affects the valve bore sealing mechanism shall require revalidation.

6.3 Scaling of Service Class III Validation Results

6.3.1 Requirements and Limitations

Scaling of Service Class III validation results shall be permitted within a product family when the criteria in 6.3 are satisfied.

6.3.2 Product Family

A product family shall meet the following design requirements.

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

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

6.3.3 Scaling by Pressure Rating

The validation results of a test valve shall validate products of the same product family having equal or lower pressure ratings.

6.3.4 Scaling by Size

The validation results of one size of a product family shall validate products one nominal size larger and one nominal size smaller than the tested size.

The validation results of two sizes of a product family shall validate all nominal sizes between the two sizes tested and the sizes one nominal size larger and one nominal size smaller than the tested size (if applicable). The valve nominal size shall be defined as the nominal size of the end connectors, as defined in API 6A or API 17D or by the bore size of the valve bore sealing mechanisms, if not defined in API 6A or API 17D.

For valves of the same product family:

a) the $1^{13}/_{16}$ and $2^{1}/_{16}$ sizes shall be considered as one size for scaling purposes;

b) the $3^1/_{16}$, $3^1/_8$, and $3^3/_{16}$ sizes shall be considered as one size for scaling purposes;

c) the $4^1/_{16}$, $4^1/_8$, and $4^1/_4$ sizes shall be considered as one size for scaling purposes;

d) the 6, $6^1/_8$, $6^3/_8$, $6^5/_8$, $7^1/_{16}$, and $7^1/_8$ sizes shall be considered as one size for scaling purposes.

For valves where the flow bore diameters do not follow API 6A or API 17D nominal sizes in table 8; the scaling based on flow bore diameters shall be used. The validation results of two tested valves of a product family shall validate all flow bore diameters between**.**

Bibliography

[1] API Manual of Petroleum Measurement Standards (MPMS) Chapter 15, *Guidelines for the Use of the International System of Units (SI) in the Petroleum and Allied Industries*

[2] API Specification Q1, *Quality Management System Requirements for Organizations Providing Products for the Petroleum and Natural Gas Industry*

[3] ISO 9001, *Quality Management Systems - Requirements*

[4] API Specification 6A, *Specification for Wellhead and Christmas Tree Equipment*, 19th and 20th editions

[5] API Specification 14D, *Specification for Wellhead Surface Safety Valves and Underwater Safety Valves for Offshore Service*, 8th edition