1 of 1

SUPPORTING DOCUMENT		1. Total Pages 1824 <i>and 18-24-93</i>	
2. Title PUREX Style Jumper Connector Type III Gasket Test Report		3. Number 9/26/93 WHC-SD-HWVP-TRP-006	4. Rev No. 0
5. Key Words JUMPER CONNECTOR GASKET APPROVED FOR PUBLIC RELEASE 8/19/93 <i>DSOA</i>		6. Author Name: DA Austin <i>[Signature]</i> Signature 22360/C55302 Organization/Charge code	
7. Abstract This Report Summarizes tests performed on PUREX Style Jumper Connectors under simulated operating conditions.			
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9. Impact Level 30			

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**PUREX JUMPER CONNECTOR
TYPE III GASKET TEST REPORT**

July 1993

Prepared for

Westinghouse Hanford Co.
P. O. Box 1970
Richland, WA 99352

By
David A. Austin

Reviewed and Edited by
Russell N. Wagner

Abstract

This report summarizes data obtained from testing of type III Teflon gaskets used on PUREX-type process jumper connectors. The purpose of these tests was to assess the performance characteristics of the type III gaskets, currently planned to be used in the Hanford Waste Vitrification Plant (HWVP).

Results indicate that the Teflon gaskets deform severely under heat and applied moment loads. The gaskets also lose their ability to hold pressure when thermally cycled, and cannot hold elevated pressures unless they are retorqued between cycles. Gasket failure ultimately occurs after one or more cycles.

¹ Teflon is a registered trademark of the Dupont Corporation.

**PUREX JUMPER CONNECTOR
TYPE III GASKET TEST REPORT**

CONCURRENCE

David Austin
Cog. Engineer

Gordon L. Neer
Manager, Equipment Testing Laboratories

Russ N. Wagner
Hanford Waste Vitrofication Plant Funding Customer

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1.0 INTRODUCTION

The Hanford Waste Vittrification Plant (HWVP) will employ PUREX-style process jumper connectors. The type of gasket under consideration for these connectors is a 25% carbon fiber-impregnated Teflon¹, designated the type III design. Testing of these gaskets was conducted in the Equipment Testing Laboratory, 305 Building, 300 Area on March 17, 1993 through May 7, 1993.

Connectors will be subject to temperature variation and moment loading while in use. The tests documented in this report were designed to simulate plant operating conditions.

2.0 DESCRIPTION OF TESTS AND METHODS

The gaskets were tested in PUREX-type jumper connectors. The general design of the connector mock-up is similar for all of the gaskets (Figure 1). With the exception of the connector nozzles, which were machined at the 274 W machine shop, the connector components were obtained from 200 E Site Warehousing Services.

The test stand was equipped with four heating elements inserted in the bottom of the nozzle. Heater power was supplied by a digital control unit. The connectors were pressurized with water via a manually controlled Microflo pump. Pressure was monitored with a 600 psi analog gauge. Internal temperature was monitored by a data acquisition unit which received input from two thermocouples located in the block and the nozzle. These temperatures were displayed and plotted on a monitor. Moment loads were applied to the connector via a threaded rod and a 15-inch moment arm. The threaded rod was fitted with a load cell connected to a digital readout, allowing the applied moment to be monitored.

Pressure was monitored for a period of two minutes to determine gasket sealing ability. The target sealing pressure was 250 psig, while the target temperature for elevated temperature testing was 390 °F.

Operating screw torque was applied with a hydraulic wrench.

Each test was considered complete if any of the following conditions were met:

- Required torque to reseal the connector between cycles exceeded 100 ft-lbf over the original torque
- Gasket showed obvious signs of leakage and could not be resealed
- For cycling tests, the maximum number of cycles was set at six.

¹ Teflon is a registered trademark of the DuPont corporation.

Each gasket was subjected to some or all of the following conditions at 250 psig:

- Ambient temperature
- Ambient temperature with moment load
- 390° F with moment load
- Thermal cycling
- Thermal cycling with moment load.

2.1 AMBIENT TEMPERATURE WITH NO APPLIED MOMENT LOAD (Condition 1)

A new gasket was installed in the connector. The operating screw was torqued in 50 to 100 ft-lbf increments. After each increment, the system was pressurized to 250 psig and monitored for two minutes using a stop watch.

This procedure was repeated as a preliminary to all tests to determine the operating screw torque necessary to retain 250 psig at ambient temperature.

2.2 AMBIENT TEMPERATURE WITH MOMENT LOAD (Condition 2)

A new gasket was installed in the connector. After completion of the Condition 1 procedure, the 15-inch moment arm and load cell were attached to the connector. Load was applied to the end of the moment arm in increments of 200 lbf, up to 1000 lbf. The pressure was monitored for two minutes after each incremental torque increase. The load was removed following the final increment. Gasket sealing ability was then measured with no additional operating screw torque. The operating screw was subsequently retorqued as necessary, up to 100 ft-lbf over the original sealing torque, to restore the 250 psig sealing capability.

2.3 INCREASED TEMPERATURE WITH MOMENT LOAD (Condition 3)

A new gasket was installed in the connector. After completion of the Condition 1 procedure, the connector was heated to approximately 390 °F. The system was considered to be at equilibrium when the thermal graph indicated minor (± 5 °F) variations of block and gasket temperatures with respect to time. The system then was subjected to moment loading per Condition 2. After moment loading, the system was allowed to cool, and residual sealing ability was measured as in Condition 2.

2.4 THERMAL CYCLING WITH NO MOMENT LOAD (Condition 4)

Condition 4 was essentially Condition 3 without applied moment. Instead, the system was held at elevated temperature for 1.5 hours. An average of three hours was required for the systems to reach thermal equilibrium at 390 °F. One thermal cycle was defined as beginning and ending at ambient temperature.

2.5 THERMAL CYCLING WITH MOMENT LOAD (Condition 5)

Condition 5 was essentially a combination of Conditions 3 and 4. For Condition 5 tests, an attempt was made to measure the block displacement due to moment, and return it to its original position after each cycle, thus simulating thermal expansion and contraction of jumpers in an operating plant.

Figure 1 Photograph showing 3-inch connector with load cell and moment apparatus.

3.0 TEST RESULTS

Test results are summarized chronologically. A complete listing of measurements is given in Appendix A.

The three inch connector system was installed on the test stand. A new gasket was installed, and the required operating screw torque to hold 250 psig was determined to be 330 ft-lbf. Testing was conducted per Condition 2.

Following each incremental applied moment increase, the pressure slowly increased while the load drifted downward. This appeared to indicate that the load caused the gasket to compress and flow, thus relieving the load slightly while increasing the system pressure due to decreased internal volume.

3.2 THREE-INCH ELEVATED TEMPERATURE WITH MOMENT LOAD

A new gasket was installed in the connector. The operating screw torque required to hold 250 psig was recorded as 380 ft-lbf. The system was heated to equilibrium at approximately 390 °F. Pressure gauge indication was erratic throughout the heating procedure and varied approximately ± 5 psi when the temperature was elevated. There was no evidence of gasket failure after 1000 lbf was applied to the moment arm. The pressure increased gradually while the load was maintained.

After the system cooled to ambient, pressure was recorded at approximately 1 psig, and the load cell indicator measured 764 lbf. After repressurization, the system held 65 psig and leaked at 70 psig.

Figure 2 shows a 3-inch gasket before and after a trial Condition 3 test, demonstrating the gasket flow phenomena. Some gasket material adhered to the nozzle after the gasket was removed.

Figure 2 Cross section sketch of three-inch gasket before and after trial run.

3.3 FOUR-INCH GASKET ELEVATED TEMPERATURE WITH MOMENT LOAD

280 ft-lbf initial operating screw torque was required to retain 250 psig. Moment load was applied in 200 lbf increments after the system was heated to 390 °F. At 600 lbf, the pressure increased slowly with time and the load cell indicated a decrease in the applied load. The pressure gauge reading varied ± 5 to 10 psig. At 800 lbf applied load the pressure reading appeared to be less erratic, but increased slowly over time with a corresponding decrease in measured load. The system held no pressure after it cooled to ambient, and there was no measurable torque on the operating screw. The operating screw was retorqued to original and the system held 250 psig for two minutes.

3.4 THREE-INCH GASKET THERMAL CYCLING WITH MOMENT LOAD

The three-inch gasket successfully completed two thermal cycles with applied moment loading.

3.4.1 Cycle 1

330 ft-lbf initial operating screw torque was required to retain 250 psig. The vertical distance measured to establish a reference for the pre-test connector position was 26.5 inches.

After the system temperature stabilized at approximately 390 °F, moment load was applied in 200 lbf increments. System pressure increased in rough proportion to the applied load. At 200 lbf applied load, the pressure increased approximately 8 psig; at 400 lbf, pressure increased 20 psig; at 800 lbf, pressure increased 70 psig. Above 800 lbf applied load, the pressure was returned to 250 psig and maintained via fine adjustment. Load cell thread capacity limited the maximum applied load on this cycle to 934 lbf. No pressure loss was observed after this maximum load was applied. Measurement of the connector position reference dimension with the system at temperature indicated a 3/32-in shift in connector position. The reference dimension did not change after the system returned to ambient temperature. No attempt was made to return the connector to its original position.

The gasket held 50 psig at ambient temperature. The operating screw was retorqued to the original 330 ft-lbf and the system held 250 psig.

3.4.2 Cycle 2

The Cycle 2 results were similar to Cycle 1. The pressure increased much less with the applied load. At 200 lbf load, the pressure increased approximately 1 psig; at the 600 lbf and 800 lbf loads, the pressure increased between 0.5 psig and 2 psig. Maximum applied load was limited to 982 lbf due to load cell thread capability. No system leakage was detected during this cycle.

The system sealing capability after return to ambient temperature was not recorded. The connector position reference measurement was not taken due to a miscommunication between test operators. No attempt to was made to adjust the

connector position. The operating screw torque required to hold 250 psig was recorded at 330 ft-lbf.

3.4.3 Cycle 3

In Cycle 3, the load cell was modified to accommodate a maximum load of 1000 lbf. Results for this cycle were similar to those in Cycle 2, with the exception that the 2-10 psig pressure variation previously observed was not present. The "normal" behavior of the pressure reading during a thermal cycle with an applied moment exhibits an increase or decrease in pressure and a slow variation. After an initial increase of 4 psig, the Cycle 3 pressure remained stable for five 200 lbf increments. No system leak was detected at elevated temperature.

After the return to ambient temperature, an operator miscommunication resulted in the connector being forced back to its apparent original position. The post-cycle sealing ability was not determined. There was no measurable sealing ability with 420 ft-lbf torque on the operating screw.

Figure 3 Photograph of three-inch gasket before and after thermal cycling with applied moment.

The photograph in Figure 3 shows gasket deformation after removal from the retainer ring. Separation of the gasket material most likely occurred when the connector block was removed from the nozzle.

All gaskets subjected to high-temperature testing stuck to the nozzle and tore on disassembly.

3.5 TWO-INCH GASKET THERMAL CYCLING WITH MOMENT LOAD

The two-inch gasket was unable to complete one full thermal cycle with applied moment load.

3.5.1 Cycle 1

The two-inch gasket failed to complete one thermal cycle with applied moment load.

104.4 ft-lbf operating screw torque was required to seal 250 psig initially. The connector did not indicate any sign of leaking after the internal temperature reached 390 °F equilibrium. When the moment load was applied, system pressure behaved differently than in the three-inch gasket tests.

At 200 lbf applied load, the pressure dropped 10 psig with approximately 1 psig variation; at 600 lbf, the pressure increased 15 psig; at 800 lbf, the pressure increased by 20 psig. The system held pressure for two minutes after 1000 lbf was applied.

The gasket held only 35 psig after return to ambient temperature. A water leak was observed at 110 psig, apparently coming from underneath the block. A 3/32 in rise in the reference connector dimension was noted. After the connector was pried back to its original position and repressurized, the gasket held 48 psig. The operating screw was retorqued to 102.7 ft-lbf and the connector held 130 psig. Due to the apparent water loss previously noted, the block was removed from the nozzle in an attempt to avoid damaging the connector with more applied torque on the operating screw.

The gasket appeared to tear slightly when the block was removed. Upon removal from the retainer ring, the gasket deformation appeared similar to that shown in Figure 4. Gasket compression was greatest 180° from the side on which the moment force had been applied. The gasket also appeared to have experienced shear forces around a "hinge line" on the side with greatest compression. The gasket shear appears to be the result of nozzle rotation about an axis (hinge line) 180° from the side on which the moment load was applied.

The shear forces may have induced metal-to-metal contact, severing the gasket. The greatest gasket flow occurred on the side which received the moment load. This is typical for all gaskets tested under conditions of applied moment at elevated temperature.

Figure 4 Photograph of two-inch gasket inside retainer ring. The gasket was subjected to thermal cycling with no applied moment. Thermal cycling with applied moment produced similar deformation.

3.6 TWO-INCH GASKET THERMAL CYCLING

The two-inch gasket survived one cycle with satisfactory performance.

3.6.1 Cycle 1

102.4 ft-lbf operating screw torque was required to seal 250 psig. No leaks were found during Cycle 1. The pump was turned off when the system reached 390 °F, and the system was allowed to stand at pressure and temperature for 1.5 hours. The pressure increased gradually over time with an approximate 0.5 psig variation.

Upon cooling to ambient temperature, sealing capability was established at 150 psig. After the operating screw was torqued to 102.9 ft-lbf, the sealing capability was recorded at 225 psig; leak pressure was found to be 230 psig. The system was able to retain 250 psig after the operating screw torque was increased to 160 ft-lbf. This ended Cycle 1.

3.6.2 Cycle 2

There were no obvious signs of leakage while heating, but the system did not hold 250 psig at 390 °F. Maximum hold pressure was 160 psig, and leakage occurred at 165 psig. The operating screw was not retorqued because of the rate of pressure loss and the magnitude of torque remaining on the operating screw.

The operating screw was torqued to 200 ft-lbf, the maximum allowable as stated in the test procedures. The system was unable hold 250 psig. By decreasing the pressure in 5 psig increments, holding and leak pressure were established at 200 psig and 205 psig, respectively. Since operating screw torque was at the maximum allowable, the test was considered complete.

Figure 5. Graph 5 showing cyclic behavior of the two inch gasket with respect to initially required torque, initial ambient temperature sealing ability, and end-of-cycle sealing ability.

3.7 THREE-INCH GASKET THERMAL CYCLING

The three inch gasket maintained sealing integrity through six Condition 4 thermal cycles.

3.7.1 Cycle 1

330 ft-lbf was required to hold 250 psig at ambient temperature. The pump was turned off after the system reached thermal equilibrium at 390 °F. The pressure gauge indicated a 2-4 psi variation. The connector was held at temperature for 1.5 hours with no apparent leaks.

Once cooled to ambient temperature, the system held only 5 psig. The operating screw was retorqued to 330 ft-lbf; the connector then held 250 psig for two minutes.

3.7.2 Cycle 2

Heatup proceeded satisfactorily as in Cycle 1. No leaks occurred during the 1.5 hour hold period at 250 psig.

After cooling to ambient temperature, gasket sealing ability was 235 psig. Leakage occurred at 240 psig. Sealing ability returned to 250 psig after the operating screw was retorqued 330 ft-lbf.

3.7.3 Cycle 3

A temporary power failure occurred during heatup. Once at 390 °F, the connector held 250 psig for 1.5 hours without incident.

At ambient temperature, the connector held 250 psig without the need to retorquer the operating screw.

3.7.4 Cycle 4

There was no sign of leakage during Cycle 4. The pressure gradually increased to approximately 265 psig during the 1.5 hour hold time at 390 °F.

At ambient temperature, the gasket held 235 psig and leaked at 240 psig. The system held 250 psig for two minutes after the operating screw was retorqued to 330 ft-lbf.

3.7.5 Cycle 5

There was no sign of leakage during Cycle 5. The pressure gradually increased to approximately 265 psig during the 1.5 hour hold time at 390 °F.

At ambient temperature, the gasket held 165 psig and leaked at 170 psig. The operating screw was torqued to 380 ft-lbf and the system held 230 psig. The

operating screw was to 420 ft-lbf and the connector held 250 psig for two minutes.

A leak in the pressure adjustment valve was discovered afterwards. The valve was tightened and sealing ability was maintained. This leak may have been present during the ambient temperature sealing test.

3.7.6 Cycle 6

There was no sign of leakage during Cycle 6. The pressure gradually increased to approximately 300 psig during the 1.5 hour hold time at 390 °F.

At ambient temperature, the system held 240 psig and leaked at 245 psig. The system held 250 psig after the operating screw torque was retorqued to 420 ft-lbf.

The connector was removed from the test stand nozzle and the gasket tore in a manner similar the three-inch Condition 5 test discussed in Section 3.4. The gasket appeared severed along a hinge line similar to that discussed in Section 3.5.1.

Figure 6. Graph showing cyclic behavior of the three-inch gasket with respect to the initially required torque, initial ambient temperature sealing ability, and end-of-cycle sealing ability.

4.0 DISCUSSION OF TEST RESULTS

The poorest performance was demonstrated by the two-inch gasket when subjected to elevated temperature and applied moment. This size gasket was unable to complete a single thermal cycle with applied moment, and completed only one thermal cycle without applied moment.

The three-inch gasket showed the best performance. It survived six thermal cycles without applied moment and two cycles with applied moment.

The four-inch gasket was not subjected to repetitive cyclic testing. However, the single cycle test results (Section 3.3) suggest that this size gasket would outperform both the two- and three-inch sizes.

Gasket performance appears to be related to the gasket volume. The two-inch gasket compressed, flowed, and failed much sooner than the larger gaskets. Gasket flow, particularly at elevated temperature, appears to be the primary mechanism of failure and necessitates operating screw retorquing to reseal gaskets after thermal cycling.

Gasket flow was readily apparent even at ambient temperature. All new gaskets had to be torqued twice, with a five minute waiting period between torquings, in order to retain pressure.

5.0 CONCLUSIONS

These test results indicate that Teflon-based gaskets are unable to provide reliable sealing, particularly when thermally cycled and when connectors are subjected to external loads. PUREX and B-Plant operating history indicates that retorquing of PUREX-type process connectors to achieve satisfactory sealing was commonplace. This historic experience lends additional credence to the test results.

The use of two-inch connectors should be minimized in applications where thermal cycling can occur.

Development of alternate connector sealing technology appears necessary if the HWVP is to be operated with a zero process leakage philosophy. Either a non-flowing gasket material or a new seal concept, such as O-rings, should be investigated.

6.0 DISPOSITION OF TEST ARTICLES

The test articles are currently located in the 300 Area, 305 Building Equipment Testing Laboratory. They may be used in further seal development testing. If no other work is identified, they will be disposed of as scrap.

APPENDIX A

TWO INCH HIGH TEMPERATURE CYCLING

CYCLE	TORQUE TO SEAL 250 Lbf/in ² AT AMBIENT (ft-lbf)	HOLD PRESSURE AT 390°F (lbf/in ²)	POST HOLD PRESSURE (Lbf/in ²)	POST LEAK PRESSURE (lbf/in ²)
1	102.3	250	150	155
2	200	250	200	205

TWO INCH HIGH TEMPERATURE CYCLING WITH MOMENT LOAD

CYCLE	TORQUE TO SEAL 250 Lbf/in ² AT AMBIENT (ft-lbf)	HOLD PRESSURE AT 390°F (lbf/in ²)	POST HOLD PRESSURE (Lbf/in ²)	POST LEAK PRESSURE (lbf/in ²)
1	102.3	250	35	40
2	102.7	250	130	135

THREE INCH HIGH TEMPERATURE CYCLING

CYCLE	TORQUE TO SEAL 250 Lbf/in ² AT AMBIENT (ft-lbf)	HOLD PRESSURE AT 390°F (lbf/in ²)	POST HOLD PRESSURE (Lbf/in ²)	POST LEAK PRESSURE (lbf/in ²)
1	330	250	5	10
2	330	250	235	240
3	330	250	250	NO DATA
4	0	250	235	240
5	330	250	245	250
6	420	250	240	245

THREE INCH HIGH TEMPERATURE CYCLING WITH MOMENT LOAD

CYCLE	TORQUE TO SEAL 250 Lbf/in ² AT AMBIENT (ft-lbf)	HOLD PRESSURE AT 390°F (lbf/in ²)	POST HOLD PRESSURE (Lbf/in ²)	POST LEAK PRESSURE (lbf/in ²)
1	330	250	50	55
2	330	250	NO DATA	NO DATA
3	420	0	0	0

APPENDIX B

MEASURING AND TEST EQUIPMENT LIST				
Manufacturer	Model Serial No.	Range	Calibration	Use
Proto Manual torque wrench	6008-4 S/N 120582	5 to 80 ft-lbf	750-88-01-006 Expires 4/23/93	Tie bolt torques
Snapon Manual torque wrench	Electrotork QUE-325 S/N S010020	15 to 250 ft-lbf	750-88-01-005 Expires 4/22/93	Operating Screw Torques through 250 ft-lbf
Ingersoll - Rand Hydraulic torque wrench	RT-3000 S/N DLD29123	100 to 3000 ft-lbf	752-31-04-005 Expires 11/19/93	Operating Screw Torques above 250 ft-lbf
Hewlett Packard Data Acquisition Unit	3497A	Auto ranging	750-67-11-002 Expires 4/21/94	Nozzle and block temperature display
Houston Scientific Load Cell	3500-10K S/N 8197-001	0 to 1000 lbf	752-29-05-006 Expires 6/16/93	Moment load measurement
Heise Pressure Gauge	C63H-1K-10Y1	0 to 600 lbf/in ²	752-31-04-006 Expires 4/21/94	Seal hold pressure

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