MASTER

**DUQUESNE LIGHT COMPANY
SHIPPINGPORT ATOMIC POWER STATION**

TEST RESULTS

**DLCS 2350101
T-641307**

**DETERMINATION OF WATER REQUIREMENTS FOR SHIELDING
IN THE REACTOR PIT OF CANAL DURING OPERATION**

CORE I, SEED 1

Section 1 of 1 Section

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DETERMINATION OF WATER REQUIREMENTS FOR SHIELDING IN THE REACTOR PIT OF CANAL DURING OPERATION

Purpose

The purpose of this test was to determine the radiation levels in the Reactor Pit and canal walkways with the Reactor Pit filled to various water levels and to measure the temperature at several locations on the floor of the Reactor Pit while the Reactor is at power.

Conclusions

The draining of all shielding water from the Reactor Pit while the reactor was at approximately 39 per cent of full power did not result in a radiation hazard on the canal walkways. The maximum radiation level along the walkways as indicated by a portable survey meter was 1.5 mr/hr β - γ . When the Reactor Pit was completely drained the highest radiation levels were found above the outside edge of the reactor dome approximately 25 feet from the Reactor Pit floor. These levels were the highest β - γ readings recorded during the test and, as determined by exposed film badges, amounted to 600 mr/hr. The data from neutron film badges located about the reactor dome after the reactor pit was emptied were inconclusive. The highest neutron flux level recorded during the test was measured at the bottom of the reactor dome and was 2.4×10^3 thermal n/cm²sec. The temperature of selected bolts and the surrounding concrete at the base of the reactor dome did not increase when all the water was removed from the Reactor Pit.

Description of Test Equipment and Test Procedure

While the Station was operating at 39% power, the Reactor Pit Section of the Fuel Handling Canal was drained in increments of five feet. At each increment, radiation levels were measured using portable survey meters over the reactor dome and along the canal walkways adjacent to the Reactor Pit (Figure 2). The temperatures of selected bolts on the reactor dome flange and the surrounding concrete were measured using iron-constantan thermocouples.

When the Reactor Pit was empty, 25 beta-gamma and 25 neutron sensitive film badges were suspended on cords from a framework in the manner shown in Figure 1. The badges were located as near to the side of the reactor dome as possible still allowing the cords to hang freely. To help determine the exposure time of the film packets, copper foil had been placed in contact with the reactor dome prior to the test to measure the neutron flux. The length of exposure time for the film packets was 25 minutes.

DETERMINATION OF WATER REQUIREMENTS FOR SHIELDING IN THE REACTOR PIT OF CANAL DURING OPERATION (cont'd)

Results

The test was performed on October 4, 1959. Throughout the performance of the test, the Station gross generated output remained between 23.0 to 23.5 MW with a reactor power level of 39%. The gross generated power for 40 hours previous to the test run was between 22 and 23 megawatts with a reactor power level of 37 to 39%. Tables I, II, III and X show the gross generated power at the start and end of the test, the reactor power level throughout the test, the effective full power hours of reactor operation for 40 hours prior to the test, and a log of events respectively.

Beta-gamma radiation levels along the canal walkways and over the reactor dome increased with each drop in the Reactor Pit water level. The largest increase occurred between the 20 feet and the 15 feet water depth when the reactor dome became uncovered (Table IV).

The slow neutron activity became detectable only after the reactor dome was uncovered and continued to increase with decreasing water depth (Table VI). It should be noted that the values listed in Table VI are only relative values and no units are associated with them. The neutron detector was not calibrated above 100 thermal $n/cm^2/sec$. Fast neutrons, however, were not present to any appreciable extent before or after the dome was uncovered, the level being less than five (5) $n/cm^2/sec$. (Table V).

Due to the thick metal wall of the reactor vessel and dome, essentially no beta radiation was present in the Reactor Pit. The beta-gamma film badge exposures were considered to be caused by gamma radiation only. The highest badge exposure occurred at points 13-A and 12-A (Figures 1 and 2) on the North and East sides of the reactor dome 25 feet above the Reactor Pit floor. Point 10 (Figure 2), in contact with the center of the reactor dome, received less exposure than points located in approximately the same horizontal plane along the outer edge of the reactor dome. One exception, point 14-B (Figures 1 and 2), received the same exposure as point 10. At the bottom of the Reactor Pit the badges received from 420 to 480 mr/hr (Figure 3, Tables VII and VIII). The inconsistency between the radiation monitor reading and the film badge exposure for point 10 when the pit was empty can probably be attributed to the greater sensitivity of the film badge (Tables IV and VIII).

The results show no correlation between the position of a badge about the reactor dome and the amount of exposure. Based on the limited amount of radiochemical data (copper foil data), fewer variations in exposure within a given plane and a high exposure at the bottom of the reactor would have been expected. (Figure 4, Tables VII, VIII, XI). The inconsistencies in the neutron film badge data might be attributed to the procedure used in reading the films because this was the first time neutron film badges were used in this manner at Shippingport. It is clear, however, that additional data would be necessary to evaluate any conclusions concerning the neutron flux in the Reactor Pit.

FIGURE 1

Not to scale.

FIGURE 2

Points are located one above the other.

Figure 3
Beta-Gamma Radiation
Levels in Empty
Reactor Pit (Film
Badge Results).

* Height above
floor

Figure 4

Neutron Radiation Levels
in the Empty Reactor Pit
(Film Badge Results).

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TABLE I

Gross Generated Power

Start of Test

23.0 MW

End of Test

23.5 MW

TABLE II

Reactor Power (%)

Channel	A	B	C	D
Time				
0930	39.0	39.0	39.0	39.0
0945	39.0	39.0	39.0	39.0
1000	39.0	39.0	39.0	39.0
1015	39.0	39.0	39.0	39.0
1030	39.0	39.0	39.0	39.0
1045	39.0	39.0	39.0	39.0
1100	39.0	39.0	39.0	39.0
1115	39.0	39.0	39.0	39.0
1130	39.0	38.5	39.0	39.0
1145	39.0	38.5	39.0	39.0
1200	38.5	38.5	38.5	38.5
1315	39.5	39.5	39.5	39.5
1330	39.5	39.5	39.5	39.5
1345	40.0	39.5	39.5	39.5
1400	40.0	39.5	39.5	39.5

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TABLE III

Effective Full Power Hours

Date	Time	EFPH	Date	Time	EFPH	Date	Time	EFPH	Date	Time	EFPH
10/2/59	1800	5755.8	10/3/59	0400	5759.8	10/3/59	1400	5763.7	10/4/59	0000	5767.6
	1900	5756.2		0500	5760.2		1500	5764.1		0100	5768.0
	2000	5756.6		0600	5760.6		1600	5764.5		0200	5768.4
	2100	5757.0		0700	5761.0		1700	5764.9		0300	5768.8
	2200	5757.4		0800	5761.3		1800	5765.3		0400	5769.2
	2300	5757.9		0900	5761.7		1900	5765.7		0500	5769.6
10/3/59	0000	5758.2		1000	5762.1		2000	5766.1		0600	5770.0
	0100	5758.6		1100	5762.5		2100	5766.5		0700	5770.4
	0200	5759.0		1200	5762.9		2200	5766.9		0800	5770.7
	0300	5759.4		1300	5763.3		2300	5767.3		0900	5771.1

TABLE IV

Beta-Gamma Radiation Levels (mr/hr)

Water Depth (Feet)	24.2	20.0	15.0	10.0	5.0	0.0
Point						
10	<0.5	1.3	2.10	2.9	3.1	5.0
15	0.02	0.10	0.60	0.75	1.10	1.30
16	0.02	0.15	0.70	0.85	1.30	1.45
17	0.02	0.15	0.75	0.90	1.35	1.45
18	0.02	0.20	0.85	1.00	1.20	1.40
19	0.02	0.20	0.90	0.95	1.20	1.50
20	0.01	0.20	0.80	0.90	1.10	1.30
21	0.01	0.20	0.80	1.00	1.10	1.30
22	0.02	0.30	0.80	1.10	1.10	1.30
23	0.01	0.30	0.85	0.95	1.10	1.30
24	0.01	0.30	0.85	1.00	1.10	1.40
25	0.02	0.20	0.85	0.85	1.00	1.40
26	0.01	0.15	0.75	0.80	0.90	1.10

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TABLE V

Fast Neutron Radiation Levels (n/cm²sec)

Water Depth (Feet)	24.2	20.0	15.0	10.0	5.0	0.0
Point						
15	0	<5	<5	<5	<5	<5
16	0	<5	5	<5	5	6
17	0	<5	<5	<5	<5	5
18	0	<5	<5	<5	<5	5
19	0	<5	5	<5	<5	<5
20	0	<5	<5	<5	<5	5
21	0	<5	<5	<5	<5	<5
22	0	<5	<5	<5	<5	5
23	0	<5	<5	<5	<5	<5
24	0	<5	<5	5	<5	<5
25	0	<5	5	5	<5	5
26	0	<5	<5	<5	5	<5

TABLE VI

Relative Slow Neutron Radiation Levels (Scale Reading)

Water Depth (Feet)	24.2	20.0	15.0	10.0	5.0	0.0
Point						
15	0	0	90	130	150	190
16	0	0	90	130	180	200
17	0	0	100	140	180	230
18	0	0	110	150	180	240
19	0	0	110	170	190	250
20	0	0	100	150	180	210
21	0	0	90	140	160	200
22	0	0	100	140	170	210
23	0	0	100	140	170	210
24	0	0	100	190	170	220
25	0	0	100	150	180	210
26	0	0	90	130	150	190

TABLE VII

Film Badge Calibration

Beta Gamma Film		Neutron Film	
Beta Gamma (mr)	Scale Reading	Neutron (n_t/cm^2)	Tracks/Field
0	0.00	1.44×1.0^6	0.6
25	0.01		
50	0.02		
75	0.03		
100	0.04		
150	0.06		
400	0.16		
600	0.24		
1500	0.57		

TABLE VIII

Film Badge Data

Badge Number	Location (Fig. 1)	Time (hr)	Exposure (Min)	β - γ Scale Reading	β - γ mr	β - γ mr/hr	n_t Tracks/Field	$n_t/cm^2/sec$
83	10	1350	25	0.08	200	480	0.16	256
201	11A		25	0.09	225	540	0.40	640
202	11B		25	0.09	225	540	0.15	240
205	11C		25	0.08	200	480	0.11	176
206	11D		25	0.08	200	480	0.32	512
211	11E		25	0.08	200	480	0.14	224
213	11F		25	0.07	175	420	0.087	139
97	12A		25	0.10	250	600	0.025	40
98	12B		25	0.09	225	540	0.025	40
138	12C		25	0.08	200	480	0.050	80
140	12D		25	0.08	200	480	0.15	240
141	12E		25	0.07	175	420	0.25	400
142	12F		25	0.07	175	420	0.22	352
84	13A		25	0.10	250	600	0.10	160
85	13B		25	0.10	250	600	0.22	352
86	13C		25	0.09	225	540	0.075	120
91	13D		25	0.08	200	480	0.22	352
95	13E		25	0.08	200	480	0.22	352

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TABLE VIII (cont'd)

Film Badge Data

96	13F	1350	25	0.08	200	480	0.15	240
143	14A		25	Destroyed			0.42	672
144	14B		25	0.08	200	480	0.20	360
146	14C		25	0.08	200	480	0.20	360
147	14D		25	0.08	200	480	0.12	192
148	14E		25	0.08	200	480	0.18	288
150	14F		25	0.08	200	480	0.54	863

TABLE IX

Thermocouple Data

Water Depth (Feet)	24.2		20.0		15.0		10.0		5.0		0.0	
Location	MV	F	MV	F	MV	F	MV	F	MV	F	MV	F
Bolt 17, Concrete	1.545	86.3	1.530	85.5	1.564	87.1	1.550	86.5	1.589	88.3	1.618	88.9
Bolt 17, Ring	1.545	86.3	1.560	87.0	1.605	88.3	1.570	87.3	1.640	89.3	1.628	89.3
Bolt 36, Concrete	1.530	85.7	1.552	84.5	1.571	87.3	1.523	85.3	1.590	88.0	1.590	88.0
Bolt 36, Ring	1.510	85.0	1.532	85.8	1.550	86.5	1.520	85.3	1.608	88.7	1.588	87.9

TABLE X

Time Log of Test

Water Depth (Feet)	24.2	20.0	15.0	10.0	5.0	0.0
Time (hours)	1000	1035	1110	1140	1300	1400

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TABLE XI

Radiochemistry Data (Copper Foil Data)

Copper Foil Foil Number	Location	Exposure Time	Flux Level ($n_t/cm^2 \cdot sec$)
1	West-Halfway Down	52 Hours	8.2×10^2
2	East-Top		8.2×10^2
3	West-Top		8.2×10^2
4	East-Bottom		2.4×10^3

TABLE XII

Meter Calibrations

Thyac Survey Meter Number 873

Date: 10/2/59
 Source: 1.1 mc Co⁶⁰

Calculated	Measured
0.18 mr/hr	0.18 mr/hr
1.5	1.5
15	15

Jordan Radector Number 732

Date: 10/2/59
 Source: 38 mc Co⁶⁰

Calculated	Measured
10 mr/hr	10 mr/hr
50	55
100	110
250	250
500	500
0.5 R/hr	0.5 R/hr
1.0	1.0
1.5	1.5

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TABLE XII (cont'd)

Meter Calibrations

Radiation Counter Laboratories Fast-Slow Neutron Survey Meter (Long Tom) Number 132

Date: 10/3/59

Source: Polonium-Beryllium

Meter Reading	Thermal X 1	Thermal X 10
2.35	5 n _t /cm ² sec	
3.5	10	
4.6	20	
2.7		100 n _t /cm ² sec
2.5		90
2.2		70
1.5		50
1.1		30
0.9		20
0.6		10

Meter Reading	Fast X 1	Fast X 10
0.5	5 n/cm ² sec	
2.0	10	
3.5	20	
4.5	30	
0.7		30 n/cm ² sec
1.1		50
1.4		70
1.8		90
2.0		100
2.6		150
3.0		200

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DETERMINATION OF WATER REQUIREMENTS FOR SHIELDING IN THE REACTOR PIT OF CANAL DURING
OPERATION, (cont'd)

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