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PRELIMINARY REPORT OF
PRODUCTION TEST IP-244 A

TRIP OUT OF KE REACTOR NO. 2
PROCESS PUMP SET

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PRELIMINARY REPORT OF PRODUCTION TEST IP-244-A
TRIP OUT OF KE REACTOR NO. 2 PROCESS PUMP SET

By

S. S. Jones

October 15, 1959

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PRELIMINARY REPORT OF PRODUCTION TEST IP-244 A

TRIP OUT OF KE REACTOR NO. 2 PROCESS PUMP SET

INTRODUCTION

This test was conducted to determine the flow decay characteristics following the loss of power to the primary pumps. In a full loss of pumping power, both the primary and secondary pumps decay in flow. Under this condition, the loss in the secondary pump suction pressure is balanced by a loss in pumping flow and no significant cavitation occurs in the secondary, or Hi-lift, pump. In the case of the loss of only the 4.16 kv emergency power, the primary, or Lo-lift, pumps will decay in speed and cause a rapid decrease in the secondary pumps' suction pressure while they continue to operate at full speed. Thus, in this case, severe Hi-lift pump cavitation will result.

which pumps or pipes?
Depending upon the severity of this transient either pump damage, or effluent piping damage, or both could occur.

This report presents the results of tests on the #2 KE pump-set which simulated the loss of 4.16 kv power to the water plant for both 5-pump and 6-pump reactor operation.

SUMMARY

Two tests were run on the KE-Reactor #2 pump set on May 6, 1959 to simulate the loss of 4.16 kv power to the primary pumps under 5-pump and 6-pump operating conditions. These showed the loss of 4.16 kv power under 6-pump conditions to give less than BPA failure flow decay, but severe vibrations after 25 seconds leading to possible line rupture and water failure. In the case of loss of 4.16 kv power with 5-pump operation there is a large initial flow decay followed by a satisfactory level of reactor flow without severe vibrations and pump failure conditions.

On the basis of these tests it is recommended (1) that an automatic speed reduction be installed that will reduce the Hi-lift pump speeds from 1700 to 1580, whenever there is a loss of 4.16 kv power to the lo-lift pumps, and

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(2) that the K reactors operate under revised bulk temperature limits whenever only 5 pump sets are running.

DISCUSSION

History: In the original establishment of the K-Reactor bulk temperature limits, only a general BPA outage event was considered.⁽¹⁾ Since this time the increased pumping system flow combined with the decreased reactor resistance has considerably deminished the ratio of normal pumping flow rate to the cavitation cut-off flow rate. This has raised the question of the flow decay characteristics when the 4.16 kv power is lost and severe cavitation of the Hi-lift pumps occur. Operation in the severe cavitation region presents pump failure hazards, and the effects are considered more severe for parallel pumps than for single operation, therefore, this test was devised to take advantage of the special energy absorbing piping that was installed for the testing of the new CG-775 pump-set. This permitted testing a single pump-set while simulating total reactor conditions.

Test Procedure: This test was performed on a single pump-set with the discharge flow diverted from the reactor to an energy absorption system having reactor resistance characteristics.⁽²⁾ Measurements were obtained of the following parameters:

1. Lo-lift pump discharge pressure
2. Lo-lift pump speed
3. Hi-lift pump suction pressure
4. Hi-lift pump discharge pressure
5. Pressure-drop across flow measuring orifice
6. Magnitude of pump bearing vibrations
7. Strains introduced in the first elbow in pump line downstream of the Hi-lift pump.

(1) HW-51327 "Preliminary Analysis of Bulk Outlet Water Temperatures," S. S. Jones, May 8, 1957, pg-16.

(2) HW-60659, "Report of Preliminary Testing P.T. IP-234-AE, Project CG-775, Prototype Testing of the 190-K Process Pumping Unit", M. H. Schack, et al, June 15, 1959.

The actual test consisted in establishing a flow through the No. 2 pump-set and regulating the Hi-lift pump discharge pressure to agree as nearly as possible with that expected for 6-pump operations thru the reactor. Steady state conditions were maintained long enough at this condition to obtain reference data, and then the power was tripped from the #2 Lo-lift pump motor. The decay characteristics were then followed with the test instrumentation.

A second test was performed simulating reduced speed, 5-pump operation. In each case the Hi-lift pump discharge was diverted through the special piping system installed for testing the #1 CG-775 pump-set.

Test Results: The significant data obtained or developed from this test are presented in Tables I, II, and III. Table I shows the experimental flow decay for the loss of power to the lo-lift pump while the pump-set is operating at full flow against a resistance simulating a K_{II} reactor charge. In figure 1, the resulting flow decay is compared with that for a theoretical BPA outage.

The flow decay for this case is less than for the loss of all BPA power. However, as shown in Table III, as the flow decay continues, severe cavitation is produced which could lead to the sudden failure of one or more pumps. Such a condition, therefore, might end up with severe flow reductions, caused by pump failure, that would result in much more severe flow decay than indicated by the test curves. Therefore, it is important to prevent or minimize such an operating condition.

In the case of the simulated loss of 4.16 kv power from 5-pump operation, the initial flow decay was more rapid than for a BPA outage, but it soon leveled off to a higher value. In the same manner the pump vibrations increased very rapidly at first and then leveled off at a value only one quarter those obtained for the 6-pump case. The results of this test are shown in figure 2. It is interesting to note that although the 5-pump operation goes

TEST NO. 1

K-Pump Flow Decay Simulating
6-Pump Operation

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TEST NO. 2

K-Pump Flow Decay Simulating
5-Pump Operation.

into cavitation sooner, the mechanical damage of the cavitation appears to be much less severe.

The obvious explanation for this difference in cavitation effects is the difference in secondary or Hi-Lift pump specific speed for the two cases.

CONCLUSIONS AND RECOMMENDATIONS

From these results we conclude that the loss of 4.16 kv power at an operating K-reactor will have the following effects:

1. Loss of 4.16 Kv Power With 6-Pump Operation: The initial bulk temperature surge will not exceed 40°C; but after 30 seconds severe pump damage may occur.

2. Loss of 4.16 Kv Power With 5-Pump Operation: The initial bulk temperature surge will be about 100°C; but the flow decay will level out at about 80 percent of the original value, and no severe pump vibration occurs.

To alleviate the 6-Pump operating problems, there should be an automatic Hi-Lift pump speed reduction upon the loss of 4.16 kv power. This will combine the advantages of small initial flow decay with a low level of pump mechanical damage. The problems associated with 5-Pump operation can be alleviated only by a proper suppression of the reactor bulk temperature limit. This will be presented in a future report.

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TABLE I: TEST #1

SIMULATED LOSS OF 4160 KV POWER WITH 6-PUMP OPERATION

Time After Pump Trip Sec.	Lo-Lift Pump Discharge Pressure		Hi-Lift Pump Discharge Pressure		Flow 1000 gpm	Relative Flow	
	Psig	Speed RPM	Psig	Speed RPM		Exper.	Thec.
0	42.5	590	410	1696	30.0	1.0	1.0
1	30.0	---*	404	1696	29.8	.994	.971
2	26.5	---	400	1696	29.7	.987	.945
3	16.5	---	392	1696	29.3	.976	.917
4	13.0	---	382	1696	29.0	.965	.895
5	8.5	---	372	1696	28.4	.943	.869
7	5.5	---	330	1696	26.4	.881	.825
9	5.0	---	294	1696	24.8	.828	.786
11	2.5	---	262	1696	23.4	.780	.750
15	1.0	---	220	1696	21.0	.701	.688
20	0.0	---	172	1696	18.2	.605	.623
25	---	---	150	1696	16.6	.554	.570
30	---	---	130	1696	15.3	.510	.524

* Pump speed decay did not function.

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TABLE II: TEST #2

SIMULATED LOSS OF 4160 KV POWER WITH 5-PUMP OPERATION

Time After Pump Trip Sec.	Lo-Lift Pump		Hi-Lift Pump		Flow 1000 gpm	Relative Flow	
	Discharge Pressure Psig	Speed RPM	Discharge Pressure Psig	Speed RPM		Exper.	Theo.
0	42.5	590	330	1600	32.0	1.0	1.0
1	39.5	---	294	1600	29.8	.931	.972
2	37.5	---	268	1600	28.4	.887	.948
3	34.5	514	246	1600	27.1	.848	.920
4	31.5		226	1600	26.0	.813	.897
5	28.0	464	216	1600	25.0	.782	.873
7	22.0		200	1600	23.7	.740	.831
9	18.0	397	192	1600	23.0	.718	.793
11	13.5		184	1600	22.5	.704	.758
15	6.5	327	176	1600	22.0	.688	.696
19	---	304	---		---	---	---
20	0.0	---	166	1600	21.3	.667	.632
25	---	270	162	1600	20.9	.652	.579
30	---	245	158	1600	20.6	.645	.534

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TABLE III

VIBRATION DATA - HI-LIFT PUMP

NOTE: The following vibration readings were measured with the IRD during the tests.
All readings are in mils.

<u>Test Number</u>	<u>Hi-Lift Pump Speed, RPM</u>	<u>Outboard Pump Bearing</u>			
		<u>Radial</u>		<u>Thrust</u>	
		<u>Horizontal</u>	<u>Vertical</u>	<u>Vertical</u>	<u>Axial</u>
1	1696 (Rated)	0.6	0.6	1.0	0.7
(Simulated 6-Pumps)					
	During 30 Sec. Trip			10.0 (Max. at 27 Secs.)	
2	1600	0.6	0.6	1.0	0.7
(Simulated 5-Pumps)					
	During 30 Sec. Trip	1.0	1.0	3.0	2.5

In Test No. 2, level reached 3 mils vibration quickly and remained at this level.