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FINAL RESULTS OF
PRODUCTION TEST IP-348-I
K AREA LOW-FLOW CALIBRATION TEST

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FINAL RESULTS OF
PRODUCTION TEST IP-348-I
K AREA LOW-FLOW CALIBRATION TEST

INTRODUCTION

K area emergency water backup studies have been hampered by poor data on flow through the reactor under various emergency conditions. Various tests have been run where emergency conditions have been simulated and flow measurements attempted. In all previous tests, the accuracy of the flow measurements have been questionable. Flow from the high-pressure crosstie can be measured by an orifice in the crosstie, but there has not been any method of measuring the service water contribution to total reactor flow under simulated emergency conditions.

One method of measuring the total reactor flow regardless of its source is to determine the relationship between total flow through the reactor and the bottom of riser pressure. After this relationship has been determined for the flow range of interest, then flow to the reactor can be determined by reading bottom of riser pressure (BORP) and converting that to flow.

The objective of this production test was to obtain the relationship between BORP and total reactor flow in the range of 10,000 gpm to 25,000 gpm. An additional objective of this test was to check the accuracy of the No. 2 pump discharge venturi.

SUMMARY

On November 11, 1960, the east clearwell at KW reactor was drawn down with the No. 2 low-lift pump. The flow indicated by the draw-down test and the flow indicated by No. 2 pump discharge venturi were compared. The flow indicated by the draw-down data was from 0.2 per cent to 0.6 per cent less than the flow indicated by the pump discharge venturi. The accuracy of the measurements used in the draw-down test was considered to be ± 1 per cent; therefore, the calibration curve of the venturi was not changed and its accuracy is considered better than ± 1 per cent.

On November 13, 1960, accurate measurements of reactor flow and BORP were made. The flow to the reactor was measured by supplying all flow through the No. 2 low-lift pump and using the No. 2 pump venturi to measure the flow. The BORP was measured with a Heise gauge. The flow and BORP were recorded at 26,200 gpm, 19,700 gpm, 14,000 gpm, and 12,400 gpm. A plot of flow vs. BORP is shown in Figure 1. A plot of flow vs. pressure drop due to friction (ΔP_f) is shown in Figure 2. These measurements are believed accurate within ± 2 per cent.

TEST DETAILS

On November 11, 1960, a draw-down test was conducted at KW using the procedure outlined in Appendix A. All water flow into the east clearwell was stopped and all pumps except No. 2 low-lift pumping from the east clearwell were

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stopped. The level of the clearwell was read with a bubble manometer capable of reading water level to ± 0.1 inches. Level readings were taken every ten minutes for one hour and twenty minutes at a constant flow rate. The differential pressure across the No. 2 pump venturi was recorded with a mercury manometer. During the first hour and twenty minutes, the flow indicated by the manometer, using the common calibration curve, was 10,600. The draw-down data indicated that the flow was 10,530 gpm.

The flow rate to the reactor was reduced slightly by throttling the front crossheaders. The draw down was continued for another 50 minutes. In this case the flow rate indicated by the pump venturi was 9,680 gpm, and the draw-down data indicated a flow rate of 9,700 gpm. In both portions of the test, the flow indicated by the draw-down data was slightly less than that indicated by the pump venturi. The differences were - 0.6 per cent and - 0.2 per cent.

The theoretical accuracy of the draw-down test was considered to be ± 1 per cent. The differences in indicated flow rate between the draw-down test data and the venturi are less than the theoretical accuracy of the test. Therefore, the calibration of the No. 2 pump venturi was not changed and its accuracy is considered to be better than ± 1 per cent.

On November 13, 1960, the data for the low-flow calibration of KW reactor were taken. The reactor was valved to the normal valving arrangement used when the reactor is operating. All flow was supplied to the reactor by the No. 2 low-lift pump. The flow to the reactor was measured by the previously calibrated No. 2 pump discharge venturi. The bottom-of-riser pressure was measured by a Heise gauge. All flow was supplied to the reactor through the A-B risers. Several different flow rates were obtained by throttling the No. 2 pump with its PD valve. The data shown in Table 1 were obtained.

Step No.	BORP (psig)	Venturi Δp (inches of water)	Flow (gpm)	(1)-(2) ΔP_f (psi)
1	37.5	297	26,200	13.2
2	32.0	171	19,700	7.8
3	28.5	88	14,000	4.4
4	27.6	68	12,400	3.5

- (1) ΔP_f is the pressure drop through the reactor due to friction. It is BORP minus the static head from 0' level to the level of the water overflowing into the downcomer. Static head correction from HW-59892.
- (2) HW-59892, Benson, J.L., "K Area Hydraulic Working Curves and Numerical Results of PT-IP-130-A, K Reactor Trip-Out Test Down to Crosstie Back-Up, 11/18/50 (Secret).

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The conditions under which the data in Table 1 were obtained are these:

1. Reactor valved for normal operation.
2. Flow supplied by the A-B risers only.
3. Water temperature = 12°C.
4. Effective flow tubes = 2938.
5. Reactor loaded with 2,204 tubes of K-III-N, 403 tubes of K-III-E, 603 tubes of solid metal, and 10 inactive tubes.

The data shown in Table 1 has been graphically presented in two ways. Figure 1 is a graph of flow vs. bottom of riser pressure. This curve can be used directly to convert BORP readings in any future test into flow rates, under similar loading conditions.

Figure 2 shows a plot of flow vs. pressure drop through the reactor.

This curve illustrates the very low pressure drop through the reactor under low-flow conditions. It also points out the extreme accuracy necessary in pressure measurements to insure accurate flow data.

The data provided by this document can be used in future K area tests in which low-flow measurements are needed. This document does not present actual flow rates for any particular emergency condition but presents a method of measuring flow rate after an emergency condition has been simulated. The data in this document were taken at KW reactor, but the KE-KW reactor low-flow characteristic should be very close to the same.

A word of caution is necessary regarding measurement of BORP in a flow test. An accurate BORP reading is extremely important if accurate flow data are to be obtained. An error of one psi can cause an error of ten per cent in the measured flow rate.

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Process Engineering Unit
Process Technology
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Figure - I
K W Reactor Low Flow Hydraulic Demand Curve

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Figure - 2
KW Reactor Friction Pressure Drop

NOTE: Max. Flow = 40 gpm

TI	Flow	Pressure
100	1000	1000

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APPENDIX A

DETAILED OPERATING PROCEDURE FOR PT-IP-348-I

DRAW-DOWN TEST

STEP 1

Part 1

1. As soon as possible after KW reactor has been shut down, isolate the east clearwell from the water system.
2. Set up the following pumping arrangement at KW:
 - a. Low lift #4 pressurizing the crosstie. Valves FB-5 open; FB-1, FB-2, FB-3, and FB-4 closed.
 - b. Low-lift pumps 5 and 6 supplying C-D risers.
 - c. Low-lift pump #2 supplying A-B risers.
 - d. Two service water pumps pumping from the west clearwell.
 - e. All boiler feed water coming from west clearwell. Condenser should be switched to raw water.

As soon as the pumping arrangement is established, notify all personnel to start taking readings. The readings to be taken are as follows:

- 1) Record the level of the clearwell and starting timing the drop of the clearwell with a stop watch. Record the exact time at which the stop watch is started. (Process Technology will provide someone to help take readings.)
 - 2) During the time that the clearwell is being drawn down, record the pressure drop across the #2 pump venturi with the mercury manometer. These readings must be taken at ten-minute intervals and the exact time of each recorded. Use the attached data sheet for all records.
 - 3) When the clearwell has been drawn down about three feet, take final readings and return inlet flow to the east clearwell.
- f. The reactor flow can now be returned to normal by:
- 1) Back up the crosstie with the #3 pump.
 - 2) Close FB-5 valve.

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When operations are ready, they should valve to the crossunder in the normal manner. Continue to supply the A-B side of the reactor with the #2 pump.

Part 2

1. At some time during charge-discharge, set up the following valving:
 - a. The pile will at this time be supplied by the #2 low-lift pump and #3 pump is supplying the crosstie. FB-1 and FB-2 valves will be closed.
 - b. Close FB-3 and FB-4 valves.
 - c. Start low lift #4.
 - d. Open FB-5 valve.
 - e. Stop pump #3.
 - f. If a service water pump is drawing from the east clearwell, shut it off. Two service water pumps must be running on the west clearwell.
2. Again, allow the clearwell to draw down three feet and record the necessary readings on the attached data sheet.

STEP 2

In step 2 of this test, which consists of using the #2 pump discharge venturi which was calibrated in step 1 of this test, obtain TORP and flow readings at 25,000 and 10,000 gpm. The following procedure will be used:

Part 1

After charge-discharge is complete and the reactor is valved back to normal, with flow supplied to the reactor by the #2 and #4 low-lift pump, and #3 low-lift pump supplying the crosstie, set up the following valving:

1. Place KW V-73 valve on manual close. Someone must stand by to open it if the test Heise pressure drops to 25 psi. The KW and KE V-72 valves must be open.
2. By-pass the inner and outer Ball 3X ELP trips. Process water pressure must be monitored continuously. The inner and outer ball system must be tripped upon failure of process water supply.
3. Place the V-73 valve automatic scram intertie on by-pass.
4. Close SE-1 and SE-2 valves at KW.

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5. Close FB-3 and FB-4 valves (FB-1 and FB-2 should be closed).
6. Start low lift #4.
7. Open FB-5 valve.
8. Close PD-1, PD-3, PD-5, and PD-6 valves.
9. Stop low lift #3.
10. At this point, #4 is backing up the crosstie.

Water is now being supplied to the reactor by only the #2 low-lift pump through the calibrated venturi.

At this point, take test Heise readings and pump venturi differential readings and record on the attached data sheet.

Part 2

1. Throttle the #2 low-lift flow with the PD-2 valve until a flow of 10,000 gpm is achieved. (This flow should be approached slowly and measured by the Foxboro and Republic transmitters. The Heise reading should be about 28 psi.
2. Again take TORP and venturi differential readings.
3. Return the system to normal by:
 - a. Unthrottle the PD-2 valve.
 - b. Start the #3 low-lift pump.
 - c. Open PD-1, PD-3, PD-5, and PD-6 valves.
 - d. Close FB-5 valve.
 - e. Open SE-1 and SE-2 valves.
 - f. Open FB-3 and FB-4 valves. (Pump #4 is running.)
 - g. Place the V-73 valve on automatic.

This completes the low-flow calibration test.

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