RECORD COPY

SNPO-G
Astronuclear

WANL-TME-970

October 20, 1964

Test Series FFL-13,

BAR-X SEAL TEST IN
OVERSIZE PORT

(Title Unclassified)

By

J. M. Edmiston

Fluid Flow Laboratory

MASTER

RECORD COPY

Approved By:

E. A. DeGubay
E. A. DeGubay, Manager
Fluid Flow Laboratory

H. S. McCreary
H. S. McCreary, Manager
Experimental Engineering

W. G. Roman
W. G. Roman, Manager
Reactor Engineering

NOTICE

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Atomic Energy Commission, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

INFORMATION CATEGORY

UNCLASSIFIED

9/30/64
Authorized Classifier Date

892 56 cc

se

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

TABLE OF CONTENTS

	Page
Abstract	1
Introduction	2
Test Procedure	3
Discussion	7
Conclusion	8
Summary of Test Data	10
Appendix A - Determination of Leakage Rate	11
Appendix B - Photographs and Figures	14 - 20
Appendix C - Test Fixture Components	21
Appendix D - List of Test Record Sheets	22

ABSTRACT

The hazard introduced by hydrogen leaks out of a NERVA engine makes it imperative that a suitable remedy be determined for repair of damaged instrument port seals. This test demonstrated that the two-inch port could be increased 0.0043 inches in diameter beyond the manufacturer's recommended size and still effectively seal with the standard 2-inch Bar-X seal.

The tests were conducted to satisfy test request 41:41:55-6W, originated by Reactor Design Engineering.

INTRODUCTION

In order to determine the maximum allowable diameter of the pressure vessel instrumentation ports, it was necessary to demonstrate the effectiveness of a standard Bar-X seal in an oversize port.

Reactor Mechanical Design Test Request No. 41:41:55-6W was followed.

The hardware and fixtures for the seal test were supplied by Reactor Mechanical Design. See Figure 4. A list of supplied parts is included in the Appendix.

TEST PROCEDURE

The following tests were performed on the test fixture, seals, and associated hardware:

- I. Qualify Test Fixture
 - A. Hydrostatic Check
 - B. Helium Check
 - C. Hydrogen Check

- II. Hydrogen Test

- I. Qualify Test Fixture

The test fixture was leak-checked under pressure to insure the integrity of the fixture seals.

- A. Hydrostatic Check

The test fixture was assembled minus the internal seal and with a substitute seal fixture housing. The fixture was tested at 1500 psig. The plenums failed to seal and had to be refaced to remove scratches. The bolts were torqued uniformly to 30 ft-lb. Upon successful completion of this test, Test I, Part B was initiated.

- B. Helium Check

The test fixture assembled as in Test I, Part A, was pressurized to 800 psig with helium gas and checked for leaks with Leak Tec solution. No leak was detected over a 15-minute period. Test I, Part C was then followed.

C. Hydrostatic Check

The test fixture as above, and then with the oversize bore seal fixture housing, was pressurized with 700 psig hydrogen gas at room temperature and examined first for leaks with Leak Tec and re-examined with a Mine Safety Appliances Company Model 3 hydrogen leak detector. When a leak was not detected, the fixture was thermal cycled from room temperature to -320°F (in liquid nitrogen) and soaked in the liquid nitrogen bath until the nitrogen practically ceased to boil. The area above the bath was sniffed with the Explosimeter. The fixture was removed from the nitrogen bath, allowed to warm up to near room ambient temperature. The torque on the bolts had dropped to about 20 ft-lb. It was decided at this point that all subsequent assemblies would be cold shocked, as in above cycle, and re-torqued prior to any further testing. This was done from here on. The fixture was further thermal cycled successfully.

II. Hydrogen Test

1. All parts were cleaned with acetone and then examined for the condition of the sealing surfaces.
2. If scored, the seal block was lapped on the sealing area.
3. The test fixture was assembled per Drawing NT701140, the seal compression nut, Drawing 945C469, torqued to 220 ft-lb, and the one-half inch bolts torqued to 30 ft-lb.

4. The fixture was cold soaked in liquid nitrogen until the nitrogen ceased to be agitated. The fixture was then removed from cold soak. It was then warmed with warm tap water and the bolts re-torqued to 30 ft-lb. (Torque always seems to drop off to 20 ft-lb after cold soak.)
5. The fixture was installed in the test loop of Figure 1. It was raised off the cell floor with a block and tackle. See the photographs of the cell layout in Figures 2 and 3.
6. The helium pressure regulator was set to 300 psig. The helium supply solenoid valve (1), the by-pass valve (2), and then the vent valve (3) were opened. The loop was then purged with helium. These valves were then closed in the same order.
7. The hydrogen valve (5) and the by-pass valves (2) were opened. The hydrogen pressure was raised to 20 psig and the by-pass valve (2) closed. The vent valve (3) was opened and remained open until the pressure on the outlet plenum dropped to 10 psig. The solenoid valve (4) to the manometer and the hand valve on the atmospheric side of the manometer were opened.
8. The hydrogen pressure regulator was set to 700 psig. The fixture was examined with the MSA meter for leaks.
9. The following readings were recorded every 10 minutes for one hour:
 - a. Time
 - b. Inlet pressure
 - c. Outlet gauge pressure
 - d. Outlet manometer reading

Also recorded were:

Barometric pressure

Ambient temperature

Any pertinent notes

10. If the leakage rate exceeded 10^{-2} scc/sec, i.e., a discharge plenum pressure change of 0.4 HgG in 10 minutes, the test would have been discontinued.
11. After successfully completing the above procedure, the fixture was submerged in a liquid nitrogen bath in a dewar.
12. After about 15 minutes the nitrogen in the bath would have ceased to be agitated. The pressure would have dropped on the downstream plenum so that enough additional hydrogen had to be bled into the downstream plenum through the by-pass until the manometer registered about 20" HgG again. The inlet pressure, because of the hydrogen regulator, held at 700 psig.
13. Data was recorded as above under 9.
14. If the leakage rate exceeded 10^{-2} scc/sec, i.e., a discharge plenum pressure change of 0.1" HgG in 10 minutes, the test would have been discontinued.
15. After successful completion of the test, the fixture was disassembled and the condition of the seal and sealing surfaces examined. Any changes in condition were noted under Remarks.
16. A test failure would have been relayed to Reactor Mechanical Design for comment before proceeding further.

The preceding test procedure was employed in testing the seal housing with the following internal diameter and test variations noted. See Figure 7.

	<u>Diameter</u>	<u>Test Time</u>	<u>Outlet Plenum Pressure</u>
1)	2.0227	1 hour cycle	0 psig
2)	2.0235	1 hour cycle	0 psig
3)	2.0253	2 hour cycle	0 psig
4)	2.0253	Retest as in above (3)	+ 20" Hg

DISCUSSION

1. On all tests except the last, the seal block, 909E375G01, sealing surface was lapped with Clover Grade A on a cotton glove to remove superficial scratches.
2. On each assembly, relative displacement axially of the nut 945C469H01 from the hand tight position to the 220 ft-lb torqued position was measured. These measurements indicated that the Bar-X seal was compressed 10 mils (.913" - .903", .9115" - .901", etc.)
3. After each test the seal was difficult to remove. It cut thin shavings of aluminum from the housing bore. This was caused by the Bar-X seal digging into and grooving the aluminum housing port in order to seal the oversized port. See Figures 5 and 6.
4. After the third test, and the port was .0043" oversize, machining was terminated. An additional test was conducted to determine that if the instrument capsule had to be disassembled and reassembled without modification, it could be resealed again. None of the steps taken on the first three tests to recondition the sealing surfaces or the seal itself were taken.

5. Determination of the leakage rate limit for the fixture is explained in Appendix A. This method was also used in the previous tests of these seals that determined torque requirements for this assembly.
6. Considerable difficulty was experienced in sealing the fixture housing to the end plenums due to torque limitation of the aluminum thread in the housing. Some redesign is planned for future testing to correct these deficiencies.
7. Testing was discontinued with the port .0043" oversize. Bar-X seals are to be obtained .003" and .006" outside diameter over the standard size stocked by the manufacturer to compensate for any necessity to increase the port size beyond this test limit.
8. The threads of the bolts and seal block nut, and the faces of the spacer were coated with Neolube, a dry lubricant, to reduce torquing friction to a minimum.
9. The seal block was lapped to remove axial scratch marks in the seal area before each of the first three assemblies.
10. A test summary sheet is on Page 10.

CONCLUSIONS

1. A standard Bar-X seal described in Westinghouse Dwg. 963B320, Rev. A, (1.748 I.D. Inconel, without plating) will seal satisfactorily in a port as shown on Westinghouse Dwg. 1NT600835, Item 101, under 220 ft-lb of torque to better than a leakage rate of 10^{-2} scc/sec, even if the port is .0043" over the manufacturer's recommended limit.

2. With care to prevent damage to seal and sealing surface, this seal can be reassembled and sealed as well as on the first assembly, even with the port .0043" oversize.

Summary of Test Data

<u>Test Description</u>	<u>Gas</u>	<u>Torque (ft-lb)</u>	<u>Temperature</u>	<u>Pressure (psig)</u>	<u>Remarks</u>
Flow Test (2.0227" diam port)	Hydrogen	220	Ambient	700	No leakage
Flow Test	Hydrogen	220	Liquid Nitrogen	690	Fixture seal leaked
Flow Test (2.0234 diam port)	Hydrogen	220	Ambient	715-780	No leakage
Flow Test	Hydrogen	220	Liquid Nitrogen	750	No leakage
Flow Test (2.0253 diam port)	Hydrogen	220	Ambient	700	No leakage
Flow Test	Hydrogen	220	Liquid Nitrogen	690	No leakage
Flow Test (2.0253 diam port)	Hydrogen	220	Ambient	700	No leakage*
Flow Test	Hydrogen	220	Liquid Nitrogen	705	3.7×10^{-3} scc/sec* for 30 min (3/8 of allowable leakage rate)**

* Disassembly and reassembly without modifying port size

** This is maximum because gas temperature seemed to be rising

APPENDIX A

PURPOSE:

Determination of acceptable leakage rate in terms of rate of pressure change.

PROCEDURE:

By dead-ending the outlet plenum, i.e., close the vent and by-pass valves shown in Figure 1, the volume trapped will experience a change in pressure and temperature approximately according to the Perfect Gas Laws.

$$\frac{\Delta P}{\Delta t} V = \frac{\Delta M}{\Delta t} R T \quad (1)$$

where

$$\frac{\Delta P}{\Delta t} = \text{change in pressure with respect to time}$$

$$V = \text{fixed volume}$$

$$\frac{\Delta M}{\Delta t} = \text{change in mass with respect to time}$$

$$R = \text{H}_2 \text{ gas constant}$$

$$T = \text{temperature in } ^\circ\text{R in fixed volume}$$

Also

$$\frac{\Delta M}{\Delta t} R T_s = P_s \frac{\Delta V_s}{\Delta t} \quad (2)$$

where, in addition

$$\begin{aligned} P_s &= 14.7 \text{ psia} = \text{standard pressure} \\ T_s &= 520^\circ\text{R} = \text{standard temperature} \end{aligned}$$

$$\begin{aligned} \frac{\Delta V_s}{\Delta t} &= \text{volumetric rate of change at standard condition} = \\ 10^{-2} \text{ scc/sec} &= \frac{10^{-2}}{16.39} \text{ scu in/sec} \end{aligned}$$

Continuing equations (1) and (2)

$$\frac{\Delta P}{\Delta t} V = P_s \frac{\Delta V_s}{\Delta t} \frac{T}{T_s} \quad (3)$$

fixed volume V is composed of:

Seal fixture outlet plenum	= 186 cc	= 11.32 cu in
Flexible hose	= 45 cc	= 2.75 cu in
Stainless tubing		= 1.141 cu in
Polyflow tubing		= 0.815 cu in
Manometer		= <u>1.373</u> cu in
Total Volume		17.399 cu in

The maximum pressure rate of change on the fixed volume of gas with ambient temperature is

$$\frac{\Delta P}{\Delta t} = \frac{(14.7) (10^{-2}) (520)}{(17.399) (16.39) (520)}$$

$$\frac{\Delta P}{\Delta t} = .0005 \text{ psi/sec} = 3.6 \text{ in. Hg/hr}$$

And similarly, with the temperature at 140°R, the maximum pressure rate of change in the fixed volume is

$$\frac{\Delta P}{\Delta t} = \frac{(14.7) (10^{-2}) (140)}{(17.399) (16.39) (520)}$$

$$\frac{\Delta P}{\Delta t} = 0.8 \text{ in. Hg/hr}$$

APPENDIX B

Figure 1

Leak Test Loop For Bar-X Seal Fixture

APPENDIX B

Figure 2

Test Arrangement Through Cell Window

APPENDIX B

Figure 3

Test Arrangement - Cell Interior

APPENDIX B

Figure 4

Test Fixture Disassembled

APPENDIX B

Figure 5

Seal Block - After Test

APPENDIX B

Figure 6

Seal Test Housing - After Test

APPENDIX B

1. ORIGINAL DIAMETER 2.0205
2. DIAMETER AS TESTED JUNE 26, 11 PM 2.0227
3. DIAMETER REMACHINED JUNE 27, 8 AM 2.0234
4. AFTER TEST DIAMETER WAS MEASURED AS 2.0237
5. DIAMETER REMACHINED JUNE 29, TO 2.0253

Figure 7

Seal Test Fixture Housing

APPENDIX C

Test Fixture Components

The following parts were supplied by Reactor Mechanical Design:

3	each	963E320 Rev. A	Par X Seal*
1	each	946C242G01	Spacer
1	each	964B186H01	Washer
1	each	945C469H01	Nut
1	each	964B191H01	Pin
1	each	945C702H01	Ring
1	NT 600835	Item 101	Seal Fixture Housing
1	each	909C375G01	Seal Block

On hand from previous assembly and test:

1	each	945C472H01	Locking Cup
1	NT 700059	Item 201	Outlet Plenum
1	NT 700059	Item 203	Inlet Plenum
6	each	4" I.D. x 3/16" wide	Rubber 'O' Ring
1	each	Aluminum	Shaft Locking Plate
8	each	$\frac{1}{2}$ " - 13 UNC x 2.50 lg.	bolts
8	each	$\frac{1}{2}$ " - 13 UNC x 3.00 lg.	bolts

* E.B. Wiggins Oil Tool Co. Inc. Part No. 4101F175

APPENDIX D

The following Test Record Sheets describe the test in detail that is summarized in this report:

<u>TEST RECORD</u>	<u>DATE</u>
K1706775	6-26-64
K1706776	6-26-64
K1706777	6-29-64
K1706778	6-29-64
K1706779	6-29-64
K1706780	7-1-64

List of Test Record Sheets