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NUMERICAL RESULTS OF PRODUCTION TEST IP-651-AI, TRIPOUT TEST - H REACTOR

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NUMERICAL RESULTS OF PRODUCTION TEST IP-651-AI
TRIPOUT TEST - H REACTOR

by

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IRRADIATION PROCESSING DEPARTMENT

March 12, 1964

HANFORD ATOMIC PRODUCTS OPERATION
RICHLAND, WASHINGTON

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NUMERICAL RESULTS OF PRODUCTION TEST IP-651-AI
TRIPOUT TEST - H REACTOR

I. INTRODUCTION

During the January, 1964, outage at H reactor, major rear-face hardware modifications were performed and enlarged venturis were installed full reactor. These modifications significantly change the reactor hydraulic characteristics. Process Standards - Water Plant, 190-B-070, requires tripout tests be performed whenever a major change is made to either the process pumping system or the reactor hydraulic characteristics. Production Test IP-651-AI was performed on January 17, 1964, to evaluate (1) transient flow decay characteristics associated with complete loss of BPA electrical power to 100-H area, (2) riser pressure trip settings for the ball 3X system, and (3) backup adequacy of the last-ditch coolant system. The purpose of this document is to report the numerical results of this test.

II. SUMMARY AND DISCUSSION OF TEST DATA

There were 1985 flow tubes during the test. Of these tubes, 1975 were fitted with 0.344" venturis; the remaining 10 tubes were fitted with PCCF nozzles. The fuel loading consisted of:

<u>No. of Tubes</u>	<u>Charge Makeup</u>
1	Water column
7	Graphite stringer
10	PCCF
11	Air channels
18	36 OIIIIE plus 1 OIIIW plus three 5" I&E Li Al
30	37, 8" Pb Cd
78	62, 4" I&E Li Al, or 53, 5" I&E Li Al
96	47, 6" Li Al
643	43 OIIIIE
1110	40 OIIIIE plus 1 OIIIW plus three 5" I&E Li Al
2004	

The following data were recorded to establish the hydraulic demand curves:

<u>TORP, psig</u>	<u>Flow, gpm</u>	<u>T₁, °C</u>	<u>T₀, °C</u>
561	88,200	8.9	14.9
543*	91,750	7.5	86
19.5	11,100	4.4	--
108	30,385 (7 steam turbines)		

*Determined during reactor operation.

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The above pressures and flow were determined with the reactor completely unthrottled. The flow of 88,200 gpm was measured by the 190 electric pump flow meters. The flow of 91,750 gpm was measured by the 105 flow transmitters. The 11,100 gpm flow was calculated from high-tank water level drop data. The 30,385 gpm flow was measured by the steam pump flow meters. These data are plotted as hydraulic demand curves in Figure 1. The curves are parallel to the previous H reactor demand curves published in HW-72699.¹

The steam pump flow data point does not fall on the curve. The riser pressure was measured independently at two separate stations with agreement. Apparently the steam turbine pump flow meters are in error. This has not been verified.

A TORP of 22.4 psig was obtained by plotting the test TORP versus the high tank level data and extrapolated to full high tank level (Figure 2). A flow rate of 12,900 gpm was determined from the hydraulic demand curve at 22.4 psig TORP.

A combined high-tank export flow of 15,000 gpm was determined from the test TORP (27 psig) and the hydraulic demand curve. The high-tank contribution was calculated from level drop data to be 8,900 gpm. The export contribution was calculated from the net difference in these flows as 6,100 gpm.

Stable export system flows (high tanks valved off) were determined from the test TORP and the hydraulic demand curve and are presented below.

<u>TORP, psig</u>	<u>Export Flow, gpm</u>	<u>Condition</u>
11.6	6,600	282-W overhead bypass open with 4.0" orifice; cone valve 40 percent open 282-E overhead bypass open with 4.0" orifice; cone valve 55 percent open.
12.4	7,100	282-E and W cone valves closed.

Export system transient and stabilized pressure data are presented in Table 1 and Figure 3. Riser pressure, pump discharge pressure, and speed transients are plotted in Figures 4, 5, 6, and 7 and presented in Tables 2 and 3.

¹Jones, S.S., J.E. Morrissey, and J.L. Manuel, Reactor Process Flow Technical Data, HW-72669, dated 2/15/62, (Secret).

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Present ball 3X riser pressure trip settings are LP = 470 psig and VLP = 320 psig. Riser pressure decay between these trip settings is 10.1 seconds. These trips are adequate; however, the time lapse between LP-VLP trip pressures can safely be lengthened to 11.3 seconds if they are reset to 440 psig and 290 psig, respectively.

Detailed test data are presented in Table 1.

Pressure instrumentation elevation corrections are presented in Table 4.

Detailed test procedures, communications systems, and instrument requirements are presented in HW-80306.²

III. GENERAL TEST PROCEDURE

Basically the test consisted of a simulated complete BPA power failure resulting in loss of power to the front and rear buses at 151-H and subsequent loss of electric pumping capacity in the 190 Annex. Prior to the test, eight 190 Annex pumps were operating at full pressure and coolant flow. The 190 steam turbine pumps were prevented from contributing coolant flow by closing the steam supply valves. The incoming electrical service to 151-H front and rear buses was tripped out, initiating the test. Riser pressure was allowed to decay until high-tank export flow stabilized. Riser pressure in the 105-H control room was continuously photographed. Speed and discharge pressure on one annex pump were continuously recorded. Export system transient response was recorded at the following locations: 105 export Grove valve, 182-B and H export manifolds, and the 282-E and W reservoir valve pits. After collecting sufficient data, the export flow was valved off. High tank flow was measured by water level drop indicated by mercury manometers. When sufficient data were collected, the high tanks were valved off and export flow restored. Export flow was measured with the 282-E and W cone valves partially open (normal position) and then completely closed. The 282-E and W overhead bypass lines (4.0" orifice) were open throughout the test. None of the area surge suppressors cycled when the export Grove valve tripped open. At the end of the test, seven steam turbine driven pumps were accelerated to full pressure and coolant flow and equilibrium data recorded.

IV. CROSSHEADER SCREEN PLUGGING

Front crossheader and Panellit pressures of the outermost gauges on each row were recorded before and after the test at 500 psig TORP to determine the extent of screen plugging. The data are presented in Table 5. Examination of crossheader screens revealed that they were partially plugged on the far side only. The relative amounts of scale found in the screens

²Morrissey, J.E., R.E. Spicka, and S.S. Jones, Production Test IP-561-AE, Tripout Test - H Reactor, HW-80306, dated January 9, 1964.

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were in general agreement with the pressure data. A flow loss of 400 gpm at 500 psig TORP was noted. Both high tank screen chests and the 105 export screen chest were examined after the test and found to be free of scale or crud. Therefore, the material found on the crossheader screens originated downstream of these chests. It is credible that the scale originated in one of the normally "dead" legs of the high-tank export piping and that the relatively high velocity during the test period removed the surface scale and transported it to the crossheader screens.

V. UNUSUAL OCCURRENCES

At 2:21 pm following acceleration of the 182-H steam turbine pumps, 190 Power personnel heard a loud bang when a check valve slammed. This noise was not heard or felt in the 105 control room. Personnel at the near high tank screen chest heard a slight noise about the same time.

At 3:55 pm when the steam turbine pumps were being dropped off the line at a fast rate and the annex pumps were being accelerated, both 190 Power and 105 Control Room personnel heard a loud bang as a check valve slammed.

It has not been conclusively established which check valve(s) was involved.

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FIGURE 1

H REACTOR DEMAND CURVE

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FIGURE 5

190-H ANNEX PUMP
TRANSIENT PERFORMANCE DATA

TABLE 1

TRIPOUT MASTER DATA SHEET

Time 1/17/64 Minutes	Remarks (') denotes minutes (") denotes seconds	Near High Tank Level		Near Screen Chest Pressure		ΔP psi	Far High Tank Level		Far Screen Chest Pressure		ΔP psi
		Mano. In Hg.	In Hg. Min.	Upstm. psig	Dnstm. psig		Mano. In Hg.	In Hg. Min.	Upstm. psig	Dnstm. psig	
(14:11 hrs) 0		43-11/16		69.1	69.1	0	115-1/16		69.4	69.4	0
1		43-11/16	0				115-1/16	0			
2	2'+5" near & far high tanks check valves open	43-11/16	0	53.0	48.0	5.0	114-14/16	3/16	63.1	57.0	6.1
3		43-11/16	0				114-8/16	6/16			
4		43-8/16	3/16	---	---	---	114-1/16	8/16	53.4	47.5	5.9
5		43-6/16	2/16				113-1/16	15/16			
6		42-14/16	10/16	52.0	46.6	5.4	112-6/16	11/16	52.7	47.6	5.1
7		42-6/16	8/16				111-13/16	9/16			
8	8'+55" Grove valve trip	41-13/16	9/16	52.0	46.3	5.7	111-4/16	9/16	52.7	47.3	5.4
9		41-5/16	8/16				110-12/16	9/16			
10	10'+10" 182-H steamer came up.	40-15/16	6/16	57.0	53.0	4.0	110-4/16	8/16	59.5	56.9	2.6
11		40-9/16	6/16				109-15/16	5/16			
12		40-4/16	5/16	56.8	53.5	3.3	109-9/16	6/16	59.2	56.3	2.9
13	Far high tank in straight section.	39-13/16	7/16				109-2/16	7/16			
14		39-7/16	6/16	56.5	53.0	3.5	108-12/16	6/16	58.9	56.0	2.9
15		39-1/16	6/16				108-6/16	6/16			
16		38-11/16	6/16	56.0	53.0	3.0	108-0/16	6/16	58.7	55.8	2.9
17		38-5/16	6/16				107-9/16	7/16			
18	Near high tank in straight section.	37-15/16	6/16	56.0	52.5	3.5	107-3/16	6/16	58.5	55.7	2.8
19		37-9/16	6/16				106-13/16	6/16			
20		37-3/16	6/16	55.7	52.5	3.2	106-7/16	6/16	57.6	55.2	2.4
21	Stable hightank- export flow.	36-12/16	7/16				106-2/16	5/16			
22		36-6/16	6/16	55.5	52.3	3.2	105-11/16	7/16	57.5	55.2	2.3
23		36-1/16	5/16				105-5/16	6/16			
24		35-11/16	6/16	55.0	52.0	3.0	105-0/16	5/16	57.7	55.0	2.7
25		35-5/16	6/16				104-10/16	6/16			
26	Start valving export flow off.	35-0/16	5/16	55.0	51.7	3.3	104-4/16	6/16	57.1	54.8	2.3
27		34-10/16	6/16				103-14/16	6/16			

TABLE 1 (Cont.)

[illegible]

TABLE 1 (Cont.)

<u>Time</u>	<u>Remarks</u>	Near High <u>Tank Level</u>	Near Screen <u>Chest Pressure</u>	Far High <u>Tank Level</u>	Far Screen <u>Chest Pressure</u>	
<u>1/17/64</u>	(') denotes minutes	<u>Mano.</u> <u>In Hg.</u>	<u>Upstm</u> <u>Dnstm.</u>	<u>Mano.</u> <u>In Hg.</u>	<u>Upstm.</u> <u>Dnstm.</u>	<u>ΔP</u>
<u>Minutes</u>	(") denotes seconds	<u>In Hg.</u> <u>Min.</u>	<u>psig</u> <u>psig</u>	<u>In Hg.</u> <u>Min.</u>	<u>psig</u> <u>psig</u>	<u>psi</u>
55	282-E & W cone valves closed.					
56	Stable export flow					
57						
58	Start 190 steam turbines.					
59	Start opening 282-E & W cone valves.					
60						
61						
62	282-E & W cone valves open.					
63						
64						
65						
66						

TABLE 1 (Cont.)

Time 1/17/64 Minutes	TORP 105 Control Room Heise psig	TORP 190 Control Room Heise psig		TORP 105 Control Room Photographic psig	Flow 190 Flow Meters gpm
		Near	Far		
0	561	560	562	561	88,200
1	--	99		99	
2	44	45		44.0	
3	29	30		29.6	
4	22.5	23		22.5	
5	21.2	20.5		21.2	
6	21.2	20		21.2	
7	21.1	20		21.2	
8	20.9	20		21.2	
9	22.5		20.5	22.0	
10	27.6	25		27.4	
11	27.75		26.5	27.6	
12	27.5	26.2		27.5	
13	27.3		26.5	27.4	
14	27.3	26.2		27.4	
15	27.2		26.5	27.3	
16	27.2	26.2		27.3	
17	27.1		26.5	27.2	
18	27.0	26		27.2	
19	26.9		26.5		
20	26.8	26		27.2	
21	27.0		26.2	27.2	
22	26.7	26			
23	26.8		26	27.0	
24	26.6	26			
25	26.4		25.5		
26	26.4	25.9			
27	26.3		25	26.5	
28	26.2	25.8			
29	26.1	--			
30	25.9	25	24.5	26.0	
31	24.0	24.		24.8	
32	20.0		19.0		
33	19.9	19.5			
34	19.8		18.0		
35	19.7	19.2			
36	19.6		18.0		
37	19.5	19.0			
38	19.4		17.5		

TABLE 1 (Cont.)

Time 1/17/64 Minutes	TORP 105 Control Room Heise	TORP 190 Control Room Heise psig		TORP 105 Control Room Photographic	Flow 190 Flow Meters gpm
	<u>psig</u>	<u>Near</u>	<u>Far</u>	<u>psig</u>	
39	19.3	18.9		19.6	
40	19.2		17.5		
41	19.2	18.9			
42	19.1	--			
43	19.3		17.0		
44	22.8	20.0			
45	24.6		22.0		
46	21.0	23.0			
47	11.8		13.0		
48	11.6	11.0	9.5		
49	11.6	10.8	9.2	11.6	
50	11.6	10.8	9.2		
51	11.6	10.8	9.0		
52	11.8	10.8	9.0		
53	12.2		9.5		
54	12.4	11.0			
55	12.4		9.5		
56	12.4	11.0			
57	12.4			12.4	
58	12.4				
59	12.4				
60	12.4			14.0	
61		13.0	12.0		
62					
63					
64					
65					
66	108	104.5	110.4		30385

TABLE 1 (Cont.)

<u>Time 1/17/64 Minutes</u>	<u>Export Grove Valve Upstm. Pressure psia</u>	<u>Export Grove Valve Dnstm. Pressure psig</u>	<u>Export Manifold Pressure 182-H psia</u>	<u>Export Manifold Pressure 182-B psia</u>	<u>Line Pressure 282-E Valve Pit psia</u>	<u>Line Pressure 282-W Valve Pit psia</u>
0	240	300+)	245	240	58	96
1	240	300+)	245	240	58	96
2	240	125)	245	240	58	96
3	240	70)	245	240	58	96
4	240	59)	245	240	58	96
5	240	53)	245	240	58	96
6	240	50)	245	240	58	96
7	240	50)	245	240	58	96
8	240	50)	245	240	58	96
9	232	50	225	240	58	96
10	159	56	212	220	47	74
11	159	75	212	220	47	74
12	163	83	212	220	47	74
13	164	90	212	220	47	74
14	165	92	212	220	47	74
15	165	92	213	220	47	74
16	165	92	213	220	47	74
17	165	92	213	220	47	74
18	165	92	214	220	47	74
19	165	92	214	220	47	74
20	165	92	215	220	47	74
21	165	92	215	220	47	74
22	165	92	215	220	47	74
23	165	92	215	220	47	74
24	165	92	215	220	47	74
25	165	92	215	220	47	74
26	165	92	215	220	47	74
27	165	92	215	220	47	74
28	165	92	215	220	47	74
29	167	94	215	220	47	75
30	169	98	215	220	47	75
31	172	102	230	222	48	77
32	262	--	248	241	60	97
33	237	--	250	240	60	88
34	240	228	248	240	60	88
35	240	228	246	240	60	88
36	240	228	247	240	59	88
37	240	228	246	240	59	88

Data invalid due
to back pressure.

TABLE 1 (Cont.)

Time 1/17/64 Minutes	Export Grove Valve Upstm. Pressure psia	Export Grove Valve Dnstm. Pressure psig	Export Manifold Pressure 182-H psia	Export Manifold Pressure 182-B psia	Line Pressure 282-E Valve Pit psia	Line Pressure 282-W Valve Pit psia
38	240	228	246	240	59	88
39	240	228	246	240	59	88
40	240	228	246	240	59	88
41	240	228	247	240	59	88
42	240	228	247	240	59	88
43	239	228	244	240	59	88
44	233	225	220	230	53	87
45	188	170	218	220	47	72
46	163	90	222	220	46	74
47	162	85	220	219	46	74
48	154	73	220	219	46	74
49	154	73	220	219	46	74
50	154	73	220	219	46	74
51	154	73	220	220	70	74
52	154	73	224	234	92	98
53	168	76	238	248	115	118
54	178	81	250	252	117	122
55	182	82	250	252	117	122
56	182	83	252	252	117	122
57	182	83	252	252	117	122
58	182	83	250	252	107	122
59	182	83	244	240	74	106
60	173	80	225	230	55	82
61	166	80	215		55	78
62	162	80	216			
63	162	80	216			
64						
65						
66						

TABLE 2
TOP-OF-RISER PRESSURE
105-H CONTROL ROOM HEISE GAUGES

<u>Time</u> <u>Min.</u>	<u>Sec.</u>	<u>TORP-psig</u> <u>800# Gauge</u>	<u>Time</u> <u>Min.</u>	<u>Sec.</u>	<u>TORP-psig</u> <u>800# Gauge</u>	<u>TORP-psig</u> <u>100# Gauge</u>
0	-5	561		35	168	
	0	561*		40	148	
0	+	556**		45	132	
0	+	534		50	118	
	1	513		55	107	
	2	487	1	0	99	
	3	464	1	10	82	
	4	450	1	20	70	
	5	432	1	30	61	59.0
	6	416	1	40	53	51.2
	7	398	1	50	48	47.4
	8	383	2	0	45	44.0
	9	368	2	10	42	40.6
	10	356	2	20	40	38.0
	11	344	2	30	37	35.2
	12	333	2	40	34	33.0
	13	322	2	50	32	31.2
	14	310	3	0	31	29.6
	15	298	3	30	27	25.2
	16	288	4	0	24	22.5
	17	280	4	30	22	21.4
	18	269	5	0	22	21.2
	19	261	6	0	22	21.2
	20	246	7	0	22	21.2
	22	232	8	0	22	21.2
	24	219	8	55	22	21.4***
	26	206	9	0	22	22.0
	28	194	9	10	22	24.6
	30		9	20	24	25.5
			9	30	25	26.2
			10	0	27	27.4
			10	30	28	27.8
			11	0	28	27.6
			12	0	28	27.5
			15	0	28	27.3

*BPA Separation Light Bright.

**LXX Light Dimmed

***Export Starts contribution.

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TABLE 3

190-H ANNEX PUMP TRANSIENT DATA

<u>Time After Trip Seconds</u>	<u>Discharge Pressure psig - Uncorrected</u>	<u>Pump Speed RPM</u>
0	620	1800
1	600	---
2	570	---
3	545	---
4	520	---
5	500	---
6	480	---
7	460	---
8	440	---
9	420	---
10	405	---
11	390	---
12	375	---
13	365	---
14	350	---
15	340	---
18	315	---
20	290	---
25	250	---
30	220	1200
35	195	---
40	170	900
45	150	---
50	140	---
55	130	---
60	120	750
75	95	660
90	80	600
105	70	540
120	60	460
150	55	390
180	50	360
210	50	330
240	50	300
270	45	270
300	40	260
330	35	240
360	35	210
390	35	200
420	35	190
450	35	180
480	35	170
510	35	160
540	35	150
570	35	150
600	30	140
630	30	130
660	30	120

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TABLE 4

PRESSURE INSTRUMENTATION ELEVATION CORRECTIONS

Data presented in this report are in the as recorded state; i.e., correction factors have not been made.

1. TORP - no correction necessary.
2. Near high tank screen ΔP gauge center was located - 9'-3" from 105 0'-0" elevation.
3. Far high tank screen ΔP gauge center was located - 10'-1" from 105 0'-0" elevation.
4. Grove valve station pressure recorders were located - 8'-5" from 105 0'-0" elevation.
5. 182-H manifold pressure recorder was located 21" above the pump room floor.
6. 182-B manifold pressure recorder was located approximately 3' above the pump room floor.
7. 282-East and West recorders were located approximately 3' above the valve pit floor.
8. 190 Annex pump pressure transducer was located - 12' from the annex pump room floor.

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TABLE 5

FRONT CROSSHEADER AND PANELLIT PRESSURE DATA

Data taken before and after tripout test to determine the extent of crossheader screen plugging. Data taken at 500 psig, TORP.

<u>Header</u>	<u>Header Pressure psi</u>	<u>Row</u>	<u>Panellit Pressure-psi</u>		<u>Header</u>	<u>Header Pressure psi</u>	<u>Row</u>	<u>Pressure Pressure-psi</u>	
			<u>Near</u>	<u>Far</u>				<u>Near</u>	<u>Far</u>
1	-1	1	0	-7	23	-2	23	-1	-2
		2	0	+11			24	-4	-2
3	-12	3	-6	-7	25	0	25	0	+4
		4	-6	-5			26	+1	+2
5	-10	5	-3	-4	27	-1	27	0	+2
		6	-6	-2			28	0	-2
7	0	7	0	+5	29	-2	29	0	+2
		8	+1	+2			30	0	0
9	-1	9	0	-3	31	-2	31	-1	0
		10	-1	-3			32	-1	0
11	-6	11	-4	-4	33	-3	33	-1	-1
		12	-5	-4			34	-1	-1
13	-8	13	-5	-5	35	-2	35	+1	-1
		14	-7	-5			36	+1	0
15	-5	15	-4	-4	37	-2	37	-1	-1
		16	-4	-5			38	0	0
17	-7	17	-3	-5	39	-1	39	+1	-1
		18	-4	-5			40	+2	+1
19	-1	19	+1	0	41	0	41	+1	-1
		20	0	-1			42	+1	0
21	-7	21			43	0	43	0	+1
		22					44	0	0
					45	--	45	+1	0
							46	+3	+1

Subsequent screen examination revealed all far screens partially plugged and the far screens were clean. Relative amount of scale in general agreement with data. A total flow loss of 400 gpm was noted.

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HIGH TANK FLOW CALCULATIONS

The flow from the high tanks was measured by a rate of level drop calculation. The high tank water level drop was determined from mercury manometer readings.

A high tank diameter of 42 feet was used. The following method of calculation was used:

Volume of water per foot of high tank =

$$\frac{\pi D^2}{4} \times 1 = \frac{\pi (42)^2}{4} \times 1 = 1,385 \text{ ft.}^3$$

Gallons of water per foot of high tank =

$$1,385 \text{ ft.}^3 \times 7.481 \text{ gallons/ft.}^3 = 10,360 \text{ gallons.}$$

1 inch of mercury = 1.13 feet of water.

Then, 1 inch of mercury drop =

$$10,360 \text{ gallons/ft.} \times 1.13 \text{ ft/in Hg.} = 11,710 \text{ gallons/ in Hg.}$$

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8/10/94

END