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100 AREA PROCESS WATER PRESSURE DECAY TEST
PROGRAM - PART I

11

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Richland, Washington
January 2, 1953

R. C. Mehann, Superintendent
Process Unit
REACTOR SECTION

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100 AREA PROCESS WATER PRESSURE DECAY TEST PROGRAM - PART I

INTRODUCTION

The increase in process tube outlet water temperature to 90 °C⁽¹⁾ resulted in increased emergency water flow requirements as indicated by recently approved curves ⁽²⁾ which establish minimum crossheader pressure requirements for the first three minutes following an electrical power failure. To determine whether 190 Building secondary process water pump capacities are adequate for current minimum reactor water pressure requirements, process water pump trip-cut tests are being conducted at all reactors by the Process Unit in accordance with recommendations of the Reactor Process Committee⁽³⁾.

The results obtained to date in these tests, as well as current plans for the remaining tests, are presented in this document.

(1) HW-24918, Reactor Process Committee Meeting, June 27, 1952.

(2) HW-25558, Header Pressure Requirements Immediately Following an Electrical Power Failure.

(3) HW-25961, Reactor Process Committee Meeting, October 13, 1952.

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-2-

January 2, 1953

SUMMARY**DECLASSIFIED**

On October 16 and November 21, 1952, simulated electrical power failure tests were conducted in 100-B and C Areas respectively. In each test, the normal number of process pump sets were operated at normal discharge pressure, then an electrical power outage was simulated by tripping-out electric power feeding the 190 Building process-water secondary pump motors, and the 182 Building electric condenser-water pump motors, where applicable. Transient water pressure conditions (pressure decay) were recorded until stable "emergency" conditions were reached.

On October 29, 1952, a simulated electrical power failure test was run at 100-D. However, due to last minute difficulties at 100-DR it was inadvisable to run the DR steam turbines non-condensing. Since D and DR turbines utilize a common condenser water supply, the D turbines were necessarily operated condensing. Data from the test are included in this report for record purposes only, since the conditions under which the test was run did not meet the specific requirements of this program.

Documented data from previous tests at DR and H Areas, which were run under the conditions required for the current trip-out test program, are reproduced in this document for completeness of the report.

Minimum 105 crossheader pressure requirement curves presented in documents HW-25558 and 25675 are compared, in this report, with pressure decay curves obtained in the simulated power failure tests at B, C, D, DR, and H Areas. All results show that the process water pressure will be maintained above the minimum required pressure.

DISCUSSION

Reactor crossheader pressure requirements for the first three minutes following an electrical power failure were recently reviewed⁽²⁾ following the increase in the tube outlet water temperature limit based on slug corrosion to 90°C⁽¹⁾. New curves were presented⁽²⁾ which establish minimum crossheader pressure requirements for the first three minutes following an electrical power failure for equilibrium tube outlet water temperatures up to 90°C. To determine whether or not 190 Building pump capacities are adequate to supply the pressures specified in these curves, process water secondary pump trip-out tests are being conducted at all reactors by Process Unit personnel in accordance with the recommendations of the Reactor Process Committee⁽³⁾.

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-3-

DISCUSSION (Continued)

These tests are being run from approximately 400 psi (438 psi at C Reactor) initial equilibrium riser pressure with the normal number of process water pumps operating. Except at C Area, the turbines will operate condensing at trip out, and non-accelerating and non-condensing after trip-out since this is the worst condition expected during unplanned "Critical Z" emergency electrical power conditions, assuming normal steam back-up. At C Area, these tests must be run accelerating and non-condensing since this is the designed mode of operation following electrical power failure.

To date, two such tests have been completed, one at 100-B Area⁽⁴⁾ on October 16, the second at 100-C Area⁽⁵⁾ on November 21. A third test, at 100-D Area on October 29, was run with D turbines operating condensing following trip-out due to last minute difficulties at 190-DR which made it inadvisable to run the test under non-condensing conditions. This was necessary since D and DR turbines utilize a common condenser water supply. The data obtained in the 100-D test, although not the information sought in connection with the subject program, are included in this document for record purposes. The schedule of remaining trip-out tests is outlined in Appendix A.

Data obtained during the trip-out tests at 100-D (on October 29, 1952) were on actual crossheader pressure, and were obtained using an impulse line from the mid-point of reactor crossheader #23. All other data covered in this report were obtained from riser pressures which have been corrected to "crossheader pressure as read in the control room" by subtraction, where applicable, of an assumed 15 psi pressure drop between riser and crossheader. Pressures to be taken during future tests will be actual mid-crossheader pressure "as read in the control room" on a central crossheader, in order to obtain direct pressure readings on the crossheaders supplying tubes more or less representative of the hottest tubes in the central zone of the reactor.

Tests were run at DR and H Areas in 1951 under the conditions specified for the current program of tests. Curves from the documented results of these tests (HW-23041 for DR, and HW-22190 for H) are reproduced herein for completeness of this report. The trip-out tests at H, and possibly DR, will be re-run, as indicated in Appendix A, following orifice changes in connection with reactor enrichment and/or installation of larger pigtails.

(4) By Power and Maintenance Unit personnel.

(5) By Plant Engineering Services Unit personnel in conjunction with Chas. T. Main engineers, for acceptance test purposes.

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R. O. Mehamn, Superintendent

-4-

DISCUSSION (Continued)

The accompanying curves present all presently available pressure decay data on trip-out tests run with the normal number of process water pumps operating, and with turbines operating non-condensing and non-accelerating after trip-out, from approximately 400 psi initial equilibrium riser pressure ("accelerating", and from 430 psi riser pressure at C Reactor). The curves include the following information:

Figure 1 - Presents a comparison of pressure-decay curves obtained at 100-B (on 10-16-52) and 100-D (on 10-29-52) with the current minimum crossheader pressure requirement curve (HW-25558) for B and D Reactors. Test data from which these curves were plotted appear on charts in Appendix B.

Figure 2 - Presents a comparison of pressure decay curves for 100-H and 100-DR with the current minimum crossheader pressure requirement curve (HW-25558). Data for these curves were obtained from document HW-22190 and HW-23041, respectively.

Figure 3 - Presents a comparison of the pressure decay curve for 100-C with the current minimum crossheader pressure requirement curve (HW-25675). This test was run as part of Charles T. Main's acceptance tests. Test data will be published in the C. T. Main Acceptance Test Report on C Reactor. A copy of the chart from which the curve was derived appears in Appendix B.

Data other than that required for pressure decay curves, such as turbine rpm, inter-stage pump pressure, water flow, steam load, etc. were taken during the tests and are documented in Appendix C of this report.

CONCLUSION

The trip-out tests at 100-B, C, DR and H indicate that under unplanned "Critical Z" emergency electrical power conditions, and based on current reactor flow characteristics, the reactor crossheader pressures during the pressure decay period following electrical power failure would exceed the minimum reactor crossheader pressure requirements specified in documents HW-25558 and HW-25675. This is assuming normal equilibrium crossheader pressure prior to pump motor trip-out, normal steam back-up and the normal number of turbines operating non-condensing and non-accelerating (accelerating at 100-C) after trip out.

Subsequent tests, as outlined in Appendix A, will establish the relationship between transient reactor water pressure immediately following electric power failure and the corresponding minimum reactor water pressure requirements for the remaining reactors.

P. Thompson
P. Thompson
Process Unit
REACTOR SECTION

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Crossheader Pressure - psig - As Read In The Control Room

Figure 1

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Time After Electrical Power Failure - Seconds

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-5-

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100 PROCESS WATER PUMPS - PRESSURE DECAY
AFTER ELECTRICAL POWER FAILURE

- A. TRIP-OUT TEST - 100-H - August 30, 1951
Turbines condensing at trip-out. Non-accelerating
and non-condensing after trip-out, 15 units operating.
Data from document HW-22190.
- B. TRIP-OUT TEST - 100-DR - November 19, 1951
Turbines condensing at trip-out. Non-accelerating
and non-condensing after trip-out, 13 units operating.
Data from document HW-23041.
- C. Min. required crossheader pressure from doc. HW-25558.

"Top of riser pressure" shown in HW-22190 and HW-23041
is equivalent to "crossheader pressure as read in the
control room" shown on curves A and B.

Figure 2 Time After Electrical Power Failure - Seconds

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190 PROCESS WATER PUMPS - PRESSURE DECAY
AFTER ELECTRICAL POWER FAILURE

- A. TRIP OUT TEST - 100 C - Nov. 21, 1952
Turbines non-condensing at trip-out. Accelerating and non-condensing after trip-out, 8 units operating.
- B. Minimum 105 crossheader pressure requirements from document HW-25675.

Riser pressure data obtained in the test was corrected to crossheader pressure by subtracting 15 psi.

Figure 3 Time after Power Failure - seconds

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-8-

January 2, 1953

APPENDIX A

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Process Water Pressure Decay Test Schedule

- 100-B Area Pressure-decay data (turbines non-accelerating and non-condensing) were obtained from an initial equilibrium 400 psig riser pressure on October 16, 1952 by Power sub-unit. No additional tests are planned.

- 100-C Area Pressure-decay data (turbines accelerating and non-condensing) were obtained from an initial equilibrium 438 psig riser pressure on October 21, 1952 by Charles T. Main engineers. A full report on this test will be issued by Charles T. Main in their C Area Acceptance Test Report.

- 100-D Area The pressure-decay test of October 29 (turbines non-accelerating and non-condensing) will be re-run to obtain non-accelerating, non-condensing data. This test is tentatively planned for the scheduled shutdown of D-Reactor, on or about, February 16, 1953.

- 100-DR Area A pressure-decay curve (turbines non-accelerating and non-condensing) from an initial equilibrium 395 psig riser pressure (maximum pressure due to present pump casing limits) is available in document HW-23041, dated November 11, 1951. An additional test will be run if larger pigtails are installed during the Ball 3X outage. Completion of the additional test, if one is necessary, may be expected in May or June, 1953.

- 100-F Area A pressure-decay curve (turbines non-accelerating and non-condensing) will be obtained following replacement of blank tubes at F Reactor during the Ball 3X outage. Completion of this test is expected in January, 1953.

- 100-H Area A pressure-decay curve (turbines non-accelerating and non-condensing) from an initial equilibrium 400 psig riser pressure is available in document HW-22190, dated August 30, 1951. An additional test will be run following completion of orifice changes in conjunction with reactor enrichment. Completion of this test is expected by January 12, 1953. A second test will be run if larger pigtails are installed during the Ball 3X outage. Completion of the test, if necessary, may be expected in June or July, 1953.

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APPENDIX B

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Actual Pressure Measured at Impulse Line, to C Riser, in 190-C Control Room.
 Trip-Cut Test, 11-21-52. 2 Pumps in service. Steam turbines operated
 accelerating and non-condensing. Chart drive - 1 revolution per minute.

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APPENDIX B

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APPENDIX B

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AUXILIARY TEST DATA FROM 100-B and 100-D TRIP-OUT TESTS

AREA: 100-B

DATE OF TEST: October 16, 1952

Simulated Electrical Power Failure

The test was run with non-accelerating and non-condensing operation of the 190 primary pump steam turbines. The three auxillary nozzle sections on each turbine were closed.

Process water pressure decay data was recorded by two Taylor recorders connected to the impulse lines from C and D risers at their terminations in the 190-B control room.

The elapsed time from trip-out at equilibrium 400 psig riser pressure to steady state conditions at 135 psig riser pressure was 2.7 minutes.

Barometer (200 Area Tower) - inches of mercury at sea level	30.2"
Outside Temperature	64°F
190 Room Temperature	76°F

Operating conditions were normal with 12 pump sets operating, out of a possible 13.

	<u>Before Trip-Out</u>	<u>After Trip-Out</u>
Total Process Water Flow - gpm	37,300	13,825
Process Water Riser Pressure (as read in 190-D control room) - psig	400	135
Total Steam Load (Bldg. 184) - lbs/hr	200,000	200,000
Steam Pressure (Bldg. 184) - psig	225	225
Steam Pressure (Bldg. 190) - psig	218	218

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-14-

Simulated Electrical Power Failure Test - 100-B Area (Cont.)Individual steam turbine data before test:

Pump Set No.	1	2	3	4	5	6	7	8	9	10	11	12
Turbine Speed, rpm	2225	2220	2225	2050	2175	2200	2250	2225	2200	2200	2200	2200
Water Flow, gpm	3100	3000	3050	3150	3100	3050	3250	3200	3100	3200	3000	3100
Between Pump Pressure, psig	186	182	182	163	178	181	190	192	192	186	181	184
Steamchest Pressure, psig	115	113	116	101	109	111	124	124	122	117	105	105
Vacuum, In. of Hg	26.4	25.6	26.6	26.2	25.4	26.2	25.8	25.4	25.4	26.2	26.6	26.5

Individual steam turbine data after test:

Pump Set No.	1	2	3	4	5	6	7	8	9	10	11	12
Turbine Speed, rpm	1975	1950	1950	1850	1875	1925	2000	2025	2000	1925	1950	1950
Water Flow, gpm	1850	1575	1575	1300	1450	1400	1900	1900	1800	1725	1625	1725
Between Pump Pressure, psig	162	159	162	154	156	160	169	170	170	164	164	167
Steamchest Pressure, psig	114	112	115	95	105	105	123	121	119	111	107	112
Vacuum, In. of Hg	0	0	0	0	0	0	0	0	0	0	0	0

Steam flow to #12 Turbine was 9,600lbs/hr before and after test.

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-15-

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APPENDIX C (Cont.)

AREA: 100-D

DATE OF TEST: October 28, 1952

Simulated Electrical Power Failure

The test was run with non-accelerating and condensing operation of the 190 steam turbines. One of the three auxillary nozzle sections on each turbine was closed.

Process water pressure-decay data was recorded by two Taylor recorders, one connected to the impulse line, from the mid-point of crossheader #23, at its termination in the 105-D control room, the other was connected to the impulse line from "B" riser at its termination in the 190-D control room.

The elapsed time from trip-out at 400 psig riser pressure to steady state conditions at 200 psig riser pressure was 2.7 minutes.

Operating conditions were normal with 12 pump sets operating out of a possible 13.

	<u>Before Trip-Out</u>	<u>After Trip-Out</u>
Total Process Water Flow - gpm	37,600	25,130
Process Water Riser Pressure - psig (As read in the 190-D control room)	400	200
Total Steam Load (Bldg. 184) - lbs/hr	361,000	342,000
Steam Pressure (Bldg. 184) - psig	225	225
Steam Pressure (Bldg. 190) - psig	220	220

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-16-

Simulated Electrical Power Failure Test - 100-D Area (Cont.)
Individual steam turbine data before test:

Pump Set No.	1	2	3	4	5	6	7	8	9	10	11	12
Discharge Pressure, psig	415	424	422	415	412	415	420	417	420	417	416	418
Water Flow, gpm	3100	3100	3100	3025	3075	3075	3200	3100	3100	3050	3100	3125
Between Pump Pressure, psig	184	186	187	191	184	179	187	185	187	186	183	176
Steamchest Pressure, psig	120	120	105	127	116	105	120	118	121	117	118	112
Vacuum In. of Hg	26	25	26	25	25	26.7	26	27	26	26	27	24

Individual steam turbine data after test:

Pump Set No.	1	2	3	4	5	6	7	8	9	10	11	12
Discharge Pressure, psig	208	208	205	206	201	204	205	208	204	210	205	202
Water Flow, gpm	1850	2100	2300	2150	2100	2175	2200	1800	2200	2125	2100	2100
Between Pump Pressure, psig	240	250	254	257	244	250	255	238	254	252	252	247
Steamchest Pressure, psig	105	120	106	125	108	102	117	97	119	115	117	110
Vacuum In. of Hg	26	25	26	25	25	26.5	26	27	26	26	27	24

Steam flow to the #5 turbines was:

10,740 lbs/hr before test
10,109 lbs/hr after test.

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