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Simulant Test Plan for Safety Significant Isolation Valves for Double Valve Isolation

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Abstract:  RPP-PLAN-44556 provides the plan for the leakage testing of a representative sample of the safety-significant isolation valves for Double-Valve Isolation (DVI) in an environment that simulates the abrasive characteristics of the Hanford Tank Farms Waste Transfer System operating and cycling conditions.

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Simulant Test Plan for Safety Significant Isolation Valves for Double Valve Isolation

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1.0 INTRODUCTION

This document provides the proposed plan for the leakage testing of a representative sample of the safety-significant isolation valves for Double Valve Isolation (DVI) in an environment that simulates the abrasive characteristics of the Hanford Tank Farms slurry. The DVI valves provide a barrier to physically disconnect interfacing systems and inactive portions of the waste transfer piping systems from an active portion of the Waste Transfer System.

This test plan addresses a Documented Safety Analysis (DSA) “Design/Operational Improvement 2” commitment (DSA section 3.3.2.3.5), of providing an improvement plan for life cycle testing using waste simulants. The DVI valves in the Waste Transfer System perform a safety-significant function by preventing (or limiting to an inconsequential volume), the misrouting (i.e. leakage) of waste into physically disconnected piping during transfers.

The materials of the DVI valve bodies, valve balls, and valve seats are chemically and radiologically resistant to the transferred waste, and are acceptable for the temperatures and pressures expected in waste transfer operations. Based on manufacturer’s data the seat materials were selected to be abrasion resistant however the testing of these valves in the fluids representative of the transferred waste has not been performed.

RPP-RPT-41859, Safety-Significant Isolation Valves for Double Valve Isolation – Functions and Requirements Evaluation Document, examines the failure modes of these DVI valves as a result of the waste transfer process operating conditions including exposure to corrosion, erosion, radiation fields, system operating pressures and temperatures, issues related to aging, structural loading, external events, external environmental conditions and other failure modes. The above evaluation document concludes that the materials used for the DVI valves provide adequate capability to withstand the postulated failure modes due to operation in the waste transfer system. It is recognized however that valve seat exposure to abrasive particles in the waste can limit valve life. The simulant testing proposed in this plan will address this issue.

This plan describes the selection of the valves to be tested; the composition of the simulant which is intended to replicate the abrasive characteristics of the waste; the waste transfer system parameters including pressure, temperature and flow rate; test methodology including a generic schematic diagram of the test skid, description of test equipment, testing sequence, test acceptance criteria, and the quality assurance requirements.

1.1 Background

In FY 2007, the Tank Operating Contractor (TOC), CH2M Hill, initiated an evaluation of the valves in the DST System based on a valve misalignment that was identified during a pit video inspection. Ultimately two Problem Evaluation Requests (PERs) were generated to document the problems identified: CH2M-PER-2007-0988 and CH2M-PER-2007-1220. Both of these PER’s were identified as “Significant PER’s”. Each PER was presented at the Executive Safety Review Board (ESRB). The ESRB assigned corrective actions for each PER. Isolation valve problems and plans for resolution are documented in RPP-PLAN-34886, Investigation and Work Plan for the Resolution of the Double Shell Tank Valve Positioning Problem, which was issued in response to the corrective actions identified by the ESRB.
Many existing waste transfer system DVI valves have been installed for 10 or more years. Once the installed valve comes in contact with tank waste, whether or not it is cycled opened/closed, it is considered to be “in service.” Due to infrequent DST transfer operations, the valve cycles (open and close) are estimated to amount to no more than 500 cycles during the life expectancy of the valves. Valve use for high demand waste feed delivery routes is also estimated to be approximately 500 cycles per SVF-2348, WFD_INPUT_TRANSFER_EQUIPMENTS.xls Rev 0. Pre-installation testing of all DVIs with minimal cycling is performed using clean water to demonstrate no leakage or leakage rates less than that specified in RPP-14541, Jumper Fabrication and Testing Specification for Tank Farms. The DSA acceptance criterion for acceptable leakage for DVI valves is 0.1 gal/min. The basis for the DSA criteria is further discussed in Section 5.0.

“Dry” cycling (no liquid against the ball and seat) of representative (2-way and 3-way) DVI ball valves has been performed to determine their performance characteristics and demonstrate compliance with TFC-ENG-STD-22, Piping Jumpers and Valves. Following the cycling the test valves passed a seat leak tightness test however the testing did not address DSA concerns about the past potential erosive properties of the tank waste.
2.0 PURPOSE AND OBJECTIVES

The purpose of the simulant test is to leak test representative samples of the currently used DVI valves in a simulated environment representative of the abrasive properties of the waste and Waste Transfer System operating and cycling conditions. The simulant test will establish the performance characteristics and verify compliance with the DSA.

Key functional and performance requirements for testing the DVI valves include:

- Valves used within the DST transfer system shall be cycled a maximum of 1,500 times, or up to the DSA seat leakage rate acceptance criterion of 0.1 gal/min. A cycle count of 1,500 times will provide a broad resolution on the performance characteristics of the valve over its service life.
- Valves used within the single shell tank retrieval and closure transfer systems shall be cycled a maximum of 5,500 times, or up to the DSA seat leakage rate acceptance criterion of 0.1 gal/min. A cycle count of 5,500 times will provide a broad resolution on the performance characteristics of the valve over its service life.
- If the valve seat leakage rate is less than 0.1 gal/min after 500 and 1000 cycles, valves shall demonstrate seat and pressure boundary integrity at the applicable waste transfer system design pressure and temperature (400 psig @ 200°F for Kynar® and Tefzel® seated valves and 400 psig @ 180°F for UHMWPE valves).
- Measure operating torque of valves to track changes in torque over valve cycle periods.

The simulant test objectives include the following:

- Measure leak tightness after prolonged cycling of the valves in abrasive service.
- Measure operating torque variance over prolonged cycling of the valves in abrasive service.
- Identify differences in leak rates between valves which are flushed prior to any rotation versus those valves which are rotated to introduce flush water into the system.
3.0 SAFETY SIGNIFICANT ISOLATION VALVE DESCRIPTION

3.1 Description

The safety function of the safety significant valves is to limit leakage of waste in order to decrease the consequences of a fine spray leak due to a transfer misroute. Preventing a misroute also protects the facility worker from wetting spray/jet/stream leaks into a normally occupied area which could result in flammable gas deflagrations in a waste transfer associated structure. The DVIs also provide a barrier to physically disconnect interfacing systems and inactive portions of waste transfer primary piping from an active portion of the waste transfer system.

All new DVIs are installed in shop-fabricated jumper assemblies and leak tested in accordance with TFC-ENG-STD-22, before they are installed on site. The jumpers with the DVI valves are located within below-grade concrete pits or above ground, steel, portable valve boxes. A detailed description of the DVIs is provided in RPP-RPT-41859 and a list of the different types of DVIs that are the subject of this simulant testing is provided in Appendix A of this test plan. The DVIs that are to be evaluated with respect to abrasive effects include full port 2-way ball valves in 1-inch, 2-inch and 3-inch nominal diameter sizes and 3-way ball valves in 2-inch and 3-inch nominal diameter sizes. The pressure boundary components of the valves that are considered to be safety significant include the valve body, valve ball, valve seat, and back-up O-rings. Various types of actuators are used to open and close the valves however the type of actuator is not a relevant parameter in regard to simulant testing for valve leakage.

A summary of the relevant characteristics for the isolation valves used in the Waste Transfer System includes:

- Manufacturer
  - Pittsburgh Brass Manufacturing (PBM®)
  - Flow-Tek®
- Size – 1-inch, 2-inch, and 3-inch
- Pressure Class – 300 psig
- Configuration – 2-way and 3-way
- Body Material -316 SS
- Seat material
  - Tefzel® with a back-up ethylene-propylene-rubber (EPR) O-ring
  - Kynar® with a back-up ethylene-propylene-rubber (EPR) O-ring
  - Ultra high molecular weight polyethylene (UHMWPE)
- Seal Material
  - Kynar
  - UHMWPE
- Ball Material
  - 316 SS
  - 316 SS with electroless nickel plating
### 3.2 Selection of Valve Types to be Used for Testing

Although all of the DVI valves in service are full port ball valves, there are multiple combinations of manufacturer, size, and flow configuration installed at tank farms for the purpose of waste transfers:

- Four different PBM 2-inch 2-way valve types
- Three different PBM 3-inch 2-way valve types
- Five different PBM 2-inch 3-way valve types
- Five different PBM 3-inch 3-way valve types
- Three different types of Flow-Tek valves (1-inch, 2-inch 2-way, and 2-inch 3-way)

Due to the many types of valves, it is necessary to select representative valve types for testing. The following types of valves are selected to undergo testing:

- 2-inch, 2-way Flow-Tek ball valve with UHMWPE seat
- 2-inch, 3-way Flow-Tek ball valve with UHMWPE seat
- 3-inch, 2-way PBM ball valve with Tefzel seat and back-up O-ring
- 3-inch, 3-way PBM ball valve with Tefzel seat and back up O-ring
- 3-inch, 2-way PBM ball valve with Kynar seat and back-up O-ring
- 3-inch, 3-way PBM ball valve with Kynar seat and back-up O-ring

The rationale for selection of the above six valve types is:

- Valve types from both manufacturers are included
- Flow-Tek valves are typically used for waste retrieval operations in the 2-inch size; 1-inch and 3-inch are not commonly used
- All three seat materials currently in service are tested
- 3-inch valves have more in-line exposed seating surface area to capture abrasive particles than 2-inch
- Both 2-way and 3-way valves are tested because of differences in seat designs
- The PBM valves with the Tefzel seats have ported balls with an electroless nickel plating; whereas the in-service PBM valves with Kynar seats do not
4.0 SIMULANT DESCRIPTION

4.1 Composition

The slurry simulant composition to be used for valve seat leakage testing is identified in RPP-RPT-54347, Rev 0, Simulant Development for Hanford Tank Farms Double Valve Isolation (DVI) Valves Testing. The simulant is representative of sampled Hanford tank waste feed to the Waste Treatment Plant (WTP) as well as retrieval and closure activities. This composition is based on single-shell tank (SST) and double-shell tank (DST) sample characterization performed in recent years to support the WTP erosion testing, slurry mixing testing, and slurry transport testing.

4.2 Basis

The primary purpose of this testing is to identify abrasive wear on valve sealing components during valve cycling and its effect on the valve’s ability to satisfy the isolation requirements identified in the DSA. These sealing components include the valve seats and the full-ported balls. Determining the erosion rate of the connected piping is not within the scope of this testing.

Due to the operation, configuration, and positioning of valves during service, abrasive wear is anticipated to occur primarily during cycling and not during waste transfers. Abrasive wear on ball valves in a slurry service are known to occur when valves are used to throttle flow causing an impinging effect on the valve internals and subjecting the ported ball to direct impingement from oncoming slurry flow. Valves used for double-valve isolation are not utilized to throttle flow and the relationship of the valve port diameter (i.e. full port) to seat sizing protects the sealing surface of the ball when routing slurry through it. Damage caused by the slurry would more likely occur after the transfer and flush where particles that are unable to be flushed out are trapped in the seat/ball interface leading to galling of the ball or the resilient seat surface.

Solids Loading

Solid concentration allowed by ICD-19, Interface Control Document for Waste Feed, is specified at 200 g/L, which is equivalent to approximately 13-18 weight percent (wt%) depending on the bulk density of the transferred material. Review of SVF-1953 to obtain information for transfers based on ORP-11242 Rev. 5, River Protection Project System Plan, identified DST transfers to WTP or other DSTs contain an average solids loading of 13.1 wt%.

As recommended by Interoffice Memorandum, WRPS-1100312, Valve Cycle Testing Parameter: WT% Solids, solids loading for valve cycle testing shall be approximately 13 wt% based on nominal solids loading for DST transfers.

4.3 Simulant Conformance Verification and Replenishment Strategy

Simulant constituents that will be used to prepare the test simulant shall conform to that specified in RPP-RPT-54347 or an approved substitute. Prior to utilizing simulant for testing, each constituent shall be tested for conformance to the characteristics identified in RPP-RPT-54347. No specific acceptance criteria will apply to the analyses performed since these analyses are simply to confirm that the observed compounds and particle sizes are consistent with the manufacturer-specified values (i.e., to confirm that no gross errors, such as the supply of the wrong constituent/compound or the incorrect particle size, have occurred).
Prior to initiating cycle testing in the test loop, the mixed simulant shall be sampled and analyzed to show conformance with to the specified overall solids weight concentration and particle size. This analysis shall include a particle size distribution (PSD) curve to act as a baseline for the simulant. Additional samples shall be collected during testing to provide adequate certainty that the degradation of simulant constituents do not adversely affect the test results. The subcontractor shall recommend an appropriate simulant replenishment and/or replacement frequency to maintain appropriate constituent characteristics. The frequency of sampling may be adjusted depending on a technical basis to support the periodicity (e.g. simulant degradation tests). WRPS engineering shall concur with the frequency recommendation before valve cycle testing is authorized to restart. At the approved replenishment/replacement interval, the mixed simulant batch shall be sampled and tested before and after its use to identify the start/finish simulant wt% and PSD characteristics.

Based on product availability and vendor supplied material conformance to the required characteristics, simulant vendors, as specified in RPP-RPT-54347, Rev. 0, may be changed with WRPS engineering approval.
5.0 ACCEPTANCE CRITERIA

The primary objective of this testing is to satisfy the DSA “Design/Operational Improvement 2” commitment (DSA section 3.3.2.3.5) of providing life cycle testing using waste simulants to address whether or not valves in use for extended periods of time and with repetitive cycling in abrasive service may develop excessive leak through. The acceptance criteria for DVI valves subject to testing is a leak rate less than or equal to 0.1 gal/min after the maximum number of valve cycles under the test conditions described in Section 6.0. The basis of this acceptance criterion is the following excerpt from the DSA:

“The functional requirement for isolation valves for double valve isolation is to limit through valve leakage (i.e., leak rate) to a rate that ensures that onsite worker consequences due to a waste transfer leak accident are below 100 rem and Protective Action Criteria (PAC)-3. To provide a margin of safety, the performance requirement for isolation valves for double valve isolation is through valve leakage (i.e., leak rate) that is ≤ 0.1 gal/min. This performance requirement ensures that onsite worker consequences of a waste transfer leak accident are below 5 rem and PAC-2. See section 3.3.2.4.3 for the basis of this performance requirement.”
6.0 TEST PROTOCOL

This section outlines the test equipment, seat leakage requirements, and sequence of testing for Waste Transfer System isolation valves with simulant slurry. Note, Units Under Test (UUTs) are 2-inch and 3-inch full ported 2-way and 3-way ball valves, as selected in Section 3.2.

All UUTs shall be serialized and all test data shall be traceable to the UUT. The test program is designed to meet the objectives established in Section 2.0. The basis for the acceptance criteria is provided in Section 5.0.

6.1 Test Equipment

A process flow diagram of the proposed flow test system is presented in Figure 1 and 2. The UUT in Figure 1 represents a test manifold similar to that shown in Figure 2. Figure 2 provides the proposed manifold configuration to comply with the valve cycle sequence described in Section 6.1.3. The testing service Subcontractor may propose an alternate design subject to approval by WRPS Engineering, however the design should incorporate an automated configuration to allow the testing of multiple valves without equipment reconfiguration to minimize the testing duration. No-flow temperature testing capability as described in Section 6.3.7 may be incorporated in the flow test system at the Subcontractor’s option.

The total number of valves that will undergo cycle testing at any one time is ten. As seen in Figure 2, this includes four 3-inch 3-way valves, two 3-inch 2-way valves, three 2-inch 2-way valves, and one 2-inch 3-way valve.

WRPS engineering shall review and approve the design drawings or sketches of the test apparatus that show the physical layout of the equipment, sizes and layout of piping, and locations of all valves and instruments. The testing subcontractor shall minimize valve cycles to the UUTs during their initial system testing. WRPS shall approve the flow system for use prior to initiating simulant through the test valves to being cycle testing.

6.1.1 Description

The flow test equipment will be custom fabricated and configured for the purpose of this test. Components should be skid mounted, and transportable, for additional future use if desired following the initial testing program. The test system may be comprised of two sections; a pump skid and valve test manifold. The pump skid consists of an agitated open-top slurry tank with a low level alarm, an electric motor driven centrifugal pump, and isolation and pressure control valves. The test manifold is capable of testing multiple valves at a time. Back pressure on each UUT can be adjusted using a flow control valve. Flow rate measuring device(s) shall be suitable for slurry service. Most piping, from the pump discharge out, is 3-inch IPS, except for that required to interface with the 2-inch valves to be tested. Adequate run lengths shall be provided for flow measurement device accuracy. Long radius elbows should be used to minimize pressure drops and measures should be implemented to prevent air pocketing and settling of solids. Valves shall be mounted in horizontal runs with the stem up. Pipe runs shall be either horizontal or slightly sloped to prevent hold up of solids and allow free-draining. Disassembly and test item change-out shall be facilitated by the piping design. The reservoir, piping and UUT shall be easily drained and flushed. Welding of ANSI B16.5 flanged ends to valve side fittings will be
required for 2-inch Flow-Tek valves. In order to avoid damage to the elastomeric seats, gaskets, packing, and cavity fillers in the valve, disassembly of the valve is required prior to welding the end or side fittings to the flanges.

6.1.2 Valve Operation

For testing purposes, significant portions of the testing sequence should be automated to require minimum intervention by test personnel. Simulant is made up in batches for each test period, as determined by simulant sample results described in Section 4.3, and is continuously agitated and maintained at 110° to 120°F throughout the duration of the test period to maintain particles in suspension.

It is estimated the valves cycle (open-closed-open for a two-way valve and open [fully counterclockwise], closed [fully clockwise – no flow] then open [fully counterclockwise] for a three-way valve) approximately ten to twelve times per hour, therefore about 100 cycles can be accumulated per day to provide for periodic valve seat leakage testing. Number of cycles performed each day is dependent on the configuration of the UUT. Testing can take place on an intermittent basis (allowing for weekend and evening shutdowns of the test facility). The test setup shall remain un-pressurized, with flush water being the last fluid routed through the valve prior to shutdown of testing.

6.1.3 Valve Cycle Sequence

Configuration of a valve manifold as shown in Figure 2, allows for multiple valves to be subject to slurry flow, cycling, flushing, and testing. Between each valve cycle the applicable valve test manifold shall be flushed with water to represent operational practice used in the waste transfer system. As shown in Figure 3, Kynar and Tefzel Seated Valve Sequence, there are three valves to be tested in each manifold. One of the valves (labeled as V-1 in Figure 3) is to be used to direct slurry or flush water into the manifold. Valve V-1 shall be repositioned after the simulant has free drained out of the test manifold to allow the introduction of flush water. V-1 shall be rotated at a rotational rate of approximately 90 degrees every two seconds. After the test manifold has been flushed and the flush water has free-drained out of the test manifold, the remaining valves, V-2 and V-3, shall be rotated to the position shown in “Valve Step #3” of Figure 3 at a rotational rate of approximately 90 degrees every two seconds. At the completion of valve rotation, the valves will be repositioned back to allow slurry flow through the manifold. This evolution equates to a total of one complete cycle per valve in accordance to the definition of a cycle provided in Section 6.1.2.

This is representative of how the DST waste transfer system operates and will provide data on the differences in wear rates between a the majority of transfer DVI valves which are flushed between cycles and flush system isolation valves which are cycled prior to flushing. For simulating the retrieval and closure (UHMWPE valves) operating practices, the introduction of flush water into the manifold requires the manipulation of two 2-way valves instead of one 3-way valve. The configuration and valve manipulation sequence is identified in Figure 4, UHMWPE Seated Valve Sequence. Valve positioning shall be performed at rotational rate of approximately 90 degrees every two seconds.
6.1.4 Basis of valve operation

The fluid used is intended to simulate abrasive characteristics of mixed (homogenized) waste retrieved from Hanford waste storage tanks (dissolved salts, sludge, suspended solids, and supernatant) on valve sealing components during cycling activities. During some waste transfers, pressures approaching 400 psig may be possible near the transfer pump discharge piping. Because of piping friction losses the pressure will be considerably less near the waste receiving tank. Prior to a waste transfer operation all valves in the transfer path are opened and left open during the transfer. Jumpers (containing valves) are designed for 400 psig, and RPP-RPT-41859 specifies 400 psig as the pressure design basis for DVI. Due to material limitations the design temperature is 200°F for PBM valves and 180°F for Flow-Tek valves.

A minimum velocity design point in 3-inch diameter transfer lines to assure that solids remain in suspension is six feet per second (fps). The test system shall be designed to provide a simulant flow velocity of seven to nine fps, which is representative of the transfer system flows. This velocity results in flow rates of approximately 160-210 gpm through a 3-inch valve. Operating pressure for the valves in the flow path shall be less than the design pressure previously identified in this section.

The flushing of valves is a standard operating practice used in the waste transfer system. Typical flow rates observed in the 3-inch DST waste transfer system piping when flushing lines after supernant transfers range from 40-70 gpm depending on the route and service water conditions. For slurry transfers, flush systems to be used will provide significantly greater flows. To match expected flush velocities for slurry transfer in the 3-inch DST waste transfer system this test shall provide flush flow rates of 100 to 150 gpm through the 3-inch valves. Flow rates used for SST waste retrieval are typically higher than that in the present day DST system due to the output of the pressure source. For the purposes of this testing, the test system shall be designed to provide flush flow rates of 90 to 110 gpm through the 2-inch valves. Operating pressure for the valves in the flow path shall be less than the design pressure previously identified in this section. Flush water may be filtered and reused in flush activities to reduce waste water and simulant.
Figure 1. Valve Test Loop
Notes to Figure 1:

1) Flow measurement device (for simulant flow) shall be capable of measuring a range of 0-250 gpm with an accuracy of 2.0 percent of range.
2) Pressure measurement device(s) shall be capable of measuring a range of 0-500 psig (minimum) with an accuracy of 0.5 percent of range.
3) Leakage flow measurement device(s) shall be capable of measuring ranges of flow within the range of interest. This should be between 0.01 mL/min and 400 mL/min (not necessarily the same instrument). Leak test instruments subjected to test pressures shall be rated in excess of the leak test pressure (400 psig) and shall have an accuracy of +/- 10% of full scale. The gage fluid shall be clear water if rotameters are used (subject to an alternate recommendation by the testing service Subcontractor).
4) Line sizes for simulant flow between pump outlet and return to reservoir shall be 3-inch diameter (IPS). Pipe elbows should have a bend radius equal to or greater than a long radius elbow. Measures should be taken in the piping design that prevents settling of solids and air pockets within the circulation loop of the test setup. UUTs should be mounted such that their removal and replacement with another valve type, size or configuration is facilitated. A re-locatable skid mounted setup with access to an overhead hoist is recommended. For simplicity, the system sketch is configured for a two-way valve test installation – additional piping is required for three-way valve testing.
5) In general piping should be ASTM A312 type 304L, stainless steel with ASME B16.5 flanges and fittings; ball valves shall be full ported, and meet the applicable design, fabrication and test requirements in ASME B16.34; the pump skid and valve manifold skid shall be designed and fabricated to meet commercial standards to assure safety.
6) Alternate schematics for testing and measuring valve performance shall be submitted by the testing service Subcontractor for consideration by WRPS Engineering.
7) Valve position limit switches or selected method for valve positioning shall actuate within +/- 2 degrees of the zero and 90° true position of the valve ball.
8) Torque wrench, torque transducer and/or torque produced by actuator vs. pneumatic pressure shall be subject to calibration procedure to achieve readings within +/- 5% between 50 and 1,000 ft-lbs (higher torque range may be required based on test results).
9) Heating device type/location at subcontractor’s option.
Figure 2. Generic Valve Test Manifold Schematic
Figure 3. Kynar and Tefzel Seated Valve Sequence

Valve Step #1
- Align valves for slurry
- Initiate slurry

Valve Step #2
- Free drain slurry
- Rotate V-1 for manifold flush
- Initiate flush water

Valve Step #3
- Free drain flush water
- Rotate V-2 and V-3
- Restart at Valve Step #1
Figure 4. UHMWPE Seated Valve Sequence

Valve Step #1
- Align valves for slurry
- Initiate slurry

Valve Step #2
- Free drain slurry
- Rotate V-1 and V-2 for manifold flush
- Initiate flush water

Valve Step #3
- Free drain flush water
- Rotate V-3 and V-4
- Restart at Valve Step #1

Slurry Flow

V-1

V-2

V-3

V-4

Flush Water

Slurry Discharge

Water Discharge
6.1.5 Design Pressure and Temperature Leak Testing

Demonstration of the different valve types maintaining pressure boundary integrity while also meeting the seat leakage criteria at the design temperature shall be performed as a part of this testing. These tests shall be performed after 500 and 1,000 cycles have been completed on the UUT. Valve seat leakage testing using water at non-hazardous temperatures will also be performed at 500 and 1,000 cycles, prior to the testing described in this section. As a result of the preceding testing, the scope of testing (number seat leakage tests) shall be limited to minimize high temperature hazards in the testing facility. Testing will be performed at or near the valve design pressure and temperature. The design pressure and temperature is 400 psig at 200°F for PBM valves and 400 psig at 180°F for Flow-Tek valves.

The purpose of this testing is to identify any differences in the isolation capabilities of valves at normal service water temperatures and high design temperatures. As equipment upgrades are completed for waste feed to the WTP, waste feed temperatures are expected to increase from present day operating temperatures. This assumption is primarily attributed to the use of mixer pumps in the DSTs and the heat created by their operation.

Each valve shall undergo the design pressure/temperature leak test described in this section. For seat leakage testing of a 2-way valve at the design temperature, all directions identified in Section 6.2 Figure 6 shall be performed, however only the 400 psig pressure test applies. This equates to two seat leakage tests for a 2-way valve. For testing a 3-way valve at the design temperature, all directions identified in Section 6.2 Figure 6 shall be performed, however this test is only required for one valve position at 400 psig. This equates to two seat leakage tests for a 3-way valve.

Valves to be tested shall be adequately isolated to ensure personnel safety in the event of a leak during the tests. The test apparatus shall allow the heating of the valve internals through either hot water recirculation via a small test loop or by other means recommended by the test subcontractor with WRPS engineering approval. Fluid temperature for heating the valve internals and seat leakage testing shall be 200°F +0/-10°F for PBM valves and 180°F +0/-10°F for Flow-Tek valves. Allowable tolerance for seat leakage pressures are the same as that identified in Section 6.2. Time for heating the valve internals shall be for a minimum of one hour or until the external valve body reaches a constant temperature, whichever occurs first.

If seat leakage test results exceed the leak rate criteria during the design pressure/temperature testing, valve cycle testing shall continue on that specific valve.

6.2 Seat Leakage Test Requirements

The seat leakage testing pressure requirements applicable to the valve testing as described in this document shall be that identified in RPP-14541 Section 4.7.2.2:

"Seat leakage testing requires low pressure and high pressure tests using water. Test duration is for a minimum of five (5) minutes for each test. The low pressure seat leakage test is performed at 50 ±5 psig. The high pressure seat leakage test is performed at 400 ±0/-20 psig."
Seat leakage testing for 2-way and 3-way valves as a part of cycle testing requires the performance of seat leakage testing at all specified pressures, in all directions while in the closed or block flow positions. Water test medium shall be normal service water temperature. For 2-way valves this results in a total of 4 seat leakage tests per cycle test period. For 3-way valve this results in a total of 12 seat leakage tests per cycle test period. See Figure 6 for a description of the valve seat leakage testing required after each completed cycle test period.

Perform a Pre-Test Assessment seat leak test on the UUT prior to being place in the test loop to ensure assembly and components of the valve are as found in new valve installations in the waste transfer system. Once the simulant testing has begun, perform seat leakage testing after every 25 cycles for the first hundred cycles and after every 100 cycles thereafter, with the exception of the valves containing UHMWPE. After valve containing UHMWPE reach 1,000 cycles, the seat leakage tests shall be performed after every 250 cycles. WRPS engineering shall be notified of seat leakage test results in excess of the allowable identified in Table 6-1. Direction from WRPS engineering shall be provided for the replacement or rebuilding of the valve if the applicable valve cannot pass the Pre-Test Assessment. Replacement or rebuilding of the applicable valve shall be performed if the failure criteria of 0.1 gal/min is reached with less than 500 cycles. Replacement or rebuilding of the valve resets the cycle count to zero for that specific valve size/type (e.g. 3-inch 2-way Kynar seated valve). Pre-test assessment seat leakage tests/inspections shall be completed prior to reinitiated simulant testing through the valve. The summation of valve cycles on a specific valve size/type shall be no greater than 1,500 cycles for PBM valves and 5,500 for Flow-Tek valves. Excess leakage of valve seats after 500 cycles shall result in the suspension of further seat leakage testing of that specific valve type.

<table>
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<tr>
<th>Valve Manufacturer</th>
<th>Valve Type</th>
<th>Valve Seat</th>
<th>Pre-Test Assessment Allowable Leakage¹</th>
<th>Allowable Leakage After Test Period²</th>
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<td>PBM</td>
<td>3-Inch 2-Way</td>
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<td>≤ 0.1 gal/min</td>
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<td>≤ 0.2 mL/min</td>
<td>≤ 0.1 gal/min</td>
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<td>Kynar</td>
<td>≤ 0.2 mL/min</td>
<td>≤ 0.1 gal/min</td>
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<td>Flow-Tek</td>
<td>2-Inch 2-Way</td>
<td>UHMWPE</td>
<td>≤ 4 mL/min</td>
<td>≤ 0.1 gal/min</td>
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<tr>
<td>Flow-Tek</td>
<td>2-Inch 3-Way</td>
<td>UHMWPE</td>
<td>≤ 4 mL/min</td>
<td>≤ 0.1 gal/min</td>
</tr>
</tbody>
</table>

¹ - See Section 6.3.1
² - See Section 6.3.5
Figure 6. Valve Test Pressures, Positions, and Directions

Test #1: Ports B and C @ 50 psig (measure leakage at Port A).
Test #2: Ports B and C @ 400 psig (measure leakage at Port A).
Test #3: Port A @ 50 psig (measure leakage at Port B and/or C).
Test #4: Port A @ 400 psig (measure leakage at Port B and/or C).

Test #5: Ports A and C @ 50 psig (measure leakage at Port B).
Test #6: Ports A and C @ 400 psig (measure leakage at Port B).
Test #7: Port B @ 50 psig (measure leakage at Port A and/or C).
Test #8: Port B @ 400 psig (measure leakage at Port A and/or C).

Test #9: Ports A and B @ 50 psig (measure leakage at Port C).
Test #10: Ports A and B @ 400 psig (measure leakage at Port C).
Test #11: Port C @ 50 psig (measure leakage at Port A and/or B).
Test #12: Port C @ 400 psig (measure leakage at Port A and/or B).

Test #1: Port A @ 50 psig (measure leakage at Port B).
Test #2: Port A @ 400 psig (measure leakage at Port B).
Test #3: Port B @ 50 psig (measure leakage at Port A).
Test #4: Port B @ 400 psig (measure leakage at Port A).
6.3 Test Sequence

A general flow sheet of the test sequence including the items identified in this section is shown on Figure 6, Valve Cycle Test Sequence Flow Sheet.

6.3.1 Pre-Test Assessment

Prior to routing simulant through a valve to be tested (UUT):

a. Disassemble, inspect, and reassemble valve using the supplied manufacturer recommended procedures. Photograph as-found valve seat and ported ball condition and any anomalies noted.

b. Install the valve into the test apparatus, and perform a leak test at 50 +/- 5 psig and 400 +0/-20 psig as described in Section 6.2. **NOTE:** Leak rates of new valves should not be in excess of that specified in Table 6-1. Notify WRPS Engineering if initial leak rate is in excess of the stated leak rates.

c. Measure the peak torque required to open and close the valve.

6.3.2 Simulant Mixing and Testing

Prepare a new batch of simulant mixture to initiate valve cycle testing.

a. See Simulant Slurry recipe in RPP-RPT-54347.

b. Prior to first initiating cycle testing in the test loop, the simulant shall be sampled and analyzed to show conformance with respect to the specified solids concentration and particle size. Acceptance criteria for tested simulant solids concentration is as stated in Section 4.3.

c. Simulant feed is continuously agitated and maintained at 110° to 120°F throughout the duration of the test period.

d. At the approved replenishment/replacement interval (see Section 4.3), the simulant batch shall be sampled and tested before and after its use to identify the change in simulant wt% and PSD characteristics.

6.3.3 Simulant and Water Flush Durations

See Section 6.1.3 for the sequence of simulant/flush water flow and valve cycling. See Section 6.1.4 for specified simulant and flush water flow rates.

a. Simulant flow duration through the UTT(s) should be approximately three minutes.

b. Allow free-draining of simulant from test manifold prior to applicable valve cycling.

c. Flush water flow duration through the UTT(s), should be approximately one minute.

d. Allow free-draining of flush water from test manifold prior to applicable valve cycling.
6.3.4 Torque Test

Measure peak actuating torque for each cycle:

a. Measure and record the torque required to actuate the UUT from closed to open, and open to closed.

b. Exceeding the valve manufacturer’s listed torque recommendation is cause for concern. Notify the WRPS Engineer if greater than two times the manufacturer’s maximum recommended torque is required to open or close the valve.

6.3.5 Leak Test

Follow the methodology for leak testing, as specified in Section 6.2. Proposed alternatives to pressure test arrangement and sequence can be performed with WRPS Engineering approval.

a. As necessary, disconnect the test manifold and install blank flanges on each end with fittings to allow the applicable of water pressure and bleed trapped air. The downstream side of the test manifold will require a graduated cylinder to monitor/capture valve seat leakage.

b. Select and perform valve pressure testing in a sequence which limits the amount of manipulation of the test valves.

c. Partially rotate the UUT and fill the valve and manifold test piping with water allowing the release of captured air. After rotating the UUT to the test position, pressurize the system with water on the upstream side of the UUT to 50 +/-5 psig. Check for leaks around the valve stem packing gland and flanged joint.

d. Record the test pressure on the upstream side of the UUT, and observe the graduated cylinder downstream of the UUT.

e. Measure and record the leakage capturing by the graduated cylinder including the start/stop time for testing. Test duration specified in Section 6.2.

f. Observe the UUT and record any anomalies. Visually detectable leakage through the valve pressure boundary walls and any fixed body joint or stem is not permitted.

g. With valve still isolated, regulate test pressure to 400 +0/-20 psig and repeat steps d, e, and f of this section. Test duration specified in Section 6.2.

h. Perform applicable tests in accordance with Section 6.3.5 to comply with the test configurations shown in Figure 6.
6.3.6 Repetition of Cycle Testing

After every 25 cycles for the first hundred cycles and after every 100 cycles thereafter. For Flow-Tek valves containing UHMWPE cycle increments shall increase from every 100 cycles to every 250 cycles after 1,000 cycles have been reached. Repeat the applicable steps identified in Sections 6.3.2 through 6.3.5 until either:

d. The total number of cycles identified in Section 2.0 are accomplished, or
e. The 0.1 gal/min seat leak rate criterion is exceeded.

As specified in Section 6.2, replacement or rebuilding of the applicable valve shall be performed if the failure criteria of 0.1 gal/min is reached with less than 500 cycles. Replacement or rebuilding of the valve resets the cycle count to zero for that specific valve size/type (e.g. 3-inch 2-way Kynar seated valve). Pre-test assessment seat leakage tests/inspections shall be completed prior to reinitiated simulant testing through the valve. Excess leakage of valve seats after 500 cycles shall result in the suspension of further seat leakage testing of that specific valve type.

6.3.7 Design Pressure and Temperature Leak Testing

At the completion of 500 cycles and 1,000 cycles (if reached) perform a leak test at the valve design pressure and temperature (a separate test stand is recommended) as specified in Section 6.1.5. Required measurements and visual inspections required in Section 6.3.5 apply to leak testing.

If seat leakage test results exceed the leak rate criteria identified in Table 6-1 during the design pressure/temperature leak testing, valve cycle testing shall continue on that specific valve.

6.3.8 Post Cycle Test Inspection

After 1,500 cycles (PBM valves) or 5,500 cycles (Flow-Tek valves) or after failing the leak test, disassemble the UUT and provide a detailed description including high resolution photographs (≥ 12 megapixels) of the as-found condition. If directed by WRPS Engineering send the tested valve to the manufacturer for their assessment of the valve condition.
Figure 6. Valve Cycle Test Sequence Flow Sheet

1 – Applicable steps based on results of the simulant replacement evaluation, RPP-PLAN-44556 Section 4.3
6.4 Documentation

Document test results as follows:

- UUT item, size, model number, and serial number
- All manufacturer’s catalog data and documentation specific to the UUT including purchasing documents, manufacturer’s tests and QA records (as applicable) shall be provided including record of the unique identification (serial) number assigned
- Test system configuration (drawings, photos, purchased item, instrument and measurement device specs), includes skid design (piping, valves, pumps, instrumentation etc.) documentation
- Identification of measuring and test equipment used during the test
- Calibration records
- Instructions for operating the test setup
- Test fluid makeup recipe and sampling results including PSDs
- A test log including dates, times, names of individuals performing the test, observations and recorded test data
- Identification of test criteria or reference documents used to determine acceptance
- Test data records and traceability to UUT
- Description of any known conditions that adversely affected the results of the test
- Results (e.g. description of test fluid, amount of leakage, test duration, location of leakage, torque, etc.)
- Instrument calibration checklist as applicable
- Any deviation experienced during conduct of the test and the action taken in connection with the noted deviation including notification of WRPS
- Test exceptions that were encountered during testing and any impacts to the UUTs
- Nonconforming items and control of nonconformance (if any)
- Disposition of items following testing
- Amplifying instructions, directions, etc. provided by WRPS staff
7.0 TEST OPERATIONS AND CONTROLS

7.1 Selection of a Qualified Testing Subcontractor

WRPS will pre-qualify testing firms that have demonstrated experience in design, fabrication, and operation of pilot-scale test facilities for pumping systems. Testing firms will either be selected from WRPS’ existing qualified supplier list for testing or will be required to submit qualification information to demonstrate the expertise and capacity to perform the testing in the required time frame with an acceptable quality level. The quality level assigned to this testing is designated as full quality with quality assurance requirements to be listed in the applicable statement of work.

7.2 Testing Subcontractor Submittals

This test plan presents the objectives, concept, and performance requirements for the testing. The testing service Subcontractor will be required to submit the following to WRPS for review and approval.

- Design drawings or sketches of the test apparatus that show the physical layout of the equipment, sizes and layout of piping, and locations of all valves and instruments.
- Catalog cut sheets and vendor specifications on all pumps, tanks, mixers, valves, actuators, and instruments to be used for the test apparatus.
- A detailed test procedure including step by step testing sequence, calibration methods, and data collection record sheets
- Instrument calibration certifications
- Applicable personnel certifications
- Test Loop Start-Up and Readiness Checklist identifying the key test parameters for cold run demonstration.
- Valve Cycle Test Report including all documentation required in Section 6.4.

7.3 Measurement Equipment Tools

Measurement equipment and tools used as part of valve cycle testing data collection shall be calibrated to comply with the requirements of ASME NQA-1 (2004) and ANSI/NCSL Z-540.1-1994. Measurement equipment and tools include:

- Pressure gages
- Temperature gages
- Flow meters
- Torque wrench/sensor
- Applicable instruments/equipment for valve seat leakage measurement

7.4 Quality Assurance/Quality Control

Quality Assurance (QA) is defined as an integral program designed to ensure the reliability of the test inspection, monitoring and measurement data. Quality Control (QC) is defined as the application of procedures for obtaining prescribed standards of performance in the monitoring
and measurement process. QA procedures such as inspection, reviewing and auditing shall be carried out as necessary to ensure that all project work is performed in accordance with professional standards, regulations and guidelines, and specific project goals and requirements.

The WRPS TFC-PLN-02, Quality Assurance Program Description (QAPD) is the management system that implements the requirements of DOE 414.1C, *Quality Assurance*, and 10 CFR 830, Subpart A, for managing, performing and assessing the adequacy of the work. WRPS conducts work in-accordance with the QAPD, and where appropriate, uses a graded approach to implement the DOE directives and external requirements. The testing Subcontractor shall perform all work in accordance with a QA/QC program that complies with the applicable portions of the WRPS QAPD.

Important QA/QC parameters, as applied to the DVI simulant test program, are precision, accuracy, representativeness, completeness and comparability. In general this includes the following:

- Using traceable standards and standard procedures for instrument calibration
- Documenting deviations from procedures and methods
- Using approved procedures for testing operations and ensuring changes are rigorously controlled

Commercial QA/QC requirements shall be applied to:

- Design, procurement, and fabrication of the test skid(s) including all equipment

This testing program does not require handling of nuclear or hazardous materials; therefore, commercial quality assurance practices will be adequate. The design, fabrication, testing, and inspection of the test skids shall be in accordance with commercial practices to assure the test system will operate safely. All block valves in the test skids shall be tested per the requirements of ASME B16.34, *Valves – Flanged, Threaded, and Welding End*.

The government furnished valves to be tested will have been purchased from the same suppliers that provided the DVI isolation valves installed in the field, and shall be the same make and design (except end-fittings) as those provided for field installation. The government furnished valves will have been certified to comply with ASME B16.34 by the manufacturer.
8.0 REFERENCES


APPENDIX A

DVI ISOLATION BALL VALVE TYPES FOR WASTE TRANSFER AT HANFORD SITE
### PBM Ball Valves

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<th>Body Type</th>
<th>Seat Material</th>
<th>Seal Material</th>
<th>Filler Material</th>
<th>O-Ring Material</th>
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**FLOW-TEK BALL VALVES**

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Notes:
PBM- Pittsburgh Brass Manufacturing, Irwin, PA, www.pbmvalve.com
Flow-Tek-Houston, TX, www.flow-tek.com
SS- stainless steel
BW - butt weld
EPR - ethylene propylene rubber
UHMWPE - ultra high molecular weight polyethylene