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DUQUESNE LIGHT COMPANY
SHIPPINGPORT ATOMIC POWER STATION

TEST EVALUATION

DLCS 2180101

PERIODIC CHARACTERIZATION OF RADIOACTIVE WASTE DISPOSAL SYSTEM EFFLUENTS

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Purpose

The purpose of this test is to characterize the major nuclides present in the Radioactive Waste Disposal System effluent water and gas. As supplementary information, the System performance in regard to the activities present, can also be evaluated.

Conclusion

During this test performance, the Radioactive Waste Disposal liquid waste process stream effectively reduced the activity present in the 1C Surge and Decay Tank to well within limits for discharge to the Ohio River. The major gamma emitting nuclides were accounted for in the Surge and Decay Tank, Waste Gas and Chemical Waste Tank; the activity of Special Wastes during the period of the test were of too low activity level to characterize. The major gamma activity in all of the liquid samples analyzed was Cobalt-60. The Radioactive Waste Disposal Ion Exchangers and Gas Stripper removed the major activities in both particulate and filterable (through type HA millipore filter) form, and reduced the gross activity to well within limits for discharge to the environment. The resins and Gas Stripper removed particulate matter with a 98.8% efficiency.

Table VII of this report lists the Maximum Permissible Concentrations values based on continuous exposure (168 hour/week) and it is apparent from this data that the isotopes present in the test tank (Table V) were below their respective tolerances before being diluted with condenser circulating water.

Strontium-90 was not detectable in the reactor plant effluent. The method employed was the standard technique which involves removal of the active Yttrium-90 daughter after approximate equilibrium is reached. The samples were counted on a Model C-14 Low Background Counter having an average background of 0.8 cpm. (Tracer Labs Inc.)

The vent Gas System was sampled on November 27, 1961. The major activity was Xenon-133. A small amount Krypton-85 activity was observed when the sample was recounted on December 28, 1961. The delay between sampling and radio assay is necessary in Krypton-85 analysis because of its very low gamma-ray abundance (0.36 percent)¹ and low activity level.

The 1B Chemical Waste was sampled on September 22, 1961. The tank had been receiving Decontamination Room effluents. The major activity was Cobalt-60 which accounted for 53.6% of the activity. The filtrate, or filterable activity, contained Manganese-54 activity in a ratio of 1 to 3 with Cobalt-60 where as normally waterborne crud or crud from components has a ratio of 1 to 8. The 1 to 8 ratio is also present in non-filterable, or the crud retained when the chemical waste tank was filtered through HA millipore filter.

¹ B.F. Rider (General Electric Co., San Jose, Calif.) Branching Ratio of Krypton-85, Proceedings of the Third Conference on Analytical Chemistry in Nuclear Reactor Technology, Gatlinberg, Tenn. 1960.

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Results

On August 16, 1961, it was observed that the LC Surge and Decay Tank contained activity of level sufficiently high to meet the conditions necessary to perform Section IV-A of this test. The LC Surge and Decay Tank had been valved to receive reactor plant effluents from August 7, until August 12, 1961, when it reached the 86% indicated level. The water collected was due mostly to a performance of DLCS 30701, Primary Plant Self-Actuated Relief Valve Operation. The test required that valves 06-H15-3 and 9 be popped and 06-H15-1, 2, 8 and 10 be flushed. The LC Surge Tank was recirculated for mixing on August 12, 1961. Initial sampling and analysis were completed and processing was begun on August 16. The fluid flow path for this water was from LC Surge Tank through C, B, A and D Ion Exchangers in series, followed by the Gas Stripper, operating at the normal flow rate of 3 gpm. The 1A Test Tank was receiving for the 24 hour sampling period. Hourly samples were taken while the tank was being recirculated and processed.

The history of flow through the ion exchangers prior to the performance of this test is shown in Table VI.

It should be noted that all of the resin beds contained mixed-bed resin in Hydrogen-hydroxide form. Each ion exchanger contained 10 cu. ft. of resin. The demineralizers are designed to operate with a 12 cu. ft. bed however, for operating convenience the 10 cu. ft. charge is used.

There is little doubt from the operating history of the resins that the beds were classified. They had been backwashed several times and there is no provision in the system for air mixing to re-distribute the anion and cation resins into a uniformly mixed bed. Classified resin beds are inherently less effective ion exchangers.

The gross beta activity of the samples taken over the 24 hour sampling period varied over a wide range (211 to 1029 dpm/ml) and had a random distribution with an arithmetic mean of 573 ± 209 dpm/ml. The gross β activities of the hourly surge tank samples are shown in Table I. The hourly samples were mixed and filtered. Since the mixing of these very large sample volumes and filtration through HA millipore filter require extremely long times, the gamma balance and specific activities were calculated approximately thirty days after sampling. The specific activities are shown in Tables II, III, IV and V for the surge tank, first ion exchanger, last ion exchanger and the test tank respectively. The major activity in all the liquid samples analyzed was Co^{60} . This is further substantiated by the Gamma Ray spectra of the liquid samples of the surge, last ion exchanger, and test tank which are shown in Figures 1, 2 and 3.

The Radioactive Waste Disposal System process removed the activity present in reactor plant effluent water affectively. The decontamination factors for soluble (any particulate or soluble matter that pass through type HA millipore filter paper) and particulate activity were determined.

There was a negative decontamination across the first ion exchange for Cesium-137 activity. This was due to the long service (149,600 gallons) on stream that the resin in the 1C Ion Exchanger had seen. (See Table VI). The activity was removed by the resins down stream of 1C Ion Exchanger and the process stream showed a decontamination factor of 2 from the activity in the surge tank and a D.F. of 11 considering the Cesium-137 activity introduced by the 1C Ion Exchanger. It is apparent from the data that the resins, after long service, are regenerated to a form (probably the Li-Cs form)² which exchanges the Cesium-137 and Li for other cations. This tends to confirm the work of Lindsay and Abrams (See reference 2).

There was an increase in the filtrate Co⁶⁰ activity between the last ion exchanger and test tank where the activity increased from 9.8 dpm-ml to 14.1 dpm-ml, and an increase in Manganese-54 activity from 4.2 dpm-ml at the last ion exchanger effluent to 8.7 dpm-ml in the 1A Test Tank. Because of this increase, the Radioactive Waste Disposal System process stream showed a decontamination factor of only 2.4 for soluble Manganese and Cobalt activity. The increase was due to contamination in the test tank. A routine Health Physics survey prior to a performance of DLCS 25501, Radioactive Waste Disposal System Test Tank Thermal Agitation, showed that the tank had a general radiation level of 5 mr/hr and a contamination level of 100,000 dpm-su.

The resins also removed the activated particulate matter (crud) effectively by filtration. The activity distribution in the surge tank showed that particulate matter contained the major amounts of the total activity, 68%. The filtrate contained approximately 20% of the gross non-volatile gamma-ray activity. Based on the Co⁶⁰ activity in the material retained on HA millipore filter paper, the first ion exchanger had an efficiency of 94.5%. The RWD process equipment, which included four ion exchangers and the Gas Stripper had an overall efficiency of 98.8% for particulate activity.

The Gas Decay Drums were isolated on November 27, 1961 and discharged to the atmosphere at a rate of 20 standard cubic feet per hour on November 27 and 28, 1961. Prior to discharge, a gas sample was taken and characterized using a Nuclear Data 512 Channel Pulse Height Analyzer. The major activity was Xe¹³³. In order to determine the Kr⁸⁵ activity, a 500 cc gas sample was saved and re-counted on December 28, 1961. The one month delay time is necessary in Kr⁸⁵ analysis, because of its low gamma ray abundance (0.36 percent)¹, and low activity level. Xe¹³³ and Kr⁸⁵ accounted for 100% of the Gross Gamma activity. The Xe¹³³ activity on November 27, 1961 was 745 dpm/cc, and Kr⁸⁵ was 202.9 dpm/cc. A spectrum of the gas sample is shown in Graph 3.

² W. T. Lindsay Jr. and C. S. Abrams, Ion Exchanger Removal of Fission Products from High Purity Water. WAPD-PWR-CP-2636 page 45.

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The 1B Chemical Waste was sampled on September 22, 1961. During sample time, the 1B Chemical Waste Tank was at the 27% level and waste was being processed by evaporation.

Prior to sampling, the 1B Chemical Waste Tank had been receiving Decontamination Room effluent. A characterization of this waste (See Table VIII) shows that the major activities were Co^{60} and Mn^{54} which accounted for 53.6% and 11.7% of the gross gamma activity respectively. The filterable material (crud) contained Mn^{54} to Co^{60} activities in a ratio of 1-8. This is consistent with normal water borne crud. However, the activity ratio of Mn^{54} to Co^{60} for the filtrate is 1-3 which is not consistent with data on filtrate of canal water or primary coolant. These values normally exceed the 1-8 ratio.

The fact that the wastes collected are of greatly varying chemical nature and because the chemical waste tank is very highly contaminated from prior service make it impossible to speculate as to reasons for this different ratio.

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TABLE I

Sample - 1C Surge Tank
Sample time - August 17-18, 1961

Hourly Sample No.	Gross Beta Act. at Sample Time	
	dpm-ml	Deviation from Avg
1	249	324
2	584	11
3	653	80
4	262	311
5	843	270
6	1 029	456
7	211	362
8	1 022	449
9	527	46
10	237	336
11	899	326
12	744	171
13	231	342
14	720	147
15	829	256
16	434	319
17	734	161
18	663	90
19	424	149
20	369	204
21	679	106
22	480	93
23	434	139
24	402	171
25	667	94
Average	573	209

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TABLE II

Sample - 1C Surge Tank

Gross γ activity (degassed) - 79.7 cpm/ml*

Gross γ activity (non-degasses) - 114 cpm/ml*

Sample Time - August 17-18, 1961

	dpm/ml*		% Gross γ Recovered*
	Filtrate	Crud	
Co ⁶⁰	33.74	112.25	83.5
Mn ⁵⁴	3.74	5.94	3.4
Cr ⁵¹	N.D.	N.D.	
Fe ⁵⁹	N.D.	0.94	0.3
Ba ¹⁴⁰	0.11	0.09	
Sr ⁸⁹	N.D.	N.D.	
Sr ⁹⁰	N.D.	N.D.	
Cs ¹³⁷	4.79	N.D.	1.7
Cs ¹³⁶	N.D.	N.D.	
Hf ¹⁸¹	N.D.	N.D.	
Zr ⁹⁵	N.D.	N.D.	
TOTAL			88.9

H³ Concentration was 1 μ c/l

N.D. = Not Detectable

* All activity measured on or corrected to September 18, 1961. A 2ml aliquot was counted in a Na I (Tl) well counter for all gross γ measurements.

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TABLE III

Sample - First Ion Exchanger Outlet
 Gross γ activity (degassed) - 29.9 cpm/ml*
 Gross γ activity (non-degassed) - 31.3 cpm/ml*
 Sample time - August 17-18, 1961

	dpm/ml*		% Gross γ Recovered*
	Filtrate	Crud	
Co ⁶⁰	33.85	6.36	63.0
Fe ⁵⁹	N.D.	N.D.	
Cr ⁵¹	N.D.	N.D.	
Mn ⁵⁴	0.91	N.D.	
Ba ¹⁴⁰	N.D.	N.D.	0.8
Sr ⁸⁹	N.D.	N.D.	
Sr ⁹⁰	N.D.	N.D.	
Cs ¹³⁷	25.51	N.D.	
Cs ¹³⁶	N.D.	N.D.	21.0
Hf ¹⁸¹	N.D.	N.D.	
Zr ⁹⁵	N.D.	N.D.	
TOTAL			84.8

N.D. = Not Detectable

* All activity measures in or corrected to September 18, 1961. A 2ml aliquot was counted in a Na I (Tl) well counter for all gross measurements.

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TABLE IV

Sample - Last Ion Exchanger Outlet
 Gross γ activity (degassed) - 8.66 cpm/ml*
 Gross γ activity (non-degassed) - 9.15 cpm/ml*
 Sample time - August 17-18, 1961

	dpm/ml*		% Gross γ Recovered*
	Filtrate	Crud	
Co ⁶⁰	9.70	2.94	68.5
Fe ⁵⁹	N.D.	N.D.	
Mn ⁵⁴	0.42	1.39	6.1
Cr ⁵¹	N.D.	N.D.	
Ba ¹⁴⁰	N.D.	N.D.	
Cs ¹³⁷	1.37	N.D.	4.5
Cs ¹³⁶	N.D.	N.D.	
Sr ⁹⁰	N.D.	N.D.	
Si ⁸⁹	N.D.	N.D.	
Hf ¹⁸¹	N.D.	N.D.	
Zr ⁹⁵	N.D.	N.D.	
TOTAL			79.1

N.D. = Not Detectable

* All activity measured on or corrected to August 27 1961. A 2ml aliquot was counted in a Na I (Tl) well counter for all gross measurements.

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TABLE V

Sample - Test Tank
Grossy activity - 6.8 cpm/ml*
Sample time - August 18, 1961

	dpm/ml*		% of Gross (γ) Activity*
	Filtrate	Crud	
Co 60	14.08	1.06	100.0
Fe 59	N.D.	N.D.	
Mn 54	0.87	N.D.	3.6
Cr 51	N.D.	N.D.	
Ba 140	N.D.	N.D.	
Cs 136	0.22	N.D.	0.9
Cs 137	N.D.	N.D.	
Sr 89	N.D.	N.D.	
Sr 90	N.D.	N.D.	
Hf 181	N.D.	N.D.	
Zr 95	N.D.	N.D.	
TOTAL			104.5

H³ Concentration was 1 μc/l

N.D. = Not Detectable

* All activity measured on or corrected to September 18, 1961. A 2ml aliquot was counted in a Na I (Tl) well counter for all gross measurements.

TABLE VI

OPERATING HISTORY OF ION EXCHANGERS PRIOR TO TEST

Total Flow, gpm	Operation
6/ 9 3:30/P 0	Replaced resin in 1C Ion Exchanger. Backflushed 1B, 1A & 1C Ion Exchangers. Flow path: B-A-D-C
6/15 1:30/P 12 150	Replaced resin in 1B Ion Exchanger.
6/16 11:40/A 16 550	Returned 1B Ion Exchanger to service. A-D-C-B.
6/31 2:10/A 73 550	Backflushed 1A Ion Exchanger.
7/ 6 1:15/P 87 650	Replaced resin in 1A Ion Exchanger.
7/ 7 2:45/P 97 150	Returned 1A Ion Exchanger to service. Backflushed 1D, 1C & 1B Ion Exchanger. Changed flow from A-D-C-B to D-C-B-A.
7/11 6:05/P 104 050	Backflushed 1D Ion Exchanger. Changed flow from D-C-B-A to C-B-A-D.
7/26 10:20/A 108 450	Changed flow from C-B-A-D to A-D-C-B.
7/31 10:00/A 120 850	Changed flow from A-D-C-B to D-C-B-A.
8/ 9 7:30/P 134 150	Replaced resin in 1D Ion Exchanger. Changed flow from D-C-B-A to C-B-A-D.
8/12 4:10/A 136 600	Backflushed 1C and 1B Ion Exchanger.
8/18 3:00/P 149 600	End of DLCS 218

TABLE VII

MAXIMUM PERMISSIBLE CONCENTRATIONS OF RADIO NUCLIDES IN AIR & WATER

Isotope	Half Life	MPC (168 hr week)*	
		Air	Water
		µc/cc	µc/cc
Co ⁶⁰	5.2 years	10 ⁻⁷	5 x 10 ⁻⁴
Mn ⁵⁴	310 days	3 x 10 ⁻⁷	10 ⁻³
Cs ¹³⁷	28 years	2 x 10 ⁻⁸	2 x 10 ⁻⁴
Ba ¹⁴⁰	12.8 days	4 x 10 ⁻⁸	3 x 10 ⁻⁴
La ¹⁴⁰	40.8 hours	5 x 10 ⁻⁸	2 x 10 ⁻⁴
Cr ⁵¹	27 days	4 x 10 ⁻⁶	2 x 10 ⁻²
Fe ⁵⁹	45 days	10 ⁻⁷	6 x 10 ⁻⁴
Sr ⁸⁹	50.5 days	10 ⁻⁸	10 ⁻⁴
Sr ⁹⁰	19 years	10 ⁻¹⁰	10 ⁻⁶
Y ⁹⁰	64 hours	4 x 10 ⁻⁸	2 x 10 ⁻⁴
Xe ¹³³	5.36 days	3 x 10 ⁻⁶	
Xe ¹³⁵	9.2 hours	10 ⁻⁶	
Kr ⁸⁵	10.2 years	3 x 10 ⁻⁶	

* NBS Handbook 69 dated June 5, 1959.

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TABLE VIII

Sample - 1B Chemical Waste Tank
 Grossy activity - 336 cpm/ml*
 Sample time - September 22, 1961

	dpm/ml*		% Grossy Activity*
	Filtrate	Crud	
Co ⁶⁰	301.0	67.6	53.6
Co ⁵⁸	66.5	N.D.	5.3
Mn ⁵⁴	139.0	8.03	11.7
Fe ⁵⁹	1.9	1.95	0.3
Hf ¹⁸¹	0.7	0.37	
Zr ⁹⁵	N.D.	N.D.	
Cr ⁵¹	N.D.	N.D.	
Cs ¹³⁶	N.D.	N.D.	
Cs ¹³⁷	N.D.	N.D.	
TOTAL			70.9

N.D. = Not Detectable

* All activities measured on or corrected to September 22, 1961.
 A 2ml aliquot was counted in a Na I (Tl) well counter for all
 gross measurements.

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