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TITLE

PRODUCTION TEST IP-338-A, SUPP. A
DR REACTOR HEAT DECAY TEST AT HIGH OUTLET
WATER TEMPERATURES

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HW-65789 SUP A
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PRODUCTION TEST IP-338-A SUPP. A

DR-REACTOR HEAT DECAY TEST AT HIGH OUTLET

WATER TEMPERATURES

by

S. S. Jones

May 18, 1962

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HW-65789 SUP A
Page 2

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HW-65789 SUP A
Page 3

PRODUCTION TEST IP-338-A, SUPP. A
DR REACTOR HEAT DECAY TEST AT HIGH
OUTLET WATER TEMPERATURES

OBJECTIVE

To determine the heat output from the reactor to the cooling water when the coolant temperature is maintained at an elevated temperature of $68 \pm 2^{\circ}\text{C}$.

DISCUSSION

This test is identical to the original⁽¹⁾ except that it authorizes the performance of a trial reduction in reactor flow during a prior reactor shutdown. This trial flow reduction will be performed in the same manner as proposed for the actual test, with one exception. This is, that based upon the results of this preliminary test some changes in the timing of the different steps may be indicated. Such changes can readily be handled by making each step dependent upon the observed reactor outlet temperature during the test performance.

The other significant change in the production test is the increase in the allowable bulk outlet temperature from $T_1 + 40 \pm 3^{\circ}\text{C}^*$. This change is needed to obtain a reasonable extrapolation of the results of tests #1 and #2 to 90°C , and is justified, from a hazards standpoint by the excellent flow control achieved during test #1 and by the trial test that will be run prior to the performance of the actual test #2.

Other aspects of the test basis and justification are presented in the original production test.

TEST PREPARATION

This is similar to the original test. The instrumentation requirements have been formalized in a separate document⁽²⁾ that has been distributed to the people concerned with the test arrangement and instrumentation. In performing the trial portion of test #2, the instrumentation requirements will be the 105 and 190 Heise gage arrangement and motion pictures of the 105 TORP pressures; the temperature monitoring of the 20 central and 20 fringe high exposure, high powered tubes; and the monitoring of the cross-header front-to-rear pressure drop on the top three cross-headers.

SUMMARIZED TEST PROCEDURE

1. Trial Test: (Reactor Down > 20 hrs.)

A. Preliminary Procedure

- 1) To ensure adequate reactor flow backup, the high tank and export lines

- (1) HW-65789, "Production Test IP-338-A, DR Reactor Heat Decay Test at High Outlet Water Temperatures", S. S. Jones, 3-6-61.
- (2) HW-73492, "Instrumentation for DR Heat Output Test, Production Test IP-338-A, Supplement A", S. S. Jones, 4-26-62.

* This is an increase of only 5°C for summer time operation.

DECLASSIFIED

HW-65789 SUP A
Page 4

should be flushed and the strainers cleaned. Their Groves valves must be set for prompt manual trip upon demand by the test coordinator* and the flow balance valve must be open.

- 2) It should be determined that all reactor pumps and power supplies are normal and no reactor cross-header valving will be done during the course of this test.

B. Test Procedure

With all preliminary preparations completed, adjust the reactor pumping system to yield a flow from 8 electric pumps ≥ 96 percent of equilibrium flow with their by-pass lines closed and have seven steam pumps operating at full speed, their p. d. valves open.

- 1) Conduct a test count-down from 10, starting the cameras at 5 and at zero start closing all electric pump cone valves by means of their master controls.
- 2) At 90 seconds after time zero turn off two steam pumps, one on each side of the system.
- 3) At 120 seconds after time zero turn off one more steam pump leaving two steamers in operation on each side of the system.
- 4) At 150 seconds after time zero the 190 power operator will start making 15 psi reductions in the front riser pressure TORP as directed by the test coordinator.

NOTE:

(a) These initial reductions in the steam pumping output will be accompanied by a considerable reduction in TORP produced by the continued closing of the electric pump p. d. valves. To avoid any confusion during this period the 190 operator will be requested to reduce TORP to a certain value selected by the test coordinator. As soon as this new TORP value is reached the 190 operator will make no further changes in the steam turbine pump speeds until again requested to go to a new TORP value by the test coordinator.

(b) In every case the 190 operator will be directed to reduce pressure to a certain TORP value. The 105 Heise gages will be considered correct, and Instrument Maintenance will adjust the 190 Heise gage as necessary to give similar pressure readings.

* The manual trip operation of these valves is a non-standard procedure and several time checks of this arrangement should be made to determine the opening reliability and time delay of this system.

DECLASSIFIED

HW-65789 SUP A
Page 5

- 5) Further reductions in TORP will be made as shown in Table I, until a minimum value of 11 psig is reached. At this point the four steam pumps will be returned to full speed and the reactor returned to normal shut-down flow conditions.

NOTE: During this testing program the following precautions will be observed.

- a) If bulk outlet temperatures exceed $T_1 + 20^{\circ}\text{C}$ or tube outlet temperatures exceed $T_1 + 26^{\circ}\text{C}$, accelerate all seven steam pumps, and reduce TORP to previous setting + 5 psi as soon as bulk temperatures drop to $T_1 + 10^{\circ}\text{C}$. If tube temperatures also drop to $T_1 + 22^{\circ}\text{C}$, continue test.
- b) If bulk outlet temperatures continue to increase and exceed $T_1 + 35^{\circ}\text{C}$ or tube outlet temperatures exceed $T_1 + 45^{\circ}\text{C}$, immediately open the high-tank and export Groves valves; and conduct a rapid investigation of the reasons for the elevated temperatures.
- c) If there is a BPA failure or a critical "Y", accelerate seven steam pumps to full flow and cancel the test.
- d) If there is a failure of one or two steam pumps, the 190 Operator is to immediately start one or two of the 190 idling steam pumps.
- e) If there is total steam system failure, immediately advise the test coordinator who will direct the opening of the high tank and export Groves valves and starting the electric pumps by opening their PD valve bypass lines.

2. High Temperature Test (Test #2) Reactor at Equilibrium Operation

A. Preliminary Procedure

- 1) To ensure adequate reactor flow backup, the high tank and export lines should be flushed and the strainers cleaned. Their Groves valves must be set for prompt manual trip upon demand by the test coordinator and the flow balance valve must be open. In addition, detailed 105 and 190 buildings test procedures must be prepared and reviewed by all parties concerned with the test prior to its performance.
- 2) It should be determined that all reactor pumps and power supplies are normal and no reactor cross-header valving will be done during the course of this test.
- 3) The results of the trial test must be incorporated into a set of tables and curves that show the expected flows and temperatures to be obtained during the different phases of this test procedure. In addition, detailed 105 and 190 buildings test procedures must be prepared and reviewed by all parties concerned with the test prior to its performance.

DECLASSIFIED

HW-65789 SUP A
Page 6

TABLE I

FLOW REDUCTION STEPS FOR TRIAL RUN OF TEST #2

Step No.	Time After Zero Min-Sec.	Riser TORP		No. of Oper. Steam Pumps		Estimated Reactor Flow, 1000 gpm	
		Before step psig	After step* psig	Before step	After step	Before step	After step*
1	0	550	550	7	7	82	82
	0-30	550	550	7	7	82	82
	1-00	540	535	7	7	81	80
2	1-30	490	470	7	5	78	76
3	2-00	350	305	5	4	64	60
	2-15	255	225	4		53	50
	2-30	195	175	4		46	43
	2-45	150	135	4		39.3	37
	3-00	120	113	4		35	33.5
4a	3-15	100	85	4		31.3	28.5
	3-30	85	70	4		28.5	25
	3-45	70	55	4		25	21.5
5a	4-00	55	45	4		21.5	19.3
5b	4-15	45	35	4		19.3	16.2
6a	4-30	35	30	4		16.2	14.5
7a	4-45	30	28	4		14.5	13.7
7b	5-00	28	26	4		13.7	13.1
7c	5-15**	26	24	4		13.1	12.3
7d	5-30	24	22	4		12.3	11.5
8a	5-45	22	21	4		11.5	11.1
8b	6-00	21	20	4		11.1	10.7
8c	6-15	20	19	4		10.7	10.2
8d	6-30	19	18	4		10.2	9.8
8e	6-45	18	17	4		9.8	9.2
8f	7-00	17	16	4		9.2	8.6
8g	7-15	16	15	4		8.6	8.0
8h	7-30	15	14	4		8.0	7.4
8i	7-45	14	13	4		7.4	6.7
8j	8-00	13	12	4		6.7	6.0
8k	8-15	12	11	4		6.0	5.1
8l	8-30	11	10	4		5.1	5.1

* Step is assumed completed in ~10 seconds

** During actual test the time delays between steps will become greater from about this point on through the rest of the test.

DECLASSIFIED

HW-65789 SUP A
Page 7

B. Test Procedures

With all preliminary conditions completed, as for Test No. 1, close the electric pump bypass line valves and accelerate seven steam pumps to full speed, their PD valves open. Allow this flow condition to stabilize and check readiness for start of test*.

- 0: When all preparations are completed start the test countdown from 10 to 0. Start the recorders at 8 and the cameras at 5. At the count of zero, scram the reactor and observe that at least 27 VSR rods have seated in the reactor and neutron flux has decayed.*
- 1: At 30 seconds after scram, at the direction of test coordinator, close the electric pump PD valves simultaneously by means of their master controller. This will cause a flow decay similar to that in the trial test.
- 2: At 2-00 minutes after time zero the 190 chief operator will be instructed to turn off two of the seven operating steam pumps, one on each side.
- 3: At 2-30 minutes he will be instructed to turn off one of the five steam pumps. This will leave four steam pumps on the line, two on each side.
- 4: At 3-30 minutes to 3-45 the chief operator will be requested to lower the reactor TORP pressure to 85 psig. As soon as this pressure is reached the operator will make no further changes until these are requested by the test coordinator.

The rest of the test will consist in the chief operator making small steam pump reductions at the request of the test coordinator in order to reduce the reactor flow and maintain high bulk outlet temperatures.

NOTE:

1) During this time, as well as the rest of the test, the coordinator will maintain a continuous watch of the bulk outlet, 20 central zone, and 20 fringe zone tube temperatures. He will not request a further flow reduction until the following conditions are met at each step.

- a) The bulk temperature $\leq 68^{\circ}\text{C}$
- b) The monitored tube outlet temperatures $\leq 82^{\circ}\text{C}$
- c) The cross-header pressure drop of the top headers is not less than the values shown in Figure I, page 11.

This procedure will continue down to a TORP of 11 psig unless conditions such as those noted prevent reducing the flow to such a low level.

* i.e., No more than two rods out of unit.

DECLASSIFIED

HW-65789 SUP A
Page 8

B. Emergency Procedure

During the course of this test, the same emergency procedures and precautions will be observed as in the trial test. These are outlined as follows:

- 1) If bulk outlet temperatures exceed 73°C or tube outlet temperatures exceed 90°C during the course of this test, accelerate all seven steam pumps to full speed and flow. If the temperature drops to 68°C continue the test by returning to the previous TORP + 5 psig.
- 2) If bulk outlet temperatures continue to rise and exceed 76°C or tube outlet temperatures exceed 94°C immediately open the high tank and export Groves valves and conduct a rapid investigation of the reasons for these elevated temperatures.
- 3), 4), and 5) These safety steps for BPA and steam system difficulties are the same as in Test No. 1.

PROCESS STANDARDS

This production test authorizes exceeding the following Process Standards:

1. A-030.01 which specified minimum shut-down riser pressure and flows.
2. A-080.01 which specified by intent that high tank flow be available automatically during operation in case of a loss in water supply from other sources.
3. 190-B-070.03 (Water Plant Standards) which specifies that the export Groves valve be kept on automatic during reactor operation.

HAZARDS REVIEW:

The hazards associated with this supplement are essentially the same as those associated with the original production test. The increase in the degree of hazard associated with the increased outlet temperatures is balanced by the high level of flow control achieved by the first test and by the trial run of the second test prior to the test performance. Because of the importance of this flow control feature it will be very important to have, as much as possible, the same test personnel conducting this Test #2 that performed the trial test as described in this supplement.

The expected temperature changes resulting from this test performance are shown in Table II. This illustrates the relatively small temperature change for each step. These changes will be monitored and the next step will not be ordered by the test coordinator until or unless the preceeding step shows cooling adequacy to exist within the test limits.

TABLE II - ANTICIPATED CONDITIONS FOR TEST

Step No.	Time After Scram Mins-Sec.	Riser TORP		Flow		No. of Oper. Steam Pumps		Heat Output	
		Before step psig	After step psig	Before step 1000 gpm	After step gpm	Before step	After step	Decay Factor	He Out
0	0	540	550	86.0	82.0	7	7	1.0	160
1	0-30	550	550	82.0		7	7	.25	40
	1-00	550	550	82.0		7	7	.163	26
	1-30	540	540	81.5		7	7	.140	22
2	2-00	500	480	78		5	5	.127	20
3	2-30	350	350	64		4	4	.120	19
	2-45	250	210	52.5		4	4	.117	18
	3-00	195	175	46		4	4	.115	18
	3-15	150	135	39.3		4	4	.112	17
	3-30	120	113	34.8		4	4	.111	17
4a	3-45	100	80	31.3	27.3	4T	4T	.110	17
b	4-00	80	60	27.3	22.8	4T	4T	.108	17
5a	4-15	60	50	22.8	20.4	4T	4T	.107	17
b	4-30	50	40	20.4	17.5	4T	4T	.105	16
6	4-45	38	33	17.0	15.4	4T	4T	.104	16
	5-00	31	30	14.8	---	4T	4T	.103	16
	5-15	29	28.5	14.0	---	4T	4T	.102	16
7a	5-30	28	26	13.7	13.0	4T	4T	.101	16
b	5-45	26	24	13.0	12.3	4T	4T	.100+	16
8a	6-00	24	23	12.3	11.9	4T	4T	.100	16
b	7-00	23	22	11.9	11.5	4T	4T	.098	15
c	9-00	22	21	11.5	11.1	4T	4T	.094	15
d	11-00	21	20	11.1	10.7	4T	4T	.090	14
e	13-00	20	19	10.7	10.2	4T	4T	.086	13
f	15-00	19	18	10.2	9.8	4T	4T	.083	13
g	18-00	18	17	9.8	9.2	4T	4T	.078	12
h	21-00	17	16	9.2	8.6	4T	4T	.074	11
i	25-00	16	15	8.6	8.0	4T	4T	.069	11
j	30-00	15	14	8.0	7.4	4T	4T	.063	10
k	37	14	13	7.4	6.7	4T	4T	.058	9
l	45	13	12	6.7	5.9	4T	4T	.050	8
m	60	12	11	5.9	5.1	4T	4T	.043	6

* Estimated value 12 seconds after start of step.

ANTICIPATED CONDITIONS FOR TEST #2*

No. of Oper. Steam Pumps		Heat Output		Temperatures						
				Before Step			After Step			
				Inlet	ΔT	Outlet		ΔT	Outlet	
Before step	After step	Decay Factor	Heat Output			Bulk (riser)	Central Tube		Bulk	Central Tube
7	7	1.0	1600	17	70.6	87.6	108.8			
7	7	.25	400		18.5	35.5	41			
7	7	.163	261		12.1	29.1	32.7			
7	5	.140	224		10.4	27.4	30.5			
5	4	.127	203		9.9	26.9	29.9			
4	4	.120	192		11.4	28.4	31.8			
4	4	.117	187		13.5	30.5	34.6			
4	4	.115	184		15.2	32.2	36.8			
4	4	.112	179		17.3	34.3	39.5			
4	4	.111	178		19.4	36.4	42.2			
4T	4T	.110	176		21.4	38.4	44.8	24.5	41.5	48.8
4T	4T	.108	173		24.0	41.0	48.2	28.8	45.8	54.5
4T	4T	.107	171		28.5	45.5	54.1	31.9	48.9	58.5
4T	4T	.105	168		31.3	48.3	57.7	36.4	53.4	64.3
4T	4T	.104	166		37.2	54.2	65.4	41.0	58.0	70.3
4T	4T	.103	165		42.3	59.3	72			
4T	4T	.102	163		44.2	61.2	74.5			
4T	4T	.101	161		44.6	61.6	75	47.0	64.0	78.1
4T	4T	.100+	160.5		46.9	63.9	78	49.5	66.5	81.4
4T	4T	.100	160		49.7	66.4	81.6	51.0	68.0	83.4
4T	4T	.098	157		50.1	67.1	82.1	51.9	68.9	84.5
4T	4T	.094	150		49.5	66.5	81.4	51.4	68.4	83.8
4T	4T	.090	144		49.4	66.4	81.2	51.1	68.1	83.4
4T	4T	.086	138		49.0	66.0	80.7	51.4	68.4	83.8
4T	4T	.083	133		49.5	66.5	81.4	51.5	68.5	84.0
4T	4T	.078	125		48.5	65.5	80.1	51.6	68.6	84.1
4T	4T	.074	118		48.7	65.7	80.3	52.1	69.1	84.8
4T	4T	.069	110		48.6	65.6	80.2	52.3	69.3	85.0
4T	4T	.063	101		47.9	64.9	79.3	51.9	68.9	84.5
4T	4T	.058	93		47.7	64.7	79	52.7	69.7	85.5
4T	4T	.050	85		45.4	62.4	76	51.5	68.5	84.0
4T	4T	.043	68		43.7	60.7	73.8	50.6	67.6	82.8

Central Tube T = 17 + 1.3 ΔT
 Revised 7-5-62

DECLASSIFIED

HW-65789 SUP A
Page 10

SCHEDULE

The trial test will be performed at the DR Reactor outage following the approval of this test. The Test #2 will be completed at the shutdown of the block discharge of the current fuel charge, i.e. it will involve shutting down the reactor for this outage under production test conditions. This is currently scheduled for June 15 and the trial test will have to be prior to this date.

COSTS

A total of four hours of outage time is authorized for this test. All other costs will be as indicated in the original test.

RESPONSIBILITIES

These will be identical to the original test supplement except that the trial test will determine satisfactory pumping characteristics of the steam pumps and no further review of the Power Operations procedures by Water Plant & Utilities Operation will be requested.

S. S. Jones, Engineer
Reactor Engineering Unit
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DECLASSIFIED

HW-65789 SUP A
Page 11

DECLASSIFIED

HW-65789 SUP A
Page 12

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HW-65789 SUP A ADD
Page 13

ADDENDUM TO PRODUCTION TEST IP-338-A, SUPPLEMENT A
DR REACTOR HEAT DECAY TEST AT HIGH OUTLET WATER TEMPERATURES

The third or last-ditch cooling system at the old reactors consists of the high tanks and the export system. The high tanks take over from the pump flywheel decay in 3 to 6 minutes, and the export takes over from the emptying high tanks in 20 to 60 minutes. During the period after a reactor scram of 3 to 300 minutes, the source of coolant heating is essentially:

1. Decay of radioactive fission products.
2. Release of the sensible heat in the graphite moderator.

The latter is quite dependent upon the temperature of the water to which the graphite is cooling. The normal experimental heat output data have been obtained with cooling water outlet temperatures in the range of 5 to 20°C above the temperature inlet. Under severe emergency conditions, these temperatures would be 70 to 85°C above the coolant inlet temperature.

The purpose of this testing program is to determine the decrease in total heat output obtained with high outlet water temperatures. To achieve this result, it is necessary to reduce the test conditions, as much as possible, to a change in only one variable, the outlet water temperature.

Therefore, this addendum specifies that Supplement A of Production Test IP-338-A be conducted at conditions as close to those of last September as possible, in order to eliminate the additional variables of gas composition, power level, and graphite temperatures, from masking the goal of the test; i.e., determining the effects of increased coolant outlet temperature.

Approval of this test addendum approves the DR power level reductions and gas composition changes according to the attached Table I. It is estimated that duplicating the conditions of last September will cost 750 MWD of DR production.

S. S. Jones
Reactor Engineering Unit
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SSJ:vw

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HW-65789 SUP A ADD
Page 14

TABLE I

Approximate Transfer to Test No. 1 Conditions

<u>Days Before Test #2</u>	<u>Power Level</u>	<u>MWD</u>	<u>% He</u>	<u>Graphite Temp.</u>	
10	1700		98	600	-- Probable Operating Conditions
9	1675	25	98	590	
8	1650	50	98	580	
7	1625	75	98	570	
6	1600	100	98	560	
5	1600	100	98	560	
4	1600	100	98	560	
3	1600	100	94	570	
2	1600	100	90	585	
1	1600	<u>100</u> 750*	87	600	-- Proposed Test Conditions

* Estimated lost production

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HW-65789 SUP A ADD
Page 15

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8/2/94

END