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FEED TEST

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K REACTOR LOW ALUM FEED TEST

BY

R. G. Geier
Research and Engineering Section

May 24, 1967

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K REACTOR LOW ALUM FEED TESTINTRODUCTION

The production reactors operated by Douglas United Nuclear, Inc., use treated Columbia River water as the coolant on a once through basis. Thus, radionuclides formed largely by the neutron activation of river salts are discharged to the river. One method of reducing the quantity of radionuclides in the effluent is to increase the efficiency of parent isotope removal during the water treatment process.

Prior to 1961 the water treatment process for preparing reactor coolant had been improved to the point that reactor quality coolant could be produced using an average alum flocculant feed rate of 6 ppm. Laboratory experiments carried out in 1959 and 1960 demonstrated that a markedly increased removal of parent isotopes resulted when alum feed rates in the neighborhood of 20 ppm were used. The results were confirmed by two half-plant tests of short duration.⁽¹⁾ In July, 1961, all water treatment plants began to use alum at a somewhat arbitrarily selected rate of 18 ppm. The practice continues to date at all plants except at the K Reactors. The K Reactor alum feed has been limited to a nominal 15 ppm because of the high filtered water requirements.

The use of the high alum feed rate did reduce the quantity of radionuclides in the reactor effluent. However, early in 1965 it was requested that a test be carried out at the K Reactors to determine the magnitude of the improvement.⁽²⁾ This report summarizes the results of that test.

SUMMARY

The alum feed rate at KE Reactor was held at 16-18 ppm. At KW Reactor the alum feed rate was held at 3 ppm, 6 ppm, 9 ppm, and 12 ppm for periods of two to three months. Radionuclide concentration ratios, KW/KE, showed that at alum feed rates of 3 and 6 ppm very substantially higher As-76 and Np-239 concentrations were present in the KW effluent. At the same KW alum feed rates moderately higher P-32 concentrations were observed at KW and at a 3 ppm alum feed rate even the Cr-51 concentration was higher at KW. At an alum feed rate of 9 ppm some effluent radioactivity penalty was observed at KW. The data appeared to converge to a concentration ratio of 1 at between 13 and 15 ppm indicating little if any benefit from higher alum feed rates.

DISCUSSIONA. OPERATING CONDITIONS1. Alum Feed

An initial reduction in alum feed rate at KW Reactor was made early in February, 1965. However, changing water conditions did not permit stabilization of the feed rate for sufficient lengths of time to obtain valid

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test data. As a matter of interest the alum feed rate at KE Reactor averaged 13.6 ppm over the period February through July, 1965.⁽³⁾ The alum feed rate at KW Reactor averaged 8.9 ppm during the same time period.⁽³⁾

Beginning in August, the alum feed rate at KW Reactor was progressively reduced until a feed rate of 3 ppm was reached on August 20, 1965. This was considered to be the start of the test. Periods of stable alum feed rate are shown below.

<u>Time</u>	<u>Alum Feed, ppm</u>
August 20, 1965 - October 14, 1965	3
October 15, 1965 - January 11, 1966	6
January 12, 1966 - March 26, 1966	9
March 27, 1966 - June 30, 1966	12

The alum feed rate at KE Reactor was increased to 16-18 ppm early in August. Over the period August 20, 1965, through June 30, 1966, the alum feed rate averaged 16.3 ppm.

2. pH and Sodium Dichromate

A sodium dichromate feed rate of 1 ppm and a coolant pH of 6.6 were maintained at both K Reactors throughout the test.

B. EFFLUENT RADIOACTIVITY RESULTS

Samples of reactor effluent are taken every week day during operation from each effluent riser. The two riser samples are combined and the resultant sample analyzed for phosphorus-32, arsenic-76, neptunium-239, and chromium-51. The results of the daily analyses which are reported routinely on a quarterly basis⁽⁴⁾ were used in evaluating the test. Each of the test periods was divided in half on a calendar basis and the daily results were averaged for the time periods involved. The averages are shown in Tables I through IV, each being for a specific KW alum feed rate. It is of interest to note that the concentration of the radionuclides in the KE Reactor remained remarkably constant throughout the entire test averaging:

	<u>pCi/ml</u>
Phosphorus-32	6.7
Arsenic-76	51
Neptunium-239	37
Chromium-51	125

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Splitting the test periods permits an examination of the approach to equilibrium which has been known to be lengthy. At a KW Reactor alum feed rate of 3ppm equilibrium was approached in the direction of increasing effluent

activities. The concentration ratios, KW/KE, for the two halves of the 3 ppm alum period are shown in Table V. It is obvious that there was a difference in the concentration ratios with those in the latter half being higher. Similarly during the 6 ppm alum feed period in which equilibrium was approached in the direction of decreasing effluent radioactivity, the concentration ratios shown in Table V for the second half of the period were lower than in the first half. It is quite possible that in neither the 3 nor the 6 ppm alum feed rate period had equilibrium truly been reached. However, in view of the magnitude of the KW Reactor effluent concentrations, it did not seem prudent to extend the test periods inordinately to insure equilibrium. Differences in the concentration ratios between the test period halves are also present in the 9 and 12 ppm alum feed periods. However, they are not as large due to the relatively smaller concentration changes which are taking place.

The concentration ratios in the second half of each alum feed rate period are shown in Table VI and have been plotted against alum feed rate in Figure 1. It is apparent that at alum feed rates of 3 and 6 ppm the concentrations of As-76 and Np-239 are very substantially higher than at a 16-18 ppm alum feed rate. There is a moderate increase in P-32 concentration at both 3 and 6 and even an increase in Cr-51 concentration at a 3 ppm alum feed rate. At an alum feed rate of 9 ppm there still appears to be an effluent radioactivity penalty associated with the use of the lower feed rate. However, the curves appear to converge toward a concentration ratio of one, i.e., no difference between the KE and the KW concentration, at 13 to 15 ppm alum feed. Thus, no benefit was being obtained from the additional alum being used at KE Reactor.

The reduction in effluent radioactivity produced by alum feed rates above the minimum possible feed rate is generally consistent with Silker's original data. (1)

The 13 to 15 ppm alum feed rate is consistent with the feed rate required to keep the electrokinetic potential (zeta potential) of the floc at zero. (5)

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TABLE I

K REACTOR ALUM FEED TEST
EFFLUENT RADIOACTIVITY RESULTS

KW Alum Feed Rate = 3 ppm

Radionuclide Concentration, pCi/ml

	<u>August 20, 1965 - September 16, 1965</u>	
	<u>KE</u>	<u>KW</u>
Phosphorus-32	7.6	11.4
Arsenic-76	41	232
Neptunium-239	33	138
Chromium-51	120	161

	<u>September 17, 1965 - October 14, 1965</u>	
	<u>KE</u>	<u>KW</u>
Phosphorus-32	6.1	17.0
Arsenic-76	40	394
Neptunium-239	32	168
Chromium-51	121	178

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TABLE II

K REACTOR ALUM FEED TEST
EFFLUENT RADIOACTIVITY RESULTS

KW Alum Feed Rate = 6 ppm

Radionuclide Concentration, pCi/ml

October 15, 1965 - November 27, 1965

	<u>KE</u>	<u>KW</u>
Phosphorus-32	7.7	13.0
Arsenic-76	59	280
Neptunium-239	35	133
Chromium-51	132	149

November 27, 1965 - January 11, 1966

Phosphorus-32	7.0	9.4
Arsenic-76	48	226
Neptunium-239	32	110
Chromium-51	131	128

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TABLE III

K REACTOR ALUM FEED TEST

EFFLUENT RADIOACTIVITY RESULTS

KW Alum Feed Rate = 9 ppm

Radionuclide Concentration, pCi/ml

January 12, 1966 - February 17, 1966

	<u>KE</u>	<u>KW</u>
Phosphorus-32	6.7	8.1
Arsenic-76	44	134
Neptunium-239	34	107
Chromium-51	122	131

February 18, 1966 - March 26, 1966

	<u>KE</u>	<u>KW</u>
Phosphorus-32	7.6	9.0
Arsenic-76	57	122
Neptunium-239	42	78
Chromium-51	116	100

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TABLE IV

K REACTOR ALUM FEED TEST

EFFLUENT RADIOACTIVITY RESULTS

KW Alum Feed Rate = 12 ppm

Radionuclide Concentration, pCi/ml

March 27, 1966 - May 13, 1966

	<u>KE</u>	<u>KW</u>
Phosphorus-32	7.2	8.5
Arsenic-76	59	113
Neptunium-239	50	87
Chromium-51	125	112

May 14, 1966 - June 30, 1966

	<u>KE</u>	<u>KW</u>
Phosphorus-32	4.1	6.6
Arsenic-76	61	91
Neptunium-239	43	68
Chromium-51	132	119

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TABLE V

K REACTOR ALUM FEED TEST
EFFLUENT RADIOACTIVITY RATIOS

KW Alum Feed Rate = 3 ppm

	Ratio	$\frac{\text{Conc. KW}}{\text{Conc. KE}}$
	<u>8/20 - 9/18</u>	<u>9/17 - 10/14</u>
Phosphorus-32	1.5	2.8
Arsenic-76	5.7	9.8
Neptunium-239	4.2	5.2
Chromium-51	1.3	1.5

KW Alum Feed Rate = 6 ppm

	Ratio	$\frac{\text{Conc. KW}}{\text{Conc. KE}}$
	<u>10/15 - 11/28</u>	<u>11/27 - 1/11</u>
Phosphorus-32	1.7	1.3
Arsenic-76	4.7	4.7
Neptunium-239	3.8	3.4
Chromium-51	1.1	1.0

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TABLE VI

K REACTOR ALUM FEED TEST
EFFLUENT RADIOACTIVITY RATIO
SUMMARY

KW Alum Feed Rate, ppm	Ratio		Conc. KW Conc. KE	
	<u>3</u>	<u>6</u>	<u>9</u>	<u>12</u>
Phosphorus-32	2.8	1.3	1.2	1.6
Arsenic-76	9.8	4.7	2.1	1.5
Neptunium-239	5.2	3.4	1.9	1.6
Chromium-51	1.5	1.0	0.9	0.9

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K REACTOR ALUM FEED RATE TEST

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The Effect of Alum Feed Rate on Effluent Radioactivity

FIGURE 1