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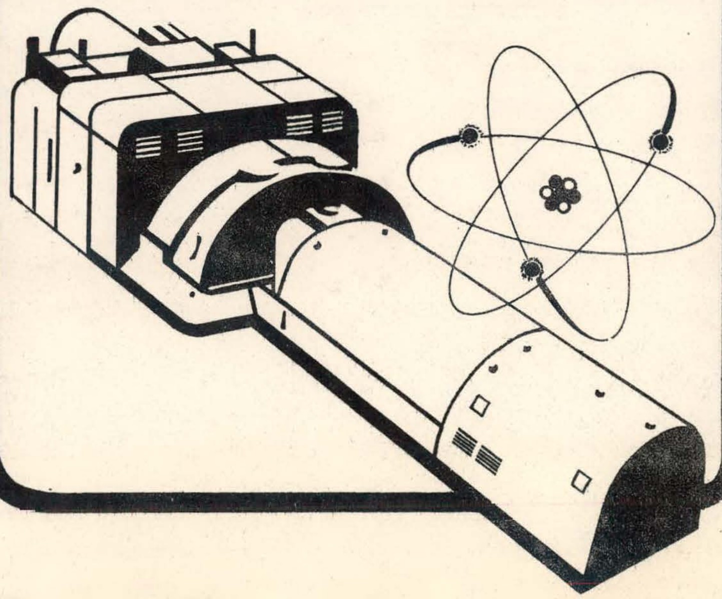
DLCS 5000472

DUQUESNE LIGHT COMPANY

Shippingport Atomic Power Station

Quarterly

OPERATING REPORT



Fourth Quarter 1972

Contract AT-11-1-292

United States Atomic Energy Commission

DISCLAIMER

QUARTERLY OPERATING REPORT
Fourth Quarter 1972
DLCS 5000472

Approved by
F. J. Bissert
Superintendent

Contract AT-11-1-292
United States Atomic Energy Commission

Preface

This Quarterly Report is prepared and issued by the Duquesne Light Company to disseminate information relative to all significant activities conducted at the Shippingport Atomic Power Station. Consistent with the premise that Shippingport was built to provide information and not power at competitive costs, this report makes no effort to analyze power production costs and makes no deductions regarding costs which might be achieved if Shippingport had been built and operated solely to produce power.

In preparation of these reports, it has been presumed that the reader has a working knowledge of nuclear reactors, reactor technology and/or electric utility generating station operations. The reader is reminded, however, that this is an operating report rather than a technical report. Anyone desirous of obtaining advice on recent technical progress related to the nuclear portion of the Shippingport Atomic Power Station is therefore referred to the United States Atomic Energy Commission, Office of Technical Information Extension at Oak Ridge, Tennessee, where this information is readily available.

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1. SUMMARY OF OPERATIONS

During the fourth quarter of 1972, the Shippingport Atomic Power Station was operated as required for Duquesne Light Company system load demand, testing, and maintenance. There were no forced outages and the Heat Dissipation System remained shutdown during this period.

The cold plant station shutdown continued from the previous quarter for testing, training, and maintenance. On October 13, 1972 the AC core removal cooling was removed from service and plant pressurization and heat-up commenced. During the shutdown, the 1A Loop was returned to service following steam generator repairs. On October 20, 1972 a weld leak developed on the 1C loop outlet manual valve bonnet leak off line. The plant was cooled down and necessary repairs performed. A plant heat-up was again performed on October 22, 1972 and the station returned to power operation at 1848 hours on October 23.

Upon return to power with 4 loop operation, it was established that a minor leak existed in the 1A Steam Generator. This leak was not detected during the leak test performed before returning the 1A Steam Generator to service. The leak has remained essentially constant at approximately 1.5 gph.

Also during the shutdown "Loss of AC power Drills" were conducted and on December 5 the "Minor Release to Atmosphere" of the Emergency Plan was performed.

A station shutdown and start-up was performed on November 12 to perform maintenance repairs on river water screens and steam system valves.

One operational incident occurred during the report period which involved momentary overpressurization of the BD purification loop system due to a valving error. Back-up relief valve operation provided equipment protection and the system was returned to normal service.

During the period of the fourth quarter two off-site shipments of solid radioactive waste were made. Total shipments contained 320 drums of waste, weighing 64,057 pounds and contained 458.9 millicuries of activity.

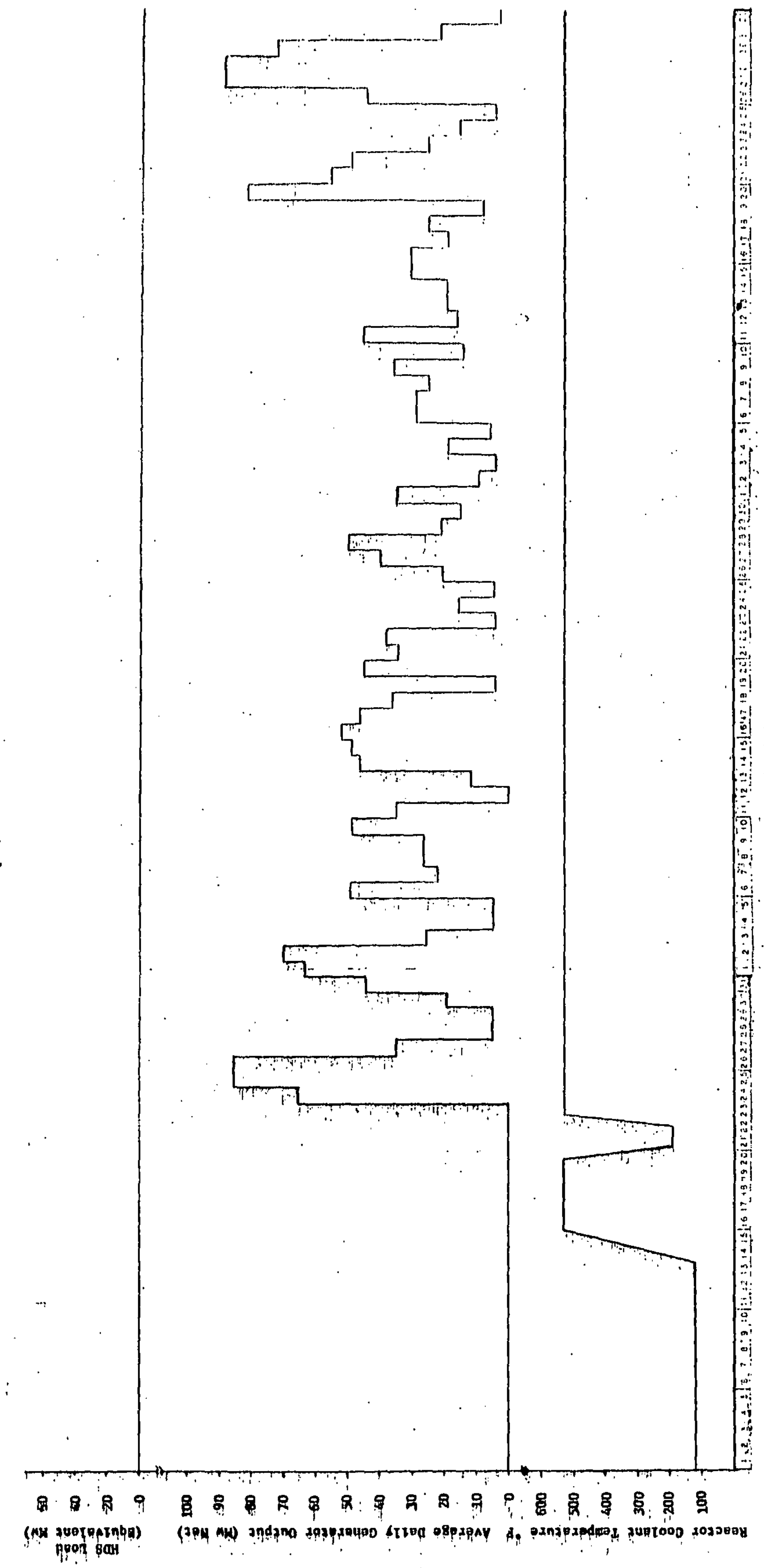


FIGURE 1
Generator Output, HDS Load and Reactor Coolant Temperature During Fourth Quarter Period

2. SUMMARY OF CORE 2 STATION PERFORMANCE

Electrical output (Gross) to date	kwhr	3,180,797,300
EFPH to date (Blanket operating time)	hr	21,844.7
EFPH to date (Seed 2 operating time)	hr	8,192.7
EFPH for the quarterly period	hr	469.4
Hours reactor critical to date	hr	54,317.0
Hours reactor critical for the quarterly period . . .	hr	1,654.3
No. 1 main unit service hours (quarterly period) . .	hr	1,648.4
Net Station output (quarterly period)	kwhr	50,608,000
No. of forced outages*		0

* Interruption of electrical output due to protective relay action and/or operator action as required to protect the Station.

3. CHEMISTRY

During the fourth quarter of 1972 the chemistry section maintained specifications in the various plant systems and fulfilled station manual requirements.

Reactor Plant

During the fourth quarter the station operated using the 1A, 1B, 1C, and 1D reactor coolant loops and the AC and BD purification demineralizers. One out of specification reactor coolant condition was experienced during operation. This condition was a low pH which occurred after a transition of the reactor coolant system from hot lay-up (≥200 °F.) to operating conditions (536 °F.). Treatment with Ammonium Hydroxide (NH_4OH) brought the pH back into specifications. No out of specification conditions were experienced during hot and cold reactor plant lay-ups. See Tables I and II.

The reactor plant auxiliary systems also developed out of specification conditions during this quarter. The component cooling water chromate concentration ([$CrO_4^{=}$]) dropped below the 500 ppm minimum. Treatment with Potassium Chromate (K_2CrO_4) remedied this out of specification condition. Another system without of specification conditions was the coolant charging system. High specific conductivity (>2.50 μmhos) and pH (>8.00) conditions in the Primary Water Storage Tank were a result of back leakage and recirculation following NH_4OH addition to the reactor coolant system. The canal waters were maintained within specifications. See Table III for further information.

The Cs^{138} activity of the reactor coolant remained relatively constant during this quarter. All values are corrected to standard base of 67% reactor power, four reactor coolant loops in service, two purification demineralizers in service at full flow and 536 °F. Tavg operation.

AVERAGE Cs^{138} ACTIVITY

Month	dpm/ml	μCi/ml	No. of Observations
October	514	2.31×10^{-4}	2
November	584	2.63×10^{-4}	12
December	622	2.80×10^{-4}	13

The gross non-volatile gamma activity of the reactor coolant after a 15 minute decay ranged from 4,949 cpm/ml at 11% reactor power to 47,057 cpm/ml at 67% reactor power. The D.F. (decontamination factor) across the demineralizer ranged from 94 to 788 after a 15 minute decay.

As required by the station manual, radiochemical analysis of reactor coolant for insoluble activity as performed each 1000 EFPH. Samples for the eighth performance of this requirement were collected from 10-24-72 to 10-26-72. See Tables IV and V for results of the analysis.

Turbine Plant

During the entire fourth quarter all boilers operated on volatile chemistry. The 1A, 1B, 1C, and 1D heat exchangers were in service throughout the quarter. At the beginning of the quarter the heat exchangers were in cold and then hot lay-up. There were many out of specification conditions during the lay-up period of approximately three weeks. High specific conductivities (greater than the maximum specification) were experienced in all of the heat exchangers during both hot and cold lay-up. The hot lay-up high specific conductivity (>10 μmhos) resulted from NH_4OH formation in going from cold to hot lay-up. This condition lasted approximately two days and was remedied by "steaming" the heat exchangers. The high specific conductivity (>30 μmhos) during cold lay-up was due to the formation of NH_4OH from Hydrazine (N_2H_4) decomposition also resulted in below minimum (<50 ppm) N_2H_4 concentration. Daily N_2H_4 additions were necessary in order to maintain the N_2H_4 concentration.

In going from hot lay-up to operating conditions a primary to secondary leak was discovered in the 1A heat exchanger. The leak rate at the end of the quarter was approximately 2.5 gallons per hour with an activity in the heat exchanger of approximately 3.6×10^{-6} μCi/ml at 11% reactor power. Operating out of specification conditions encountered during this quarter were high specific conductivities (>10 μmhos) in the 1A, 1B, 1C, and 1D heat exchangers and low pH values (<8.00) in all four heat exchangers. Direct treatment with morpholine (C_4H_9NO) remedied the latter out of specification condition and "blowdowns" remedied the high specific conductivities. See Tables VI and VII.

Radioactive Waste Disposal System

During the quarter, 67 Test Tanks were discharged to the Ohio River. The Xe^{133} activity for the quarter ranged from 6.52 dpm/cc to 50.4 dpm/cc (2.93×10^{-6} μCi/cc to 2.27×10^{-5} μCi/cc) contained in the gas hold tanks and associated system. No gaseous discharges to the environment were made during the quarter. The total liquid activity discharged exclusive of tritium and fluorine 18 was 12.624 milicuries for the year 1972.

TABLE I

Reactor Coolant System

Water Conditions and Chemical Adjustments

Operating Conditions

Chemical Condition	Specifications	Analytical Results Min.	Analytical Results Max.	NH4OH Additions Liters	Degassification Hours
1. pH @ 25 C.	10.20 ± 0.10	9.94*	10.30	124.4	89.7
2. Specific Conductivity umhos	------	28	49		
3. Total Gas - cc/kg	125 Maximum	59	100		
4. Hydrogen - cc/kg	10 - 60	22	45		

* See Reactor Plant section of Chemistry Summary, page 4.

TABLE II

Reactor Coolant System

Water Conditions and Chemical Adjustments

Shutdown Conditions

Chemical Conditions	Temp.	Specifications	Analytical Results Min.	Max.	NH_4OH Additions Liters	Degassification Hours
1. pH @ 25° C.	> 200°F	10.10 - 10.30	10.13	10.24	6.5	97
	< 200°F	6.0 - 10.50	9.35	10.20	-	30
2. Total Gas - cc/kg	> 200°F	80 Max	25	55		
	< 200°F	25 Max*	17	17		
3. Hydrogen - cc/kg	> 200°F	10 - 60	10	24		
	< 200°F		3	23		
4. Oxygen - ppm	> 200°F	< 0.14	0.010	0.020		
	< 200°F	< 0.3	0.010	0.020		
5. Chloride - ppm	> 200°F	< 0.1	<0.05			
	< 200°F	< 0.1	<0.05			

* Degassification to 25 cc/kg must be accomplished prior to reducing reactor coolant pressure below the minimum required for reactor coolant pump operation.

TABLE III

Reactor Plant Auxiliary Systems

Water Conditions

System	Specific Conductivity umhos	pH at 25° C	Conc. - ppm			Gross Gamma* Activity-dpm/ml
			CrO_4	Cl	Dis. O_2	
Component Cooling						
Specifications	None	8.30-10.50	500-1000	1 ppm max.	none	none
Observed	1000-1320	8.48- 9.13	468**-658	< 0.05-0.10	-	-
Coolant Charging Water						
Specifications	2.50 max.	6.00- 8.00	none	0.1 ppm max	none	none
Observed	1.0-2.3	6.77- 7.93	-	< 0.05	8.5 ppm	-
Canal Water						
Specifications	5.00 max.	6.00- 8.00	none	none	none	none***
Observed	0.99-1.05	6.12- 6.19	-	-	-	BKGD-.99 ± .83

* Multiply tabular value by 4.55×10^{-7} to obtain μc/ml
** See Reactor Plant section of Chemistry Section, page 4
*** Normally near background

TABLE IV

Primary System Resin and Crud Analysis

In Service			Out Service							Activity dpm/mg at 120 hr. **							
EFPH	Date	Time	Date	Time	Type Sample	Volume Coolant Liters	Crud Weight mg.	Resin Weight gms.	Sp. Act.* cpm/mg @ 120 hrs.	Co^{60}	Co^{58}	Fe^{59}	Cr^{51}	Mn^{54}	Hf^{181}	Zr^{95}	% Acc
									$x10^7$	$x10^6$	$x10^6$	$x10^3$	$x10^3$	$x10^3$	$x10^3$	$x10^4$	
950	9/18/69	1400	9/19/69	1400	Crud	437	1.61		2.30	31.6	13.0	100	1.72	13.0	0.002	0.113	91
1690	12/08/69	1200	12/10/69	1200	Crud	873	1.78		2.64	31.2	31.2	24.1	39.4	13.9	1.56	15.5	96.7
2445	2/12/70	1000	2/13/70	1000	Crud	437	0.13		9.69	97.5	120	52.6	208	45.8	10.7	87.5	91.3
3814	8/25/70	0925	8/26/70	0925	Crud	437	2.25		2.67	37.7	22.8	11.8	39.0	14.6	1.5	4.1	94.1
4535	1/06/71	1320	1/07/71	1320	Crud	437	1.48		1.02	14.1	8.2	8.4	20.8	7.8	0.5	1.5	92.8
5746	6/16/71	0830	6/18/71	0830	Crud	874	3.72		3.51	23.9	58.4	10.1	82.3	10.5	2.16	8.73	90.8
6654	2/02/72	0830	2/04/72	0830	Crud	874	0.07		6.64	45.6	73.4	10.8	36.3	70.2	5.30	17.4	71.3
7725	10/24/72	1115	10/26/72	1115	Crud	874	8.76		3.51	30.3	53.1	8.5	39.8	9.2	1.76	7.45	92.4
									cpm/gm @ 120 hr.	Activity dpm/gm at 120 hr. **							
									$x10^4$	$x10^4$	$x10^4$	$x10^3$	$x10^2$	$x10^3$			
950	9/18/69	1400	9/19/69	1400	Resin	219		50.1	17.0	6.79	4.08	1.77	1.89	1.07			25
1690	12/08/69	1200	12/10/69	1200	Resin	437		42.5	56.9	74.1	46.7	18.1	407	181			94.1
2445	2/12/70	1000	2/13/70	1000	Resin	129		42.7	29.4	32.0	15.4	11.0	47.4	162			67.2
3814	8/25/70	0925	8/26/70	0925	Resin	219		42.5	51.5	95.7	8.5	7.8	80	133			92.9
4535	1/06/71	1320	1/07/71	1320	Resin	219		43.5	16.0	12.1	5.3	15.7	Bkgd	103			64.2

* For conversion to the microcurie unit, multiply tabular value by 1.07×10^{-6}
** For conversion to the microcurie unit, multiply tabular value by 4.55×10^{-7}

TABLE V

1000 Hour Fission Product Analysis

1000 Hour (Run Number) and E.F.P.H.	Cs^{137} dpm/ml	Cs^{134} dpm/ml	I^{131} dpm/ml	I^{133} dpm/ml	Xe^{133} dpm/ml	Ar^{41} dpm/ml
(1) 950	non-dect.	non-dect.	4.2	1.04×10^{2}	29	1.43×10^{4}
(2) 1690	non-dect.	non-dect.	3.2	8.70×10^{1}	98	4.44×10^{4}
(3) 2445	non-dect.	non-dect.	5.2	7.60×10^{1}	84	3.37×10^{4}
(4) 3814	non-dect.	non-dect.	6.9	1.99×10^{2}	57	4.22×10^{4}
(5) 4535	non-dect.	non-dect.	3.8	4.70×10^{1}	47	4.71×10^{4}
(6) 5746	non-dect.	non-dect.	2.3	2.77×10^{1}	-	2.24×10^{4}
(7) 6654	3.12	2.51	22.4	1.46×10^{2}	277	2.77×10^{4}
(8) 7725	1.45	1.96	17.1	1.62×10^{2}	76	3.50×10^{4}

Multiply above values by 4.50×10^{-7} to obtain μCi/ml

TABLE VI

Operating Heat Exchanger Chemistry

Volatile Water Chemistry

Water Conditions	Specifications	Heat Exchangers			
		1A	1B	1C	1D
1. Cond - μmho	Min. ---- Max. 10	6.2 14.0*	5.6 11.0*	6.0 10.9*	6.3 10.5*
2. Phosphate - ppm	Min. ---- Max. 2	0.10 0.50	0.10 0.10	0.00 0.10	0.10 0.10
3. Chlorides - ppm	Min. ---- Max. 0.5	0.08 0.35	<0.05 0.35	0.06 0.25	0.05 0.25
4. Hydrazine - ppm	(residual)	0.002 0.058	0.005 0.086	0.002 0.073	0.002 0.072
5. Silica - ppm	Min. ---- Max. 25	0.95 1.18	1.60 1.67	1.35 1.37	1.15 1.35
6. pH at 25° C	Min. 8.0 Max. ----	7.67* 9.07	7.57* 8.96	7.90* 9.00	7.71* 8.97
7. Chemicals Used					
Na_3PO_4		-	-	-	-
Na_2HPO_4		-	-	-	-
NaH_2PO_4					
N_2H_4					
C_4H_9NO		0.25	0.50	0.25	0.25

* See Turbine Plant section of Q.O.R.

TABLE VII

Non-Operating Heat Exchangers

Water Chemistry

Water Conditions	Specifications	Non-Operating Heat Exchangers 1A	1B	1C	1D
1. Specific Cond. - μmho					
(Hot Lay-up)	Min. ---	8.3	4.5	4.7	4.3
	Max. 10	17*	28*	28*	36*
(Cold Lay-up)	Min. ---	133*	92	65*	67*
	Max. 30	194*	122*	116*	120*
2. pH					
(Hot Lay-up)	Min. 8.00	8.60	7.35*	7.10*	8.38
	Max. ---	9.60	9.88	9.86	9.91
(Cold Lay-up)	Min. 8.00	10.35	10.40	10.30	10.30
	Max. ---	10.73	10.70	10.70	10.70
3. Chloride - ppm	Min. ---	<0.05	<0.05	<0.05	<0.05
	Max. 0.50	0.25	0.25	0.25	0.25
4. Hydrazine - ppm					
(Hot Lay-up)	Min. Residual	0.002	0.002	0.002	0.002
	Max. ---	0.44	52	61	33*
(Cold Lay-up)	Min. 50	5*	35**	51	50
	Max. 100	100	120**	126**	113**
5. Chemicals Used (Pounds)					
Na_3PO_4					
Na_2HPO_4					
N_2H_4		132	93	54	54

* See Turbine Plant section of Q.O.R.
** Sample taken before complete mixing

4. MAINTENANCE

Repairs of major components, as well as routine maintenance on equipment, instruments, controls and preventive maintenance were performed during the quarterly report period. Major work items which were attended to during this report period are summarized as follows:

Refueling Equipment Inventory

The inventory of refueling equipment stored at SAPS and the evaluation of its condition continued during the report period.

1A Traveling Intake Screen

The 1A Traveling Intake Screen was rebuilt and returned to service.

Soft Water System

A section of three inch Soft Water System piping was renewed at the south end of the Fuel Handling Building.

Resin Storage Tanks

Provided maintenance support for sampling resin in the Resin Storage Tanks.

LWBR

Reactor Plant modification and clean up preparations for PWR-2 Defueling and LWBR Installation were in progress during the period. A number of LWBR Components were received, inspected and placed in storage.

Neutralizing Tank

Modifications were made to the Neutralizing tank and associated systems to control the pH of water collected after regeneration of demineralizers so that it meets present requirements for discharge to the River.

Turbine Plant

The following equipment was overhauled during the report period:

a. River Water Booster Pump
b. 1A Clear Well Pump
c. No. 2 Control Air Compressor
d. Heater Drain Pump

Fall Station Shutdown

The following Fall Shutdown Items were completed during the Report period:

1. Exclusion Area Barriers

Exclusion Area Barriers were installed at the entrances to all exclusion areas.

2. Condensate Storage Tank

The top of the Condensate Storage Tank was pulled out to its original contour and an additional vacuum breaker was installed.

3. 1C Loop 18" Manual Outlet Valve

1C Loop 18" Manual Outlet Valve bonnet vent line leak was repaired.

4. PWR Pressurizer

Five heating elements were replaced and two heating elements were removed from service in the 1-BC1 Pressurizer Heater Bank.

5. Miscellaneous Valves

General valve inspection and maintenance was performed on numerous plant valves during the shutdown. Valve leaks were repaired and several damaged valve stems were replaced.

5. TEST PROGRAM

The primary objective of the Test Program during the quarterly report period was to continue reactivity depletion of Core 2 Seed 2 in order to determine irradiation and reactivity lifetime properties and core power distribution as a function of lifetime. Other objectives for this period were to complete periodic calibrations of the primary plant temperature, flow, and pressure instrumentation, and also the Data Acquisition System. Tests were also performed to check the operation of the FEDAL System, the Nuclear Protection System, and the Control Rod Drive Mechanisms. Special tests performed during this period included SPD 178, Sampling Resin Storage Tanks, and a test to determine the air flow capacity of the Reactor Plant air handling system.

Ten tests were performed during the report period. Eight tests were completed and two remained in progress at the end of the quarter. Table VIII lists these tests and Figure 2 indicates the performance dates. Information pertaining to chemistry tests may be found in the chemistry section of this report.

The Periodic Intercalibration of Temperature Sensing Elements (DLCS 60901) which was started last report period on September 24, was completed on October 20. This completed the sixteenth performance of this test. The fifteenth performance of the Periodic Calibration of Reactor Plant Flow Instrumentation (DLCS 61301) included the calibration of all four coolant loop flows and was completed on October 4. On October 7 and 8 (DLCS 61401) Periodic Calibration of Reactor Plant Differential Pressure Instrumentation was performed. The 1D Main Coolant Pump d/p cell was replaced on October 5, 1972. Data Logger readings were taken by the computer and scaled to within ± 1.25% of full scale in the normal operating range. Parts I-V, VI A-E, G, H, and VII of the test procedure were performed at this time completing the fifth performance of the test.

In conjunction with the above instrument calibration tests the Data Acquisition Calibration Test was performed on October 8, 16, 17, 18 completing the sixteenth performance of DLCS 60401.

The FEDAL System (Operation during Station Start-Up) Test (DLCS 58302) was performed monitoring Seed Assembly E-10, which corresponds to Port 9. Performance 88 was completed on October 23.

Nuclear Protection System (Checkout of Pump Power, SLOFA and CLOFA Circuitry) (DLCS 60802) was performed for the ninth time on October 20. Data collected from this performance showed all response times to be within specified limits.

The second performance of (DLCS 63703) control rod positions for Criticality at Operating Temperature was performed on October 23. The Period Measurement Technique (STOP watch method) was omitted for this performance. Used exclusively was the Inverse Kinetic Simulator which performed satisfactorily during the test.

The Control Rod Drive Mechanism Periodic test was performed on October 17 and 18 with four reactor coolant pumps operating on fast speed. All rod full travel scram times were below the allowable maximum full travel scram time of 1.80 seconds. This completed the tenth performance of DLCS 66101.

Special tests included (SPD 178) Resin Storage Tank Sampling. This test was performed on November 3, 8, 11, December 1, 4, 5, and 8 for its initial performance and an air flow determination test of the Reactor Plant air handling system was performed on November 15.

TABLE VIII

Tests Performed During Fourth Quarter of 1972

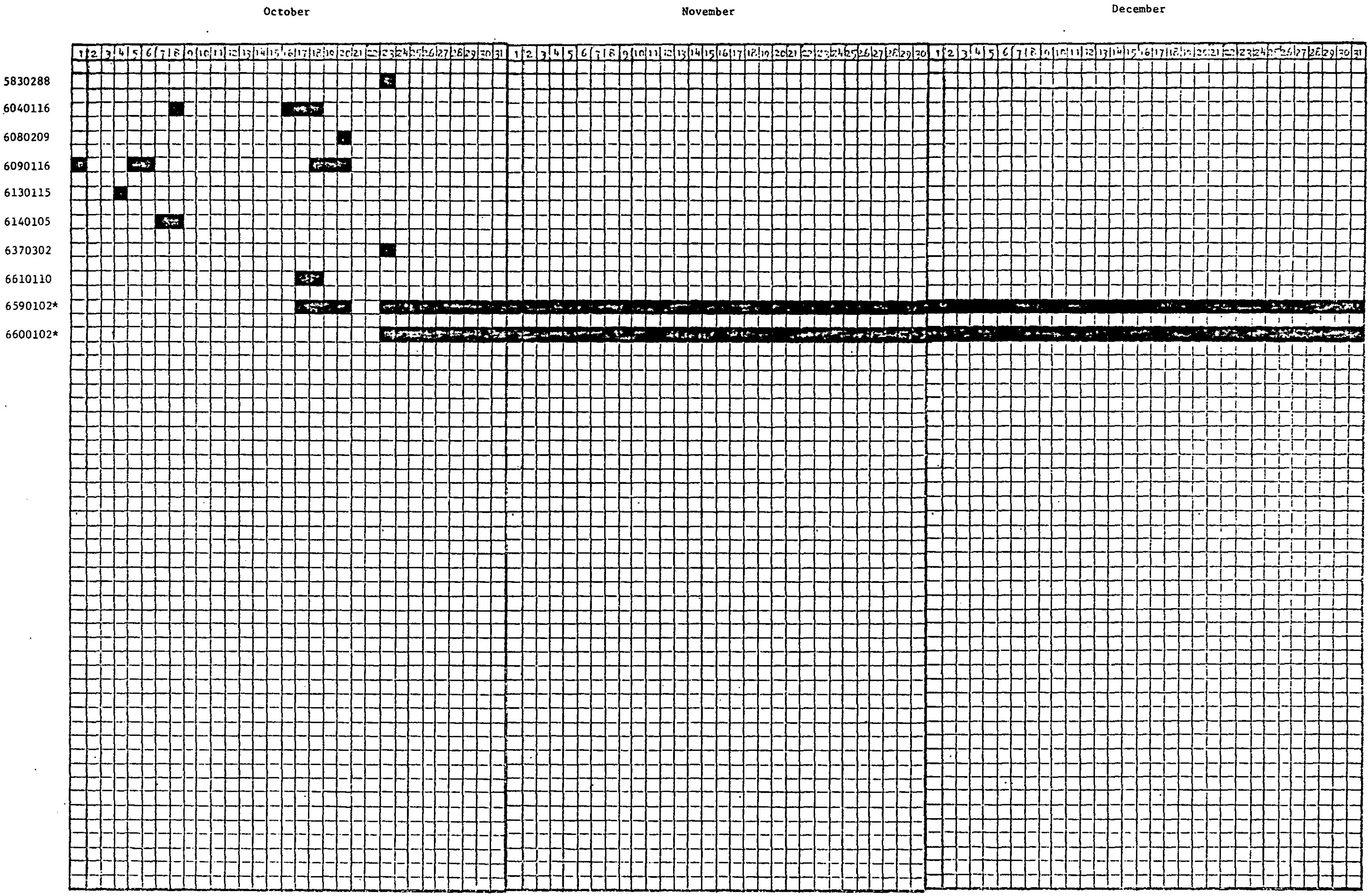
DLCS	5830288	FEDAL System (Operation during Station Start-Up)
DLCS	6040116	Data Acquisition System Calibration Test
DLCS	6080209	Nuclear Protection System (Checkout of Pump Power, SLOFA, and CLOFA Circuitry)
DLCS	6090116	Periodic Intercalibration of Temperature Sensing Elements
DLCS	6130115	Periodic Calibration of Reactor Plant Flow Instrumentation
DLCS	6140105	Periodic Calibration of Reactor Plant Differential Pressure
DLCS	6370302	Control Rod Position for Criticality at Operating Temperature (Critical bank height and bank worth measurements)
DLCS	6610110	Control Rod Drive Mechanism Periodic Test

Tests Remaining in Progress at End of Report Period

DLCS	6590102	Reactor Pressure Drop and Coolant Flow Characteristics
DLCS	6600102	Reactivity Lifetime Test

FIGURE 2

Performance Dates
of
Tests Performed During Fourth Quarter 1972



* Performance incomplete at end of the Report Period

6. TRAINING

During the fourth quarter of 1972, the following items were accomplished by the Shippingport Training Section:

1. Completed training for 10 Radiation Technicians in the Shippingport Radcon Training School (Class I). This course required approximately 6 months to complete and all 10 trainees qualified.

2. Completed the theoretical training of Class IV - Operations Supervisors (2 men).

3. Conducted three month refresher training programs for recertication of operators and supervisors.

4. Conducted training for one Station Operator to certify as Operations Supervisor.

5. Produced a "Contamination Containment Devices" training program consisting of a television tape demonstration and an in-class practical exercise.

6. Developed a program for re-establishing on-the-job proficiency of previously certified Operations Supervisors.

7. GLOSSARY

AEC	United States Atomic Energy Commission
AIX	after ion exchanger (outlet)
a/o	atomic percent
BAPL	Bettis Atomic Power Laboratory
BIX	before ion exchanger (inlet)
bkgd	background
CIC	compensated ionization chamber
DAS	Data Acquisition System
DE	demineralizer effluent
DF	decontamination factor
EFPH	equivalent full power hour
FEDAL	Failed Element Detection and Location System
Hc	critical height
HDS	Heat Dissipation System
magamp	magnetic amplifier
MELBA	Multipurpose Extended Life Blanket Assembly
mr	milliroentgen
mrem	milliroentgen equivalent man
NPS	Nuclear Protection System
ORMS	Operational Radiation Monitoring System
PWR	Pressuriser Water Reactor
R	roentgen
RC	resistance capacitance
μc	microcuries

RCS . . . . Reactor Coolant System
rem . . . . roentgen equivalent man
RPC . . . . Reactor Plant Container
RWDS . . . . Radioactive Waste Disposal System
STP . . . . standard temperature and pressure
su . . . . smear unit (100 sq. cm.)
Tavg . . . . average reactor coolant temperature
Tc . . . . reactor coolant inlet temperature
Th . . . . reactor coolant outlet temperature
Ts . . . . time of sample isolation
v/o . . . . percent by volume
VOS . . . . Valve Operating System