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HW--68224

DE91 000048

REACTOR TEST PROGRAM FOR COLUMBIA RIVER RADIOISOTOPE
REDUCTION STUDIES

by

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SEP 28 1990

Radiological Chemistry Operation
Chemical Research Operation
HANFORD LABORATORIES OPERATION

January 20, 1961

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HANFORD ATOMIC PRODUCTS OPERATION
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REACTOR TEST PROGRAM FOR COLUMBIA RIVER RADIOISOTOPE REDUCTION STUDIES

J. M. Nielsen

INTRODUCTION

This report presents a planned reactor test program in support of the research and development study to investigate the formation of radioisotopes in reactor cooling water and to devise means of reducing the amounts of those radioisotopes formed which result in significant exposures to downstream users of the Columbia River water.

SUMMARY

The effects of water treatment process changes and reactor operation on the formation of radioisotopes of radiological interest will be studied utilizing four of the 1706-KE single-pass tubes together with special demineralizer and water treatment facilities to be obtained in 1961. Specially treated water containing no salts, single salts, mixtures of salts, special additives, and complexing agents will be investigated. The effects of varying water composition and pH, of using aluminum and zirconium reactor tubes, and of varying reactor conditions of tube outlet temperature, water flow rate, flux, and power level will be tested.

DISCUSSION

Objective

The objective of this study is to investigate the formation of radioisotopes in reactor effluent water (1) to provide information and understanding necessary to determine the feasibility of processes for reduction or elimination of those radioisotopes which may result in conditions restrictive to proposed future use of the reactors, and (2) to determine relationships which will allow estimation of changes in the types and amounts of radioisotopes resulting from changes in reactor operating conditions.

The principal radioisotopes to be studied will be P^{32} , As^{76} , Np^{239} and Zn^{65} . Under present operating conditions calculations have shown⁽¹⁾ that the body burden of P^{32} in the average whitefish fisherman in the Ringold area might be about 10 per cent of the maximum permissible body burden (MPBB) as given in Handbook 69 for persons in the neighborhood of controlled areas. The continuous consumption of one pound per week of whitefish would result in nearly 100 per cent of the MPBB during normal river flow years. Any further increase in production would cause these values to increase. As^{76} and Np^{239} are the major contributors to the gastrointestinal (GI) tract exposure resulting from drinking Columbia River water. This exposure due to drinking Columbia River water near Pasco is calculated to be about 15 per cent of the maximum

permissible exposure for the GI tract (MPE-GI) for persons in the neighborhood of controlled areas. The Hanford control limit has been stated as 30 per cent of the Handbook 69 MPE(GI) which indicates that we are presently at 50 per cent of the control limit. Zinc-65 is important because of its significant contribution to the reactor "rear face" dose which is restrictive to operations, and because the Zn^{65} concentration in the Columbia River as it empties into the ocean is close to the values under consideration as limits for radioisotopes in ocean waters (Reference 1, p 36).

The radioisotopes in reactor effluent water are formed from neutron activation of Columbia River salts not removed in the water treatment process, water treatment salt additives, corrosion products from the water system surfaces, and impurities left on or imbedded in the fuel element can surfaces. By reducing any or all of these sources of parent materials reductions in production of radioisotopes will be accomplished. These parent materials adhere onto a film on the reactor tubing and fuel elements for extended periods of time to further increase the radioisotope production. Processes to eliminate or reduce the time of adherence by changes in the chemical constitution of the water, chemical form of the parent materials, or changes in the reactor film itself will be sought as means for reducing the production of radioisotopes.

Anticipated concentrations of radioisotopes resulting from proposed reactor operation changes cannot be estimated with much certainty from past data because good correlations have not been obtained with reactor variables. Studies to determine some of the relationships are included.

Test Facilities

1. Single-pass In-Reactor Tubes. Four KE reactor tubes which receive water from the 1706 KE Building have been made available for these studies. These tubes have available and will require for the duration of the test provision for continuously flowing sample lines, and facilities for addition of chemical solutions to the cooling water. For the major portion of the test period the tubes must be of the same inside diameter and configuration so that identical loadings can be made in pairs. Periodic chemical decontamination will be required. For one test a tube with reduced inside diameter will be used so that conditions of fuel charge, flux, and outlet temperature are the same but the flow rate differs from control tube.
2. Deionized Water Facility. Procurement is underway to provide a deionized water facility with a capacity of 150 gallons per minute by May 1961. This water will be furnished a pair of tubes and must be supplied continuously, even during outages (at reduced flow rates). Provisions will be included to add selected chemical solutions to this water prior to entering the reactor tubes.
3. Water Treatment Facility. Design work is in progress for a small water treatment facility capable of supplying specially treated water to two reactor tubes by November 1961. This plant will be a scaled-down version of the present reactor water treatment plants and capable of flexibility of operation so that new or improved water treatment processes resulting from laboratory studies may be tested. This unit must be able to operate continuously for periods of several months at a time.

Fuel Elements and Loading Patterns

For some of the radioisotope studies the fuel element loading may be chosen on the basis of corrosion study interest so long as loadings are the same in the pairs of tubes in any given test. In later tests, where conditions representative of those which are anticipated under future plans will be duplicated or where effects of specific reactor variables are being sought, choice of fuel element will be dictated by the results desired and may or may not be suitable for corrosion measurements. Plans include measurements on the effect of cladding material (Al, Ni, Zn), shape of element, degree of enrichment, and loading pattern. Certain loading patterns will require adjustments in adjacent tube loadings for proper reactor operation. All loadings should consist of numbered elements so that post-irradiation measurements may be related to the position in the tube.

At the time the four tubes are changed or decontaminated at the start of the testing period for deionized water (about May 1961), each load will contain two dummy elements about four inches long constructed to contain demountable surfaces for reactor film studies. One of these elements would be placed two-thirds of the way in from the front of the active charge while the other would be placed downstream out of the active zone. These dummies will be picked up as soon as possible after discharge of the fuel loading and placed in casks for shipment to the Laboratories area. Any tube decontaminations should be done after discharging the fuel elements so that the film on the dummies will be intact.

Testing Program

Tubes 4355 (Zr) and 4456 (Al) will continue as presently operated to give background data on new tubes until discharge time for the fuel elements. Following recharge of tubes 4355 and 4456 with standard elements additions of specific process water salts will be made to the cooling water to test the effect of varying process water salt concentrations. This test will continue until the deionized water becomes available.

Tubes 4963 and 5063 will be chemically decontaminated in January, following which two parts per million of EDTA will be added to tube 5063 for 6 to 8 weeks. After chemical decontamination and fuel element discharge and recharge, a separate complexing agent will be added to each tube for 6 to 8 weeks, or until the deionized water is available.

Upon completion and testing of the deionized water facility (estimated to be May 1961), tube 4355 will be chemically decontaminated and tubes 4456, 4963 and 5063 will be removed at the same outage. Small samples of tube 4456 with the adhering film will be taken immediately for laboratory analysis. New ribless aluminum tubes will be installed in 4456 and 4963. A new zircaloy tube will be installed in 5063. Identical fuel element loadings will be charged in all four tubes. Tubes 4355 and 4456 will operate on process water and, following decontamination of the influent piping, tubes 4963 and 5063 will operate on deionized water. After about 2 months chemical additions will be started with one additive into tubes 4355 and 4456 and another additive (probably sulfate and later arsenate) in tubes 4963 and 5063. Operating conditions of flow rate and outlet temperature should be the same. More

additions (decontamination after each addition may be required) will continue with changes in agent composition until November 1961 when the water treatment facility is scheduled for completion. At this time the fuel elements will be discharged, all of the tubes will be chemically decontaminated, and a new similar loading charged. Tubes 4355 and 4456 will operate on specially prepared water from the new water treatment plant. The first test is tentatively scheduled to use a composite flocculating agent. In the following 6 to 12 months other processes will be tested. Special single salt or salt mixture additions will be continued in tubes 4963 and 5063. The effect of nickel or zircaloy fuel element jackets will be investigated in corrosion test tubes. At this time tests to measure the effect of raising the outlet temperature and flow rate to proposed future conditions will be started in tube 4355.

REFERENCE

1. Foster, R. F. and R. L. Jenkins, "Off-Project Exposure From Hanford Reactor Effluent", HW 63654 Rev., No. 27, February 1, 1960.

TEST SCHEDULE

TUBE	Date Jan 1961	Feb 1961	Mar 1961	Apr 1961	May 1961	June 1961	July 1961	Aug 1961
4355	New zircaloy tube on process water. Reactor variables same as 4456.		Add individual process water salt.		Decontaminate. Run on process water as control. Fuel loading with two coupon dummies same as tubes 4456, 4963 and 5063.		Add individual process water salts.	
4456	New aluminum tube on process water.		Add same salt as 4355.		Remove old tube and take samples for film studies. Install new ribless aluminum tube. Run on process water as control. Loading same as 4355.		Add individual process water salts	
4963	Decontaminate aluminum tube and run on process water.		Decontaminate. Run on process water with few ppm complex agent 2.		Install new ribless aluminum tube. Run on deionized water. Loading same as 4355.		Add sulfate.	
5063	Decontaminate aluminum tube and use process water with 2 ppm EDTA added. Reactor variables same as tube 4963.		Decontaminate. Run on process water with few ppm complex agent 3.		Install new zircaloy tube. Run on deionized water. Loading same as 4355.		Add sulfate.	

TEST SCHEDULE (cont.)

TUBE	Sept 1961	Oct 1961	Nov 1961	Dec 1961	Jan 1962	Feb 1962	Mar 1962	June 1962
4355	○			Decontaminate, Recharge as before. Operate test of new water treatment process with mixed coagulating agents.○				Decontaminate. Operate under proposed future conditions of outlet temp., flow rate, water, etc.
4456				Decontaminate. Recharge as before. Operate test of new water treatment process with mixed coagulating agents.○				Install new tube with reduced annular water space so effect of flow rate on film is obtained.
4963	Add arsenate with and without iron.○			Decontaminate. Add ion mixtures.○				Decontaminate. Operate as control for 4456.
5063	Add arsenate with and without iron			Decontaminate. Add ion mixtures.○				Decontaminate. Operate on process water as control for 4355.

END

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