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SUBJECT: Proposed Development Program for Treatment of
Radioactive Wastes from Merchant Ship Reactors

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ABSTRACT

A proposed development program is made for the treatment and disposal of radioactive wastes from Merchant Ship Reactors. Both ion exchange resin and filters are to be used for coolant system cleanup. The development program is concerned with methods of handling and packaging of the spent resin, filter cake and rare gases for safe disposal.

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INTRODUCTION

Chemical Technology Division has been requested to develop an optimum waste disposal procedure to be used on the NS Savannah. Both dockside and disposal at sea are to be considered. The merchant ship reactor is of the PWR type and the principal source of activity to be considered is the primary coolant system.

The specific sources of activity are:

1. Primary coolant blow-down
2. Filter cake and ion-exchange resin
3. Radioactive gases
4. Shield water
5. Coolant samples

It has been possible to evaluate the distribution of the various fission products and corrosion products in the system by consulting the literature, principally the Westinghouse PWR reports. Additional information will have to be obtained regarding planned procedures for shipboard handling of the resin, the filter cake and the primary coolant blow-down.

PROPOSED DEVELOPMENT WORK

1. A literature survey is in progress to uncover pertinent facts regarding fission and corrosion product levels and their distribution in the primary coolant system. Some of the more important information obtained to date follows.

Information has been obtained regarding the distribution of the isotopic activities on the system surface and the ion-exchange resin bed (Table 1) in the Westinghouse PWR X-1 loop test.¹ In this test a purposely defected stainless steel clad UO_2 fuel element was tested under simulated PWR conditions in the Chalk River NRX reactor for a four month period. The isotopic rate of escape from a defected fuel element was found to be proportional to the isotopic concentration in the fuel. The escape rate coefficient, v , is defined as the proportionality constant relating the rate of escape of a fission product (in atoms per second) from a defected fuel element, to the total number of atoms of the isotope in the fuel element. The fission products may be placed into three major groups based on the escape rate coefficient (Table 2).

For Nautilus operations $0.3 \mu\text{c/cc}$ is indication of abnormal operating conditions in the primary coolant system. Representative values have been obtained for corrosion product and fission product activities in the coolant water^{1,2} (Table 3). The fission product activities in the cooling water would approach the maximum values expected to occur in the coolant system since these values were obtained from a loop test with purposely defected stainless-steel clad UO_2 fuel elements.

An estimate has been made of the specific activity of the resin in the PWR purification system demineralizer at the end of 100 days service assuming

Table 1. Total Isotopic Activities on System Surface and Ion-Exchange Resin Bed in X-1 Loop Test

Isotope	Activity On Resin(%)	Activity On System Surface(%)	v, sec^{-1}
Sr ⁸⁹	56.0	44.0	4.49×10^{-12}
Zr ⁹⁵	18.9	81.1	9.34×10^{-12}
Cs ¹³⁷	99.5	0.5	1.1×10^{-8}
Ba ¹⁴⁰	14.7	85.3	10.0×10^{-12}
Ce ¹⁴⁴	9.0	91.0	7.75×10^{-12}
Y ⁹¹	24.0	76.0	1.88×10^{-12}
I ¹³¹	100.0	----	1.1×10^{-8}

v = the escape rate coefficient

Table 2. Escape Rate Coefficient, v , for a Normal PWR Fuel Element

Group	Elements	v, sec^{-1}
I	Cs, I, Xe, Kr, Rb, Br	1.3×10^{-8}
II	Sr, Ba	1.0×10^{-11}
III	Zr, Ce, other rare earths	1.6×10^{-12}

Table 3. Average Activities in Loop Coolant Water Related to Drinking Water MPC Values

Isotope	Average Activity ($\mu\text{c/cc}$)	MPC ($\mu\text{c/cc}$)
I ¹³¹	3.6×10^{-3}	3×10^{-5}
Cs ¹³⁷	1.1×10^{-3}	1.5×10^{-3}
Ba ¹⁴⁰	2.4×10^{-6}	2×10^{-3}
Sr ⁸⁹	4.3×10^{-6}	7×10^{-5}
Sr ⁹⁰	2.3×10^{-8}	1×10^{-6}
Y ⁹¹	1.4×10^{-7}	
Zr ⁹⁵	2×10^{-5}	
Ce ¹⁴⁴	1.5×10^{-6}	
Co ⁶⁰	5.7×10^{-6}	2×10^{-2}
Fe ⁵⁹	1.5×10^{-4}	1×10^{-4}
Gross corrosion products ^a	5×10^{-2}	
Gross fission products β - γ ^b	4.3×10^{-1}	
Delayed neutron	1.4×10^{-4}	
Steady state Kr ⁸⁸	2.9×10^{-1}	
Steady state Xe ¹³³	2.4×10^{-1}	

^a Counted 15 min after sampling.

^b Counted 1 hr after sampling.

1% of the core elements are defective.³ The average resin activity will not be greater than 10 $\mu\text{c}/\text{ml}$ of resin if no separated fuel particles reach the resin bed.

2. It would be advantageous if trips could be arranged to Babcock and Wilcox, Shippingport, Pa. and Groton, Conn. to obtain recent information regarding characterization of fission products in the primary coolant system. A knowledge of operational techniques in regard to removing the filter cake, resin bed and primary coolant blow-down from the coolant system would be of particular interest. Opinions on disposal philosophy aboard ship would also be of value.

3. One method of disposal at sea would be to "fix" the resin and filter cake in some media such as cans, cement, ceramics, etc. The simplest case would be the discharging of the resin bed into the ocean. The eluting effect of sea water on a mixed bed loaded with trace fission products will be undertaken. The resin will then be "fixed" in various media and the leaching effect of sea water will be studied.

The effect of pressure buildup in a sealed container due to radiation damage on the resin will be investigated. This could be accomplished by placing a sealed container, equipped with a suitable pressure recording device, in the Co^{60} source and recording the pressure buildup as a function of radiation dosage.

4. Investigate or obtain information on radioactive gas solubilities and methods of holding rare gases for an adequate decay period before venting to the environment.

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