SNPO 3
Westinghouse Electric Corporation

Astronuclear Laboratory

Box 10864 Pittsburgh 36 Pa
Telephone 466-6800

December 17, 1963

*
Mr. R. W. Schroeder
Space Nuclear Propulsion Office
NASA Lewis Research Center
21000 Brookpark Road
Cleveland 35, Ohio

Subject: WANL-TME-532 dated October 30, 1963, "Test Series B 3 Single Seal
Low Pressure Isothermal Test"

Dear Mr. Schroeder:

Transmitted herewith are three (3) copies of the subject report. This
report is transmitted for your information.

Respectfully,

H. F. Faught
jm

H. F. Faught
Program Manager
NERVA Nuclear Subsystem

Enclosures - 3

cc: SNPO-C Pittsburgh Resident Office

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.

MASTC

DISTRIBUTION

Se

WANL-TME-532

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.

SN 700

#10
Pearls
Astronuclear

WANL-TME-532

October 30, 1963

TEST SERIES B 3
-SINGLE SEAL LOW PRESSURE
ISOTHERMAL TEST.

Distribution:

Dr. W. H. Esselman
Mr. H. F. Faught
Dr. W. H. Arnold, Jr.
Mr. H. S. McCreary

67
by

-G. W. Bauserman
-W. L. Jacob
R. J. Steffen

Approved:

WJ Lavenex

Supervisor, High Temperature Programs

W L Jacob

Manager, Fluid Flow Laboratory

INFORMATION CATEGORY

Unclassified

WJ Lavenex *12/2/63*

Authorized Classifier Date

PURPOSE

The purpose of this experiment was to determine preliminary qualitative flow coefficients past the support segment in the lateral support system of the NERVA Reactor.

Air flow experiments on a small model were conducted by varying conditions of pressure and configuration.

DESCRIPTION OF TEST PIECE AND PROCEDURE

Figure 1 is the flow schematic of the system. The test model, shown in cross-section in Figure 2, consists of a single flat graphite support bar resting on graphite blocks simulating the core filler strips. A plexiglas piece simulates the graphite cylinder of the inner reflector. These pieces are enclosed in a plexiglas box with inlet and outlet flow plenums.

Figure 3 is a photograph of the model and test loop and Figure 4 shows the model in greater detail.

Air enters the model inlet plenum (Figure 4) through a three port manifold ($5/16$ " dia. holes), passes through six $5/32$ " dia holes into the model, then flows past the support bar and out through six $5/16$ " dia holes into the discharge plenum. The air is then metered by a nozzle and discharged to the atmosphere.

The test piece design permits independent variation of the side and top clearance between the support bar and the plexiglas cylinder piece and the spacing between the individual filler strips. Figure 5 shows these spacings: (a) and (b) are side gaps and (c) is the top gap, while (x) is the spacing between the filler strips.

Experiments were conducted for 0.010-inch inlet and 0.010-inch discharge support bar side clearance at 3/16, 3/32, and 3/64-inch top clearance, and for 0.020-inch inlet and 0.000-inch discharge support bar side clearance at 3/16 and 3/32-inch top clearance. Selected points were duplicated with filler strip gaps of 0, .001, .006, .010, .015, and .020 inches. It was found that the plunger loading springs were not strong enough to hold the seal segment in the proper position so all runs were made with the springs bottomed in order to maintain accurately the dimensions and to keep the segment against the filler strips.

The data was taken by maintaining the inlet pressure constant and varying the flow by varying the downstream pressure. This data was recorded and then a new inlet pressure was obtained and the process repeated.

ANALYSIS OF RESULTS

The tests conducted with zero gap between the filler strips were analyzed to determine the loss coefficients for each configuration.

The loss coefficient is defined by

$$C = 2g \rho \Delta P A^2 / W^2$$

where

A	is the flow area
ρ	the fluid density
ΔP	the pressure drop across the support bar
W	the mass flow rate
g	the acceleration due to gravity

The results are shown in Figure 6 as a function of Reynolds number.

The test results with various filler strip gaps were not so readily amenable to analysis in terms of Reynolds number and loss coefficient because the flow area is difficult to predict. Therefore, flow coefficients were calculated.

The flow coefficient is defined as:

$$K = \frac{m}{\sqrt{P_1 \Delta P}}$$

where

m is the mass flow rate

P_1 the upstream pressure

ΔP the pressure drop across the resistance

By measuring the flow through and the ΔP across the test rig, it is possible to relate the two through a constant which is the flow coefficient for the particular configuration of the test rig.

A typical curve for the determination of this flow coefficient is shown in Figure 7, the abscissa being the mass flow through the section and the ordinate being a function of the inlet pressure and the ΔP across the test section. The slope of this straight line plot gives the flow coefficient.

The straight lines do not pass through the origin because the flow through a resistance changes from a dependance upon the square root of pressure drop to a first order dependance, so the lower part of the curve of flow coefficient vs $\sqrt{P \Delta P}$ becomes curved. These non-linear regions are at extremely low flow rates.

DISCUSSION OF RESULTS

Refer to Figure 6, a plot of pressure loss coefficient versus Reynolds number. The loss coefficient density is based on the inlet pressure and the loss coefficient area is based on the area resulting from the support bar top clearance. It can be seen that as the top clearance decreases, the loss coefficient decreases despite the fact that the pressure drop increases when the support bar discharge side clearance is decreased; this is because the pressure drop increases due to throttling at this decreased clearance condition.

The data points for the determination of the flow coefficients, of which Figure 7 is typical, conform well to a linear curve.

The tabulated data in Figure 8 give the flow coefficients and the corresponding configuration. The assumption here is that any change made to restrict the flow passage in any manner will tend to increase the resistance and thus decrease flow, since the proportion is direct. The flow coefficient would also decrease. This assumption would also hold if the change helped the flow by a resultant increase in the flow coefficient. In tests G thru K and O thru W, the assumption is followed very nicely. The resistance is increased and the coefficient decreases. In tests L, M and N, side leakage, that is, leakage in other regions of the rig, showed up due to the decreasing of the support bar clearance to zero. The increased pressure created by this resistance produced leaks in the seams of the plastic box and the combination of these leaks made the results deviate from our original assumptions. Side leakage is believed to have existed for all tests to some extent. It was necessary to dismantle and reassemble the test piece to alter the dimensions of any component, and the degree with which the leak paths were closed could not be determined by inspection, nor could the side leakage be measured during the tests. Data spread is undoubtedly due to the variation in the amount of side leakage.

CONCLUSIONS

The results show that, as expected, the flow coefficients are affected by configuration. The results are, in general, consistent with predictions. The apparent anomalies are undoubtedly the result of uncontrolled leakage in regions other than across the support bar. The results with any group are reasonably consistent. The loss coefficient analysis also shows reasonable consistency, although deviation from a constant value for each configuration is evident. The coefficient is strongly affected by the configuration. No unexpected results occurred due to the general make-up of the seal system.

It is recommended that testing be concluded using the plexiglas model and that a more durable model be designed and built. Model leakage increases with continuing rig assembly and disassembly, hence erroneous results will prevail and the data obtained will be misleading.

AIR FLOW LOOP
FOR
SUPPORT BAR AND SEAL TEST MODEL

FIGURE 1

FIGURE 3

TYPICAL LATERAL SUPPORT AND SEAL ARRANGEMENT

Figure 5

FIGURE 6

Typical Curve for Determination of Flow Coefficients

$$\dot{m} = \sqrt{\frac{A}{\Delta T}} \sqrt{\frac{P_1}{P_1 - 2}} = K' \sqrt{\frac{P_1}{P_1 - 2}}$$

$$K' = \text{slope of curve} = \frac{\dot{m}}{\sqrt{\frac{P_1}{P_1 - 2}}}$$

$$K' = .000379$$

Mass Flow Rate - $\dot{m}$ - lb/sec

a	c	e	f
.010	.10	3/4	0

$$\sqrt{\frac{P_1}{P_1 - 2}}$$

Figure 7

Figure #8

Single Seal Low Pressure Isothermal Test Results

Test	a"	b"	c"	x"	K $\times 10^4$	
G	.010	.010	3/16	0	3.79	
H	.010	.010	3/32	0	2.01	
J	.010	.010	3/32	0	2.22	
K	.010	.010	3/64	0	1.81	
L	.020	0	3/32	0	1.34	
M	.020	0	3/16	0	1.28	
N	.020	0	3/16	0	1.19	
O	0	.020	3/32	0	0.80	
P	0	.020	3/16	0	0.51	Pressure Range 5-25 psig
Q	.020	0	3/32	.001	0.49	Flow Rate Range 0-0.01 l6/sec air
R	.020	0	3/32	.006	0.74	
S	.020	0	3/32	.010	1.04	Seal segment 6" long, 1 7/16" wide, 5/16" thick
T	.020	0	3/32	.010	1.22	
U	.020	0	3/32	.015	1.22	
V	.020	0	3/32	.020	1.45	
W	.020	0	3/16	.020	1.70	