JUN 21 1961

MASTER

DUQUESNE LIGHT COMPANY
SHIPPINGPORT ATOMIC POWER STATION

TEST RESULTS

DLCS 2150201
T-641113

CORE REMOVAL COOLING SYSTEM - SECTION II

CORE I SEED I

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Section 2 of 2 Sections

First Issue, May 19, 1961

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TEST RESULTS

DLCS 2150201

T-641113

CORE REMOVAL COOLING SYSTEM SECTION II

CORE I SEED 1

Purpose

The purpose of this test is to determine the capacity of the Core Removal Cooling System for removing reactor decay heat under "split-flow" conditions.

Conclusions

The Core Removal Cooling System operated satisfactorily during this test. The core removal cooling pumps developed a flow of approximately 73 gpm or 36,000 lb/hr, at a total head of 254 feet of water. The rated capacity of these pumps is 75 gpm or 37,000 lb/hr at a total head of 250 feet of water.

The 1-BD non-regenerative heat exchanger (NRHX) removed decay heat satisfactorily when the 1-AC heat exchanger was isolated.

Description of Test Equipment and Test Procedure

The test was conducted in accordance with the first issue of DLCS 21502 approved June 17, 1959. The Core Removal Cooling System was placed in service with the 1-C and 1-D reactor coolant loops isolated and with all stop valves in the 1-A and 1-B reactor coolant loops open. This valve arrangement established "split-flow" conditions in the operating loops, that is, the core removal cooling pump discharge from the 1-AC and 1-BD NRHX's was returned to loops 1A and 1B up-stream of the reactor coolant pump inlet. Part of the flow returned directly through the reactor with the remainder flowing in a reverse direction through the steam generator to join the reactor discharge at the core removal cooling system inlet connection, Figures 2 and 3 in the Appendix. Temperature and flow readings of both the reactor coolant and the component cooling water entering and leaving the 1-AC and 1-BD NRHX's were taken at prescribed time intervals for three hours and entered in Table I of the Appendix. The various flow rates were determined by measuring the differential pressure across an orifice plate with a Barton indicator. The meter scale was calibrated in terms of the square root of the differential pressure in pounds per square inch. Calculated flow in gpm is the product of the scale reading and the orifice constant. The orifices and their constants are:

Fluid	Orifice No.	Installation	Constant- $\frac{\text{gpm}}{\sqrt{\text{psi}}}$
Reactor Coolant	-75-45-A	1-AC NRHX Tube side	37.50
Reactor Coolant	-75-45-B	1-BD NRHX Tube side	37.50
Component Cooling Water 17-J4-3		1-AC NRHX Shell side	31.74
Component Cooling Water 17-J4-4		1-BD NRHX Shell side	31.74

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In accordance with an agreement between Duquesne Light Company and the Atomic Energy Commission, the test was extended with only one reactor coolant loop in operation. The 1A reactor coolant loop was isolated and readings were taken over a four hour period with only the 1B reactor loop in operation.

On June 18, 1959, the core removal spool pieces and the orifice runs were installed and the component cooling water pump discharge pressure transmitter and Barton differential pressure indicating meters were calibrated. The following day, June 19th, the primary system was filled solid at 1030 hours and cooldown was resumed until the test was started at 1500 hours. The temperature indicators applied to the component cooling water and reactor coolant are identified by instrument number in Table X. The calibration data for these indicators is included in Table X.

Results

The test of the Core Removal Cooling System, DLCS 2150201, was completed on June 19, 1959, between the hours of 1500 and 2230. At that time there were 5032 EFPH on Core I, Seed 1.

The Core Removal Cooling System under the operating conditions during this test, removed heat from the reactor coolant in the 1-AC NRHX at a maximum rate of 27,200 BTU/min., approximately 46.6 hours after shutdown with a reactor coolant inlet to the NRHX at 151 F and flowing at 75 gpm and component cooling water inlet temperature at 120 F. In the 1-BD cooling system, heat was removed at a rate of 37,000 BTU/min., 46.8 hours after shutdown with the reactor coolant inlet to the NRHX at 164 F and flowing at approximately 72 gpm and component cooling water inlet temperature at 120 F.

The failure of 1A Tc and a misplaced thermometer intended for 1-BD component cooling water outlet temperature, resulted in data that was insufficient to evaluate both cooling systems either individually or comparatively. The inclusion of the secondary side steam generator temperature, 1B Tb, would have simplified the investigation to determine the reason why Tc was hotter than Th for the 1-BD primary loop.

A difference in primary coolant flow as determined by the flow meter, in comparison to the flow from the capacity curve corresponding to the developed head of the pump was established for both coolant loops. In the 1AC loop this difference was considerably higher than for the 1BD loop, provided the curves in Figure 1 which are not positively identified, were properly selected. For this determination the upper curve was identified with the 1AC loop and the lower curve with the 1BD loop. Simultaneous readings of flow and pump pressures would improve the accuracy of the flow comparisons. Also, the two differential pressure indicating meters, though calibrated before the test, gave flow indications from the same orifice which differed by a value of 0.21 psi, which was equivalent to 7.8 gpm. It was impractical to check the calibration at the end of the test because both meters had become contaminated by radiation and had to be dismantled for decontamination.

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CORE REMOVAL COOLING SYSTEM - SECTION II

Calculations showing head developed by the Core Removal Cooling System pumps are shown in Table IV.

Flow of primary coolant based on head developed by the LBD core removal cooling pump was calculated to be 78 gpm; the flow as measured by the Barton D/P cell showed 74.2 gpm. For the LAC loop the flow based on pump head was calibrated to be 88 gpm and the measured flow was 72 gpm.

Since there was a difference of 7.8 gpm in metered flows, it is reasonable to say that the LAC meter reading should have been corrected to read 0.21 psi higher or the flow rate adjusted by an addition of 7.8 gpm for a total metered flow of 80 gpm. For both loops, the difference in flow rates is due to a calculated head pressure which does not include mechanical losses, disc friction loss and leakage loss. A higher pump head would indicate a lower flow rate, see Figure 1, Pump Performance Curves. The equipment on hand was not suitable for determining the additional losses.

The heat removed by both NRHX's from the primary loops and the heat absorbed by the component cooling water of the LAC NRHX are shown in Tables V, VI, and VII.

The location of the 1A and 1B loop Th and Tc is indicated in the schematic piping prints, Figures 2 and 3. The Th's measured the reactor hot-leg coolant temperature while the Tc's measured the temperature of the Core Removal Cooling System pump discharge in the reverse flow branch of the primary system. At the beginning of the test 1A Th and 1B Th were very nearly identical in temperature as seen on the Bristol recorder chart, No. 05-J3-20R. (This chart is to be micro-filmed.) Primary loop Tc's were measured by individual Leeds and Northrup Co., Mueller Bridge resistance thermometer recorders. At this time the Tc instruments, originally a Westinghouse installation, were being replaced by Duquesne Light Company procured replacements. The 1A recorder was a new replacement unit and had been recently installed. One and one half hours after beginning the test, the temperature measurement of this loop became unreliable and the instrument was taken out of service for adjustment. An attempt to replace the erratic Tc with a manual balance potentiometer was unsuccessful because of wiring difficulties. The 1A Tc was returned to service one hour later for the duration of the test. The Tc for the 1A loop is located at the outlet of the 1A steam generator and ahead of the check valve and reactor coolant pump. (See Figure 2.) The Tc for the 1B loop is located at the outlet of the 1B steam generator and ahead of the reactor coolant pump, but downstream of the check valve. (See Figure 3.) In the 1A loop, the Tc could be considered normal because it read 20 to 30 F lower than Th, Figure 4, reflecting the drop in temperature of the fluid passing through the heat exchanger. In the 1B loop the Tc was about 20 F hotter than the Th. (See Figure 4.) This was not according to expectations since the conditions in the 1B loop were superficially the same as in 1A, except that the temperature of the mixed loop fluids was higher than the Th of the loop. Loop Th's were recorded on the 0 to 700 F, 12 point Bristol resistance thermometer recorder. The individual points are indentified as follows:

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1. Tb 1A Steam Generator	7. Tb 1C Steam Generator
2. Th 1A Reactor Loop	8. Th 1C Reactor Loop
3. Pressurizer Water	9. Pressurizer Water
4. Tb 1B Steam Generator	10. Tb 1D Steam Generator
5. Tb 1B Reactor Loop	11. Th 1D Reactor Loop
6. Pressurizer Water	12. Pressurizer Water

An examination of the conditions of the loop during the test and just prior to the start of the test, supported by the information offered below, suggested a logical explanation for the above departure from normal behavior. From the Station Engineer's Report, June 19, 1959, 8 to 4 shift, the 1011 hour entry reads, "1A reactor coolant pump shutdown for venting purposes." From the temperature recorder, Bristol chart No. 05-J3-20R, the Tb's for all four loops were approximately 250 F. The Tb for 1A and 1B loops were very slightly lower than those for the 1C and 1D loops.

With the above information and from experience gained in operating the plant, it is safe to say that since the 1A reactor coolant pump was the last to operate, the check valve in the 1A loop was open. Also, because reverse flow occurs in loops open to the reactor, when the reactor coolant pump of the loop is down, it is most likely that the check valve in the 1B loop was closed. Information indicates that a check valve closes when the reverse flow approaches 135 gpm. Under these conditions the Core Removal Cooling System discharge in the 1A loop would split flow almost equally between the reactor and the steam generator while the discharge of the 1B core removal cooling pump would be restricted in the direction of flow through the steam generator by the 13/16" hole drilled through the 1B loop check valve. Since the steam generator temperatures were 250 F the temperature of the NRHX discharge in the restricted flow loop would rise, picking up heat from the steam generator, while the freely flowing cooled mixture passing 1A Tc would show a slow steady fall. The Th's are located in the reactor outlet piping, downstream of the hydraulic valves but ahead of the loop bypass, see Figures 2 and 3. At the start of data taking, 1A Th was 187 F, 1B Th was 175 F, 1C Th was 200 F and 1D Th was 163 F. The 1B loop core removal cooling system had been operating for about two and one half hours before data was recorded. (See Electrical Operator's Report, 8-4 shift in Table VIII). At the end of the test the 1A, 1B and 1D reactor coolant loop temperatures were at 150 F, the 1C main coolant loop was at 175 F.

The steam generator secondary side temperatures, 1A, 1B, 1C and 1D Tb's were not required data for this test. However, it was necessary to determine the cause for a rise in 1B Tc, and the loop Tb's were logical indicators of a heat source. The Bristol temperature recorder chart, No. 05-J3-20R, was therefore incorporated into the test information. Figure 4 shows graphically the relation between the 1A loop Th and Tc and the 1B Th and Tc. Figure 5 shows the heat removal potential of both systems. The 1BD loop removed more decay heat than the 1AC system, because the reactor coolant temperature, inlet to the NRHX was higher and the mean temperature difference wider. The relation between the heat given up by the primary coolant fluid through the 1AC - NRHX to the component cooling water is shown graphically by the curves of Figure 6. A similar comparison of the heat transferred in the 1BD loop NRHX is not available because the outlet temperature of the component

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cooling water was not available as test data. The thermometer which was to measure this temperature had been installed in the wrong place. The change in temperature of primary coolant passing through the LBD NRHX is shown in Figure 7.

Core instrumentation, seed and blanket inlet and exit water temperature recorders were biased to a range of 0 to 300 F. The information from these recorders supported the Th temperature measurement. The core temperatures are tabulated in Tables II and III. No special calibrations were made of the core instrumentation thermocouples and correction factors for normal operating temperatures are invalid for the low range temperatures of this test.

A transcript of the Electrical Operator's Report, the Station Operating Engineer's Report, Log of Events, test data, schematic piping points, recorder charts, and various related performance curves are included in the Appendix.

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FIGURE - 2

FIGURE 3

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CORE REMOVAL COOLING SYSTEM,
SYSTEM II, DLCS 2150201
(TS-641113)

TABLE I
Non-Regenerative Heat Exchanger and Core Removal Cooling Pump Test Data

Date 6/19/59

Hours After Shutdown Time	1505	1509	1512	1515	1525	1533	1535	1540	1545	1550	1552	1555	1602	1605	1607	1610	1613	1615	1620	1625	1627	1630	1634	1535	
Non-Regenerative Heat Exchangers																									
1A Loop Reactor Coolant Water																									
Inlet Temperature F	187	---	---	179	170	---	163	---	159	---	---	154	---	148	---	---	---	146	---	142	---	---	---	---	139.5
Outlet Temperature F	134	---	---	136	137	---	137	---	125	---	---	108	---	105	---	---	---	113	---	117	---	---	---	---	115
Differential Pressure $\sqrt{\text{psi}}$	---	---	---	---	---	---	---	---	---	2.0	---	---	---	---	---	---	---	---	---	---	1.92	---	---	---	---
Flow Rate gpm	---	---	---	---	---	---	---	---	---	75	---	---	---	---	---	---	---	---	---	---	72	---	---	---	---
1A Loop Component Cooling Water																									
Inlet Temperature F	---	---	---	129.5	129.5	---	130.0	---	130.0	---	---	107.0	---	98.0	---	---	---	105.0	---	110.0	---	---	---	---	110.5
Outlet Temperature F	---	---	---	---	---	150	---	---	---	---	142	---	138	---	---	135	---	---	135	---	---	132	---	---	---
Differential Pressure $\sqrt{\text{psi}}$	---	---	---	---	---	---	---	---	---	2.78	---	---	---	---	---	---	---	---	---	---	2.78	---	---	---	---
Flow Rate gpm	---	---	---	---	---	---	---	---	---	88	---	---	---	---	---	---	---	---	---	---	88	---	---	---	---
1B Loop Reactor Coolant Water																									
Inlet Temperature F	175	---	---	174	172	---	171	---	168	---	---	165	---	163	---	---	---	162	---	161	---	---	---	---	160
Outlet Temperature F	134	---	---	138	135	---	138	---	133	---	---	110	---	107	---	---	---	116	---	117	---	---	---	---	115
Differential Pressure $\sqrt{\text{psi}}$	---	---	2.18	---	---	---	---	2.2	---	---	---	---	---	---	2.19	---	---	---	---	---	---	---	---	---	---
Flow Rate gpm	---	---	74	---	---	---	---	75	---	---	---	---	---	---	74	---	---	---	---	---	---	---	---	---	---
1B Loop Component Cooling Water																									
Inlet Temperature F	---	---	---	129.5	129.5	---	130.0	---	130.0	---	---	107.0	---	98.0	---	---	---	105.0	---	110.0	---	---	---	---	110.5
Outlet Temperature F	---	---	WRONG TEMPERATURES WERE RECORDED										---	---	---	---	---	---	---	---	---	---	---	---	---
Differential Pressure $\sqrt{\text{psi}}$	---	2.57	---	---	---	---	2.57	---	---	---	---	---	---	---	---	---	2.59	---	---	---	---	---	---	---	---
Flow Rate gpm	---	82	---	---	---	---	82	---	---	---	---	---	---	---	---	---	82	---	---	---	---	---	---	---	---
Core Removal Cooling Pumps Pressure																									
1A Pump Suction Pressure psig	---	---	---	---	---	31.0	---	---	---	---	30.0	---	29.5	---	---	30.5	---	---	30.5	---	---	30.5	---	---	---
1A Pump Discharge Pressure psig	---	---	---	---	---	140.0	---	---	---	---	139.5	---	139.0	---	---	140.0	---	---	140.5	---	---	140.0	---	---	---
1A Pump Total Head Ft-Water	---	---	---	---	---	253	---	---	---	---	254	---	254	---	---	254	---	---	255	---	---	254	---	---	---
1B Pump Suction Pressure psig	30.5	---	---	30.5	30.5	---	30.5	---	30.5	---	---	30.5	---	30.5	---	---	---	30.0	---	30.0	---	---	---	---	30.0
1B Pump Discharge Pressure psig	141.0	---	---	140.0	140.0	---	140.0	---	140.0	---	---	141.0	---	141.0	---	---	---	140.0	---	140.0	---	---	---	---	140.0
1B Pump Total Head Ft-Water	256	---	---	254	254	---	254	---	254	---	---	256	---	256	---	---	---	255	---	255	---	---	---	---	255
Reactor Coolant Loop Temperatures																									
1A T _c (Calibrated) F	141.1	---	---	135.4	134.8	---	134.1	---	133.1	---	---	120.6	---	110.7	---	---	---	106.0	---	005	---	---	---	---	005
1B T _c (Calibrated) F	183.9	---	---	182.3	181.9	---	181.1	---	181.1	---	---	180.3	---	179.8	---	---	---	179.0	---	177.8	---	---	---	---	176.1
1A T _h (Bristol Recorder) F	---	---	---	---	---	---	163.0	---	163.0	---	---	162.0	---	160.0	---	---	---	159.0	---	158.0	---	---	---	---	157.0
1B T _h (Bristol Recorder) F	---	---	---	---	---	---	163.0	---	160.0	---	---	160.0	---	158.0	---	---	---	157.0	---	156.0	---	---	---	---	156.0

*Corrected Differential Pressure.

†Gage Elevated 15" Above Suction Gage.

True Discharge Pressure = Gage Reading + 0.50

NOTE:

1550 hours - River water flow increased to component cooling water heat exchanger.

1615 hours - 1A T_c Mueller Bridge recorder out of service.

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DUQUESNE LIGHT COMPANY
POWER STATIONS DEPARTMENT
SHIPPINGPORT ATOMIC POWER STATION

CORE REMOVAL COOLING SYSTEM,
SYSTEM II, DLCS 2150201
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TABLE I (cont'd)

Date 6/19/59

Hours After Shutdown Time	1640	1645	1648	1650	1651	1655	1657	1700	1705	1710	1715	1720	1721	1724	1725	1730	1735	1738	1740	1742	1745	1750	1755	1759
Non-Regenerative Heat Exchangers																								
LAC Loop Reactor Coolant Water																								
Inlet Temperature F	---	138.5	---	---	---	136.5	---	---	134.5	---	133	---	---	---	131	---	129	---	---	---	129	---	128.5	---
Outlet Temperature F	---	115	---	---	---	114	---	---	113	---	113	---	---	---	113	---	113	---	---	---	113	---	113	---
Differential Pressure $\sqrt{\text{psi}}$	---	---	---	---	---	---	1.92	---	---	---	---	---	1.92	---	---	---	---	---	---	---	---	---	1.91	---
Flow Rate gpm	---	---	---	---	---	---	72	---	---	---	---	72	---	---	---	---	---	---	---	---	---	---	72	---
LAC Loop Component Cooling Water																								
Inlet Temperature F	---	110	---	---	---	110	---	---	109.5	---	110	---	---	---	110	---	110	---	---	---	110	---	110	---
Outlet Temperature F	131	---	---	130	---	---	---	129	---	128	---	127	---	---	---	126	---	---	125	---	---	124	---	---
Differential Pressure $\sqrt{\text{psi}}$	---	---	---	---	---	---	2.76	---	---	---	---	2.77	---	---	---	---	---	---	---	---	---	---	2.76	---
Flow Rate gpm	---	---	---	---	---	---	88	---	---	---	---	88	---	---	---	---	---	---	---	---	---	---	88	---
LBD Loop Reactor Coolant Water																								
Inlet Temperature F	---	159	---	---	---	157	---	---	155	---	153.5	---	---	---	151.5	---	149.5	---	---	---	149	---	148	---
Outlet Temperature F	---	120	---	---	---	118	---	---	117	---	117	---	---	---	117	---	117	---	---	---	117	---	117	---
*Differential Pressure $\sqrt{\text{psi}}$	---	---	2.2	---	---	---	---	---	---	---	72.19	---	---	---	---	---	---	2.19	---	---	---	---	---	---
Flow Rate gpm	---	---	75	---	---	---	---	---	---	---	74	---	---	---	---	---	74	---	---	---	---	---	---	---
LBD Loop Component Cooling Water																								
Inlet Temperature F	---	110	---	---	---	110	---	---	109.5	---	110	---	---	---	110	---	110	---	---	---	110	---	110	---
Outlet Temperature F	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
*Differential Pressure $\sqrt{\text{psi}}$	2.59	---	---	---	---	---	---	---	---	---	2.59	---	---	---	---	---	---	2.59	---	---	---	---	---	---
Flow Rate gpm	82	---	---	---	---	---	---	---	---	---	82	---	---	---	---	---	---	82	---	---	---	---	---	---
Core Removal Cooling Pumps Pressure																								
1A Pump Suction Pressure psig	30.5	---	---	30.5	---	---	---	30.5	---	30.5	---	30.5	---	---	---	30.5	---	---	30.5	---	---	30.5	---	---
1A Pump Discharge Pressure psig	140.0	---	---	140.0	---	---	---	140.0	---	140.0	---	139.5	---	---	---	139.5	---	---	139.5	---	---	139.5	---	---
1A Pump Total Head FT-Water	254	---	---	254	---	---	---	254	---	254	---	252	---	---	---	252	---	---	252	---	---	252	---	---
1B Pump Suction Pressure psig	---	30.0	---	---	---	30.0	---	---	30.0	---	30.0	---	---	---	30.0	---	30.5	---	---	---	30.0	---	30.0	---
1B Pump Discharge Pressure psig	---	140.0	---	---	---	140.0	---	---	140.0	---	140.0	---	---	---	140.0	---	140.0	---	---	---	140.0	---	140	---
1B Pump Total Head FT-Water	---	255	---	---	---	255	---	---	255	---	255	---	---	---	255	---	254	---	---	---	255	---	255	---
Reactor Coolant Loop Temperatures																								
1A T _c (Calibrated) F	---	005	---	---	---	005	---	---	005	---	005	---	---	---	112.8	---	112.6	---	---	---	112.4	---	112.0	---
1B T _c (Calibrated) F	---	173.9	---	---	---	172.4	---	---	170.9	---	169.6	---	---	---	168.1	---	166.3	---	---	---	165.5	---	163.9	---
1A T _h (Bristol Recorder) F	---	155	---	---	---	154	---	---	153	---	151	---	---	---	150	---	147	---	---	---	146	---	145	---
1B T _h (Bristol Recorder) F	---	155	---	---	---	154	---	---	153	---	151	---	---	---	149	---	147	---	---	---	146	---	145	---

*Corrected Pressure

*Gage Elevated 1'0" Above Suction Gage

True Discharge Pressure Gage Reading 45#

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DUQUESNE LIGHT COMPANY
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CORE REMOVAL COOLING SYSTEM,
SYSTEM II, DLCS 2150201
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TABLE I (cont'd)

Date 6/19/59

Hours After Shutdown Time	1800	1805	1810	48.9 1815	1820	1821	1825	1830	1835	1838	1842	49.4 1845	1855	1905	1910	49.9 1915	1925	1930	1935	1939	50.4 1945	1955	2005	2008
Non-Regenerative Heat Exchangers																								
LAC Loop Reactor Coolant Water																								
Inlet Temperature F	---	128	---	127	---	---	126.5	---	---															
Outlet Temperature F	---	113	---	113	---	---	113	---	---															
Differential Pressure $\sqrt{\text{psi}}$	---	---	---	---	---	1.91	---	---	---															
Flow Rate gpm	---	---	---	---	---	72	---	---	---															
LAC Loop Component Cooling Water																								
Inlet Temperature F	---	109.5	---	109.5	---	---	110	---	---															
Outlet Temperature F	123.5	---	122.5	---	122	---	---	122	---															
Differential Pressure $\sqrt{\text{psi}}$	---	---	---	---	---	2.76	---	---	---															
Flow Rate gpm	---	---	---	---	---	88	---	---	---															
1BD Loop Reactor Coolant Water																								
Inlet Temperature F	---	147	---	146	---	---	145.5	---	144.5	---	---	146	146.5	147	---	147	147	---	147	---	147	146	146	---
Outlet Temperature F	---	117	---	117	---	---	117	---	117	---	---	117	117	117	---	117	117	---	117	---	115	115	115	---
Differential Pressure $\sqrt{\text{psi}}$	---	---	2.19	---	---	---	---	---	---	2.19	---	---	---	---	2.19	---	---	---	2.19	---	---	---	---	2.19
Flow Rate gpm	---	---	74	---	---	---	---	---	---	74	---	---	---	---	74	---	---	---	74	---	---	---	---	74
1BD Loop Component Cooling Water																								
Inlet Temperature F	---	109.5	---	109.5	---	---	110	---	110	---	---	109.5	---	---	---	---	---	109	---	---	110	110	110	---
Outlet Temperature F	---	---	---	---	---	---	---	---	off scale	---	---	---	---	---	2.59	---	---	---	2.59	---	---	---	---	2.59
Differential Pressure $\sqrt{\text{psi}}$	---	---	2.59	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Flow Rate gpm	---	---	82	---	---	---	---	---	---	---	---	---	---	---	82	---	---	---	82	---	---	---	---	82
Core Removal Cooling Pump Pressures																								
1A Pump Suction Pressure psig	30.5	---	30.5	---	30.5	---	---	30.5	1-AC	Core Removal Cooling System Pump Down 18:35														
1A Pump Discharge Pressure psig	139.5	---	139.5	---	139.5	---	---	139.5	---															
1A Pump Total Heat Ft-Water	252	---	252	---	252	---	---	252	---															
1B Pump Suction Pressure psig	---	30.0	---	30.0	---	---	30.0	---	37.0	---	---	37.0	35.0	31.0	---	30.0	30.0	---	30.0	---	30.0	30.0	30.0	---
1B Pump Discharge Pressure psig	---	140.0	---	140.0	---	---	140.0	---	150.0	---	---	149.0	145.0	142.0	---	140.0	140.0	---	140.0	---	140.0	140.0	140.0	---
1B Pump Total Heat Ft-Water	---	255	---	255	---	---	255	---	262	---	---	260	255	258	---	255	255	---	255	---	255	255	255	---
Reactor Coolant Loop Temperatures																								
1A T _c (Calibrated) F	---	111.8	---	111.7	---	---	111.7	---	111.7	---	---	111.7	111.7	111.7	---	111.7	111.8	---	111.8	---	111.8	111.7	111.7	---
1B T _c (Calibrated) F	---	162.2	---	160.7	---	---	159.6	---	158.9	---	---	158.5	157.2	157.0	---	156.5	156.5	---	156.3	---	155.6	155.0	154.5	---
1A T _h (Bristol Recorder) F	---	144	---	143	---	---	142	---	124	---	---	122	121	120	---	120	119	---	119	---	119	119	119	---
1B T _h (Bristol Recorder) F	---	144	---	143	---	---	142	---	141	---	---	141	141	141	---	141	141	---	141	---	140	140	140	---

* Corrected Differential Pressure

DUQUESNE LIGHT COMPANY
POWER STATIONS DEPARTMENT
SHIPPINGPORT ATOMIC POWER STATION

CORE REMOVAL COOLING SYSTEM,
SYSTEM II, DLCS 2150201
(TS-641113)

TABLE I (cont'd)

Date 6/19/59

Hours After Shutdown Time	50.9 2015	2025	2035	2042	2043	51.4 2045	2055	2105	2106	51.9 2115	2125	2135	2139	2140	52.4 2145	2155	2205	2206	52.9 2215	2225	2235
Non-Regenerative Heat Exchangers																					
IAC Loop Reactor Coolant Water																					
Inlet Temperature F																					
Outlet Temperature R																					
Differential Pressure $\sqrt{\text{psi}}$																					
Flow Rate gpm																					
IAC Loop Component Cooling Water																					
Inlet Temperature F																					
Outlet Temperature F																					
Differential Pressure $\sqrt{\text{psi}}$																					
Flow Rate gpm																					
IBD Loop Reactor Coolant Water																					
Inlet Temperature F	145	145	145	---	---	145	145	145	---	145	144	144	---	---	144	144	144	---	144	144	---
Outlet Temperature F	115	115	116	---	---	115	115	115	---	115	115	115	---	---	114	114	114	---	114	114	---
*Differential Pressure $\sqrt{\text{psi}}$	---	---	---	2.19	---	---	---	2.19	---	---	---	---	2.19	---	---	---	2.19	---	---	---	2.19
Flow Rate gpm	---	---	---	74	---	---	---	74	---	---	---	---	74	---	---	---	74	---	---	---	74
IBD Loop Component Cooling Water																					
Inlet Temperature F	110	109.5	110	---	---	110	110	110	---	110	110	110	---	---	110	110	110	---	110	110	110
Outlet Temperature F	---	---	---	2.59	---	---	---	2.59	---	---	---	---	2.59	---	---	---	2.59	---	---	---	2.59
*Differential Pressure $\sqrt{\text{psi}}$	---	---	---	82	---	---	---	82	---	---	---	---	82	---	---	---	82	---	---	---	82
Flow Rate gpm	---	---	---	82	---	---	---	82	---	---	---	---	82	---	---	---	82	---	---	---	82
Core Removal Cooling Pump Pressures																					
1A Pump Suction Pressure psi																					
1A Pump Discharge Pressure psi																					
1A Pump Total Head Ft-Water																					
1B Pump Suction Pressure psi	30.0	30.0	30.0	---	---	30.0	30.0	30.0	---	30.0	30.0	30.0	---	---	30.0	30.0	30.0	---	30.0	30.0	30.0
1B Pump Discharge Pressure psi	140.0	140.0	140.0	---	---	140.0	140.0	140.0	---	140.0	140.0	140.0	---	---	140.0	140.0	140.0	---	140.0	140.0	140.0
1B Pump Total Head Ft-Water	254	254	254	---	---	254	254	254	---	254	254	254	---	---	254	254	254	---	254	254	254
Reactor Coolant Loop Temperature																					
1A T _c (Calibrated) F	111.7	111.7	111.7	---	---	111.7	111.7	111.7	---	111.7	111.7	111.7	---	---	---	---	---	---	---	---	---
1B T _c (Calibrated) F	154.3	153.9	153.4	---	---	153.2	152.7	152.7	---	152.0	151.6	151.2	---	---	150.7	150.5	150.4	---	149.7	149.4	---
1A T _h (Bristol Recorder) F	119	119	118	---	---	118	119	118	---	118	118	118	---	---	118	118	118	---	118	118	---
1B T _h (Bristol Recorder) F	140	139	140	---	---	139	139	139	---	139	139	139	---	---	139	139	139	---	139	138	---

*Corrected Differential Pressure

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DUQUESNE LIGHT COMPANY
POWER STATIONS DEPARTMENT
SHIPPINGPORT ATOMIC POWER STATION

CORE REMOVAL COOLING SYSTEM,
SYSTEM II, DLCS 2150201
(TS-641113)

TABLE II
BLANKET INLET AND EXIT WATER TEMPERATURES

Date: 6/19/59

Time: Hours After Shutdown Point	1507	1527	1547	1607	1627	1647	1707	1727	1747	1807	1827	1907	1927	1947	2007	2027	2047	2107	2127	2147	2207	2227
	45.8	46.1	46.4	46.8	47.1	47.4	47.8	48.1	48.4	48.8	49.1	49.8	50.1	50.4	50.8	51.1	51.4	51.8	52.1	52.4	52.8	53.1
1	164.5	161.5	160.0	159.0	158.0	156.0	152.0	148.5	146.5	144.5	143.5	142.5	141.5	140.5	140.5	140.5	140.0	139.0	139.0	139.0	139.0	139.0
2	165.0	162.0	160.5	160.0	159.0	156.0	153.0	149.5	147.0	145.0	144.0	142.0	142.5	140.5	141.0	140.5	140.0	140.0	140.0	139.0	139.0	139.0
3	165.0	162.0	161.0	160.0	159.0	157.0	152.0	149.5	147.5	145.5	144.5	143.0	142.5	141.5	141.0	141.0	140.0	140.0	140.0	140.0	140.0	140.0
4	164.5	162.0	160.5	160.0	159.0	156.0	152.0	149.5	147.0	145.0	144.0	143.0	142.0	141.0	140.0	140.5	140.0	140.0	140.0	140.0	140.0	140.0
5	163.5	161.0	159.5	159.0	158.0	155.0	151.0	148.5	146.0	144.5	143.0	142.0	141.0	140.0	140.0	140.0	139.0	139.0	139.0	139.0	139.0	139.0
6	164.0	162.0	160.0	159.0	158.0	156.0	151.0	148.0	146.0	144.5	143.0	142.0	142.0	141.0	140.5	140.5	140.0	140.0	139.0	139.0	139.0	139.0
7	166.0	163.0	161.0	160.0	160.0	157.0	153.0	149.5	148.0	146.0	145.0	142.0	143.0	142.0	142.0	141.5	141.0	141.0	140.0	140.0	140.0	139.0
8	166.0	163.0	161.0	161.0	160.0	157.0	153.0	150.0	148.0	146.0	145.0	143.0	143.0	142.5	142.0	142.0	141.0	141.0	141.0	141.0	141.0	141.0
9	166.0	163.5	161.5	161.0	160.0	157.0	153.0	150.0	148.0	146.0	145.0	144.0	143.5	142.5	142.5	142.0	141.0	141.0	141.0	141.0	141.0	141.0
10	166.0	163.5	161.5	161.0	160.0	157.0	153.0	150.0	148.0	146.0	145.0	144.0	143.5	142.5	142.5	142.0	141.0	141.0	141.0	141.0	141.0	141.0
11	130.5	130.5	130.5	131.0	130.0	130.0	130.0	130.5	130.5	130.5	130.5	130.0	130.0	129.5	129.5	129.0	128.0	128.0	127.0	127.0	127.0	125.0
12	86.5	86.5	86.0	87.0	87.0	86.0	87.0	87.0	87.0	87.5	87.0	86.5	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0
13	86.0	86.0	85.0	85.0	85.0	85.0	87.0	87.0	87.0	87.5	87.0	86.5	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0
14	84.0	84.5	83.0	84.0	84.0	82.0	86.0	87.0	87.0	87.5	87.0	86.5	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0
15	82.0	84.0	81.0	81.0	82.0	80.0	85.0	87.0	87.0	87.0	87.0	86.5	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0
16	79.5	82.5	78.0	78.0	77.0	77.0	84.0	87.0	87.0	87.0	87.0	86.5	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0
17	77.0	80.5	75.0	75.0	74.0	76.0	83.0	87.0	87.0	87.0	87.0	86.5	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0
18	162.5	160.0	158.5	157.0	156.0	153.0	150.0	146.0	145.5	144.0	142.0	141.5	140.5	140.0	139.0	138.5	138.0	138.0	138.0	138.0	138.0	138.0
19	171.5	171.0	171.0	171.0	171.0	170.0	170.0	170.5	170.0	170.0	170.0	170.0	169.0	169.0	169.0	169.0	168.0	168.0	168.0	168.0	167.0	167.0
20	170.0	162.0	159.0	159.0	158.0	156.0	152.0	149.5	147.0	144.5	144.0	142.5	142.0	141.0	140.5	140.0	140.0	140.0	140.0	139.0	139.0	139.0
21	163.5	162.0	159.0	159.0	158.0	156.0	152.0	149.5	147.0	144.5	144.0	142.5	142.0	141.0	140.5	140.0	140.0	140.0	140.0	139.0	139.0	139.0
22	163.5	162.0	159.5	159.0	158.0	156.0	152.0	149.5	147.0	144.5	144.0	142.0	142.0	141.0	140.5	140.0	140.0	140.0	139.0	139.0	139.0	139.0
23	163.5	162.0	159.5	159.0	158.0	156.0	152.0	149.5	147.0	144.5	144.0	142.0	141.5	141.0	140.0	140.0	140.0	140.0	139.0	139.0	139.0	139.0
24	163.0	162.0	159.0	159.0	158.0	156.0	152.0	149.5	147.0	144.5	143.0	142.0	141.5	141.0	140.0	140.0	139.0	139.0	139.0	139.0	139.0	139.0
25	162.5	162.0	159.5	159.0	158.0	156.0	152.0	149.5	147.0	144.5	143.0	142.0	141.5	140.5	140.5	140.0	139.0	139.0	139.0	139.0	139.0	139.0
26	163.0	162.0	159.5	159.0	158.0	156.0	152.0	149.5	147.0	144.5	143.0	142.0	141.5	140.5	140.5	140.0	140.0	140.0	139.0	139.0	139.0	139.0
27	177.5	177.0	177.0	177.0	177.0	177.0	177.0	176.0	176.0	175.5	175.5	175.5	175.5	175.5	175.0	175.5	174.5	174.0	174.0	174.0	174.0	174.0
28	134.0	135.5	135.5	133.0	122.0	121.0	120.0	120.0	119.0	118.5	118.0	117.5	117.0	117.5	117.5	117.5	117.0	117.0	117.0	118.0	118.0	118.0
29	132.5	134.0	135.0	133.0	122.0	121.0	120.0	119.0	119.0	118.0	117.5	117.0	117.0	117.0	117.0	117.0	117.0	117.0	117.0	118.0	118.0	118.0
30	132.0	133.0	135.0	132.0	121.0	120.0	120.0	119.0	118.0	118.0	117.0	117.0	116.5	117.0	116.5	116.5	117.0	117.0	117.0	117.0	117.0	117.0
31	131.5	133.0	135.0	132.0	121.0	120.0	120.0	119.0	118.0	118.0	117.0	116.0	116.5	116.5	116.5	116.5	117.0	116.0	117.0	117.0	117.0	117.0
32	131.5	133.0	135.0	132.0	121.0	120.0	120.0	119.0	118.0	118.0	117.0	116.0	116.5	116.5	116.0	116.5	117.0	116.0	117.0	117.0	117.0	117.0
33	169.0	166.0	165.0	163.0	161.0	159.0	154.0	151.0	149.0	147.0	145.0	144.5	144.0	143.5	143.0	142.0	142.0	141.0	140.0	142.0	142.0	140.0
34	165.5	163.0	161.0	161.0	157.0	156.0	154.0	151.0	149.0	146.0	145.0	144.5	144.0	143.5	142.0	142.0	141.0	141.0	140.0	142.0	141.0	140.0
35	165.0	162.5	161.0	160.0	157.0	161.0	152.0	149.5	148.0	145.0	145.0	143.5	143.5	144.0	137.0	137.0	141.0	141.0	140.0	141.0	140.0	140.0
36	157.5	155.5	154.5	154.0	153.0	154.0	145.0	143.0	145.5	144.0	144.0	143.0	138.0	137.5	140.0	140.0	137.0	137.0	136.0	136.0	136.0	136.0
37	163.0	161.0	161.0	159.0	156.0	155.0	151.0	147.0	146.0	144.0	143.0	142.0	142.0	140.5	140.5	140.5	140.0	139.0	138.0	138.0	138.0	138.0
38	163.5	161.0	159.5	159.0	158.0	155.0	151.0	148.0	146.0	144.0	143.5	142.0	142.0	140.5	140.5	140.5	140.0	139.0	139.0	139.0	139.0	139.0

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DUQUESNE LIGHT COMPANY
POWER STATIONS DEPARTMENT
SHIPPINGPORT ATOMIC POWER STATION

CORE REMOVAL COOLING SYSTEM,
SYSTEM II, DLCS 2150201
(TS-641113)

TABLE III

SEED EXIT WATER TEMPERATURES

Date: 6/19/59

Time: Hours After Shutdown: Point	1505	1525	1545	1605	1625	1645	1705	1725	1745	1805	1825	1905	1925	1945	2005	2025	2045	2105	2125	2145	2205	2225
	45.7	46.1	46.4	46.7	47.1	47.4	47.7	48.1	48.4	48.7	49.1	49.7	50.1	50.4	50.7	51.1	51.4	51.7	52.1	52.4	52.7	53.1
1	163.5	161.0	159.5	158.0	157.5	156.0	150.5	149.0	147.0	146.0	144.0	143.0	142.0	141.0	142.0	140.0	140.0	140.5	141.5	140.0	140.0	140.0
2	164.0	162.0	160.0	158.5	158.5	156.0	151.0	149.0	147.0	146.0	144.0	143.0	142.0	142.0	142.0	141.0	141.0	141.0	140.5	140.5	140.0	140.0
3	164.0	162.0	160.0	159.0	158.5	155.5	151.0	149.0	147.0	146.0	144.0	143.0	143.0	142.0	142.0	140.0	141.0	141.0	140.0	140.0	140.0	140.0
4	164.0	161.5	160.0	159.0	157.5	155.5	151.0	149.0	147.0	145.0	143.0	143.0	143.0	141.0	140.0	139.0	139.5	140.0	140.0	140.0	140.0	140.0
5	165.5	162.5	161.5	160.0	159.5	156.5	157.5	149.0	148.0	146.0	145.0	144.0	143.0	142.0	142.0	141.0	141.0	141.0	141.0	140.0	140.0	141.0
6	165.0	162.5	161.5	160.0	158.5	156.5	152.5	150.0	148.0	146.0	144.0	144.0	142.0	142.0	142.0	140.0	141.0	140.5	140.5	140.0	140.0	140.0
7	165.0	162.5	161.5	160.0	158.5	156.5	152.5	150.0	148.0	146.0	144.0	144.0	143.0	143.0	142.0	142.0	142.0	141.0	141.0	141.0	141.0	140.0
8	170.0	107.0	165.0	165.0	162.0	160.0	156.0	153.0	151.0	149.0	146.0	146.0	145.0	146.0	145.0	143.0	143.0	143.0	141.5	142.5	143.0	141.0
9	163.5	161.5	161.0	158.0	157.0	155.0	152.5	147.0	147.0	145.0	144.0	142.0	141.0	141.0	140.0	140.0	140.0	140.0	140.0	140.0	140.0	139.0
10	165.0	162.5	161.0	159.5	159.0	156.0	153.0	150.0	148.0	146.0	145.0	143.0	144.0	143.0	142.0	141.0	141.0	140.5	140.0	140.0	140.0	140.0
11	165.0	162.5	161.5	160.5	160.0	156.5	153.0	150.0	148.0	147.0	145.0	143.0	144.0	143.0	143.0	142.0	142.0	142.0	142.0	142.0	142.0	142.0
12	187.0	186.0	186.5	185.5	186.0	186.0	186.5	187.0	187.0	187.0	186.0	186.0	186.0	186.0	187.0	187.0	187.0	187.0	187.0	187.0	187.0	187.0
13	163.0	161.0	160.0	159.0	158.5	156.5	151.5	149.0	147.0	145.0	144.0	142.0	142.0	141.0	141.0	140.0	140.0	139.5	139.5	139.5	139.0	139.0
14	164.0	161.0	160.5	159.0	159.0	156.5	152.0	149.0	147.0	146.0	144.0	142.0	142.0	142.0	141.0	140.0	140.0	140.0	140.0	140.0	140.0	140.0
15	164.0	161.0	160.5	159.5	159.0	156.5	152.0	149.0	147.0	145.0	144.0	143.0	143.0	142.0	142.0	141.0	141.0	140.5	140.5	140.5	140.0	140.0
16	164.0	161.0	160.5	159.0	158.0	156.5	152.0	149.0	147.0	145.0	143.0	143.0	142.0	142.0	141.0	140.0	140.0	140.0	140.0	140.0	140.0	140.0
17	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
18	165.0	161.5	161.0	160.0	158.5	157.0	152.0	150.0	148.0	146.0	144.0	143.0	143.0	143.0	141.0	141.0	141.0	140.0	140.0	140.0	140.0	140.0
19	165.0	161.5	161.0	160.0	158.0	157.0	152.0	150.0	148.0	146.0	144.0	143.0	143.0	143.0	141.0	141.0	142.0	140.0	140.0	140.0	140.0	140.0
20	165.0	161.0	160.5	159.5	158.0	157.0	152.0	149.0	148.0	146.0	144.0	143.0	143.0	142.0	141.0	141.0	140.0	140.0	140.0	140.0	140.0	140.0
21	165.5	162.5	161.0	161.0	159.0	158.0	152.0	150.0	149.0	146.0	144.0	144.0	144.0	143.0	142.0	142.0	142.0	141.5	141.0	141.0	141.0	140.5
22	166.0	162.5	161.0	161.0	159.0	158.0	153.0	150.0	149.0	146.0	144.0	144.0	144.0	143.0	142.0	142.0	141.5	141.5	141.0	141.0	141.0	140.5
23	166.0	162.5	161.5	161.5	159.0	158.0	153.0	150.0	149.0	147.0	145.0	144.0	144.0	143.0	142.0	142.0	142.0	142.0	141.0	141.0	141.0	140.5
24	166.0	162.5	161.5	161.0	159.0	157.5	152.5	150.0	149.0	147.0	145.0	144.0	144.0	143.0	142.0	141.0	141.5	141.5	140.5	140.0	140.0	140.0

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TABLE IV

Pump Head Calculation
1BD Core Removal Cooling Pump 45-G2-2

This information taken from Table I:

Time - 1605

Inlet Pressure - 30.5 psig

Discharge Pressure - $141.0 + 0.5 = 141.5$ psig (Discharge pressure corrected to compensate for elevation of pressure gage 15" above pump discharge.)

Flow: $Q = 74.2$ gpm

$$\text{Velocity Suction Head; } H_{vs} = \frac{V^2}{2g} = \frac{\left(\frac{74.2 \text{ gpm} \times 0.13368 \text{ Ft}^3/\text{gal}}{60 \text{ sec/min} \times 0.0513 \text{ Ft}^2} \right)^2}{2 \times 32.17 \text{ Ft/sec}^2} = 0.159 \text{ ft. of water pressure.}$$

$$\text{Velocity Discharge Head; } H_{vd} = \frac{V^2}{2g} = \frac{\left(\frac{74.2 \text{ gpm} \times 0.13368 \text{ Ft}^3/\text{gal}}{60 \text{ sec/min} \times 0.0233 \text{ Ft}^2} \right)^2}{2 \times 32.17 \text{ Ft/sec}^2} = 0.774 \text{ ft. of water pressure.}$$

Suction Head = $H_s = 30.5 \text{ psig} \times 2.31 \text{ Ft H}_2\text{O/psig} = 70.455 \text{ ft. of water pressure.}$

Discharge Head = $H_d = 141.5 \text{ psig} \times 2.31 \text{ Ft H}_2\text{O/psig} = 326.86 \text{ ft. of water pressure.}$

Total Head; $H_t = H_d - (H_s + H_{vs}) + H_{vd}$
 $= 326.86 - 70.45 - 0.16 + 0.77 = 257.02 \text{ ft. of water pressure.}$

Flow; Q corresponding to H_t of 257.02 = 78 gpm

Q as measured by ΔP meter = 74.2 gpm

Pump Head Calculation
1AC Core Removal Cooling Pump 45-G2-1

Time - 1620

Inlet Pressure - 30.5 psig

Discharge Pressure - $140.5 + 0.5 = 141.0$ psig Corrected for datum plane.

Flow: $Q = 72.0$ gpm.

$$\text{Velocity Suction Head; } H_{vs} = \frac{V^2}{2g} = \frac{\left(\frac{72 \text{ gpm} \times 0.13368 \text{ Ft}^3/\text{gal}}{60 \text{ sec/min} \times 0.0513 \text{ Ft}^2} \right)^2}{2 \times 32.17 \text{ Ft/sec}^2} = 0.15 \text{ ft. of water pressure.}$$

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TABLE IV (cont'd)

$$\text{Velocity Discharge Head; } H_{vd} = \frac{\left(\frac{72 \text{ gpm} \times 0.13368 \text{ Ft}^3/\text{gal}}{60 \text{ sec/min} \times 0.233 \text{ Ft}^2} \right)^2}{2 \times 32.17 \text{ Ft/sec}^2} = 0.74 \text{ feet of water pressure}$$

$$H_s = 30.5 \text{ psig} \times 2.31 \text{ Ft H}_2\text{O/psig} = 70.45 \text{ ft. of water pressure.}$$

$$H_d = 141.0 \text{ psig} \times 2.31 \text{ Ft H}_2\text{O/psig} = 325.71 \text{ ft. of water pressure.}$$

$$\begin{aligned} \text{Total Head } H_t &= H_d - (H_s + H_{vs}) + H_{vd} \\ &= 325.71 - 70.45 - 0.15 + 0.74 = 255.85 \text{ ft. of water pressure.} \end{aligned}$$

Flow: Q corresponding to H_t of 255.85 = 88 gpm

Q as measured by ΔP meter = 72 gpm

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TABLE V
HEAT REMOVED FROM PRIMARY COOLANT TOLAC- NRHX

Date 6/19/59

Time	Hours After Shutdown	Primary Coolant ΔP psi	Flow Constant C	Q Flow GPM	Reactor Inlet Temperature	Reactor Outlet Temperature	Temperature Difference $\Delta T^{\circ}F$	Average Coolant Temperature	Specific Volume Cu Ft/lb	Specific Heat BTU/lb F	Reactor Coolant Flow lb/min	Reactor Coolant Flow lb/hr	Heat Removed BTU/min	Approx. Heat Removed BTU/min
15:15	45.9													
15:25			37.5	75.2	172.0	136.5	35.5	154.2	0.01636	0.9997	614.5	36,870	21,808	21,800
15:35			37.5	75.0	165.7	135.2	30.5	150.4	0.01634	0.9994	613.6	36,816	18,704	18,700
15:45	46.4		37.5	74.6	160.0	133.7	26.3	146.8	0.01632	0.9992	611.1	36,666	16,706	16,700
15:55			37.5	74.1	154.8	118.0	36.8	136.4	0.01627	0.9983	608.8	36,528	22,366	22,400
16:05			37.5	73.5	150.0	105.0	45.0	127.5	0.01623	0.9977	605.4	36,324	27,180	27,200
16:15	46.9		37.5	72.8	146.0	113.0	33.0	129.5	0.01625	0.9979	598.9	35,934	19,722	19,700
16:25			37.5	72.4	142.5	116.0	26.5	129.2	0.01625	0.9979	595.6	35,736	15,750	15,750
16:35			37.5	72.1	139.5	116.3	23.2	127.4	0.01623	0.9977	593.9	35,634	13,746	13,700
16:45	47.4		37.5	72.0	136.8	115.3	21.5	126.0	0.01623	0.9977	593.0	35,580	12,721	12,700
16:55			37.5	71.8	134.5	114.3	20.2	124.4	0.01622	0.9976	591.8	35,508	11,925	11,900
17:05			37.5	71.9	132.6	113.6	19.0	123.1	0.01621	0.9975	592.9	35,574	11,237	11,200
17:15	47.9		37.5	72.0	131.2	113.1	18.1	122.1	0.01621	0.9975	593.8	35,628	10,721	10,700
17:25			37.5	72.0	130.0	113.0	17.0	121.5	0.01621	0.9975	593.8	35,628	10,070	10,100
17:35			37.5	72.0	129.0	113.0	16.0	121.0	0.01620	0.9974	594.1	35,646	9,481	9,500
17:45	48.4		37.5	71.9	128.3	113.0	15.3	120.5	0.01620	0.9974	593.3	35,598	9,053	9,100
17:55			37.5	71.7	127.7	113.0	14.7	120.3	0.01620	0.9974	591.6	35,496	8,674	8,700
18:05			37.5	71.6	127.1	113.0	14.1	120.1	0.01620	0.9974	590.8	35,448	8,308	8,300
18:15	48.9		37.5	71.5	126.6	113.0	13.6	119.8	0.01620	0.9974	590.0	35,400	8,003	8,000
18:25			37.5	71.4	126.1	113.0	13.1	119.5	0.01620	0.9974	589.2	35,352	7,700	7,700

All table values taken from curves plotted from test data.

TABLE VI
HEAT REMOVED FROM PRIMARY COOLANT To IBD - NRHX

Date 6/19/59

Time	Hours After Shutdown	Primary Coolant Vpsl	Flow Constant ΔP C	Q Flow Coolant GPM	Reactor Coolant Inlet Temperature	Reactor Coolant Outlet Temperature	Temperature Difference ΔT°F	Average Coolant Temperature	Specific Volume Cu Ft/lb	Specific Heat BTU/lb/°F	Reactor Coolant Flow lb/min	Reactor Coolant Flow lb/hr	Heat Removed BTU/min	Approx. Heat Removed BTU/min
15:05	45.73				175	134	41	155	0.01637					
15:12	45.85	2.18	37.5	81.75	*174	*133	41	153	0.01635	1.0091	40,104	668.4	27,653	27,650
15:15					174	138	36	156	0.01637					
15:25					172	135	37	153	0.01635					
15:35					171	138	33	154	0.01636					
15:40		2.20	37.5	82.50	168	137	31	152	0.01635	1.0091	40,470	674.5	21,099	21,100
15:45	46.4				168	133	35	156	0.01637					
15:55					165	110	55	138	0.01628					
16:05					163	107	56	135	0.01627					
16:07		2.19	37.5	82.125	163	107	56	135	0.01627	0.99978	40,488	674.8	37,780	37,800
16:15	46.9				162	116	46	139	0.01629					
16:25					161	117	44	139	0.01629					
16:35					160	115	45	138	0.01628					
16:45	47.4				159	120	39	139	0.01629					
16:48		2.20	37.5	82.50	156	120	36	138	0.01628	0.99998	40,650	677.5	24,390	24,400
16:55					157	118	39	137	0.01628					
17:05					155	117	38	136	0.01628					
17:15	47.9	2.19	37.5	82.125	153.5	117	36.5	135	0.01627	0.99978	40,488	674.8	24,625	24,650
17:25					151.5	117	34.5	134	0.01627					
17:35					149.5	117	32.5	133	0.01626					
17:38		2.19	37.5	82.125	149	117	32	133	0.01626	0.99969	40,512	675.2	21,600	21,600
17:45	48.4				149	117	32	133	0.01626					
17:55					148	117	31	132	0.01626					
18:05					147	117	30	132	0.01626					
18:10		2.19	37.5	82.125	147	117	30	132	0.01626	0.99959	40,512	675.2	20,248	20,250
18:15	48.9				146	117	29	131	0.01625					
18:25					145.5	117	28.5	131	0.01625					
18:35					144.5	117	27.5	131	0.01625					
18:38		2.19	37.5	82.125	146	117	29	131	0.01625	0.99955	40,536	675.6	19,583	19,600
18:45	49.4				146	117	29	131	0.01625					
18:55					146.5	117	29.5	131	0.01625					
19:05					147	117	30	132	0.01626					
19:10		2.19	37.5	82.125	146	116	30	131	0.01625	0.99955	40,536	675.6	20,259	20,250
19:15	49.9				147	117	30	132	0.01626					
19:25					147	117	30	132	0.01626					
19:35		2.19	37.5	82.125	147	117	30	132	0.01626	0.99959	40,512	675.2	20,248	20,250
19:45					147	115	32	131	0.01625					
19:55					146	115	31	130	0.01625					
20:05					146	115	31	130	0.01625					
20:08		2.19	37.5	82.125	145	115	30	130	0.01625	0.99950	40,536	675.6	20,258	20,250
20:15	50.9				145	115	30	130	0.01625					
20:25					145	115	30	130	0.01625					
20:35					145	116	29	130	0.01625					
20:42		2.19	37.5	82.125	145	115	30	130	0.01625	0.99950	40,536	675.6	20,258	20,250
20:45	51.4				145	115	30	130	0.01625					
20:55					145	115	30	130	0.01625					
21:05		2.19	37.5	82.125	145	115	30	130	0.01625	0.99950	40,536	675.6	20,258	20,250
21:15	51.9				145	115	30	130	0.01625					
21:25					144	115	29	130	0.01625					
21:35					144	115	29	130	0.01625					
21:39		2.19	37.5	82.125	144	115	29	130	0.01625	0.99950	40,536	675.6	19,582	19,600
21:45	52.4				144	114	30	129	0.01624					
21:55					144	114	30	129	0.01624					
22:05		2.19	37.5	82.125	144	114	30	129	0.01624	0.99946	40,560	676.0	20,270	20,300
22:15					144	114	30	129	0.01624					
22:25					144	114	30	129	0.01624					
22:35		2.19	37.5	82.125	144	114	30	129	0.01624	0.99946	40,560	676.0	20,270	20,300

1. $Q_{gpm} = C \sqrt{\Delta P}$ $Q = 37.5 \times 2.18 = 81.75$

2. $Q_b/min = \frac{Q_{gpm}}{7.48 \times 0.01635} = \frac{81.75}{0.121} = 668.4 \text{ lb/min}$

3. Heat removed BTU/min = $Q_{lb/min} \times \Delta T \times \text{sp. heat} = 668.4 \times 41 \times 1.0091 = 27,653 \text{ or approx. } 27,650 \text{ BTU/min}$

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TABLE VII

HEAT ABSORBED BY COMPONENT COOLING WATER To IAC - NRHX

Date 6/19/59

Time	Hours After Shutdown	Primary Coolant ΔP psi	Flow Constant C	Q Flow GPM	Comp. Cooling Water Inlet Temperature	Comp. Cooling Water Outlet Temperature	Temperature Difference ΔT °F	Avg. Comp. Cooling Water Temperature	Specific Volume Cu Ft / lb	Specific Heat BTU / °F lb	Component Cooling Water lb/min	Heat Removed BTU/min	Approx. Heat Removed BTU/min
15:15	45.9		37.5	88.3	129	154.4	25.4	141.7	0.01630	0.9987	724.2	43,452	18,371
15:25			37.5	88.3	130	149.0	19.0	139.5	0.01629	0.9986	724.6	43,476	13,748
15:35			37.5	88.2	130	144.2	14.2	137.1	0.01628	0.9984	724.3	43,458	10,268
15:45	46.4		37.5	88.1	113	140.3	27.3	126.6	0.01623	0.9977	727.3	43,638	19,809
15:55			37.5	88.0	98	137.0	39.0	117.5	0.01619	0.9973	726.6	43,596	28,260
16:05			37.5	87.7	105.4	134.8	29.4	120.1	0.01620	0.9974	723.7	43,422	21,222
16:15	46.9		37.5	87.7	110.0	133.0	23.0	121.5	0.01620	0.9974	723.7	43,422	16,602
16:25			37.5	87.6	110.5	131.3	20.8	120.9	0.01620	0.9974	722.8	43,368	14,995
16:35			37.5	87.6	110	130.0	20.0	120.0	0.01620	0.9974	722.8	43,368	14,418
16:45	47.4		37.5	87.7	110	129.0	19.0	119.5	0.01620	0.9974	723.7	43,422	13,714
16:55			37.5	87.7	109.5	128.0	18.5	118.7	0.01619	0.9973	724.1	43,446	13,360
17:05			37.5	87.8	110	127.0	17.0	118.5	0.01619	0.9973	725.0	43,500	12,292
17:15	47.9		37.5	88.0	110	126.0	16.0	118.0	0.01619	0.9973	726.6	43,596	11,595
17:25			37.5	87.8	110	125.0	15.0	117.5	0.01619	0.9973	725.0	43,500	10,846
17:35			37.5	87.6	110	124.5	14.5	117.2	0.01619	0.9973	723.3	43,398	10,460
17:45	48.4		37.5	87.5	110	123.6	13.6	116.8	0.01619	0.9973	722.5	43,350	9,800
17:55			37.5	87.5	109.5	123.0	13.5	116.2	0.01619	0.9972	722.5	43,350	9,727
18:05			37.5	87.5	109.5	122.5	13.0	116.0	0.01619	0.9972	722.5	43,350	9,366
18:15	48.9		37.5	87.5	110	122.0	12.0	116.0	0.01619	0.9972	722.5	43,350	8,646
18:25			37.5	87.5	110	122.0	12.0	116.0	0.01619	0.9972	722.5	43,350	8,600

All table values taken from curves plotted from test data.

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TABLE VIII

Station Electrical Operator's Report
June 19, 1959

12:00 M to 8:00 AM

12:00 M Effective Full Power Hours 5032.2.
NOTE: Reactor Plant in operation "Cooldown". Primary system being maintained at 450 F and 600 psi. Alternating A and B charging pumps on slow speed as required.

2:05 AM Primary system temperature 240 F
Pressurizer temperature 355 F

2:50 AM A and B turbine throttle valves were opened wide controlling turbine speed by load limit for Reactor cooldown.

3:15 AM Added 11 inches of water to Component Cooling Water expansion tank from 55 to 66 inches. Chemist notified.

3:33 AM 1A boiler feedwater pump in service

4:20 AM Boiler drum levels 1A-9", 1C-7", 1B-10" and 1D-9".

4:57 AM A and C temperature 166 F, B and C reactor coolant pumps shutdown.

5:07 AM No. 1 main unit on turning gear.

7:32 AM B and C reactor coolant pumps in service for one minute each and shutdown.

8:00 AM to 4:00 PM

NOTE: Component cooling water open wide to non-regenerative heat exchanger. (BD Purification System).

7:45 AM A, B, and C boiler blow down valve closed.

8:30 - 8:36 AM B and C reactor coolant pump on slow speed.

10:10 AM Stopped pumping to Primary Storage Tank.

10:03 AM 1B and 1C reactor coolant pumps started in slow speed for three minutes for temperature circulation.

10:11 AM 1A reactor coolant pump shutdown for venting purposes.

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TABLE VIII (cont'd)

11:55 AM	1BD core removal pump in service with the following valves opened: 45-H16-2, 4, and 6; 09-H16-10; 07-H16-8 and 07-H16-2 and 6 closed. Suction on the core removal pump reads 38 psi. Discharge pressure reads 140 psi. Heise gage connected to the Pressurizer transmitter reading Primary Head Tank pressure and system pressure is 38 psi.
2:22 PM	1C loop hydraulic stop valve closed.
2:45 PM	1AC core removal pump in service with the following valves open: 45-H16-1, 3, 5; 09-H16-9 and 07-H16-7. 07-H16-1 and 5 closed. Heise gage reads 38 psi. AC core removal suction pressure reads 38 psi. Discharge pressure reads 140 psi.
6:35 PM	1AC core removal cooling pump shutdown. 1A hydraulic valve closed.
4:00 PM to 12:00 M	
6:47 PM	Started filling 1B boiler drum by gravity.
7:05 PM	Stopped filling 1B boiler drum.
7:05 PM	Closed following valves: 45-H16-1, 3, 5; 09-H16-9; 07-H16-7; 17-H19-1 open 2 3/4 turns.
	NOTE: 1B reactor hydraulic inlet showing open and closed on indicating lights.
10:40 PM	DLCS 2150201 finished.
12:00 M	EFPH 5032.2.

TABLE IX

Station Operating Engineer's Report

12:00 M to 8:00 AM

Station remained shut down for maintenance and testing. Turbine used as a heat sink to cool down primary system to 167 F. 1B and 1C reactor coolant pumps shut down. 1A reactor coolant pump on slow through reactor. 1D loop remained OOS.

8:00 AM to 4:00 PM

The station is shut down and the primary coolant temperature and pressure is 180 F and 450 psig, respectively, with the 1A reactor coolant pump on slow speed circulating water in the reactor. After the 1A main coolant was shut off the dc to all 4 pumps opened, the primary system was depressurized and placed on the reactor plant storage tank head pressure. The 1BD core removal cooling pump was placed in service to maintain coolant temperature at 180 F and prepare for DLCS 2150201. The clearance on the 1AC purification loop was removed (H_2 gage remains isolated) and the 1AC core removal cooling pump was placed in service for DLCS 2150201.

4:00 PM to 12:00 M

Station shutdown. 1A, 1B, 1C and 1D reactor coolant pumps are shutdown. 1AC and 1BD core removal cooling pumps in service. System pressure 40 psig. System temperature, 155 F. 1C and 1D loop hydraulic valves closed. Shutdown 1AC core removal cooling pump at 6:30 PM. Closed 1A loop hydraulic valve. Completed DLCS 2150201 Core Removal Cooling Test at 10:30 PM. Maintained flow through core using 1BD core removal cooling pump with component cooling water temperature entering non-regenerative heat exchanger at 120 F.

TABLE X

Calibration of Temperature Indicators

Indicator No.	Application
17-J3-2	1 AC non-regenerative heat exchanger outlet temperature for component cooling water.
17-J3-8	1 BD non-regenerative heat exchanger outlet temperature for component cooling water.
17-J3-26	1 AC and 1 BD non-regenerative heat exchanger inlet temperature for component cooling water.
27-07-J3-3	1 AC non-regenerative heat exchanger inlet temperature for reactor coolant.
27-07-J3-4	1 BD non-regenerative heat exchanger inlet temperature for reactor coolant.
27-07-J3-6	1 BD non-regenerative heat exchanger outlet temperature for reactor coolant

Thermometer Calibration

Instrument Number	Calibration Date	Bath Temp.	As Found	As Left
17-J3-2	7/12/59	96	100	96
		137	141	137
17-J3-8	7/12/59	98	98	98
		135	130	135
17-J3-26	7/12/59	91	93	91
		145	147	145
<hr/>				
		L and N Checking STD	Multi-Point Indicator	
27-07-J3-3	7/29/59	167	166	
27-07-J3-4	7/23/59	100	100	
27-07-J3-6	7/24/59	119	119	

Calibration was limited to a single spot-check in the operating range.

TABLE XI
LOG OF EVENTS

Date	Time	Event
6/17/59	1721	The reactor was shutdown.
6/19/59	1155	The 1B core removal cooling pump was started.
	1445	The 1A core removal cooling pump was started.
	1545	The 1A T _C Mueller Bridge was reading erratic.
	1550	The river water flow through the component cooling water cooler was increased.
	1615	The 1A T _C Mueller Bridge was taken out of service. NOTE: The AEC requested that a potentiometer replace the 1A T _C Mueller Bridge. The 1A T _C readings from 1625 to 1725 were missed because of difficulty encountered when connecting the potentiometer.
	1725	The 1A T _C Mueller Bridge was placed in service.
	1834	The 1A core removal cooling pump was shutdown.
	1835	The 1A reactor coolant loop was isolated.
	1847	The 1B boiler was started to be filled with water by gravity. The sight glass indicated the water level was five inches from the bottom.
	1902	The 1B T _C Mueller Bridge indicated the temperature peaked.
	1905	The 1B boiler sight glass indicated the water level one inch from the top.
	2230	The test was completed.

RESULTS RLCS 2150201

T-641113

CORE REMOVAL COOLING SYSTEM

Results Prepared By C.E. Bolenz Jr.

Results Reviewed By John Swank

Approved (Duquesne Light Company)

Henry A. Santel Date 5-19-61