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**RADIAL VANE
STEAM SEPARATOR DEVELOPMENT
ELEVENTH QUARTERLY REPORT
PHASE II
JANUARY-MARCH 1968**

R.H. MOEN
J.E. GIFFORD

U.S. ATOMIC ENERGY COMMISSION
CONTRACT AT(04-3)-189
PROJECT AGREEMENT 42

ATOMIC POWER EQUIPMENT DEPARTMENT

GENERAL  ELECTRIC

SAN JOSE, CALIFORNIA

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RADIAL VANE STEAM SEPARATOR DEVELOPMENT

Eleventh Quarterly Report
Phase II
January - March 1968

R. H. Moen

J. E. Gifford

Prepared for the
U. S. Atomic Energy Commission
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TABLE OF CONTENTS

	<u>Page</u>
FOREWORD	v
1.0 SUMMARY	-1-
2.0 PRINCIPAL INVESTIGATORS AND REPORTS ISSUED	-1-
2.1 Principal Investigators	-1-
2.2 Reports Issued	-1-
2.3 Background Report	-2-
3.0 STATEMENT OF PROBLEM	-2-
3.1 Task 1 - Larger Model Separator Test	-2-
3.2 Task 2 - Reactor Separator and Dryer Design	-2-
3.3 Task 3 - Test Program Planning	-2-
3.4 Task 4 - Instrumentation Design	-3-
3.5 Task 5 - Model Vibration Tests	-3-
4.0 ACCOMPLISHMENTS DURING THE REPORT PERIOD	-3-
4.1 Tests of KRB Geometry	-3-
4.2 Rise of the Upper Vortex	-13-
5.0 FUTURE WORK	-13-
DISTRIBUTION LIST	-18-

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LIST OF ILLUSTRATIONS

<u>Figure No.</u>	<u>Title</u>	<u>Page</u>
4-1	FCRV-4 Wall Cylinder, Part 1	-5-
4-2	FCRV-4 Wall Cylinder, Circumferential Positions of Parts 2 and 3	-6-
4-3	FCRV-4 Wall Cylinder, Part 2	-7-
4-4	FCRV-4 Wall Cylinder, Parts 3 and 4	-8-
4-5	FCRV-4 Nozzle Head Loss versus Nozzle Velocity	-9-
4-6	A Function of the Upper Vortex Thickness versus Distance Below the Nozzle Bottoms	-12-
4-7	Upper Vortex Rise versus Vane Jet Momentum	-14-
4-8	Inlet Quality versus Ratio of Nozzle Velocity to Vane Jet Velocity for the Radial Vane Separator	-16-

LIST OF TABLES

<u>Table No.</u>	<u>Title</u>	<u>Page</u>
4-1	Upper Vortex Data for the FCRV-4	-10-
4-2	FCRV-4 Air-Water Data	-11-
4-3	Data for Figure 4-7	-15-

FOREWARD

The United States and the European Atomic Energy Community (Euratom), on May 29, and June 18, 1958, signed an agreement which provides a basis for cooperation in programs for the advancement of the peaceful applications of atomic energy. This agreement, in part, provides for the establishment of a Joint U.S. - Euratom research and development program which is aimed at reactors to be constructed in Europe under the Joint Program.

The work described in this report represents the Joint U.S. - Euratom effort which is in keeping with the spirit of cooperation in contributing to the common good by the sharing of scientific and technical information and minimizing the duplication of effort by the limited pool of technical talent available in Western Europe and the United States.

1.0 SUMMARY

The model separator performs satisfactorily in wall cylinders which give a 1-inch or a 1/2-inch clearance gap between the upper vortex and the separator vanes. Thus, there is an increase in the probability that the large diameter separator, as requested for the KRB reactor, will perform satisfactorily with a small clearance gap. However, with the addition of core spray and feedwater sparger pipes to the system, carryover becomes excessive with the separator operating at KRB flows and water level. This problem appears to be solvable by extending the wall cylinder to a smaller diameter in the core spray pipe region and extending the cylinder to some point below the feedwater sparger pipe. Another test is required to demonstrate the solution.

<u>EURAE C Number</u>	<u>GEAP Number</u>	<u>Title</u>
1365	4847	Radial Vane Steam Separator Development, Third Quarterly Report, January-March 1965
1450	4914	Radial Vane Steam Separator Development, Fourth Quarterly Report, April-June 1965
1533	4967	Radial Vane Steam Separator Development, Fifth Quarterly Report, July-September 1965
1585	4935	Radial Vane Steam Separator Development - Experimental Study of Carryunder Sources in a Radial Vane Separator, A. A. Kudirka and J. E. Gifford
1598	5084	Radial Vane Steam Separator Development, Sixth Quarterly Report, October-December 1965

2.0 PRINCIPAL INVESTIGATORS AND REPORTS ISSUED

2.1 PRINCIPAL INVESTIGATORS

R. H. Moen Project Engineer
J. E. Gifford Test Engineer

1656	5149	Radial Vane Steam Separator Development, Seventh Quarterly Report, January-March 1966
1854	5283	Radial Vane Steam Separator Development, Final Report - Phase I, January 1967

2.2 REPORTS ISSUED

<u>EURAE C Number</u>	<u>GEAP Number</u>	<u>Title</u>
1253	4728	Radial Vane Steam Separator Development, First Quarterly Report, June-September 1964
1301	4783	Radial Vane Steam Separator Development, Second Quarterly Report, October-December 1964

1931	5524	Radial Vane Steam Separator Development, Eighth Quarterly Report - Phase II, November 1966 - June 1967
1971	5567	Radial Vane Steam Separator Development, Ninth Quarterly Report - Phase II, July - September 1967
-	5597	Radial Vane Steam Separator Development, Tenth Quarterly Report, October-December 1967

2.3 BACKGROUND REPORT

GEAP-4272, "Nuclear Superheat Project, Internal Steam Separation, Development of Radial Vane Steam Separators," R.H. Moen, May 31, 1963.

3.0 STATEMENT OF PROBLEM

The basic purpose of the Phase II portion of the Radial Vane Steam Separator Development Program, with which this report is concerned, is to design a radial vane steam separator and related equipment for test in a boiling water reactor. Present planning is to design for test in the KRB reactor built for Rheinisch-Westfälisches Elektrizitätswerk (RWE) and Bayernwerk (BAG) at Gundremmingen, West Germany by the General Electric Company and the German electrical equipment manufacturing firm, Allgemeine Elektrizitäts-Gesellschaft (AEG). A Phase III program has been proposed for the purpose of constructing the radial vane separator and related equipment and testing this in the KRB reactor. AEG has agreed to work on Phase III with General Electric. The Phase II program includes the design mentioned above, testing of model full-circle radial vane separators in the new Large Steam-Water Test Facility of the General Electric Company, planning of the test program, test instrumentation design, and model tests to determine design data to aid in designing the reactor separator to have no vibration problems. This program is discussed in more detail in subsections 3.1 through 3.5.

The design will utilize the data and experience obtained during the Phase I program which was directed toward the development of the radial vane separator concept. Phase I work was reported in the first seven quarterly reports, a topical report, and a final report (see subsection 2.2

for list of reports). The Phase I development work was preceded by development work carried out under the Nuclear Superheat Program (Project Agreement 13 of the same contract which covers this Phase II program). The final report of this earlier work is listed in subsection 2.3.

3.1 TASK 1 - LARGER MODEL SEPARATOR TEST

Full-circle model radial vane steam separator tests at reactor conditions will be carried out for the purpose of demonstrating performance in a larger scale than has been possible in the past. Various nozzle and vane configurations will be tested with flow from all nozzles and vanes. These tests will give scale-up information to verify the reactor separator design. The tests will be performed utilizing three radial vane separators identified as RVSM-1, -2, and -3. The test will be carried out in the newly expanded Large Steam-Water Test Facility of the General Electric Company. A wide range of inlet qualities will be tested, and the normal performance indicators (carryunder, carryover, and pressure drop) will be measured.

3.2 TASK 2 - REACTOR SEPARATOR AND DRYER DESIGN

Detailed hydraulic and mechanical design of the separator and dryer system required to meet the existing design and operating requirements of the KRB reactor will be carried out. All necessary safety and operating aspects will be considered during this effort. Plans will be prepared for procurement of the separator and related equipment.

3.3 TASK 3 - TEST PROGRAM PLANNING

A test program will be set up in advance which will best demonstrate the performance

of the radial vane steam separator and prove the feasibility of operation of a radial vane steam separator in an operating boiling water reactor. Further, the test program will be designed so that the performance of the separator may be compared with the other types of steam separators if data are available. This Task will include maintaining contact with the German firm (AEG), which will work with General Electric and the reactor owners and operators (KRB, RWE, and Bayernwerk) for the purpose of coordinating work on the development program.

3.4 TASK 4 - INSTRUMENTATION DESIGN

Design and specify the instrumentation required to measure the performance of the radial vane steam separator to accomplish the needs of the test program. As a minimum, the tests will measure nozzle pressure differential, separator vibration, water level in the lower vortex, carryover from the dryers, and carryunder from the separators.

3.5 TASK 5 - MODEL VIBRATION TESTS

Carry out model tests in the Large Air-Water Test Facility of the General Electric Company to aid in the proper design of the reactor separator. Vibration tests will be performed utilizing FCRV-4 and a new radial vane separator model in the air-water facility to analyze vibration problems which may be encountered during the KRB test. The new model separator design will be based on findings from Task 5 tests of FCRV-4 and a new mechanical design for the KRB separator developed from Task 2.

4.0 ACCOMPLISHMENTS DURING THE REPORT PERIOD

Air-water tests of a model radial vane separator were conducted to test the new geometry required for the KRB reactor. Some existing data showing the height to

which the top of the upper vortex rises above the nozzle tops were correlated and the results applied to the KRB design.

4.1 TESTS OF KRB GEOMETRY

The new geometry has resulted from the KRB requirement (reported in the Tenth Quarterly Report) that a radial vane separator must permit refueling without separator removal. Design numbers showed that a separator with a plenum diameter large enough to permit refueling could be built if the vane-to-wall clearance were to be set at about 1 inch greater than the maximum calculated upper vortex thickness. This small clearance between the vanes and upper vortex reduces chances for successful reactor operation. All previous radial vane separator geometries had a factor of 2 or 3 times the maximum upper vortex thickness as clearance, i. e., 15-20 inches. An additional problem which arises in the KRB reactor is the presence of core spray pipes and feedwater spargers in the lower vortex region. Effects of the new geometry on performance in air-water were determined by the tests reported here.

The model FCRV-4 separator, modified to model the large diameter separator geometry of KRB, was used in the air-water tests. The modification consisted of making wall cylinders extending about 18 inches below the vanes with diameters to give a 1-inch and a 1/2-inch clearance gap between the upper vortex and the separator vanes. In one of the tests, simulated core spray and feedwater sparger pipes were installed beneath the wall cylinder to model this equipment in the KRB reactor. The tests are discussed below.

4.1.1 Conclusions

The model separator performs satisfactorily in wall cylinders which give a 1-inch and a 1/2-inch clearance gap between the upper

vortex and the separator vanes. Thus, there is an increase in the probability that the large diameter separator as requested for the KRB reactor, will perform satisfactorily with a small clearance gap. However, with the addition of core spray and feedwater pipes to the system, carryover became excessive with the separator operating at KRB flows and water level. This problem appears to be solvable by extending the wall cylinder to a smaller diameter in the core spray pipe region and extending the cylinder to some point below the feedwater sparger pipe. Another test is required to demonstrate the solution.

4.1.2 Test Equipment

The model FCRV-4 separator with seventy-two 6-inch active nozzles located in the lower 6 inches of the available 30-inch nozzle slot, and a flat plate located at the top of the plenum, was used for the tests. A wall cylinder of 63 inches inside diameter, which gives a 1-inch clearance between the upper vortex and the separator vanes, was used for the first test. Drawings for the cylinder which extends 22 inches above and 12 inches below the vanes are shown in Figures 4-1, 4-2, 4-3, and 4-4. After the first series of tests, the cylinder diameter was reduced to 61.8 inches to give a 1/2-inch clearance between the upper vortex and the separator vanes. Theoretically, the wall cylinder should have been reduced to 62 inches rather than 61.8 inches to give a 1/2-inch clearance gap, however, the diameter of 61.8 inches is correct. This is explained in the discussion of test results.

For the last series of tests, lengths of 3-inch-diameter pipe, each shaped to 31-1/2-inch radius and approximately 160 degrees arc length, were placed 2 inches beneath the wall cylinder to simulate KRB feedwater spargers. Two vertical core spray pipes, located 180 degrees apart

and between feedwater spargers are present in the KRB reactor, however, it was thought that a single vertical pipe in the air-water test would demonstrate the effect of the pipes. To accomplish this, a section of 3-inch pipe was installed on the outside of the separator wall extending vertically downward between feedwater sparger simulators to a distance of approximately 4 feet below the wall cylinder.

4.1.3 Test Results

Upper vortex data, i. e., water layer thickness, velocity, and angle of flow, which were obtained with a directional velocity probe through small holes in the separator wall cylinder, are tabulated in Table 4-1. Table 4-2 tabulates flow rates, pressure drop, carryunder, carryover, lower vortex level, and upper vortex level for separator tests in each geometry—the 63-inch cylinder, 61.8-inch cylinder, and the 61.8-inch cylinder with feedwater sparger and core spray pipe simulator. The data are discussed below.

Separator pressure drop is shown on Figure 4-5 as head loss, in feet of homogeneous mixture, versus nozzle velocity, in feet per second. The data agree well with a previous correlation and show scatter normal for air-water tests.

Carryunder is low—less than that equivalent to 0.1 percent in steam-water—at all test conditions and shows no dependence on wall cylinder diameter. Addition of the feedwater sparger and core spray pipe had no apparent effect on carryunder.

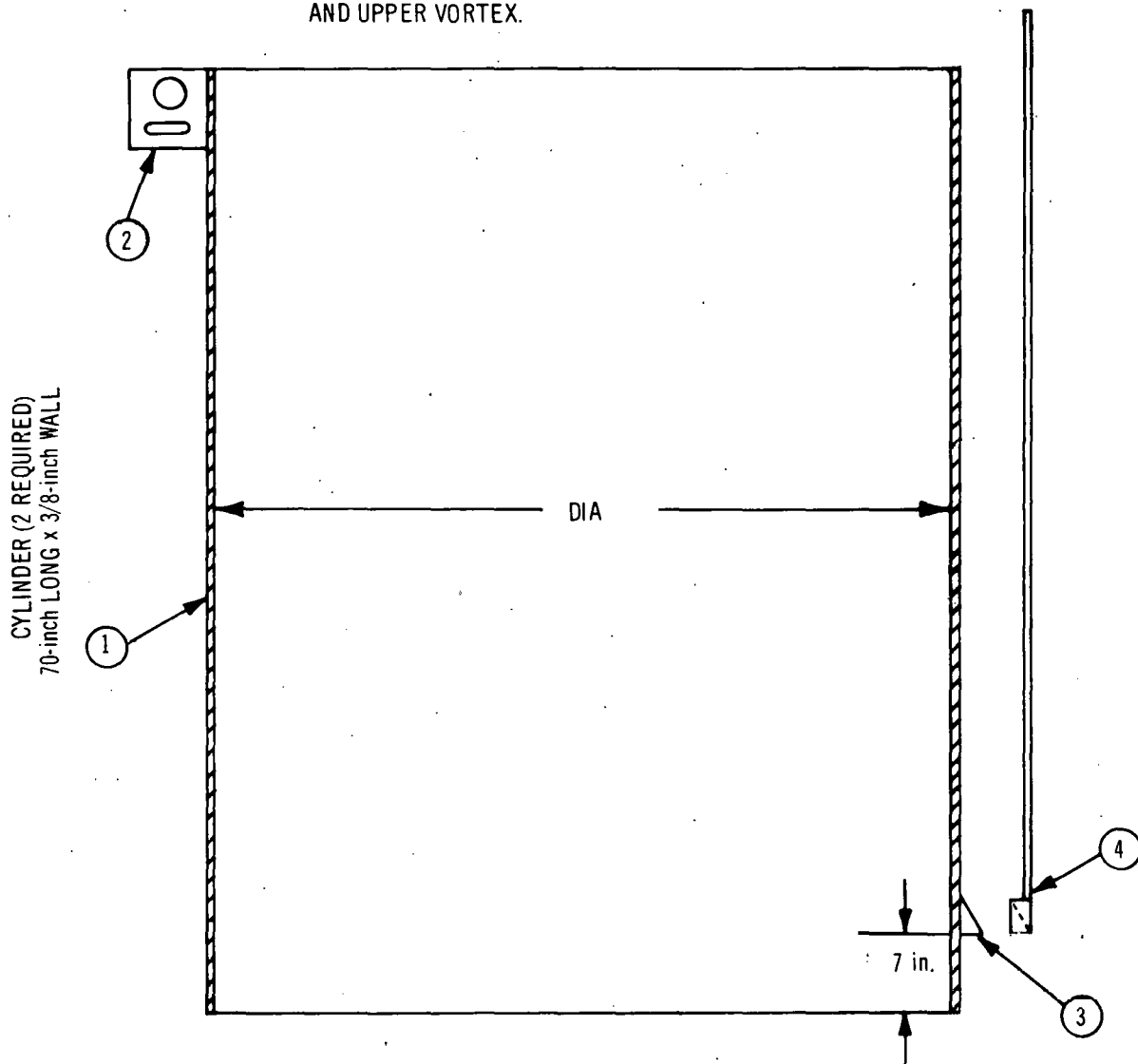
Carryover, which is determined by qualitative estimate, is low for both the 63-inch and 61.8-inch wall cylinder. It is thought that the feedwater sparger does not affect carryover, however, with the addition of the vertical core spray pipe, carryover becomes excessive when operating

ALL DIMENSIONS IN INCHES ($\pm 1/8$)

ANGLES $\pm 5^\circ$

DIAMETER = 63 inches FOR 1-inch CLEARANCE GAP BETWEEN CYLINDER AND UPPER VORTEX.

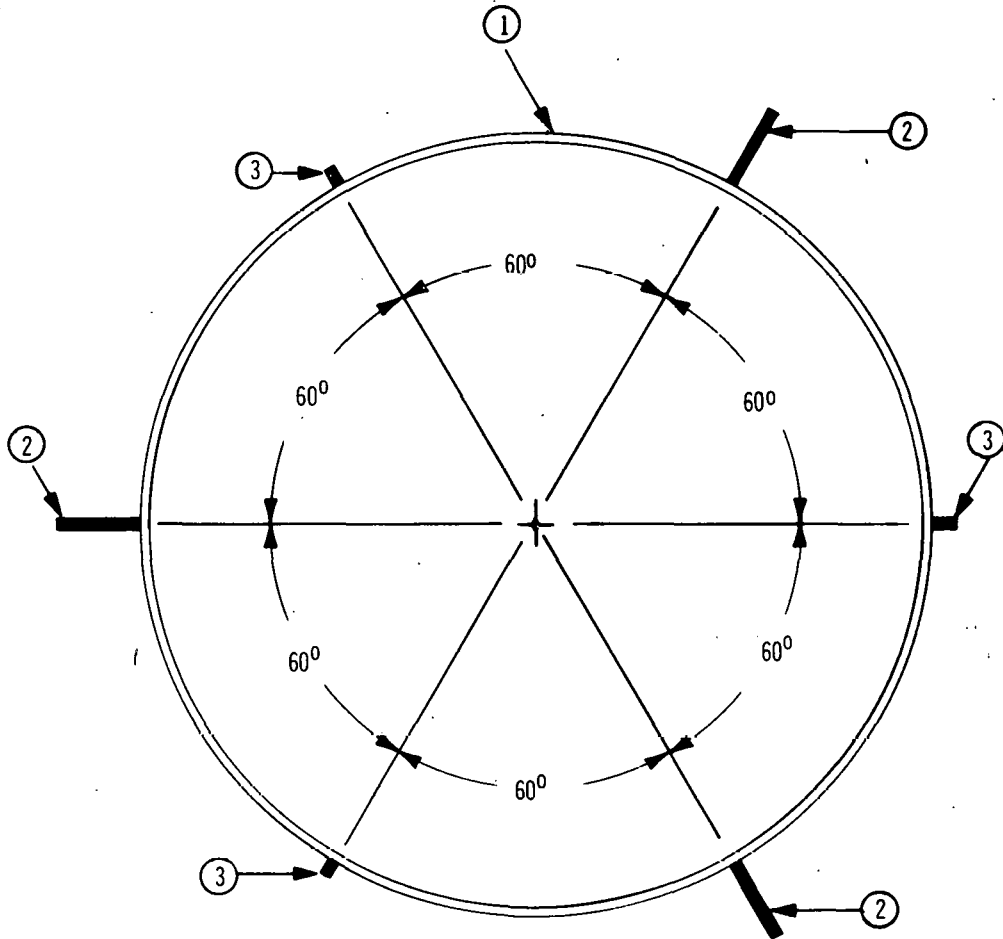
DIAMETER = 61.8 inches FOR 1/2-inch CLEARANCE GAP BETWEEN CYLINDER AND UPPER VORTEX.



"CIRCLED NUMBERS ARE PART NUMBERS"

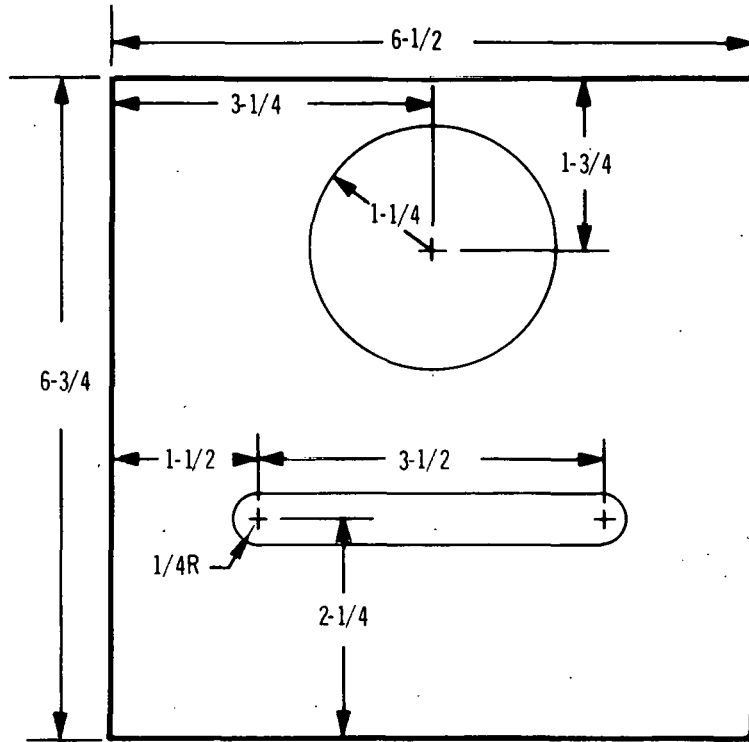
- NOTES:
1. ALL PARTS LOW CARBON STEEL
 2. PARTS 2 & 3 WELD TO PART 1
 3. SEE FIGURE 4-2 FOR CIRCUMFERENTIAL LOCATIONS
 4. SEE FIGURE 4-3 FOR PART 2 DETAILS
 5. SEE FIGURE 4-4 FOR PART 3 & 4 DETAILS

FIGURE 4-1. FCRV-4 WALL CYLINDER



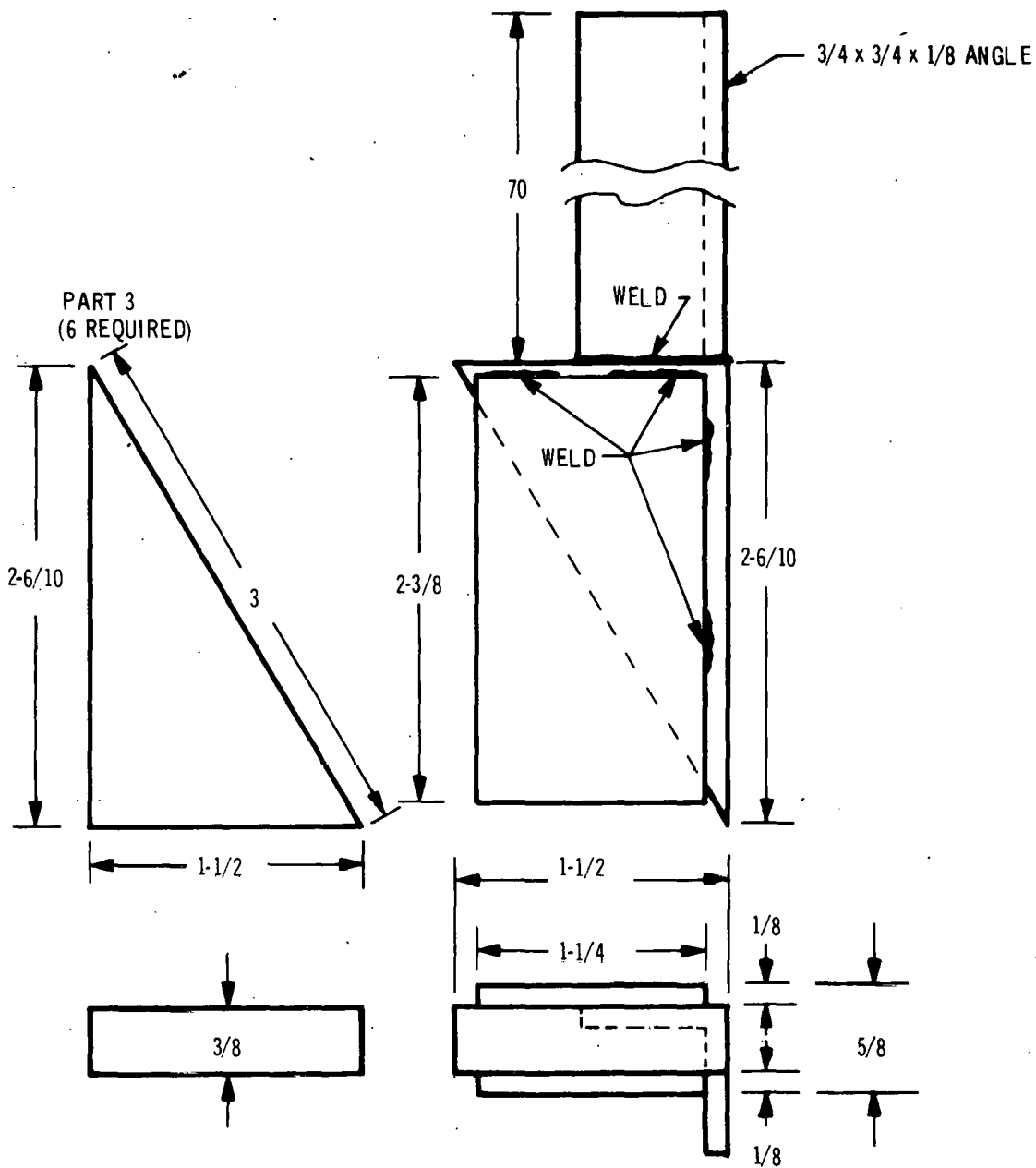
CIRCUMFERENTIAL POSITIONS OF PARTS 2 AND 3
ON PART 1

FIGURE 4-2. FCRV-4 WALL CYLINDER



ALL DIMENSIONS INCHES
PART 2 (6 REQUIRED) 3/8 inch THICK

FIGURE 4-3. FCRV-4 WALL CYLINDER, PART 2



ALL DIMENSIONS INCHES

PART 4 (6 REQUIRED)

NOTE: PART 4 MUST SLIDE ON PART 3

FIGURE 4-4. FCRV-4 WALL CYLINDER, PARTS 3 AND 4

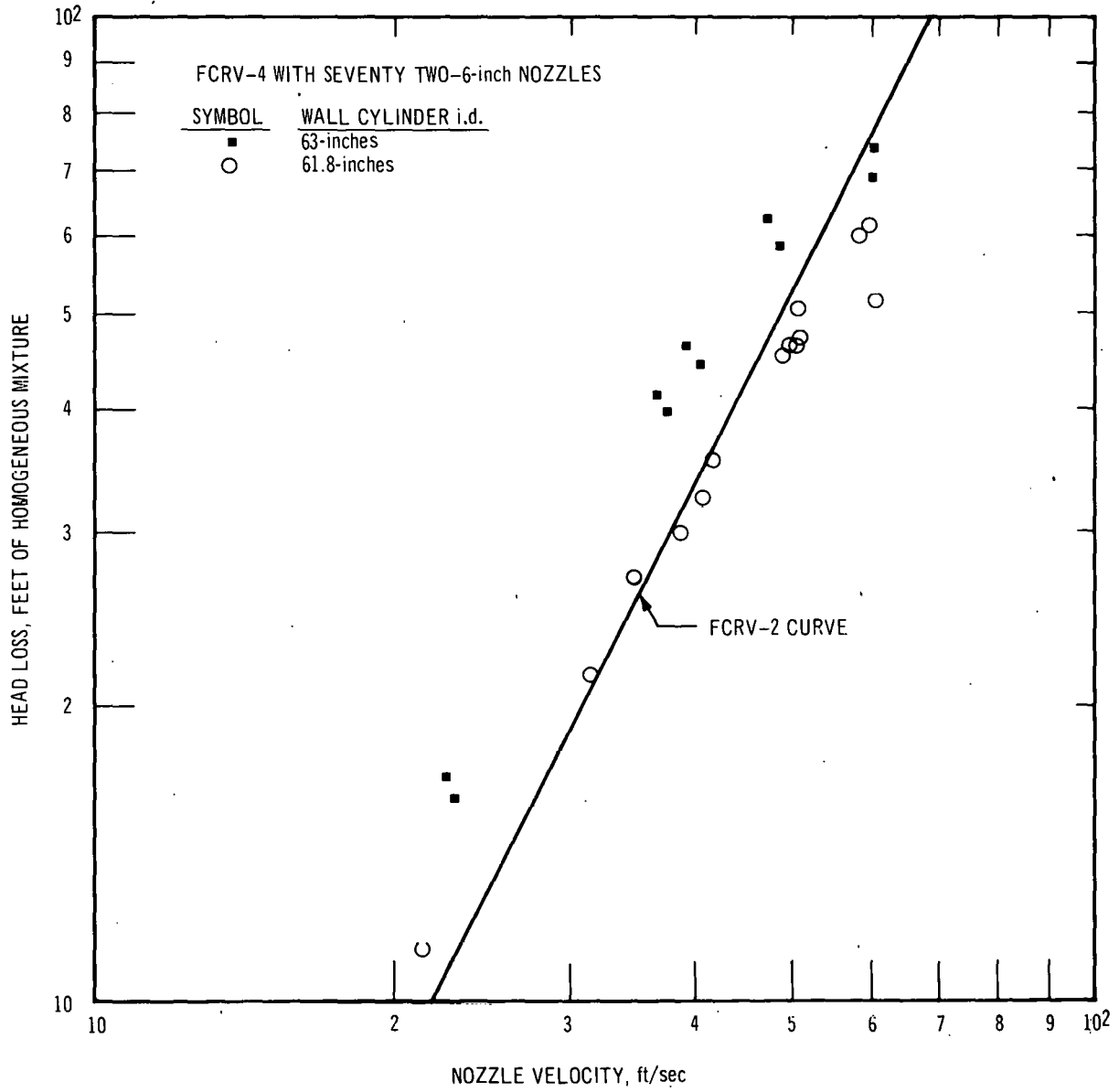


FIGURE 4-5. FCRV-4 NOZZLE HEAD LOSS VERSUS NOZZLE VELOCITY

TABLE 4-1
FCRV-4 TESTS
UPPER VORTEX DATA

Run ⁽¹⁾	Probe Position			Upper Vortex Thickness (in.)	Tangential Velocity (ft/sec)	Axial Velocity (ft/sec)
	Inches Below Nozzle Bottoms	Inches From Wall	Angle, Degrees From Horizontal			
031401	5.4	0.25	24	1.25	22.6	10.1
031402	5.4	0.25	21	1.15	19.8	7.6
031501	5.4	0.25	21	1.25	22.4	8.6
031502	5.4	0.25	21	1.45	21.8	8.4
031503	5.4	0.25	24	1.25	17.6	7.8
031801	2.4	0.25	22	1.50	24.5	9.9
031801	3.4	0.25	22	1.35	24.6	10.0
031801	5.4	0.25	21	1.30	24.9	9.6
031801	6.5	0.25	21	1.20	24.9	9.6
032201	2.4	0.25	21	1.55	20.2	7.8
033201	3.4	0.25	20	1.50	20.4	7.4
032201	4.4	-	-	1.10	-	-
032201	5.4	0.25	23	1.05	20.0	8.5
032201	6.4	-	-	1.10	-	-
032202	5.4	0.25	22	1.20	21.5	8.7
032203	5.4	0.25	24	1.15	17.0	7.6
032204	5.4	0.25	24	1.20	17.0	7.6

(1) See Table 4-2 for flow rates and separator geometry.

with the lower vortex level just under the vanes. At this high water level, corresponding to that to be used in KRB), the level of the upper vortex is approximately 12 inches higher immediately upstream of the vertical pipe than the level just downstream of the pipe. Carryover observation notes reveal that the excessive carryover emitted from between the vanes only in the region of the vertical pipe. This undoubtedly is the result of a disturbance in the lower vortex at this region, causing it to flow upward between the vanes and into the vane jets. It should be noted that carryover is low for this configuration when the lower vortex is well below the bottom of the vanes, suggesting that the excessive carryover may be eliminated by redesign of the wall cylinder.

Data from Table 4-1 for run 031801 and the equations for upper vortex thickness (Final Report, GEAP-5283, Volume I, Appendix A) were used for the plot shown on Figure 4-6. From this plot the expected maximum vortex thickness can be obtained. An extrapolation of the theoretical curve through the measured data gives a vortex thickness of 2.17 inches, hence a clearance of 1.08 inches between the upper vortex and the separator wall cylinder at the nozzle bottoms. This is very near the desired clearance of 1.0 inch for which the cylinder was designed. Also, the extrapolated value of vortex thickness shows that the wall cylinder diameter must be reduced to 61.8 inches for tests with a 1/2-inch clearance gap at the nozzle bottoms.

TABLE 4-2
FCRV-4
AIR-WATER DATA
March 1968

Run Identification ⁽¹⁾	031401	031402	031501	031502	031503	031801	031802	031803	031804	031805	032201	032202	032203	032204	032205	032206	032207	032208	032209	032210	032211	032212	032213	032214	032215	
Separator Geometry ⁽²⁾	A	A	A	A	A	A	A	A	A	A	B	B	B	B	B	B	B	B	B	B	B	B	B	C	C	
Weight Flow Rates																										
Air (10 ³ lb/hr)	9.63	13.21	6.58	5.26	0	9.91	13.99	6.50	5.18	0	9.97	12.90	6.24	4.11	4.09	6.57	7.33	13.24	12.85	96.4	9.74	0	0	9.88	10.5	
Water (10 ³ lb/hr)	3370	2280	3500	3660	3870	3410	2280	3500	3610	3800	2720	2720	2720	2720	3610	3600	2750	2710	1940	2720	3600	3610	2720	2720	2720	
Total (10 ³ lb/hr)	3380	2293	3507	3665	3870	3420	2294	3506	3615	3800	2730	2733	2726	2724	3614	3607	2257	2723	1953	2730	3610	3610	2720	2730	2730	
Volumetric Flow Rates																										
Air (10 ³ ft ³ /hr)	77.0	125.8	53.1	42.4	0	72.3	126.0	50.0	40.8	0	90.6	114.2	60.6	41.1	36.2	52.1	68.5	117.2	131.1	88.4	79.2	0	0	91.5	93.1	
Water (10 ³ ft ³ /hr)	54.1	36.6	56.2	58.7	62.1	54.7	36.6	56.2	57.9	61.0	43.7	43.7	43.7	43.7	57.9	57.8	44.1	43.5	31.1	43.7	57.8	57.9	43.7	43.7	43.7	
Total (10 ³ ft ³ /hr)	131.1	162.4	109.3	101.1	62.1	127.1	162.6	106.2	98.7	61.0	134.3	157.9	104.3	84.8	94.1	109.9	112.6	160.7	162.2	132.1	137.0	57.9	43.7	135.2	136.8	
Equivalent Inlet Quality (weight-percent steam) ⁽³⁾																										
	6.6	14.5	4.5	3.4	0	6.1	14.5	4.2	3.4	0	9.3	11.4	6.4	4.4	3.0	4.2	7.1	11.7	17.2	9.1	6.3	0	0	9.4	9.5	
Plenum Pressure Drop (psi) ⁽⁴⁾																										
	10.5	6.7	9.9	10.0	7.0	11.6	7.2	10.8	10.5	7.3	6.5	7.2	5.4	4.8	7.2	9.7	6.0	7.2	4.3	6.5	9.3	4.9	2.9	6.5	6.5	
Plenum Head Loss (feet of homogeneous mixture) ⁽⁶⁾																										
	58.4	68.7	44.5	39.8	16.2	62.1	73.5	47.1	41.3	16.9	46.1	59.9	29.8	21.5	27.0	42.6	35.3	61.3	51.6	45.2	50.7	11.3	6.7	46.3	46.8	
Homogeneous Plenum Velocity (ft/sec)																										
	3.8	4.7	3.2	2.9	1.8	3.7	4.7	3.1	2.8	1.8	3.9	4.6	3.0	2.4	2.7	3.2	3.3	4.6	4.7	3.8	4.0	1.7	1.3	3.9	3.9	
Homogeneous Nozzle Velocity (ft/sec)																										
	48.6	60.1	40.5	37.4	23.0	47.1	60.2	39.3	36.6	22.6	49.7	58.5	38.6	31.4	34.9	40.7	41.7	59.5	60.1	48.9	50.7	21.4	16.2	50.1	50.7	
Equivalent Carryover (weight percent steam) ⁽³⁾																										
	0.05	0.08	0.02	0.01	0	-	-	0	0	0	0.08	0.06	0.08	0.09	0.05	0.04	0.06	0.04	0.04	0.05	0.02	0	0	0.03	0.06	
Lower Vortex Level (inches below vanes at radius = 32.5 inches)																										
	29.0	35.0	29.0	19.0	27.0	20.0	43.0	33.0	15.0	23.0	37.0	39.0	41.0	44.0	42.0	29.0	39.0	37.0	43.0	37.0	28.0	29.0	37.0	33.0	1.0	
Upper Vortex Level (inches above nozzle tops)																										
	-	-	-	-	-	16.0	12.0	16.5	17.5	15.0	-	-	-	8.2	15.7	19.2	8.2	12.2	5.2	9.2	18.2	13.7	6.2	-	-	
Carryover Estimate ⁽⁵⁾																										
	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L-M	L-M	L	L	L	L	L	L	L	L	H	

(1) The six digits of the run identification give the month (first two digits), the date (second two digits) of the test, and the order (last two digits) in which the runs were made. Example, 031401 is the first run of March 14.

(2) The three separator geometries tested were:

- A. FCRV-4 with seventy-two 6-inch nozzles located in the bottom 6 inches of the nozzle slots. Wood nozzle plugs were installed in the upper 18 inches of the slots. No plenum deflector was used. Wall cylinder inside diameter was 63.0 inches.
- B. Same as (a) except wall cylinder inside diameter was 61.8 inches.
- C. Same as (b) except KRB core spray nozzle pipe and feedwater sparger simulators were installed.

(3) Calculated assuming an homogeneous steam-water mixture at 1000 psig with the same phase volumes as the air-water flow.

(4) Measured in the plenum, 6 inches below the nozzles.

(5) Quantitative estimate:

- L - low carryover
- M - moderate carryover, acceptable for reactor operation.
- H - high carryover, unacceptable for reactor operation.

(6) See Figure 5 for data plot of plenum head loss versus homogeneous nozzle velocity.

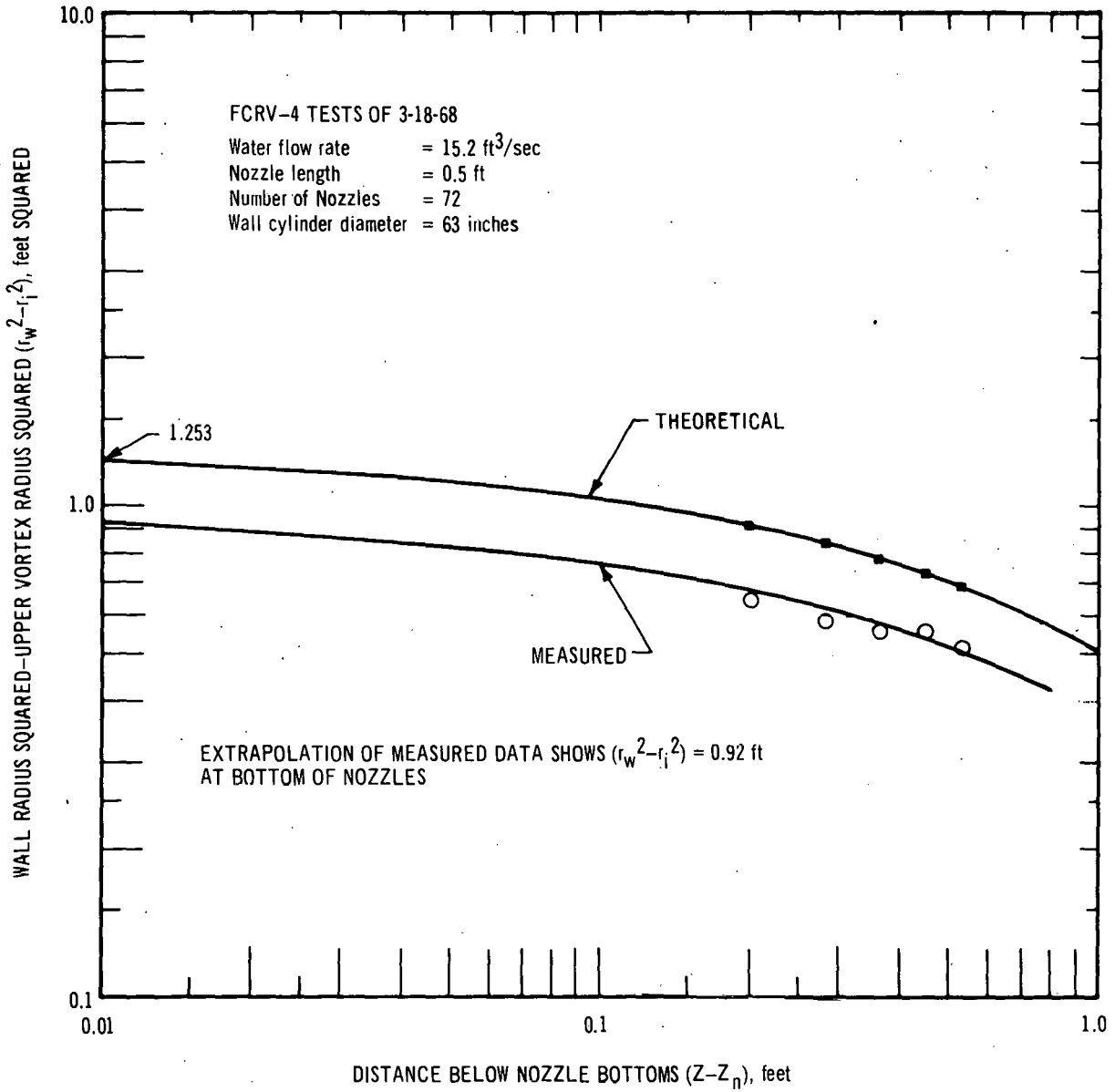


FIGURE 4-6. A FUNCTION OF UPPER VORTEX THICKNESS VERSUS DISTANCE BELOW NOZZLE BOTTOMS

4.2 RISE OF THE UPPER VORTEX

Figure 4-7 is a plot of upper vortex level (inches above nozzles) versus vane jet momentum per inch (ft-lb/sec²/in). This correlation shows that the upper vortex in the KRB radial vane separator will rise to approximately 8.8 inches above the top of the nozzles at reactor rated flow. The vane jet momentum equation used is

$$M = V_j W/Z_n$$

where

M = vane jet momentum per inch (ft-lb/sec²/in)

V_j = vane jet velocity (ft/sec)

W = water flow rate per nozzle (lb/sec)

Z_n = nozzle length (inches)

Data for Figure 4-7 are shown in Table 4-3.

Figure 4-8 is a plot of data previously published (Table VII, Final Report, GEAP-5283, Volume I) relating nozzle velocity, vane jet velocity, and inlet quality. The following equations, which represent these data, are used to calculate vane jet velocity.

For air-water,

$$V_j = V_n / (0.1 X_e + 1)$$

and for steam-water,

$$V_j = 18.1 V_n / (X + 18.1)$$

where

V_n = homogeneous nozzle velocity (ft/sec)

X_e = equivalent inlet quality for air-water tests (equivalent weight-percent steam).

X = steam-water quality (weight-percent steam).

5.0 FUTURE WORK

The development program has been stalled because KRB is only interested in the test if a new separator geometry is provided, and RWE and Bayernwerk will only agree to the test if full responsibility for downtime and damages is assumed by someone else. Until such time as these problems are resolved, the development program has been delayed. The current contract termination date is May 31, 1968. If the downtime problem can be solved, then the program would be restarted in June 1968, and Phase II completed. A new proposal for Phase III would be submitted with the work to start about October 1968. The over-all objective would be to complete Phase III during calendar year 1969. The exact timing of the Phase III program can only be set once the KRB refueling schedule is firmed up.

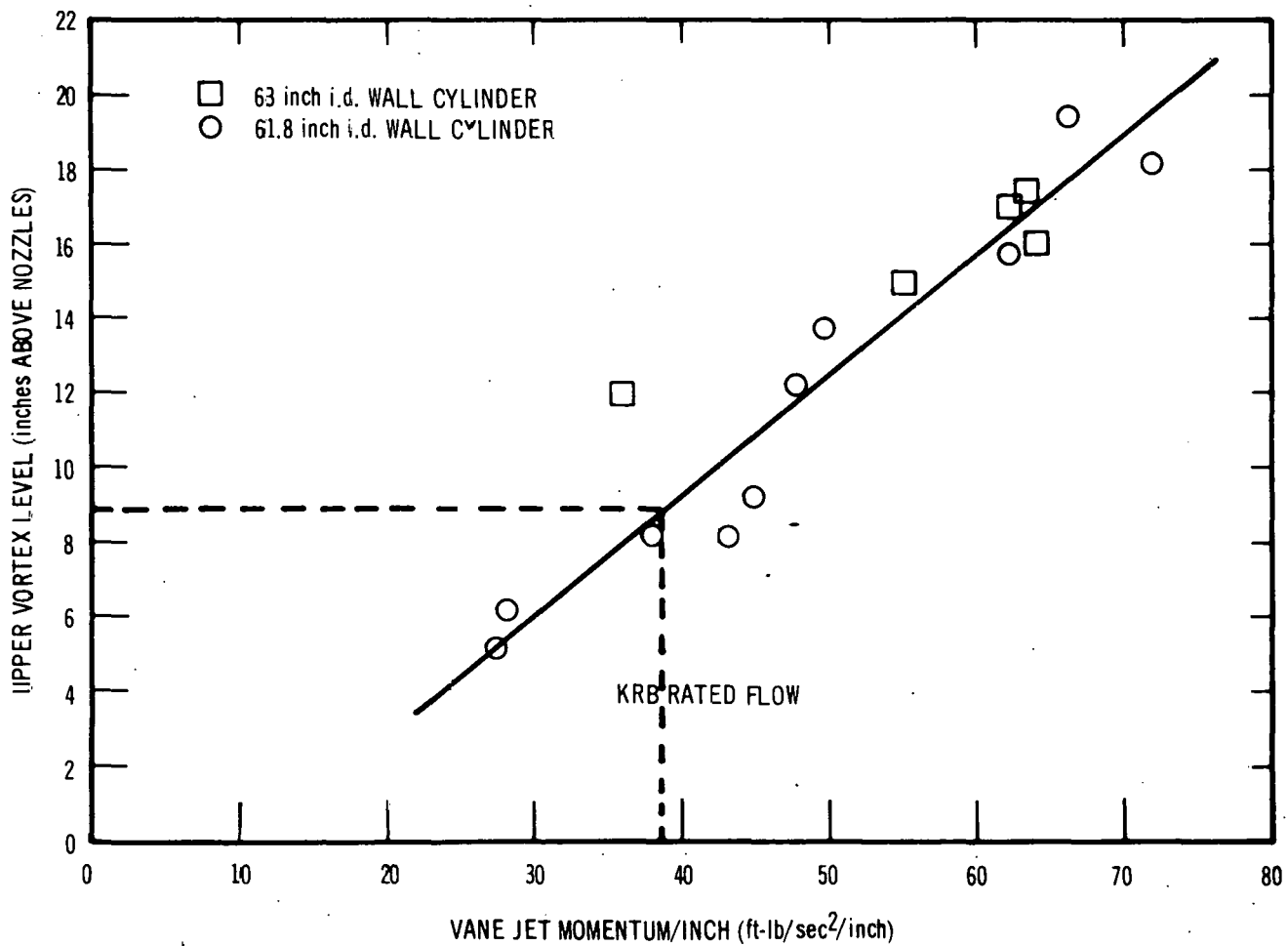


FIGURE 4-7. UPPER VORTEX RISE VERSUS VANE JET MOMENTUM

TABLE 4-3
DATA FOR FIGURE 4-7

Run	Wall Cylinder Inside Diameter (in.)	Homogeneous Nozzle Velocity (ft/sec)	Equivalent Inlet Quality (percent)	Vane Jet Velocity (ft/sec)	Water Flow Rate Per Vane (lb/sec)	Vane Jet Momentum Per Inch (ft-lb/sec ² /in)	Rise of Upper Vortex Above Nozzles (in.)
031801	63	47.1	6.1	29.3	13.2	64.1	16.0
031802	63	60.2	14.5	24.6	8.8	36.1	12.0
031803	63	39.3	4.2	27.7	13.5	62.3	16.5
031804	63	36.6	3.4	27.3	13.9	63.4	17.5
031805	63	22.6	0	22.6	14.7	55.1	15.0
932204	61.3	31.4	4.4	21.8	10.5	38.2	8.2
032205	61.8	34.9	3	26.8	13.9	62.3	15.7
032206	61.8	40.7	4.2	28.7	13.9	66.4	19.2
032207	61.8	41.7	7.1	24.4	10.6	43.1	8.2
032208	61.8	59.5	11.7	27.4	10.5	47.7	12.2
032209	61.8	60.1	17.2	22.1	7.5	27.5	5.2
032210	61.8	48.9	9.1	25.6	10.5	44.9	9.2
032211	61.8	50.7	6.3	31.1	13.9	72.0	18.2
032212	61.8	21.4	0	21.4	13.9	49.8	13.7
032213	61.8	16.2	0	16.2	10.5	28.2	6.2

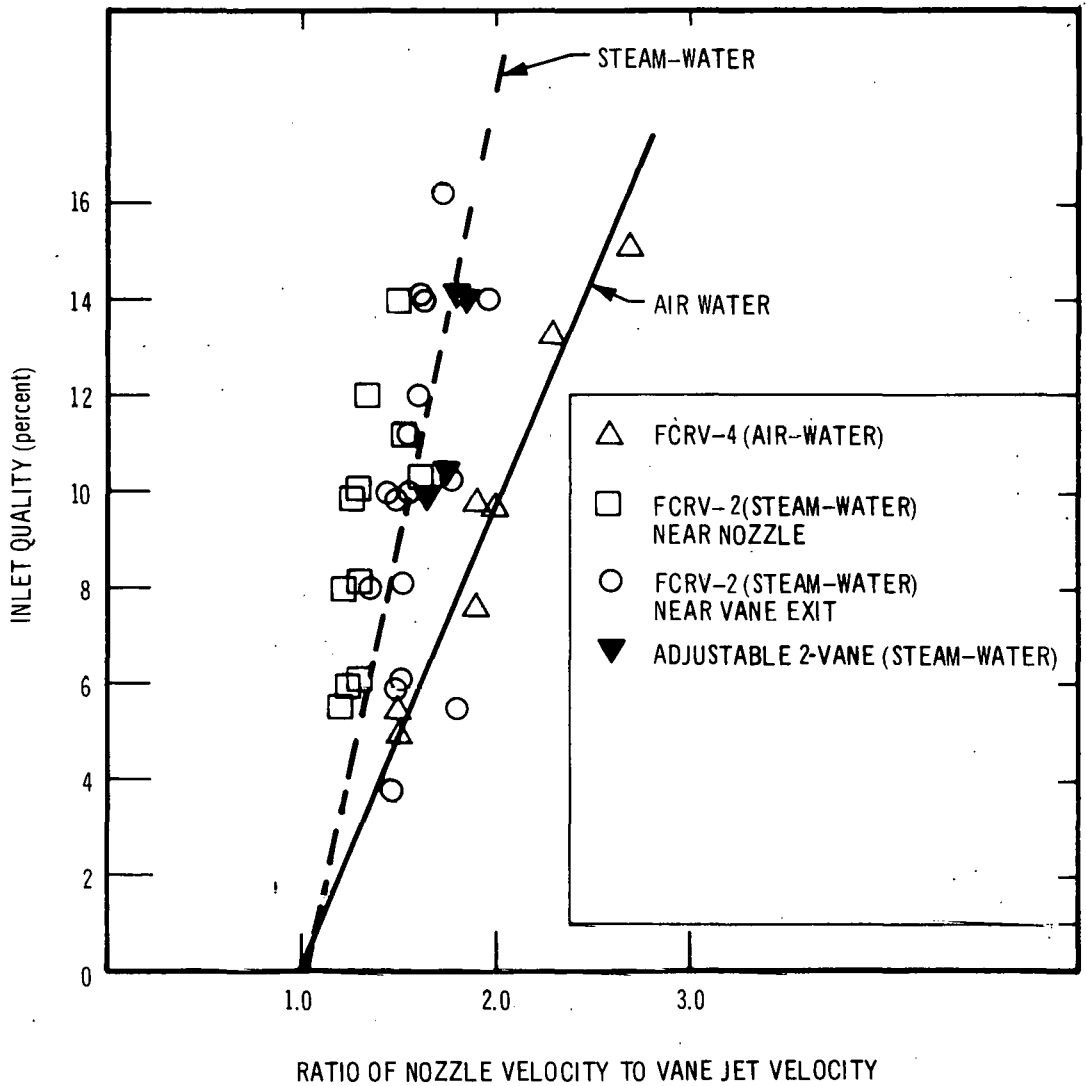
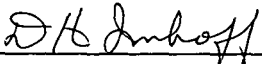



FIGURE 4-8. RADIAL VANE SEPARATOR INLET QUALITY VERSUS RATIO OF NOZZLE VELOCITY TO VANE JET VELOCITY

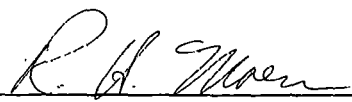
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