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LMFBR LARGE VALVE DEVELOPMENT

TASK II - IHTS ISOLATION VALVE INTERNALS
WATER TEST
INTERIM REPORT

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AMCO Report No. 1839-01(02)ER

* January 1975

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Appendix B	Water Test Plan and Procedure
AMCO Report 1773-01(10)ER
Appendix C	Wyle Labs Water Flow Test Procedure
Procedure No. 3543
Appendix D	Wyle Water Flow Test Report
Report No. 54039, Revision A
Appendix E	Typical Sodium Valve Design Requirements

I. SUMMARY

The purpose of this program was to perform proof-of-principle (POP) testing in water of a reduced bore rotating offset ball valve as required by AEC Contract No. AT(04-3)-1035. The water POP test article is shown on AMCO Drawing 16-E-4020, Sheets 1 through 4, dated 3-18-74. (See Appendix A for Sheet 1). This report presents the water flow test results and the leakage results for one of the three seal designs.

The results of the testing indicate the following:

- o The K-factor for the fully open valve is 0.70 based on a 12-inch schedule 30 line size and is essentially independent of flow direction. Prior calculations predicted a K-factor approximately 15 percent less than determined experimentally.
- o The flow induced torque of the valve was 58 inch-pounds per psi of pressure differential across the valve in the reverse flow direction. This occurred with the ball in the 80° open position. Predicted torque values were 4 percent greater than shown by testing.
- o In the forward flow direction, maximum torque was 43 inch-pounds per psi of pressure differential across the valve, occurring at the 70° open ball position. This was 25 percent less than predicted.
- o Shut-off seal leakage between the stellite (Stellite 6) ball and 304 Cres lip seal was greater than the target goal of 0.42 cc per min at 225 psi differential (page 5 of Appendix B). As part of this test program, further testing is planned to evaluate leakage using Inconel 718 seals for both the heat-treated and the annealed versions.
- o Seal flutter under flowing conditions was not a problem with the valve in the full open position with flow in either direction. The seal strain gage system failed early in the testing, precluding data acquisition during partially open testing.
- o No ball flutter was observed during the test.

II. INTRODUCTION

The purpose of this report is to document the water flow testing results and the initial seal leak test results of the water POP testing specified under Task II, Subtask A of the LMFBR Large Valve Development Program.

A flow test was conducted on the AMCO 12-inch offset rotating ball valve to evaluate its conformance with design requirements specified in Reference 1.* Leakage testing was performed at AMCO facilities. Flow testing was conducted at Wyle Laboratories in Norco, California, during the dates of 13 through 22 November 1974. A photograph of the valve installed in the test loop is shown in Figure 1.

The POP test article is shown in Appendix A. The primary objectives of the water POP testing were to:

- o Determine the test article flow resistance pressure drop coefficient (K) in both directions in various ball positions.
- o Determine the magnitude of the flow forces acting on the ball in both directions in various ball positions.
- o Evaluate the leakage and general performance characteristics of three metal lip seal material couples.
- o Evaluate ball and seal flutter under flow conditions.

The final POP test report will contain complete test results including scaling methods for evaluating the 'K' and flow torque for larger valve sizes.

The need for this testing was to verify the analysis methods used in predicting performance of the rotating offset ball valve concept. Three major areas of uncertainty required substantive information.

- o The effect of the relatively large unsealed gaps in the flow stream between the ball and the valve body.
- o Evaluation of the torques due to the flow forces on the valve operating shaft. Results of a literature search (Reference 2) indicated that the ball and butterfly valve flow forces were similar; however, no actual ball valve design data was in evidence.

*Note: References are listed on Page 25.

The 12-inch Offset Ball Valve Installed
in the Water Flow Test Facility

Figure 1

- Leakage test data obtained to date was not sufficiently complete to verify the leakage calculation due to undesirable scratching on the 304 Cres lip seal and stellited ball. Additionally, more complete leakage testing was temporarily deferred in lieu of the more important water flow tests.
- Only an actual test could establish if seal or ball flutter occurred.

III. METHOD OF ANALYSIS

A. Flow Characteristics

1. C_V (Valve Coefficient)

The C_V of the valve was found by the equation (Reference 3):

$$C_V = q / \sqrt{\frac{\Delta P}{G_f}} \quad (1)$$

where

q = Flow Rate, (gallons/minute)

ΔP = Pressure Differential Across Valve (psi)

G_f = Specific Gravity of Fluid Relative to Water
at 60°F.

2. K (Valve Resistance Coefficient)

The K of the valve was found by the equation (Reference 4):

$$K = \frac{891 d^4}{C_V^2} \quad (2)$$

where

d = Inside Diameter of Pipe (inches)

C_V = Valve Coefficient Defined Previously

3. Cavitation - The cavitation index (K_C) of a valve is defined by the following equation (Reference 2):

$$K_C = \frac{\Delta P}{P_1 - P_V} \quad (3)$$

where:

ΔP = Pressure Differential Across Valve at which
Cavitation First Occurs (psi)

P_1 = Valve Inlet Pressure (psia)

P_V = Vapor Pressure of Fluid Flowing Through Valve (psia)

B. Force Characteristics

1. Flow Torque

Several documents (References 2, 5) have established that flow torque on a partially open ball-type valve is proportional to the pressure drop across the valve. Thus, the data is reported as torque per unit of valve pressure drop.

Torque is indicated by strain gages attached to the ball trunnion shaft as shown on Figures 2 and 3. Prior to the test, the strain gages were calibrated to establish the relationship between the shaft torque and the strain gage output. Six strain gages were attached to the shaft to provide redundancy.

Since the strain gages were above the trunnion bearings, the torque measured at the strain gages was increased by the amount of friction in the bearings in order to determine the actual fluid dynamic torque. A rule-of-thumb equation for the trunnion bearing torque is given by Reference 2 as:

$$T_B = 1.75 \times 10^{-3} \Delta P^{3/2} d^3 \mu \quad (4)$$

where

T_B = Bearing Friction torque (in-lb)

ΔP = Pressure Differential Across the Ball (psi)

d = Seal Diameter (inches)

μ = Bearing Friction Coefficient, Dimensionless

The Torque Strain Gages Installed on the
Stem and the Lip Seal of the 12-inch Offset
Ball Valve Before Assembly

Figure 3

The Torque Strain Gages Installed on the
Stem of the 12-inch Offset Ball Valve

Figure 2

2. Seal Flutter

Seal flutter was evaluated by attaching six strain gages radially around the seal (Figure 2). The seal stress analysis computer model (Reference 6) was used to locate the strain gages at the most highly stressed point. The purpose of this test was to evaluate flutter and not the steady state seal deflection caused by the steady state flow pressure differentials.

Based on material allowables (Reference 7), it was determined that seal flutter which produced a strain less than 1×10^{-4} inches per inch would be well below the fatigue limit of the lip seal.

IV. METHOD OF TESTING

The water test plan and procedure for conducting the entire water POP test is shown in AMCO Report 1773-01(10)ER and is included in Appendix B of this report. The detailed water flow test procedure prepared and used by Wyle Laboratories (Procedure No. 3543) is included as Appendix C.

V. RESULTS AND DISCUSSION

A. Water Flow Test Results

1. Inspection

a. Disassembly of the valve after the water testing revealed all the test hardware was in excellent condition except for the scratches noted in Paragraph A.1.c. The metal lip seal and ball had no structural damage which could be attributed to the flow testing.

b. Close inspection of the seal strain gages revealed that the water proofing material had failed to properly adhere to the lip seal, thus allowing water to contact the gages. (Figure 4). The strain gages themselves appeared to have remained bonded to the lip seal. The water proofing of the shaft strain gages appeared to be intact.

c. Inspection of the ball and seal revealed that the Stellite 6 ball and 304 Cres lip seal sealing areas had been scratched by repeated cycling of the valve. The test article had been operated approximately 30 cycles during the test program. The valve ball for this testing was assembled with an uncoated 304 Cres lip seal. Uncoated 304 Cres will not be used as the seal material in the prototype valve; however, its physical properties were acceptable for evaluation in the flow test. (The present seal candidate materials are annealed Inconel 718 and heat-treated Inconel 718). Since the 304 Cres seal and the candidate seal are of the same configuration and possess the same spring rate, it was decided not to risk

Failure of the Strain Gage Water Proofing
on the Lip Seal. Post-Water Flow Test
Inspection of the 12-inch Offset Ball Valve

Figure 4

using the Inconel 718 seals for flow testing. Strength and resonance characteristics could be readily and adequately evaluated with the 304 Cres seal. Close examination of the scratched seal area indicated a varying degree of damage, with the more pronounced scratches occurring on the upper half of the seal and little wear on the lower half. (Figure 5). This would lead to the conclusion that the ball did not bear uniformly on the lip seal surface.

The largest scratch on the ball was approximately .001 inches deep. Prior to the final ball grinding operation, the Stellite 6 hardness was found to be R_C 43 minimum. The source of the scratches on the ball is a matter of conjecture.

There was little, if any, evidence of galling between the Stellite 6 ball seal area and the uncoated 304 Cres seal.

2. Fluid Pressure Results

a. In the fully open position, the valve resistance coefficient ('K'-factor) was found to be 0.70 in the forward direction with a standard deviation of .05; and 0.69 with a standard deviation of .02 in the reverse direction. Thus, the fully open valve K -factor is independent of flow direction. The value of the K -factor had originally been calculated as 0.61 (Reference 6).

b. A plot of the K-factor versus valve ball position is given in Figure 6, for both forward and reverse flow directions. As shown in the graph, the effective K-factor for the valve is slightly lower in the reverse flow direction but closely follows the pattern of the forward flow direction.

c. A plot of C_V versus valve ball position is given in Figure 7 for both forward and reverse flow directions. Naturally, the two curves are very similar which would be expected from the K-factor versus position graph and equation (2) of Section III.

Calculation of the valve pressure drop for fluids other than water may be done using equation (1) given in Paragraph III of this report and the C_v versus valve position plot given in Figure 7. For example, using the sodium flow parameters given in Appendix E:

Sodium Flow Rate $q = 3.026 \times 10^6$ lbs/hr at 965°F
or 7294 gallons/minute

Sodium Specific Gravity $G_f = .83$

Equation from Paragraph III.A.1

$$C_V = q / \sqrt{\frac{\Delta P}{G_f}} \quad (1)$$

Schematic Representation of the Marking
on the Cres 304 Lip Seal Area
After the Water Flow Testing

Figure 5

BALL POSITION (DEGREES OPEN)
Valve Resistance Coefficient (K-Factor)
versus Valve Position for the
12-inch Water POP Test Valve

Figure 6

Flow Coefficient (C_v) versus Valve Position
for the 12-inch Valve

Figure 7

where

C_v = Valve Coefficient, (Figure 7)

ΔP = Pressure differential across valve (psi)

G_f = Specific Gravity of Fluid Relative to
Water at 60°F

q = Flow Rate in Gallons/Minute

Rearranging equation (1) and substituting the above values, the fully open valve pressure drop when flowing sodium would be

$$\Delta P = \left(\frac{q}{C_v} \right)^2 G_f$$

$$\Delta P = \left(\frac{7294}{5250} \right)^2 (.83) = 1.6 \text{ psi}$$

d. Cavitation evidence in the fully open condition was exhibited only in the reverse flow mode at flow rates greater than the design flow rate. A plot of flow rate versus $\sqrt{\Delta P}$ (Figure 8) for the reverse flow fully open condition was used to determine the cavitation threshold. The approximate cavitation threshold occurs at the point where the slope changes. (Approximately 11,400 gpm on plot). A test using constant inlet pressure versus flow was not conducted. This would have given more exact information with which to calculate the cavitation index K_C [equation (3), Section III]. Equation (3) repeated below is

$$K_C = \frac{\Delta P}{P_1 - P_v} \quad \text{where}$$

ΔP = Pressure Differential Across
Valve, psi

P_1 = Valve Inlet Pressure, psia

P_v = Vapor Pressure of Fluid at
Flowing Temperature, psia

An approximate value of K_C was calculated based on Run 5 of Test 11 (Appendix D) which was the test which most closely approximated the 11,400 gpm flow rate at the slope change. The data for the calculation are as follows:

$$\Delta P = 5 \text{ psi}$$

$$P_1 = 39.7 \text{ psia}$$

$$P_v = .36 \text{ psia at } 70^\circ\text{F (water, Ref. 3)}$$

Valve Pressure Drop versus Flow Rate
for the 12-inch Water POP Test Valve -
Reverse Flow, Fully Open

Figure 8

therefore

$$K_c = \frac{5}{39.7 - .36} = .13$$

The value of K_c can be used to evaluate the tendency of a valve to cavitate. For example, using the sodium valve design data contained in Appendix E

$$\begin{aligned} K_c &= .13 \text{ (from above)} \\ P_v &= .105 \text{ psia} \\ P_1 &= 132 \text{ psig (147 psia)} \end{aligned}$$

thus ΔP to cause cavitation is from equation (3)

$$\Delta P = .13 (147 - .1) = 19.1 \text{ psi}$$

Therefore, as long as the flow rate through the valve does not cause a valve pressure drop approaching 19 psi, the valve would not be expected to cavitate.

A similar analysis was performed using fully open forward flow test data which did not exhibit any cavitation tendencies. The lack of cavitation was verified. Basically, the upstream pressure (P_1) was high enough to prevent cavitation in the forward flow tests.

d. Body cavity pressures were recorded during the flow tests. Data is shown in Appendix D. The pressures in the seal cavity area were also recorded and are likewise presented in Appendix D.

3. Fluid Forces

a. The use of strain gages in a water environment is always entails uncertainties (Reference 8). During testing, the water proofing of all six of the seal strain gages failed, causing the gages to become ineffective. A review of the torque strain gage verification test results indicates that four of the six strain gages were affected to some extent by the water. The strain gage verification test consisted of torquing the valve shaft into the stops prior to the first run and after the last run of the day while recording the shaft strain gage output. Any change in the ratio of strain gage readings could be noted.

After the flow testing, the shaft strain gages were soaked overnight in water at AMCO and recalibrated. The pre- and post-test calibration curves are given on Figure 9. As can be seen, only strain gage f_{10} calibration was relatively unchanged.

Pre- and Post-Water Flow Test Calibration Curves for the
Shaft Strain Gages - Torque Strain Gage Output

Figure 9

b. Seal strain gages - Seal strain gages were installed to determine if the seal fluttered during the fully open flow. This seal flutter would fatigue the seal and possibly cause premature failure. No significant seal flutter was recorded in the fully open position during either of the forward or reverse flow direction tests. The seal was found to deflect under pressure loads, but there was no significant flutter. Flutter was defined as strain greater than $\pm 100 \times 10^{-6}$ inches per inch. All strain gages failed during the first partially open test so data on seal flutter during partially open testing is not available. However, the valve is not intended for use with long-term operation in the partially open position; therefore, material fatigue in the partially open position is not a problem. Steady state loads on the seal were not sufficiently high to structurally damage the annealed 304 Cres seal during the water test as noted in post-test inspection. The final design will utilize other materials of equal or greater strength. Therefore, failures due to flow forces are not anticipated.

c. Shaft strain gages - Shaft strain gages were installed to permit measurement of flow forces acting on the ball. Because of the strain gage location (Figure 2), trunnion bearing friction reduces the recorded strain gage readings. The torque recorded by the strain gages during the test is plotted in Figure 10. Bearing friction has not been subtracted. Two things should be noted, (1) a secondary lower peak torque was recorded, and (2) one set of data (70° reverse flow) gave very low torques. A review of the data indicates that this is valid.

Figure 11 depicts the estimated fluid dynamic torque on the valve offset ball after addition of bearing torque using Equation 4, Section III.A. As shown in Figure 11, bearing friction makes only a minor contribution to the torque to overcome the flow forces.

No ball flutter was noted on the shaft strain gages, at least one of which was operable throughout the test program.

B. Leakage Testing

1. Three lip seals were to be investigated as part of the program.

- o An Uncoated 304 Cres Lip Seal
- o An Uncoated Annealed Inconel 718 Lip Seal
- o An Uncoated Aged and Hardened Inconel 718 Lip Seal

Only the uncoated 304 Cres seal has been evaluated to date.

2. In all cases, the leakage with the 304 Cres seal was found to be greater than the target goal (see Page 5 of Appendix B). In fact, the leakage may be better described as orifice or channel flow through a gap rather than the desired laminar flow. The majority of the leakage flows yielded a Reynolds number greater than 2.6×10^4 .

As Recorded Fluid Dynamic Torque versus Valve Position
for the 12-inch Water POP Test Valve

Figure 10

NOTES:

1. Positive torque tends to close valve.

2. Bearing friction calculated from following equations
 $T_B = 1.75 \times 10^3 \Delta P^{1.5} d^3 \mu$

ΔP = Pressure drop across valve, psi
 d = Seal diameter, inch

μ = Coefficient of friction

T_B = Bearing friction, inch lbs

3. Equation from fluid component design handbook EQ6.2.3.2a

μ Assumed as 0.5

ΔP Acting across valve was assumed to be acting across ball

Forward Flow (Corrected for bearing friction)

Forward Flow (Test Data)

Fluid Dynamic Torque Corrected for Bearing Friction
versus Valve Position for the 12-inch Water POP Test Valve

Figure 11

3. Microscopic examination of the sealing surfaces revealed that both the ball and lip seal had been scratched during the program. The largest scratch was measured to be approximately .001-inches deep. In addition, the seal was not uniformly seated on the ball in the closed position. This conclusion was based on the heavy scratching of the lip seal in some locations and the absence of scratches in other areas. The scratches caused by valve closure are perpendicular to the polishing marks on the ball and seal.

A combination of the undesirable seating and the damage to the 4C AA surface finish is the most likely cause of the high leakage.

4. Prior to the initiation of the leak check testing, the spring rate of the Cres 304 lip seal was determined. In order to accurately determine the spring rate, the seal was installed in the valve subhousing so it would be properly restrained. The offset ball was placed against the seal and the seal was loaded through the ball. Both the ball and seal were polished to a 4C AA finish prior to the test. The seal spring rate was determined to be 75,500 pounds per inch of seal deflection. Figure 12 is a plot of the load-deflection data.

5. Two basic leakage tests were performed:

- Leakage versus Seal Pre-load
- Reverse Flow Leakage

Leakage testing was performed as follows:

The seal was placed against the ball and shimmed. The seal area was filled with water and pressurized. As the water leaked through the seal, it was collected in a graduated cylinder. The amount of leakage was timed. The part was then disassembled and shims were removed in a pre-determined pattern in order to permit the seal to be increasingly deflected. The final deflection was 0.018-inches. Based on the spring rate, the seal load was 1360 pounds. The leakage at each seal deflection is given in Figure 13. The data is scattered because of the conditions described in Paragraph A.1.c of Section V, and above.

Figure 14 depicts the leakage before and after the water flow testing. Large changes in leakage were not noted.

A comparison of actual versus calculated leakage is given on Figure 15. This figure shows the effect of leakage due to the change in the surface finish. Leakage data was not used above a pressure differential of 50 psi. The seal load is increased by the unbalanced pressure forces acting on the seal area. Below 50 psi, the unbalanced forces due to pressure were considered negligible. Because of the complicated geometry of the lip seal, a detailed computer model (Reference 6) is required to determine this pressure load. This additional effort is not warranted at the present time since AMCO plans to evaluate other seal materials.

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Load-Deflection Data for the Cres 304 Metal Lip Seal
in the 12-inch Water POP Test Valve Subhousing

Figure 12

Water Leakage versus Seal Preload Deflection
for Cres 304 Seal in the 12-inch Water POP Test Valve

Figure 13

Water Leakage Before and After the Water Flow Testing -
12-inch Water POP Test Valve, Cres 304 Seal

Figure 14

Comparison of Calculated and Actual Water Leakage
for the 12-inch Offset Ball Valve for A Cres 304
Seal Preload Deflection of 0.018 inches

Figure 16 shows leakage in the reverse direction for a 0.018-inch seal deflection. Pressure differential across the seal in this direction tends to lift the seal from the ball. The seal load is decreased as the pressure differential increases until, at a pressure differential of approximately 150 psi, the pressure lifts the seal and major leakage occurs.

VI. CONCLUSIONS AND RECOMMENDATIONS

The 12-inch offset ball valve has successfully completed the water flow testing as required by Reference 1. Actual flow data for pressure drop and flow torque were in reasonable agreement with previous calculated values. The flow test data can be meaningfully used for conversion to sodium parameters and for scaling of the designs to larger or smaller rotating offset ball valve designs.

There was no indication of either ball or seal flutter during the testing with flow rates to 12,000 gallons per minute which is greater than the design flow rate of 8800 gallons per minute.

The elevated pressure leakage with one of the three candidate seal materials (uncoated 304 Cres) did not achieve the desired design goals due to a combination of undesirable lip seal to ball contact condition and seal scratching which increased the surface roughness.

It is recommended that the test program be continued to evaluate the leakage and wear characteristics of the Inconel 718 seals.

It is also recommended that an evaluation be made of the lip seal marking pattern to see what design changes can be effected to assure a more uniform contact pattern.

Water Leakage in the Reverse Flow Direction
versus Pressure Differential Across the Seal - 12-inch
Water POP Test Valve, Cres 304 Seal

Figure 16

VII. REFERENCES

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4. "Flow of Fluids," Crane Co., Technical Paper 410 (10th Printing 1969).
5. Dushkes, S. M., "Characteristic Coefficients of Butterfly Valves, ASME Article 46-A-39.
6. AMCO Report No. 1773-01(09)ER, "LMFBR Large Valve Development Task II-IHTS Isolation Valve Internals Summary Report," dated June 1974.
7. ASME Code Case 1592, Figure T 1420-1A, 1B, dated 29 April 1974.
8. AMCO Report No. 8705-01(01)ER dated 9/5/73, "LMFBR Components Director for Sodium Valves, Intermediate Heat Exchangers and Steam Generators. (Materials & Designs)," Reference No. D-1501 General Electric Co., Ltd., (United Kingdom).

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APPENDIX A

AMCO DRAWING 16-E-4020, SHEET 1

GENERAL NOTES:

1. TEST MEDIA: WATER
2. PRESSURE:
 - A. OPERATING PRESSURE 0-132 PSIG
 - B. PROOF PRESSURE VALVE OPEN 204 PSIG
 - C. VALVE CLOSED 340 PSIG
3. DESIGN FLOW RATE 8800 GAL/MIN
4. PRESSURE DROP 2.5 PSI AT DESIGN FLOW (CALCULATED)
5. OPERATING TEMPERATURE AMBIENT
6. ALLOWABLE LEAKAGE: MAXIMUM INTERNAL AT 225 PSI WATER 25 CC/MIN (1.42 CC/MIN)
7. ESTIMATED WEIGHT 3000 POUNDS
8. POP TEST OBJECTIVES:
 - A. INTERNAL LEAK TEST-MEASURE LEAKAGE VERSUS ΔP
 - B. MEASURE FLOW VERSUS ΔP FOR VARIOUS VALVE POSITIONS
 - C. MEASURE FLOW TORQUE VERSUS VALVE POSITION
 - D. MEASURE FLOW TORQUE VERSUS FLOW AT VARIOUS VALVE POSITIONS
9. CALCULATE ΔP VERSUS WATER FLOW AT FULL OPEN POSITION

10. CLEANLINESS PER AMCO CP 5014, LEVEL H.

12.00 DIA 2 PLACES

TO BE USED FOR LIP SEAL LEAK TEST

COVER 16-E-4036
O-RING 2-460
BOLT 1/2-20 UNF-3A x 1.87 LG (16 REQD) CARBON STEEL
WASHER 562 I.D. (16 REQD) CARBON STEEL

3/8" AN DOWN

24.66 REF (OVERALL HEIGHT)

48.80 REF (OVERALL LENGTH)

COVER 16-E-4037
O-RING 2-460
BOLT 1/2-20 UNF-3A x 5.74 LG (16 REQD) CARBON STEEL
WASHER 1/4 I.D. (16 REQD) CARBON STEEL
NUT 1/2-20 UNF-3B (16 REQD) CARBON STEEL

TO BE USED FOR HYDROTEST

		PIN	CARBON STEEL 3/16" x 3/16" DIA. x 3.25 LG	24	
1	1	16-E-4025-2	LIP SEAL	INCONEL 718	34
	1	16-E-4034	SLEEVE	CDCS 304	32
1	1	16-D-4033	SHIM	CDCS 302	31
2	2		WASHER	1.12 I.D. CARBON STEEL	30
2	2		STUD	1.00-12 UNF-3A x 5.74 CARBON STEEL	29
2	2		NUT	1.00-12 UNF-3B CARBON STEEL	28
1	1	589-042-023	GRIPTRIED	GOODYEAR	27
16	16		WASHER	.406 I.D. CDCS	26
4	4	30657 T2A-4052	RACE	TOORINGTON	25
2	2	30657 NTA-4052	BEARING	TOORINGTON	24
1	1	16-E-4035	COUPLING		23
8	8		BOLT	3/8-24 UNF-3A x 1.75 LG SA-193 CD 87	22
8	8		BOLT	3/8-24 UNF-3A x 1.75 LG SA-193 CD 87	21
2	2	16-D-4032	KEY	CARBON STEEL	20
16	16		WASHER	1.25 I.D. CARBON STEEL	19
10	10		WASHER	.562 I.D. CARBON STEEL	18
16	16		BOLT	1/2-20 UNF-3A x 5.0 LG SA-193 CD 87	17
10	10		BOLT	1/2-20 UNF-3A x 3.18 LG SA-193 CD 87	16
1	1	16-E-4031	SHAFT		15
1	1	30781 2-460	O-RING		14
1	1	30781 2-380	O-RING		13
10	10	30781 2-20	O-RING		12
1	1	30781	O-RING	1/4 I.D. 303	11
1	1	16-E-4030	LOCK PLATE	ASTM A-36, 285C, 285C OR 515	10
1	1	16-E-4029	OUTER HSG	ASTM A-36, 285C, 285C OR 515	9
1	1	16-E-4028	COVER	ASTM A-36, 285C, 285C OR 515	8
1	1	16-E-4027	SLEEVE	CDCS 302	7
1	1	16-D-4026	SHIM	CDCS 302	6
1	1	16-E-4025	LOCKNUT	CDCS 304	5
1	1	16-E-4024	RETAINER	CDCS 304	4
1	1	16-E-4023-1	LIP SEAL	INCONEL 718	3
1	1	16-E-4022	SUB HSG	CDCS 304	2
1	1	16-E-4021	BALL ASSY	CDCS 304	1

VALVE

12" OFFSET BALL, TASK II

WATER POP TEST

16-E-4020

12564

16-E-4020

APPENDIX B

WATER TEST PLAN AND PROCEDURE

12-INCH OFFSET BALL ISOLATION VALVE INTERNALS

AMCO Report No. 1773-01(10)ER, June 1974

WATER TEST PLAN AND PROCEDURE

12 INCH OFFSET BALL ISOLATION VALVE INTERNALS

AMCO Report No. 1773-01(10)ER June 1974

Revision 1 10 October 1974

APPROVED BY:

J. E. DeKlotz
Supervisor
Design Development

CONTRIBUTORS:

R. J. Glumace
L. E. DeWall
V. A. Smith

REVISION SHEET

<u>Revision</u>	<u>Description</u>	<u>Approved</u>	<u>Date</u>
1	<p>Revises and clarifies water flow test (paragraph 8.0) as follows:</p> <ol style="list-style-type: none">1. Revised flow test schematic (Figure 2) to identify it as schematic for fully open testing and reduced number of continuously recorded instruments from 22 to 14.2. Added Figure 2.1 for partially open testing.3. Revised paragraph 8 and flow test data sheet to reflect items 1 and 2.4. Identified the strain gage information which AMCO would supply (para. 8.1.3).5. This revision complies with the agreements and commitments of the Wyle/AMCO meeting at Norco, CA on 7 October 1974.	<p>LEO J. V. Kelly</p>	10-11-74

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1.0 SUMMARY

This document presents the Proof-of-Principle (POP) Test Plan and Test Procedures for water testing a test article incorporating an internal mechanism for a 12.0 inch offset ball valve.

The test article configuration simulates the internal configuration of a proposed LMFBR demonstration plant intermediate loop isolation valve.

The test program will evaluate seal leakage, seal wear, pressure drop parameters and fluid flow force effects on the test article internals. The hydrostatic pressure test will demonstrate the structural adequacy of the test article containment housing.

2.0 INTRODUCTION

The purpose of this document is to serve as a basis for detailed water POP test planning under Task II, Subtask A, of the LMFBR Large Valve Development Program.

The POP test program, the test facility requirements and test instrumentation are described.

The POP test article is shown in Appendix A - the primary objective of the planned testing will be to evaluate the following parameters:

- Test article pressure drop
- The magnitude of liquid flow forces acting on the ball
- The leakage and general performance characteristics of the metal lip seal

A secondary objective of the planned testing will be to evaluate the following parameters:

- Ball and seal flutter under flow conditions

For maximum benefit to the national LMFBR Large Valve Development Program it is necessary to produce realistic test data for scale model components that may be utilized in predicting the performance of smaller or larger components of the same general design. Therefore this POP test plan must contain sufficient water testing to produce data on the internal mechanism that may apply to any size of offset ball valve using a lip seal configuration. This data can be used to:

- Size reduced bore ball valves
- Size shafting (trunnions), operators and shaft bearing neck design
- Predict leakage and torque/seal load requirements
- Predict dynamic ball and lip seal characteristics

In order to accomplish these goals this POP test plan will direct the measurement of certain parameters in order to obtain the following data:

- Pressure drop through the test article at various water flow rates from approximately 1,000 gpm to 10,000 gpm with flow in both directions. From this data, the K factor of the test

article can be determined. K is defined as:

$$K = \frac{9273.6 \Delta P}{v^2 \rho}$$

ρ = weight density of the fluid in the upstream pipe,
pounds per cubic foot

V = average velocity of the fluid in the upstream pipe,
feet per second

ΔP = pressure loss across the valve, pounds per square inch

The K of any size of similar in-line flow passage may then be determined by using standard techniques.

- Flow torques acting on the ball in various closed positions, various flow rates and with flow in both directions. This data can then be used to correct the mathematical model for the specific offset ball geometry. The corrected mathematical model can then be applied to any size ball geometry.
- The lip seal leakage and sealing torques/loads with pressure applied in the forward flow direction. This data can then be used to refine the mathematical model for seal leakage versus seal load. The model can then be used to more accurately predict the internal leakage of any size lip seal. Lip seal to ball material couples can also be evaluated.
- Ball and seal flutter characteristics with the ball in the open position under various flow rates. This data can then be used with analytical techniques to predict flutter characteristics if any, for scaling ball and seal sizes.

3.0 DESCRIPTION OF THE TEST ARTICLE

The test article is shown in Appendix A (AMCO Drawing 16-E-4020, Sheet 2).

The dry weight of the test article is estimated at 3,000 pounds.

The test article is designed for flow in both directions.

The two in-line ports incorporate flanges per USAS B16.5 (size 12.0 inch, Schedule 40, Class 300 pounds with welding neck type).

4.0 RATED PERFORMANCE OF THE TEST ARTICLE

4.1 Test Media: Water

4.2 Pressure:

a. Operating pressure 0-132 psig

b. Proof pressure:

Test article open

264 psig

Test article closed

340 psig (upstream side)

4.3 Design Flow Rate: 7,392 gpm

4.4 Pressure Drop: 1.81 psi at design flow (calculated)

4.5 Operating temperature: Ambient

4.6 Allowable Lip Seal Leakage

Maximum Internal @225 psi water
25 cc/hr (0.42 cc/min)

5.0 RESPONSIBILITY FOR AND SEQUENCE OF TESTS

- 5.1 All tests are to be witnessed by a cognizant AMCO engineer. The cognizant engineer shall be notified 48 hours prior to start of testing.
- 5.2 The torque, lip seal leakage and hydrostatic proof pressure tests of paragraph 7.0 will be performed in the AMCO hydrostatic laboratory. These tests will be performed prior to the water flow tests.
- 5.3 The water flow tests of paragraph 8.0 will be performed by a selected outside laboratory. The unit shall be returned to AMCO for inspection immediately after the flow tests are completed.

6.0 REPORTING REQUIREMENTS

- 6.1 The AMCO Engineering Department (Engineering Research) will prepare the final test report. The outside laboratory will furnish photographs of the test unit installed in the test facility, photographs of the test facility and calibration and analogue test data for the water flow tests of paragraph 8.0 and as specified in paragraph 8.2.2.

7.0 TORQUE, LIP SEAL LEAKAGE, AND HYDROSTATIC PROOF PRESSURE TEST

7.1 Test Set-up

7.1.1 The test article is to be set up in the hydro bay at AMCO with the appropriate gages and hand valves as shown in the hydrotest schematic, Figure 1.

7.1.2 Clean, corrosion inhibited water shall be used for these tests such as a sodium chromate or sodium phosphate solution.

Record Type Water Being Used(_____)

7.2 Torque Test

7.2.1 Prior to filling with water, torque test article from open to closed position with zero pressure applied. Measure and record the running and maximum closing torque

(Running _____ in/lb)

(Closing _____ in/lb)

7.2.2 Open test article and record opening (unseating) torque:

(Opening Torque _____ in/lb)

7.3 Hydrostatic Proof, Leakage and Torque Test

7.3.1 With the valve in the open position fill valve with water through the inlet port and bleed all air from within the test article body.

7.3.2 Proof test article body with ball in the open position.

7.3.2.1 Pressurize from the inlet port of the test article internal cavity to 264^{+10}_{-0} psig and hold pressure for five minutes. There shall be no visual evidence of damage or external leakage. The pressure is to be applied at a rise rate not to exceed (100 psi/minute).

HYDROTEST SCHEMATIC

FIG. 1

- 7.3.2.2 With the pressure still applied (264 psi) actuate the test article closed and lock into position.
- 7.3.2.3 With the test article in the closed position and pressurized at 264 psig, bleed the outlet port gradually to zero psig.
-
- 7.3.2.4 With the test article in the closed position gradually increase the inlet pressure (at a rate of 100 psig per minute) to 340^{+10}_{-0} psig and hold for five minutes.
- There shall be no visual evidence of damage or external leakage.
- 7.3.2.5 Lipseal-Leakage - with the test article remaining in the closed position decrease the inlet pressure to 225 psig and the outlet port at zero psig, measure and record the lipseal leakage (_____ cc/min).
- 7.3.2.6 Repeat 7.4.2.5 at 200, 175, 150, 125, 100, 75, 50, 25 and 10 psig.

-
- 7.3.2.7 Breakaway Torque - with the ball in the closed position pressurize the upstream side in the following pressure increments, starting from 225 psig to zero. Measure breakaway torque for each pressure increment.

Pressure
225
175
125
75
25
10
0

Breakaway Torque

- 7.3.2.8 Reduce pressure to zero and drain the test article.

7.4 Torque Test

7.4.1 Actuate the test article to the open position and measure the torque (_____ in/lb). Lock the valve in the open position.

7.5 Preparation for Delivery

7.5.1 Remove the test article end covers and visually inspect the internal working mechanism - not the general condition of the internal parts.

7.5.2 Deyhydrate at 212°F for eight (8) hours.

7.5.3 Package test article and ship to the selected water flow test laboratory per AMCO instructions.

8.0 WATER FLOW TESTS

8.1 Requirements

8.1.1 The test article is to be installed in a high flow test facility similar to that shown in Figures 2 and 2.1.

8.1.2 The test article will be supplied by AMCO with the strain gages installed on the seal and shaft stem to measure strain and frequency and shaft strain due to flow forces. Tests are to be performed first in the fully open position (Fig. 2) with flow from outlet to inlet and then in the fully open position with flow from inlet to outlet. The remaining tests with the ball locked in the intermediate positions are to be performed after completion of the fully open tests (Figure 2.1). For each of the positions it is desirable to obtain flow rates and pressure as high as possible. AMCO recognizes that some laboratories utilize blow down facilities. Therefore a typical chart for varying flows could be as shown in Figure 3.

8.1.3 The flow test schematics, Figures 2 and 2.1, locate and identify the instrumentation and parameters to be measured during each test run using continuous recording equipment.

Strain gages are installed by AMCO; f_1 through f_6 on the flexible lip seal and f_7 through f_{10} on the ball trunnion shaft. Strain gage information [strain gage F factor (gage factor) and anticipated strain] will be supplied by AMCO.

8.1.4 The instruments to measure the parameters shown in paragraph 8.1.3 shall have an accuracy of $\pm 2\%$.

8.1.5 Pre and post test calibration of all parameters measured shall be recorded on the same chart as the test records. The calibrations shall be conducted immediately before and after the test runs.

8.1.6 Test witness - The cognizant AMCO engineer shall be notified 48 hours prior to any test.

8.1.7 The test article shall be visually examined for damage due to shipping or handling prior to being installed into the flow system. The AMCO cognizant engineer shall be witness to this inspection.

8.1.8 As a goal cleanliness of the test article to be maintained per AMCO CP-5014, Level H, during testing.

(FULLY OPEN TESTS)

FIG. 2

[illegible]

TYPICAL RUN USING A BLOWDOWN TEST FACILITY

FIG. 3

- 8.1.9 There shall be a sufficient length of straight pipe ahead of the test article being tested to secure a reasonably uniform velocity profile in the approaching stream. Reference 1 shall be used as a guide and the test article being tested shall be installed under the same restrictions given for the location of flow nozzles and orifice plates in Reference 1. To insure a reliable pressure measurement, there shall be a length of straight pipe equal to, or longer than, one pipe diameter downstream from the downstream pressure tap.
- 8.1.10 Pressure taps shall conform in size and configuration to that given in Reference 1 for pressure taps and orifice plate flow measurement.
- 8.1.11 Photographs shall be provided of the test article in the flow test facility. A sufficient number of photographs are to be provided to cover all views of the test valve and the instrumentation.

8.2 Flow Test Plan

- 8.2.1 A test plan is to be submitted to AMCO by the flow test facility for approval prior to testing.
- 8.2.2 The test plan must provide the data required as specified in the flow test data sheet shown in Table 1. The test data shall be provided in the test data sheet as well as the supporting run sheets (fully calibrated).
- 8.2.3 At the conclusion of the test the test article shall be delivered to AMCO with the supporting test data.

TABLE 1

Date _____

FLOW TEST DATA SHEET

Record Test ΔP in system without
valve in system

Test No.	Pos.	Run No.	W gpm	P ₁ psig	P ₂ psig	P ₃ psig	P ₄ psig	P ₅ psig	P ₆ psig	P ₇ psig	P ₈ psig	P ₉ psig	ΔP psi	f ₁ H _s	f ₂ H _s	f ₃ H _s	f ₄ H _s	f ₅ H _s	f ₆ H _s	f ₇ 10-6 in per in	f ₈ 10-6 in per in	f ₉ 10-6 in per in	f ₁₀ 10-6 in per in	T _f °F	Remarks
1	90° Full Open	1																							Reverse Flow direction
		2																							
		3																							
		4																							
		5																							
		6																							
2	90° Full Open	1																							Normal Flow direction
		2																							
		3																							
		4																							
		5																							
		6																							
3	90° From Closed	1																							Normal Flow direction
		2																							
		3																							
		4																							
		5																							
		6																							
4	70	1																							Normal Flow direction
		2																							
		3																							
		4																							
		5																							
		6																							
5	60	1																							Normal Flow direction
		2																							
		3																							
		4																							
		5																							
		6																							
6	50	1																							Normal Flow direction
		2																							
		3																							
		4																							
		5																							
		6																							
7	40	1																							Normal Flow direction
		2																							
		3																							
		4																							
		5																							
		6																							

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TABLE 1 (Cont'd.)

Date _____

FLOW TEST DATA SHEET

Record Tare ΔP in system without
valve in system

Test No.	Pos.	Run No.	W gpm	P ₁ psig	P ₂ psig	P ₃ psig	P ₄ psig	P ₅ psig	P ₆ psig	P ₇ psig	P ₈ psig	P ₉ psig	Δ P psi	f ₁ H ₂	f ₂ H ₂	f ₃ H ₂	f ₄ H ₂	f ₅ H ₂	f ₆ H ₂	f ₇ 10-6in per in	f ₈ 10-6in per in	f ₉ 10-6in per in	f ₁₀ 10-6in per in	T ₁ °F	Remarks	
8	30	1																								Normal Flow direction
		2																								
		3																								
		4																								
		5																								
		6																								
9	20	1																								Normal Flow direction
		2																								
		3																								
		4																								
		5																								
		6																								
10	15	1																								Normal Flow direction
		2																								
		3																								
		4																								
		5																								
		6																								
11	10	1																								Normal Flow direction
		2																								
		3																								
		4																								
		5																								
		6																								
12	5	1																								Normal Flow direction
		2																								
		3																								
		4																								
		5																								
		6																								
13	80	1																								Reverse Flow direction
		2																								
		3																								
		4																								
		5																								
		6																								
14	70	1																								Reverse Flow direction
		2																								
		3																								
		4																								
		5																								
		6																								

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TABLE 1 (Cont'd.)

Date _____

FLOW TEST DATA SHEET

Record Total ΔP in system without
valve in system

FLOW TEST DATA SHEET																										
valve in system																										
Test No.	Pos.	Run No.	W gpm	P ₁ psig	P ₂ psig	P ₃ psig	P ₄ psig	P ₅ psig	P ₆ psig	P ₇ psig	P ₈ psig	P ₉ psig	Δ P psi	f ₁ Hs	f ₂ Hs	f ₃ Hs	f ₄ Hs	f ₅ Hs	f ₆ Hs	f ₇ 10 ⁻⁶ in per in	f ₈ 10 ⁻⁶ in per in	f ₉ 10 ⁻⁶ in per in	f ₁₀ 10 ⁻⁶ in per in	T _i °F	Remarks	
15	60	1																								Reverse Flow direction
		2																								
		3																								
		4																								
		5																								
		6																								
16	50	1																								Reverse Flow direction
		2																								
		3																								
		4																								
		5																								
		6																								
17	40	1																								Reverse Flow direction
		2																								
		3																								
		4																								
		5																								
		6																								
18	30	1																								Reverse Flow direction
		2																								
		3																								
		4																								
		5																								
		6																								
19	20	1																								Reverse Flow direction
		2																								
		3																								
		4																								
		5																								
		6																								
20	15	1																								Reverse Flow direction
		2																								
		3																								
		4																								
		5																								
		6																								
21	10	1																								Reverse Flow direction
		2																								
		3																								
		4																								
		5																								
		6																								

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Date _____

TABLE 1 (Cont'd.)

FLOW TEST DATA SHEET

Record Take ΔP in system without
valve in system

FLOW TEST DATA SHEET																										
valve in system																										
Test No.	Pos.	Run No.	W gpm	P ₁ psig	P ₂ psig	P ₃ psig	P ₄ psig	P ₅ psig	P ₆ psig	P ₇ psig	P ₈ psig	P ₉ psig	Δ P psi	f ₁ ft/s	f ₂ ft/s	f ₃ ft/s	f ₄ ft/s	f ₅ ft/s	f ₆ ft/s	f ₇ 10 ⁻⁶ in per in	f ₈ 10 ⁻⁶ in per in	f ₉ 10 ⁻⁶ in per in	f ₁₀ 10 ⁻⁶ in per in	T, °F	Remarks	
22	5	1																							Reverse Flow direction	
		2																								
		3																								
		4																								
		5																								
		6																								
		1																							Flow direction	
		2																								
		3																								
		4																								
		5																								
		6																								
		1																								Flow direction
		2																								
		3																								
		4																								
		5																								
		6																								
		1																								Flow direction
		2																								
		3																								
		4																								
		5																								
		6																								

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9.0 POST TEST INSPECTION AT AMCO

9.1 Upon the return of the test article from the flow test facility the test article is to be returned to the AMCO hydrotest laboratory for inspection as follows.

9.1.1 Remove end covers.

9.1.2 Photograph the test article internals. Photographs of the test article are to emphasize the lip seal and ball. Photographs are to be provided with the test article open and closed.

9.1.3 Disassemble valve and inspect all parts for wear or any abnormalities. Photographs are to be taken of all parts after disassembly.

9.1.4 The disassembled valve is to be placed in a box and await further disposition by the cognizant AMCO engineer.

10.0 REFERENCES

- (1) Report of ASME Research Committee on Fluid Meters, ASME Report "Interim Supplement 19.5 on Instruments and Apparatus - Application Part II of Fluid Meters" Sixth Edition, 1971.

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APPENDIX A

AMCO Drawing 16-E-4020 Sheet 2

APPENDIX C

TEST PROCEDURE FOR WATER FLOW TESTING OF A 12-INCH OFFSET BALL ISOLATION VALVE

Wyle Laboratories Test Procedure No. 3543,
Revision A, dated 10/31/74

TEST PROCEDURE NO. 3543

DATE: 28 October 1974

WYLE LABORATORIES, Norco, California

TEST PROCEDURE
FOR
WATER FLOW TESTING OF A 12 INCH
OFFSET BALL ISOLATION VALVE
FOR
AEROJET MANUFACTURING CORPORATION (AMCO)

APPROVED BY:
FOR:

APPROVED BY:
FOR:

APPROVED BY:
FOR:

APPROVED BY:
FOR:

APPROVED BY:
FOR:

PREPARED BY:

WYLE LABORATORIES

REVISIONS

REV. NO.	DATE	PAGES AFFECTED	BY	APP'D	DESCRIPTION OF CHANGES
A	10-31-74	8	RMS	AP	Page 8, Para. 5.2, Item 19, add per attached page after "...and 10,000 gpm."
A	10-31-74	9	RMS	AP	Change 2'6" to 9'0" per telecon Bob Stepelevitch and Vince Smith of 10-31-74.

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WYLE LABORATORIES Norco, California

1.0 PURPOSE

- 1.1 This test procedure establishes the requirements and methods of test required to evaluate the pressure drop and fluid force effects on the 12 inch offset ball valve internals.

2.0 REFERENCES

- 2.1 Purchase Order Number F6198-7800.
- 2.2 Water Test Plan and Procedure, AMCO Report Number 1773-01(10)ER, dated June 1974, and Revision 1 dated 10 October 1974.
- 2.3 Drawing Number 6-E-4020, Valve - 12 Inch Offset Ball, Task II, Water Pop Test.
- 2.4 Wyle/AMCO Meeting Agreements and Commitments, 7 October 1974.

3.0 MANUFACTURER

- 3.1 Aerojet Manufacturing Company
601 S. Placentia Avenue
Fullerton, California

4.0 TEST CONDITIONS AND TEST EQUIPMENT

4.1 Ambient Conditions

Unless otherwise specified herein, all tests required by the specification shall be performed at an atmospheric pressure of 29.0 ± 2.0 inches of mercury absolute, a temperature of 77 ± 27 , -9 F, and a relative humidity of 90 percent or less.

4.2 Test Tolerances

Tolerances to be maintained during test are as follows, except as otherwise specified herein:

Temperature	$\pm 2^{\circ}\text{C}$
Humidity	$+ 5, - 0\%$
Altitude	$\pm 5\%$

4.3 Test Equipment

Measuring and test equipment to be used in the performance of this contract have been calibrated by the Wyle Laboratories Standards Laboratory, or a commercial facility utilizing reference standards (or interim standards) whose calibration has been certified as being traceable to the National Bureau of Standards. All reference standards utilized in the above calibration system are supported by certificates, reports, or data sheets attesting to the date, accuracy, and conditions under which the results furnished were obtained. All subordinate standards, and measuring and test equipment are supported by like data when such information is essential to achieve the accuracy control required by the subject contract.

Wyle Laboratories attests the commercial sources providing calibration services on the above referenced equipment, other than the National Bureau of Standards, are in fact capable of

WYLE LABORATORIES Norco, California

4.0 TEST CONDITIONS AND TEST EQUIPMENT (Continued)4.3 Test Equipment (Continued)

performing the required services to the satisfaction of the Wyle Laboratories Quality Control Department. Certificates and reports of all calibrations performed are retained in the Wyle Laboratories Quality Control files and are available for inspection upon request by the customer or government representative.

4.4 The following equipment, or equivalent equipment, will be used in the performance of the test program.

<u>Equipment</u>	<u>Manufacturer's Model No. and/or Wyle's Serial No.</u>	<u>Range and/or Accuracy</u>
Recorder	Minn. -Honeywell Model 1012 W30498 (Typical)	±2% Time ±5% Speed
Recorder	Minn. -Honeywell Model Y153X(67)	-100 to +300 F 0.5% F.S.
Carrier Modulator	Validyne Model MC1-10	±0.05% Linearity
Pressure Transducer	Taber-Teledyne Model 217 W31168 (Typical)	0-100 psi ±1%
Pressure Transducer	CEC Model 170622-0100 W31557 (Typical)	±100 psid ±1%
Millivolt Potentiometer	Minn. -Honeywell Model 2745 W2259	0.03% Range
ASME Flow Nozzle	Wyle	Avg. D ₁ -11.956 Inches Avg. D ₂ -8.999 Inches
Strain Gage Power Supply	Video Instr. 3RB200	0-15V, 200 MA, ±0.1%
Gages	Ashcroft Model 1379-D (Typical)	0-300 psig, ±0.25% F.S.
Dead Weight Tester	Ashcroft W11273	0-250 psi, ±0.1%

5.0 REQUIREMENTS AND PROCEDURES5.1 Test Requirements

The test objectives of the program are to obtain the following data:

1. Pressure drop through the test article at various water flow rates with flow in both directions.
2. Flow torques acting on the ball in various positions and flow rates with flow in both directions.
3. Ball and seal flutter characteristics with the ball in the open position under various flow rates.

5.2 Test Procedure

1. Perform a visual examination of the test article upon receipt. Record results on the Inspection Data Sheet (Wyle Form Number W614).

Note: The AMCO cognizant engineer shall be witness to this examination.

2. Install the 4 foot facility water line section in the system.
3. Proceed to connect the test article facility mating flanges to perform tare flow runs.
4. Prepare facility for flow tests as follows:
 - a. Fill prover tank to station 1200 (stabilization volume).
 - b. Open crossover valve.
 - c. Activate compressor and pump air tank pressure to a nominal value between 40-80 psig.
5. Calibrate nozzle ΔP (± 15 psid) and tare ΔP (± 5 psid).

5.0 REQUIREMENTS AND PROCEDURES (Continued)5.2 Test Procedure (Continued)

6. While maintaining nominal tank pressure, adjust the flow control valve to obtain facility nozzle ΔP values listed below:

<u>gpm</u>	<u>Nozzle ΔP psi</u>	<u>Inches of Hg</u>
1,000	0.12	0.24
2,000	0.50	1.00
4,000	1.90	3.90
6,000	4.30	8.80
8,000	7.60	15.50
10,000	11.80	24.00

7. Record tare ΔP across facility mating flanges to the test valve for each flow rate.
8. Recycle system as necessary to obtain the data points.
9. Reduce data to prepare log-log plot of flow rate versus ΔP for nozzle.
10. Secure test system.
11. Remove special tare run test section and install the test valve in the reverse flow position in the water run as shown in Figure 1.
12. Verify the system (end-to-end) calibration has been completed.
13. Install instrumentation as shown in the Instrumentation Schematic, Figure 2.
14. Connect test valve strain gages to facility acquisition system.

5.0 REQUIREMENTS AND PROCEDURES (Continued)5.2 Test Procedure (Continued)

15. Calibrate strain gages:

f_2, f_4, f_6 ---- 150 μ strains
 f_7, f_8 ---- 110 μ strains

Note: The cognizant AMCO engineer shall be notified 48 hours prior to test.

16. Adjust test valve to full open position for Test No. 1 as indicated by sequence listed on the data sheet.
17. Verify prover tank is filled.
18. Verify air tank is pressurized to nominal run value.
19. Perform Flow Test No. 1 consisting of six runs as indicated on the data sheet by maintaining tank pressure and adjusting the flow control valve to obtain the desired facility nozzle ΔP value. Each run shall be performed at varying flow rates of 1,000, 2,000, 4,000, 6,000, 8,000 and 10,000 gpm. However, the pressure drop across the valve shall never exceed 50 psi nor shall strain gage deflections (f_7, f_8) exceed 1,000 micro-inches. Minimum strain gage deflections should be 90 microinches. A pressure drop of 15 psi should be sufficient strain gage deflection. This means that for valve positions approaching the closed position, the higher flow rates cannot be achieved. Record data on data sheet. (A)
20. Repeat the Flow Test, Step 16, for the 22 conditions listed on the data sheet. Record data as required.
21. Review all test data.
22. Remove test valve and prepare for delivery to AMCO.

Figure 1

Test Procedure No. 3543

Page No.

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FLOW TEST SYSTEM

Full Open Tests

P_1 f_2
 P_2 f_4
 P_3 f_6
 P_4 T_1
 P_5
 P_6
 P_7
 P_8
 P_9
 ΔP

Partially Open Tests

P_1 f_2
 P_3 f_4
 P_4 f_6
 P_5 f_7
 P_6 f_8
 P_8
 P_9 T_1
 ΔP

1. All test runs must start with (3) Section A-A and (2) Section B-B (if required) strain gages operating. If a strain gage becomes defective during a test run, one of the spare gages shall be connected and calibrated prior to the start of another run.
2. Initial test run shall be performed using strain gages f_7 and f_8 .

Figure 2

TEST VALVE INSTRUMENTATION

TEST NO.	POSITION	RUN NO.	W	P ₁	P ₂	P ₃	F ₄	P ₅	P ₆	P ₇	P ₈	P ₉	Δ P VLV	T ₁	Δ P NOZ	F ₂	F ₄	F ₆	F ₇	F ₈		IN GAGE	IN FLG	OUT FLG	OUT GAGE	REMARKS	
1	90° FULL OPEN	1																									REVERSE FLOW DIRECTION
		2																									
		3																									
		4																									
		5																									
		6																									
2	90° FULL OPEN	1																									NORMAL FLOW DIRECTION
		2																									
		3																									
		4																									
		5																									
		6																									
3	80° FROM CLOSED	1																									NORMAL FLOW DIRECTION
		2																									
		3																									
		4																									
		5																									
		6																									
4	70°	1																									NORMAL FLOW DIRECTION
		2																									
		3																									
		4																									
		5																									
		6																									
5	60°	1																									NORMAL FLOW DIRECTION
		2																									
		3																									
		4																									
		5																									
		6																									
6	50°	1																									NORMAL FLOW DIRECTION
		2																									
		3																									
		4																									
		5																									
		6																									

Figure 3

TEST NO.	POSITION	RUN NO.	W	P ₁	P ₂	P ₃	F ₄	P ₅	P ₆	P ₇	P ₈	P ₉	Δ P VLV	T _L	Δ P NOZ	F ₂	F ₄	F ₆	F ₇	F ₈		IN GAGE	IN FLG	OUT FLG	OUT GAGE	REMARKS	
7	40°	1																									NORMAL FLOW DIRECTION
		2																									
		3																									
		4																									
		5																									
		6																									
8	30°	1																									NORMAL FLOW DIRECTION
		2																									
		3																									
		4																									
		5																									
		6																									
9	20°	1																									NORMAL FLOW DIRECTION
		2																									
		3																									
		4																									
		5																									
		6																									
10	15°	1																									NORMAL FLOW DIRECTION
		2																									
		3																									
		4																									
		5																									
		6																									
11	10°	1																									NORMAL FLOW DIRECTION
		2																									
		3																									
		4																									
		5																									
		6																									
12	5°	1																									NORMAL FLOW DIRECTION
		2																									
		3																									
		4																									
		5																									
		6																									

Figure 3

TEST NO.	POSITION	RUN NO.	W	P ₁	P ₂	P ₃	F ₄	P ₅	P ₆	P ₇	P ₈	P ₉	Δ P VLV	T _i	Δ P NoZ	F ₂	F ₄	F ₆	F ₇	F ₈		IN GAGE	IN FLG	OUT FLG	OUT GAGE	REMARKS	
13	80°	1																									REVERSE FLOW DIRECTION
		2																									
		3																									
		4																									
		5																									
		6																									
14	70°	1																									REVERSE FLOW DIRECTION
		2																									
		3																									
		4																									
		5																									
		6																									
15	60°	1																									REVERSE FLOW DIRECTION
		2																									
		3																									
		4																									
		5																									
		6																									
16	50°	1																									REVERSE FLOW DIRECTION
		2																									
		3																									
		4																									
		5																									
		6																									
17	40°	1																									REVERSE FLOW DIRECTION
		2																									
		3																									
		4																									
		5																									
		6																									
18	30°	1																									REVERSE FLOW DIRECTION
		2																									
		3																									
		4																									
		5																									
		6																									

Figure 3

[illegible]

Figure 3

Report No. 1839-01(02)ER
January 1975

APPENDIX D

DATA SHEET REPORT

WATER FLOW PRESSURE DROP
AND FLUID FORCE EFFECTS

Wyle Laboratories Report No. 54039,
dated 1/10/75

DATA SHEET REPORT

WYLE LABORATORIES

4 December 1974

Aerojet Manufacturing Co.
601 S. Placentia Avenue
Fullerton, California 92631

ATTENTION: J. VanDuren
TEST TITLE: Water Flow Pressure Drop and Fluid Force Effects
REFERENCES: Your Purchase Order No. F6198 7800
Wyle Laboratories Job No. ND 54039
Government Contract No. n/a
Wyle Laboratories Report No. 54039

Gentlemen:

This is to certify that the enclosed Test Data Sheets contain true and correct data obtained in the performance of the test program as set forth in your purchase order.

Where applicable, instrumentation used in obtaining this data has been calibrated using standards which are traceable to the National Bureau of Standards.

Test Results:

One 12 in. Ball Valve was subjected to water flow testing in accordance with Wyle Test Procedure No. 3543, Revision A and your purchase order. Test methods, results and equipment used are shown on the following data sheets. Photographs 1 through 5 depict typical test setups and instrumentation used during testing.

17 -- Page Report

STATE OF CALIFORNIA } ss.
COUNTY OF RIVERSIDE }

Ray C. Myrick, being duly sworn,
deposes and says That the information contained in this report is the result of
complete and carefully conducted tests and is to the best of his knowledge true
and correct in all respects.

Ray C. Myrick

SUBSCRIBED and sworn to before me this 4 day of December, 19 74

Thomas J. Kelly
Notary Public in and for the County of Riverside, State of California

My Commission expires 14 July, 19 75

DEPARTMENT DYNAMICS

DEPT. MGR. R. Surcek

R. Surcek

TEST ENGINEER R. Stepelevitch

R. Stepelevitch

TEST WITNESS _____

DCAS-QAR VERIFICATION

QUALITY CONTROL Al Keenman

DATA SHEET

Customer

AMCO

Job No.

54039

Date

11-6-74

Specimen

12" BALL VALVE

RECEIVING INSPECTION

No. of Specimens Received:

1

Record identification information exactly as it appears on the tag or specimen:

Manufacturer

AMCO

Part numbers

NONE

How does identification information appear: (name plate, tag, painted, imprinted, etc.)

NO IDENTIFICATION

Serial Numbers:

NONE

Examination: Visual, for evidence of damage, poor workmanship, or other defects, and completeness of identification.

Inspection Results: There was no visible evidence of damage to the specimens unless noted below.

*If additional space is required for serial numbers, use an additional page, or reference first functional test data sheet (if applicable).

Inspected By

James E. Butler

Sheet No.

Approved

R. H. Hester

of

Date: 11-6-74

B. H. Hester

WYLE LABORATORIES

DATA SHEET

Test Title: Water Flow Pressure Drop and Fluid Force Effects

Customer	Aerojet	Job. No.	ND 54039
Part No.	none	Date Test Started	11-13-74
S/N	none	Date Test Completed	11-22-74
Spec.	Wyle Test Proc. 3543, Rev.A	Amb. Temp.	n/a
Para.	as applicable	Photo	yes
		Test Med.	water
		Specimen Temp.	n/a
Specimen	12 in. Prototype Valve		

The 12 in. valve was water flow tested at various flow rates and opening configurations in accordance with Wyle Test Procedure No. 3543, Revision A.

Prior to test specimen installation in the flow loop, a series of water flow tests were performed to obtain system tare values, reference figure 1.

The flow data in the accompanying data sheets were based on a standard water density of 1.000. Actual analysis reveals a density of 0.996 g/ml at 20.7 C.

Average C_v calculated for test #2 90° full open normal flow:

$$C_{v \text{ avg.}} = \frac{Q}{\sqrt{\Delta P_{\text{net}}}} = 5063.7$$

Specimen Meets Spec. Requirements YES ☐ NO ☒

Q.C. Form Approval *[Signature]*

Tested By *[Signature]*
Witness _____ Date: _____
Sheet No. _____ of _____
Approved *[Signature]* Date: 11-22-74

351
KUFFELBERGER CO. MILWAUKEE, WIS.
2 X 3 CYCLES

SPECIMEN 12 O INCH PROTOTYPE VALVE
 CUSTOMER Acro Jet MFG.
 PART NO. NONE
 S/N NONE

JOB NO. ND54039
 DATE 10-28-74
 TEST BY S. Lingo
 WITNESS _____

WYLE LABORATORIES

TEST: WATER PRESSURE DROP AND FLUID FORCE EFFECTS

EQUIPMENT	MANUFACTURER	MODEL NO.	RANGE	WYLE NO.	CALIBRATION		ACCY.
					LAST	DUE	
Chart Recorder	Moseley	7100B	0-10	W31160	7-25-74	11-24-74	0.02 FS
ΔP Transducer	CEC	170622-0100	± 50	W31526	Systems	Calibration	0.5%
ΔP Transducer	Validyne	DP15TL	± 5	SN7014	"	"	0.5%
Pressure Gauge	Ashcroft	1279S	0-300	W30196	10-6-74	12-7-74	0.5%
PRESSURE GAUGE	Duragauge	1279A	0-160	W30725	10-6-74	12-13-74	0.5%
PRESSURE GAUGE	Duragauge	1279A	0-160	G1133	10-6-74	12-7-74	0.5%
VISICORDER	HONEYWELL	1012	24 CHANNEL	W30463	10-17-74	4-20-75	± 2% TIME ± 5% SPACE
VISICORDER	HONEYWELL	1012	24 CHANNEL	W1135	10-17-74	4-20-75	± 2% TIME ± 5% SPACE
RECORDER, TEMPERATURE	HONEYWELL	Y15301PS	-100 TO +250 °F	W30465	1-5-74	1-5-75	± 0.5% FS
SIGNAL CONDITIONER	VALIDYNE	CD19	0-50 mV/VOLT 0-1 KC	0161-50	N/A SYSTEMS CALIBRATION		
SIGNAL CONDITIONER	VALIDYNE	CD19	0-50 mV/VOLT 0-1 KC	0161-49	SYSTEMS CALIBRATION		
SIGNAL CONDITIONER	VALIDYNE	CD19	0-50 mV/VOLT 0-1 KC	0171-55	SYSTEMS CALIBRATION		
SIGNAL CONDITIONER	VALIDYNE	CD19	0-50 mV/VOLT 0-1 KC	0171-56	SYSTEMS CALIBRATION		
SIGNAL CONDITIONER	VALIDYNE	CD19	0-50 mV/VOLT 0-1 KC	0171-58	SYSTEMS CALIBRATION		
SIGNAL CONDITIONER	VALIDYNE	CD19	0-50 mV/VOLT 0-1 KC	0161-48	SYSTEMS CALIBRATION		
SIGNAL CONDITIONER	VALIDYNE	CD19	0-50 mV/VOLT 0-1 KC	0175-4	SYSTEMS CALIBRATION		
SIGNAL CONDITIONER	VALIDYNE	CD19	0-50 mV/VOLT 0-1 KC	0175-2	SYSTEMS CALIBRATION		

SPECIMEN 12.0 INCH PROTOTYPE VALVE
 CUSTOMER AERO JET MFG.
 PART NO. ACNE
 S/N ACNE

JOB NO. ND 54039
 DATE 10-28-74
 TEST BY L LINGO
 WITNESS _____

WYLE LABORATORIES

TEST: WATER PRESSURE DROP AND FLUID FLOW EFFECTS

EQUIPMENT	MANUFACTURER	MODEL NO.	RANGE	WYLE NO.	CALIBRATION		ACCY.
					LAST	DUE	
SIGNAL CONDITIONER	VALIDYNE	CD19	0-50 mv/volt 0-1 KC.	0171-24	SYSTEMS CALIBRATION		
SIGNAL CONDITIONER	VALIDYNE	CD19	0-50 mv/volt 0-1 KC.	0171-60	SYSTEMS CALIBRATION		
SIGNAL CONDITIONER	VALIDYNE	CD19	0-50 mv/volt 0-1 KC.	0171-67	SYSTEMS CALIBRATION		
SIGNAL CONDITIONER	VALIDYNE	CD19	0-50 mv/volt 0-1 KC.	0175-9	SYSTEMS CALIBRATION		
SIGNAL CONDITIONER	VALIDYNE	CD19	0-50 mv/volt 0-1 KC.	0175-8	SYSTEMS CALIBRATION		
SIGNAL CONDITIONER	VALIDYNE	CD19	0-50 mv/volt 0-1 KC.	0175-10	SYSTEMS CALIBRATION		
PRESSURE TRANSDUCER	TABER INST CO.	217	0-100 PSI	W31165	SYSTEMS CALIBRATION		
PRESSURE TRANSDUCER	TABER INST CO.	217	0-100 PSI	W31164	SYSTEMS CALIBRATION		
PRESSURE TRANSDUCER	TABER INST CO.	217	0-100 PSI	W31163	SYSTEMS CALIBRATION		
PRESSURE TRANSDUCER	STRATHAM INST.	PG246TCE	0-100 PSI	W31051	SYSTEMS CALIBRATION		
PRESSURE TRANSDUCER	STRATHAM INST.	P24-750A-500	0-500 PSI	2313	SYSTEMS CALIBRATION		
PRESSURE TRANSDUCER	STRATHAM INST.	P24-750A-500	0-500 PSI	2311	SYSTEMS CALIBRATION		
PRESSURE TRANSDUCER	VALIDYNE	DP15 TL	0-1, 20, 75 PSID	W7354	SYSTEMS CALIBRATION		
PRESSURE TRANSDUCER	VALIDYNE	DP15 TL	0-1, 20, 75 PSID	W7353	SYSTEMS CALIBRATION		
PRESSURE TRANSDUCER	VALIDYNE	DP15 TL	0-250 PSI	W7352	SYSTEMS CALIBRATION		
PRESSURE TRANSDUCER	VALIDYNE	DP15 TL	0-250 PSI	W7351	SYSTEMS CALIBRATION		
PRESSURE TRANSDUCER	VALIDYNE	DP15 TL	0-250 PSI	7014	SYSTEMS CALIBRATION		

TEST NO.	POSITION	RUN NO.	W GPM	P ₁ PSIG	P ₂ PSIG	P ₃ PSIG	P ₄ PSIG	P ₅ PSIG	P ₆ PSIG	P ₇ PSIG	P ₈ PSIG	P ₉ PSIG	Vlv. ΔP PSID	T °F	Noz. ΔP PSID	F ₂	F ₄	F ₆	F ₉	F ₁₀	Vlv. Cav.	IN GAGE	IN FLG	OUT FLG	OUT GAGE	REMARKS
1	90° Full Open	1	1696.2	41.3	34.3	39.5	32.5	34.3	22.8	31.5	32.5	32.5	0.20	78	0.34	-	31.5	40.0	-	-	27	34	30	30	31	Reverse Flow
		2	4001.8	37.5	24.5	26.8	23.8	19.0	18.8	25.4	24.5	22.3	0.78	78	1.90	-	68.8	42.0	-	-	17	34	25	20	20	
		3	5152.2	34.0	25.0	23.0	23.0	12.5	13.3	30.5	22.5	16.8	1.78	78	4.48	-	43.8	28.0	-	-	17	22	25	22	21	
		4	8452.2	20.0	10.4	-4.5	-4.3	-5.5	-2.5	15.5	10.0	1.0	3.16	78	7.84	-	120.0	44.0	-	-	0	17	8	4	8	
		5	9735.4	18.0	10.0	-2.8	-10.3	-12.5	-7.5	18.3	10.0	-4.0	4.49	78	11.20	-	120.0	22.0	-	-	0	17	18	6	9	
		6	12092.5	34.5	27.0	14.3	4.0	2.2	7.5	36.3	27.0	10.5	3.99	78	17.30	-	7.5	9.2	-	-	4	31	35	24	24	
		7	8370.6	25.5	29.5	16.9	-1.8	-2.5	4.0	43.8	34.0	7.5	7.20	78	8.28	3100	50.0	-140.0	-	-	1	37	39	26	28	
		8	5839.8	39.3	55.0	19.0	13.8	13.0	16.0	4.5	29.8	4.3	3.00	78	4.03	3250	-100.0	-400.0	-	-	15	32	35	28	28	
2	90° Full Open	1	6102.0	59.8	-	47.8	45.0	46.3	49.0	-	53.0	47.0	1.65	72	4.40	0	-2150	-2150	-1950	-2000						Normal Flow
		2	8304.7	53.8	-	33.8	31.3	32.0	33.8	-	43.8	33.8	3.35	72	8.15	750	-1500	-1200	-700	-750						
		3	10284.9	44.5	-	13.0	11.8	13.3	16.3	-	32.0	16.8	5.43	72	12.50	-	-	-	-	-						
		4	11905.6	36.5	-	-7.0	-5.5	-6.3	-2.0	-	21.5	-2.0	6.95	72	16.75	-	-	-	-	-						
		5	6102.0	65.8	-	53.0	50.5	51.0	51.8	-	57.0	52.5	1.85	72	4.40	1050	-900	-1030	-950	-700						
		6	7065.9	63.0	-	47.0	43.8	44.8	46.3	-	52.5	45.5	2.45	72	5.90	400	-1150	-1200	-400	-820						
		7	9199.1	54.8	-	28.8	26.8	28.3	30.0	-	43.8	31.3	4.00	72	10.00	-500	-1500	-1300	0	-1200						
3	80°	1	6225	47.5	-	43.3	38.3	40.5	39.3	-	40.5	39.3	9.25	66	4.65	-	-	-	-	-						Normal Flow
		2	7966.6	47.0	-	30.5	25.8	28.0	27.5	-	29.5	27.0	14.00	66	7.50	-	-	-	-	-						
		3	9310	38.5	-	23.8	17.5	21.8	18.5	-	20.8	18.8	19.50	66	10.40	-	-	-	-	-						
		4	5553	48.8	-	47.5	42.3	44.5	43.0	-	43.8	42.5	6.90	66	3.70	-100	90	50	0	0						
		5	8062	42.5	-	32.5	27.5	30.0	27.8	-	31.3	29.0	12.20	66	7.80	-250	150	110	80	50						
		6	9083	39.8	-	26.3	20.5	25.0	22.5	-	24.8	21.3	16.15	66	9.75	-300	150	140	-60	80						
4	70°	1	3562.8	54.3	-	54.0	52.5	54.5	48.8	-	50.8	52.0	6.10	66	1.50	0	0	0	40	15						Normal Flow
		2	4113.9	53.8	-	52.8	50.8	53.0	48.8	-	48.5	48.8	9.25	66	2.00	0	40	0	70	-50						
		3	4979.4	53.0	-	50.3	47.3	50.5	42.5	-	44.5	45.0	12.00	66	2.93	0	140	10	140	100						
		4	5400.0	51.3	-	45.7	44.3	48.5	38.8	-	40.0	40.5	15.20	66	3.55	-100	80	0	170	130						
		5	6293.1	50.0	-	42.8	40.0	45.0	32.5	-	35.0	36.8	18.30	66	4.68	-50	120	0	200	180						
5	60°	1	2805.3	57.5	-	57.6	58.3	57.5	54.0	-	54.5	56.3	6.85	68	0.93	50	0	100	-15	-75						Normal Flow
		2	3252.4	56.3	-	58.7	55.5	56.3	50.0	-	51.2	52.0	9.50	68	1.25	-60	10	-90	0	-50						
		3	3732.7	57.3	-	56.2	54.5	55.0	47.5	-	47.5	50.0	12.80	68	1.65	-30	100	-65	60	0						
		4	3881.1	54.8	-	53.2	52.5	53.0	45.5	-	45.8	48.0	12.40	68	1.78	-100	50	-90	50	0						
		5	3679.6	54.0	-	52.8	52.0	52.5	45.0	-	45.3	48.3	12.00	68	1.60	-75	60	-80	50	0						
		6	4225.0	53.8	-	52.5	50.3	51.3	42.5	-	42.5	45.5	14.90	68	2.11	-50	75	-100	75	0						
		7	4235.6	52.5	-	48.1	48.3	49.5	40.8	-	40.0	43.0	15.50	68	2.12	-50	100	-90	80	10						

DELETED

TEST NO.	POSITION	RUN NO.	W GPM	P ₁ PSIG	P ₂ PSIG	P ₃ PSIG	P ₄ PSIG	P ₅ PSIG	P ₆ PSIG	P ₇ PSIG	P ₈ PSIG	P ₉ PSIG	Vlv. ΔP PSID	T °F	Noz. ΔP PSID	F ₇	F ₈ Strains/Inch	F ₉	F ₁₀	F ₁₂	Vlv. Cav.	IN GAGE	IN FLG	OUT FLG	OUT GAGE	REMARKS
6	50°	1	2502.1	53.0	-	53.2	54.5	53.8	48.0	-	48.0	50.3	9.63	68	0.74	-15	0	-70	-30	-25						Normal Flow
		2	3183.3	52.0	-	51.2	50.3	50.0	41.3	-	39.8	43.8	15.75	68	1.19	-55	40	-100	25	10						
		3	2822.3	55.0	-	53.5	53.5	53.3	45.0	-	44.3	47.5	14.85	68	1.03	-50	45	-90	30	15						
		4	3714.0	54.5	-	52.5	51.3	51.3	40.5	-	38.5	42.8	19.73	68	1.63	-85	85	-110	-50	25						
		5	4009.8	52.5	-	49.5	49.5	49.3	36.3	-	32.5	38.8	24.40	68	1.90	-140	100	-150	100	45						
		6	4363.5	51.5	-	47.5	47.5	47.5	31.3	-	27.5	33.8	28.13	68	2.25	-165	115	-190	125	65						
7	40°	1	1682.2	57.0	-	57.8	58.0	57.5	52.5	-	51.3	53.8	9.38	69	0.34	-25	25	-30	20	-15						Normal Flow
		2	2398.5	58.5	-	57.7	58.3	57.8	49.3	-	47.5	51.3	15.15	69	0.69	-55	50	-60	50	0						
		3	2822.4	58.5	-	58.0	58.8	56.3	45.5	-	42.5	47.5	19.50	69	0.94	-90	90	-90	75	10						
		4	3051.0	57.0	-	53.7	55.5	54.5	41.9	-	37.5	43.5	24.00	69	1.10	-125	120	-110	115	45						
		5	3252.4	56.8	-	52.5	53.8	53.0	37.8	-	32.5	39.8	27.90	69	1.25	-185	150	-150	160	75						
8	30°	1	1354.1	57.5	-	59.7	59.5	59.5	50.5	-	50.8	45.5	9.34	69	0.22	-15	70	-25	50	0						Normal Flow
		2	1870.0	57.8	-	58.0	58.8	58.3	43.8	-	42.3	45.5	13.0	69	0.42	-80	130	-90	120	50						
		3	2308.9	56.3	-	54.7	56.5	55.8	33.8	-	30.5	35.5	19.5	69	0.63	-225	225	-175	175	75						
		4	2519.3	58.0	-	54.5	58.5	57.5	28.0	-	22.5	30.0	26.0	69	0.75	-205	175	-190	200	100						
		5	2813.3	58.0	-	52.0	58.0	57.0	23.0	-	17.5	25.0	29.2	69	0.95	-225	175	-210	200	100						
9	20°	1	707.1	59.5	-	59.2	60.5	60.5	50.5	-	51.8	51.4	10.2	69	0.065	50	50	25	20	0						Normal Flow
		2	942.6	60.0	-	58.0	60.5	60.8	42.0	-	42.3	43.0	20.0	69	0.105	40	60	25	30	0						
		3	1322.2	58.0	-	57.0	59.0	58.8	32.5	-	30.8	33.3	29.1	69	0.21	15	40	0	30	0						
		4	1414.4	58.3	-	53.7	59.3	59.5	22.8	-	21.8	24.0	39.0	69	0.24	0	0	0	40	35						
		5	1554.4	58.5	-	52.5	59.3	59.0	17.5	-	15.5	18.3	44.9	69	0.29	-50	-65	55	-15	0						
10	10°	1	707.1	59.0	-	59.0	61.0	61.3	49.8	-	51.3	51.0	10.75	69	0.063	75	45	35	0	-20						Normal Flow
		2	*	58.8	-	58.3	61.3	61.3	40.5	-	41.8	42.3	20.0	69	*	55	30	20	0	-25						
		3	*	59.8	-	58.8	61.3	61.3	30.8	-	32.0	31.8	30.5	69	*	50	5	15	5	-5						* NOT MEASURABLE
		4	*	59.8	-	58.3	62.0	62.0	22.3	-	23.5	23.3	38.8	69	*	10	-45	-40	-5	-5						
		5	*	60.0	-	58.1	62.0	62.0	17.3	-	17.5	17.8	44.5	69	*	-15	-90	-55	-45	-10						

TEST NO.	POSITION	RUN NO.	W GPM	P ₁ PSIG	P ₂ PSIG	P ₃ PSIG	P ₄ PSIG	P ₅ PSIG	P ₆ PSIG	P ₇ PSIG	P ₈ PSIG	P ₉ PSIG	Vlv. ΔP PSID	T °F	Noz. ΔP PSID	F ₇	F ₈	F ₉	F ₁₀	F ₁₂	Vlv. Cav.	IN GAGE	IN FLC	OUT FLC	OUT GAGE	REMARKS
11	90° Full Open	1	595.1	45.5	-	38.0	38.8	29.3	32.8	-	46.8	26.8	1.65	62	4.25	-70	-30	-30	-20	0						Reverse Flow
		2	812.0	42.5	-	22.7	23.3	23.3	26.3	-	39.5	24.5	3.48	62	9.00	-100	-100	-120	-90	0						
		3	1038.2	34.3	-	6.25	5.0	6.3	10.8	-	29.3	12.5	5.00	62	12.75	-180	-220	-190	-100	0						
		4	1141.5	31.2	-	-9.2	-10.0	-10.0	-2.5	-	19.5	0	6.25	62	15.40	-380	-450	-280	-480	0						
		5	1198.8	26.3	-	-12.9	-12.3	-12.3	-5.0	-	18.8	-2.5	8.00	62	16.90	-350	-340	-230	-470	0						
		6	1416.5	47.5	-	35.4	36.5	36.5	38.0	-	47.5	40.8	2.50	62	6.50	-30	-20	-50	0	-10						
		7	1229.1	27.5	-	-13.2	-12.3	-12.3	-4.8	-	19.3	-3.0	8.98	62	17.80	-380	-500	-330	-480	-100						
		8	1176.2	26.3	-	-11.4	-10.8	-10.8	-2.5	-	20.0	-1.3	6.80	62	16.35	-360	-450	-300	-450	-100						
12	80°	1	603.2	57.5	-	43.7	44.5	47.0	47.5	-	51.8	52.5	6.10	63	4.30	-120	85	-175	85	60						Reverse Flow
		2	730.5	52.5	-	29.1	32.5	35.0	48.0	-	43.5	43.8	8.70	63	6.30	-100	150	-250	150	50						
		3	828.0	47.5	-	16.1	22.3	25.0	32.3	-	35.0	35.0	11.50	63	8.00	-300	185	-350	280	75						
		4	940.7	42.5	-	2.5	7.5	13.3	22.0	-	26.5	26.5	15.65	63	10.45	-390	220	-415	245	95						
		5	1085.0	37.5	-	-9.1	-3.8	2.3	14.3	-	19.5	17.5	17.10	63	13.25	-435	195	-450	190	95						
13	70°	1	402.1	58.0	-	45.7	47.5	47.5	51.8	-	50.8	54.5	6.40	65	1.94	-50	20	-80	45	20						Reverse Flow
		2	469.6	55.0	-	39.6	41.8	42.0	47.8	-	47.0	50.5	8.85	65	2.61	-90	35	-100	50	20						
		3	544.7	55.8	-	32.6	35.5	36.0	47.3	-	42.5	48.0	12.15	65	3.55	-135	50	-150	50	0						
		4	606.2	53.0	-	24.3	27.8	27.8	39.8	-	37.3	42.8	15.35	65	4.35	-180	50	-205	75	15						
		5	650.7	50.8	-	18.2	22.0	22.5	36.0	-	33.0	38.8	18.00	65	5.00	-210	65	-225	75	15						
14	60°	1	292.5	54.8	-	44.7	46.3	46.3	50.0	-	48.8	53.0	5.65	66	1.01	-55	50	-100	30	50						Reverse Flow
		2	367.6	53.0	-	39.6	42.0	42.0	48.5	-	45.3	51.3	8.75	66	1.60	-100	75	-125	50	50						
		3	425.5	52.8	-	34.5	35.8	35.0	45.0	-	41.3	47.5	11.50	66	2.10	-135	95	-150	75	50						
		4	469.6	51.3	-	28.0	29.3	28.0	41.3	-	36.0	44.0	14.60	66	2.60	-175	120	-200	100	50						
		5	516.0	50.8	-	21.6	23.2	22.3	38.3	-	29.8	41.8	18.05	66	3.15	-215	140	-225	100	70						
15	50°	1	290.0	53.8	-	39.6	39.0	40.0	48.3	-	43.8	51.5	10.00	66	1.40	-50	5	-50	40	10						Reverse Flow
		2	363.3	54.5	-	32.2	32.0	32.5	46.3	-	38.5	49.0	15.25	66	1.56	-105	30	-95	55	40						
		3	415.2	54.8	-	28.0	27.5	27.5	45.0	-	35.0	47.5	18.75	66	2.06	-150	50	-125	95	40						
		4	416.9	57.3	-	47.8	49.5	49.5	53.5	-	51.3	53.8	5.25	66	0.56	-35	-20	-40	15	0						
		5	365.3	57.5	-	39.6	39.8	40.0	50.3	-	44.5	53.5	11.63	66	1.76	-80	20	-75	50	25						
		6	388.4	55.5	-	30.1	30.5	30.5	46.3	-	37.3	48.8	17.38	66	1.81	-140	30	-125	70	25						

TEST NO.	POSITION	RUN NO.	W GPM	P ₁ PSIG	P ₂ PSIG	P ₃ PSIG	P ₄ PSIG	P ₅ PSIG	P ₆ PSIG	P ₇ PSIG	P ₈ PSIG	P ₉ PSIG	Vlv. ΔP PSID	T °F	Noz. ΔP PSID	F ₇	F ₈	F ₉	F ₁₀	F ₁₂	Vlv. Cav.	IN GAGE	IN FLG	OUT FLG	OUT GAGE	REMARKS
16	40°	1	2345.3	70.0	-	52.1	52.0	52.0	60.8	-	54.8	64.8	10.38	66	0.65	-50	55	-70	75	35						Reverse Flow
		2	2713.3	63.0	-	48.9	43.8	44.3	57.5	-	48.5	60.8	14.38	66	0.87	-70	90	-75	115	45						
		3	3206.2	63.8	-	38.7	34.8	35.5	54.5	-	41.8	57.8	20.00	66	1.23	-100	125	-125	150	60						
		4	3502.9	62.5	-	32.2	27.5	28.8	57.5	-	35.5	54.8	24.63	66	1.45	-140	170	-150	185	85						
		5	3837.2	62.8	-	25.4	18.5	21.3	50.0	-	30.3	53.8	30.13	66	1.76	-175	215	-175	230	100						
17	30°	1	1425.1	60.0	-	47.1	46.3	45.0	54.8	-	48.0	57.5	9.63	66	0.74	-30	40	-75	45	40						Reverse Flow
		2	2057.0	62.0	-	38.8	33.8	33.8	54.3	-	38.8	57.5	21.00	66	0.50	-50	100	-100	100	75						
		3	2589.2	62.0	-	27.3	23.0	22.8	52.5	-	30.0	56.3	30.00	66	0.78	-135	155	-175	170	95						
		4	3064.8	61.0	-	13.8	10.0	10.0	50.5	-	39.5	54.5	39.88	66	1.11	-180	215	-200	225	125						
		5	4862.7	62.5	-	41.9	41.0	41.0	54.0	-	44.8	57.8	16.50	66	0.41	-150	90	-195	-25	-95						
		6	1907.6	62.5	-	42.2	41.3	40.5	57.3	-	45.0	60.0	16.75	66	0.43	-150	-100	-200	-25	-100						
18	20°	1	1020	63.8	-	56.4	51.5	50.8	64.3	-	52.5	63.5	10.38	64	0.125	-55	25	-75	40	0						Reverse Flow
		2	1414	65.0	-	52.5	42.5	42.0	62.3	-	44.8	64.8	20.00	64	0.24	-80	50	-90	50	15						
		3	1633	63.8	-	40.3	29.3	29.5	60.0	-	32.5	62.5	30.63	64	0.32	-100	75	-100	75	30						
		4	1633	63.5	-	35.0	20.3	20.0	58.8	-	24.3	63.5	40.63	64	0.32	-125	100	-125	100	45						
		5	1633	69.8	-	35.0	12.0	12.0	61.0	-	17.0	63.8	48.75	64	0.32	-125	100	-125	100	45						
		6	1633	65.0	-	32.3	12.5	12.5	60.8	-	17.5	63.8	48.13	64	0.32	-125	100	-125	100	50						
19	10°	1	*	79.0	-	69.6	70.0	68.8	77.3	-	65.0	78.0	10.00	65	*	-30	-50	45	50	0						Reverse Flow
		2	*	78.0	-	59.8	57.5	56.3	76.3	-	57.5	77.5	20.25	65	*	-50	-50	30	60	15						
		3	*	76.3	-	46.1	45.0	43.8	75.0	-	45.0	76.3	31.25	65	*	-75	-25	0	75	20						* NOT MEASURABLE
		4	*	75.5	-	36.1	35.0	33.8	74.5	-	35.5	75.5	40.75	65	*	-100	-40	-20	120	0						
		5	*	74.8	-	27.0	25.8	24.8	70.5	-	27.3	75.0	48.63	65	*	-100	-25	-10	75	10						
20	20°	1	1633	62.5	-	43.1	34.5	34.0	59.3	-	37.5	64.3	25.62	65	0.32	-85	75	-150	65	45						Reverse Flow
		2	1633	62.5	-	38.4	28.8	28.8	60.0	-	32.5	61.5	30.25	65	0.32	-100	100	-150	75	50						
		3	1826	62.5	-	36.3	25.0	24.8	59.3	-	27.5	61.3	35.38	65	0.40	-100	125	-150	100	60						
		4	1826	62.5	-	35.0	18.3	19.0	59.3	-	22.5	61.3	42.00	65	0.40	-100	150	-160	125	75						
		5	1936	62.5	-	27.5	8.8	8.8	58.3	-	13.8	64.5	48.88	65	0.45	-120	170	-175	150	90						
21	90° Full Open	1	11905.6	30.0	-	-11.4	-9.5	-9.8	-2.3	-	22.8	0	7.25	63	16.75	-220	-400	-345	-425	-100						Reverse Flow
		2	11994.1	27.8	-	-13.2	-12.3	-12.5	-5.0	-	19.8	-2.5	8.08	63	17.00	-275	-445	-330	-495	-100						
		3	11994.1	27.5	-	-13.2	-12.3	-12.5	-5.0	-	17.5	-2.5	8.98	63	17.00	-295	-450	-350	-500	-100						
		4	11994.1	27.0	-	-13.4	-12.5	-12.5	-5.0	-	17.3	-2.5	9.48	63	17.00	-300	-465	-350	-530	-100

WYLE LABORATORIES / El Segundo, California

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PHOTOGRAPH 5

Test Specimen Installation and Instrumentation

EXHIBIT I
WEST COAST TECHNICAL SERVICE INC / 17605 FABRICA WAY, SUITE D / CERRITOS, CA 90701

REPORT

(213) 921-9831
(714) 523-9200

date/ November 27, 1974 job no./ 7059

p.o. no./ 54039

prepared for/

Mr. J. Butler

Wyle Labs
Post Office Box 38
Norco, California 91760

Your sample of water has been received in our laboratory for the determination of pH and density.

The results of the tests are as follows:

pH	7.6
Density	0.996 g/ml at 20.7°C

If we can be of any further service, please call us.

Respectfully submitted,

WEST COAST TECHNICAL SERVICE INC.

H. Dwight Fisher, Ph.D.
Vice President-Technical Director

HDF/kd

Report No. 1839-01(02)ER
January 1975

APPENDIX E

TYPICAL SODIUM VALVE DESIGN REQUIREMENTS

APPENDIX E

TYPICAL SODIUM VALVE DESIGN REQUIREMENTS

The requirements for the design of the sodium valve are shown in Table 1. They are based on the sodium valve preliminary design requirements submitted by WARD (Reference 1A). The exception is the valve size of 12-inches which is in the approved AMCO Workscope FA-73S-877G. The flow rates were adjusted to the 12-inch size using the 14-inch valve sodium velocity (Reference A1).

REFERENCES:

- E1. Letter FPV-890, WARD to AMCO, titled, "Preliminary Design Requirements," 5 December 1973 (CAR 59).
- E2. AMCO Topical Report, 8716-03(03)ER, titled, "Fast Closing Intermediate Isolation Valve Design Summary Report," dated November 1973.
- E3. Liquid Metals Fast Breeder Reactor Materials Handbook, Hanford Engineering Development Laboratory, Report HEDL-TME-71-32.

TABLE I
DESIGN REQUIREMENTS

1. Nominal size, in.	12(Sched. 30)
2. Operator	- -
3. End Connections	- -
4. Valve Normal Position	- -
5. Design Pressure, psig	300
6. Design Temperature, F	965
7. Design Flow Rate per loop, lbs/hr	3.025×10^6
8. Normal operating pressure, psig	132
9. Normal operating temperature, F	936
10. Valve closed time, hrs	15,000
11. Pressure loss @ Design Flow, psi	2
12. Allowable Leakage - one direction, cc/inch of pipe size/hr	10
13. Pressure Differential for Leakage Require- ments, psi	85-225
14. Maximum Shutoff, ΔP , one direction psi	225

DERIVED PROPERTIES BASED ON ABOVE DATA

A. Specific Gravity at Normal Operating Temperature Referenced to Water at 60°F (Reference E).	.83
B. Normal Operating Fluid Pipe Line Velocity, ft/sec (based on #1, #7, and A)	20
C. Vapor Pressure at Normal Operating Temperature, psia (Reference E).	.105

AEROJET MANUFACTURING COMPANY

601 South Placentia Avenue □ Fullerton, California 92631