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SUBJECT: Power Reactor Fuel Reprocessing Process Wastes

TO: A. R. Irvine

FROM: W. L. Conger

ABSTRACT

Data on waste volumes and heat generation of several reactor fuels which may be reprocessed in the Power Reactor Fuel Reprocessing Pilot Plant at ORNL are tabulated.

DISCLAIMER

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1.0 INTRODUCTION

It is the purpose of this report to provide information on the waste volumes and fission product heat generation from power reactor fuel to be processed at Oak Ridge National Laboratory. Wastes of low specific activities are to be routed to seepage pits whereas high activity wastes must be confined in tanks designed for heat removal.

Information as to what fuels were to be reprocessed was obtained from CF-58-11-59, J. A. Swartout to H. M. Roth, and the supplimentary letter of March 31, 1959, J. A. Swartout to H. M. Roth. Recent information from H. E. Goeller indicates that all stainless steel fuels except Yankee Atomic will be committed to ORNL.

The fuels are listed in Table 1 such that the first entry denotes the year of reprocessing and every entry after that gives the heat generation that a particular fuel will have in each subsequent year. The fuels are marked to denote how they are committed at the present time.

Table 2 gives waste volumes per reactor core for both the Darex and Sulfex processes. It also gives volumes of neutralized Sulfex cladding solution for those fuels that can be treated by this process and volumes for aluminum clad and U-Mo fuels. The processing technique for the latter fuel is not at all defined at this time.

Table 3 gives totals for the volumes and heat generations of the fuels. The volumes are figured on the amount produced each year and also on the amount accumulated each year. The heat generations are figured on the amount accumulated only.

2.0 BASIS FOR CALCULATIONS

2.1 Fission Product Heat Generation

All heat generations were calculated by the use of an empirical equation presented on page 119 of Glasstone's Principles of Nuclear Reactor Engineering. One method was used instead of all three methods discussed in CF-58-12-142 for simplification of the tabulations that are made from the calculations. This particular method was chosen because it appears to be about the average value of the three methods used in the above report. The equation as presented is:

$$\frac{H}{P} \approx 5.9 \times 10^{-3} \left[(\tau - T_o)^{-0.2} - \tau^{-0.2} \right]$$

, where H/P is the heating effect in total watts per watt of reactor power level, τ is the number of days after reactor startup when the heating effect is desired, and T_o is the number of days of reactor operation.

The heating effects were all calculated for an initial cooling time of 180 days from the end of irradiation, and then for every 365 days after that time until 1965. From the information obtained in the above manner the cumulative heating effect was calculated for each year and was separated into two catagories in order to show that it is possible to store the lower heat generating wastes together in two tanks without special cooling, while the higher activity wastes must be cooled during their storage.

2.2 Neutralized Cladding Solution Volumes

The neutralized "Sulfex" cladding solution volumes were figured on a basis of 50 g/l stainless steel. Aluminum clad assemblies were considered declad with caustic; the concentration of aluminum in the cladding solution was taken as 1.65 M for the volume calculations; zirflex declad fuels were considered .5 M zirconium.

2.3 IAW Waste Volumes

All stainless steel assemblies were considered reprocessed by both "Darex" and "Sulfex"* for waste volume comparison. The "Darex" type wastes were assumed to contain 200 g/l stainless steel; Sulfex waste volumes were calculated in several ways depending on the U^{235} or Th content.

Enriched uranium fuel waste volumes were obtained by multiplying 1 1/3, the ratio of waste volume to feed volume, times the volume of the feed. The feed was considered to be either 50 g/l stainless steel or 5 g/l U^{235} (unburned) whichever was the highest volume.

Low enrichment uranium fuels were figured on a basis of .166 liters per 325 g of uranium.

Aluminum clad fuel waste was considered to be 2 M in Al; U-Mo fuel wastes contained 5 l/Kg U. Zirconium clad fuel waste solution was considered to be 1 M Al. or F. giving a volume of .323 liters per Kg uranium.

3.0 STORAGE OF WASTES

The fuels with waste heat activities of below 70,000 Btu/hr per core were compiled into one group to see how many tanks would be necessary to store the waste from these fuels on the basis of heat generated. The waste from all these fuels may be stored in two concrete storage tanks.

The fuels with waste heating values above 70,000 Btu/hr per core cannot be put in the concrete storage tank without special cooling of the tanks. The heat transmission from a full concrete tank is taken as 70,000 Btu/hr without cooling the tank.

W. L. Conger
W. L. Conger
Process Design Section
Chemical Technology Division

WLC:jh

*Considered Purex type wastes.

Table 1

Heat Generation of Fuels After 180 Days Cooling and to 1965

Reactor	1960	1961	1962	1963	1964	1965
	$\frac{Btu}{hr}$ per core					
MTR U^{233} *	3,121	1,204	Negligible →	→	→	→
OMRE **	10,900	3,520	1,850	1,270	960	770
VBWR **	21,000	6,930	3,730	2,410	1,870	1,747
SRE Core 1 **	17,240	5,860	3,430	1,817	1,620	1,172
APPR Core 1 **		23,800	9,760	6,330	4,530	3,510
SPERT-3 **		4,800	1,500	750	375	187
HTRE-1 and 2 **		Negligible				
SRE Core 2 **		25,400	11,900	9,680	4,240	3,230
BORAX-4 *		2,890	825	413	41	-
Foreign RR 6 Cores *		12,660	5,076	3,072	2,178	1,560
VBWR Core 2 **		21,000	6,930	3,730	2,410	1,870
GCRE Core 1 **						
HTRE-3 **		Negligible				
APPR Core 2 **		23,800	9,760	6,330	4,530	3,510
Foreign RR 6 Cores*			12,660	5,076	3,072	2,178
PRDC Ax Bl *			3,090	747	426	213
Rural Co-op.*			91,000	36,150	21,900	15,600
Commonwealth Ed.			117,600	54,600	36,200	23,000
Yankee Core 1			630,000	258,000	149,500	108,100
EBWR Core 3			140,750	56,300	34,100	22,200
Foreign RR 6 Cores *				12,660	5,076	3,072
A1W Inner Bl				15,630	5,390	2,700
A1W Outer Bl				19,100	6,600	3,340
EBWR Core 1				28,150	11,250	6,820
EBR Ax Bl 2,3,4				Negligible		
Consolidated Ed.*				1,060,000	455,000	293,500
Foreign RR 6 Cores*					12,660	5,076
PRDC Ax Bl 2,3 *					6,180	1,494
Rural Co-op. *					91,000	36,150
NMSR *					156,200	72,800
Yankee Core 2					712,000	291,500
CPPD 1/3 Core 1*					146,500	62,100
Foreign RR 6 Cores *						12,660
PRDC Ax and Rd Bl *						44,390
Consolidated Ed.*						1,060,000
CPPD 1/3 Core*						181,500
Florida West Coast*						440,000

*Those fuels committed to ORNL for reprocessing
**High enrichment SS fuels
Unmarked fuels--some part may come to ORNL

Table 2

Waste Volumes

Reactor	Sulfex Neutralized Cladding Solution or Declad Al Fuels Volume (l/core)	Volume (l/kg U^{235})	Composition	Purex Neutralized 1AW Volume (l/core)	Volume (l/kg U)	Darex-Purex 1AW Volume (l/core)	Volume (l/kg U^{235})	Composition	Aluminum Fuels and U-Mo Fuels Volume (l/core)	Volume (l/kg U)	Composition
Florida West Coast	37,024		50 g/l SS, 2.8 $\underline{M}$ Na_2SO_4	1,490	.155	9,256		200 g/l SS			
MTR U^{233}									2,032	88.4	2.0 $\underline{M}$ Al
OMRE						14,900	585	37.5 g/l SS			
VBWR						5,870	266	12.76 g/l SS			
SRE	2,065	26.1	50 g/l SS, 2.8 $\underline{M}$ Na_2SO_4	458	.155	516	6.5	200 g/l SS			
APPR						6,000	266	34.8 g/l SS			
SPERT-3						11,620	528	37.5 g/l SS			
HTRE 1 and 2***											
BORAX-4	5,270	270	1.65 $\underline{M}$ Al						4,350	223	2 $\underline{M}$ Al
Foreign RR									1,761	?	2 $\underline{M}$ Al
GCRE	2,440	129	50 g/l SS, 2.8 $\underline{M}$ Na_2SO_4			610	32.3	200 g/l SS			
HTRE 3***											
Commonwealth Edison**	342,000		.5 $\underline{M}$ Zr	17,000	.323						
Yankee Core 1	163,100	335.4	50 g/l SS, 2.8 $\underline{M}$ Na_2SO_4	3,320	.155	40,800	83.9	200 g/l SS			
Yankee Core 2	174,750	390	50 g/l SS, 2.8 $\underline{M}$ Na_2SO_4	3,750	.155	43,700	97.6	200 g/l SS			
EBWR Core 3	200,000		50 g/l SS, 2.8 $\underline{M}$ Na_2SO_4			60,000		200 g/l SS			
PRDC Ax Bl	2,210		50 g/l SS, 2.8 $\underline{M}$ Na_2SO_4						8,000	5	?
PRDC Rd Bl	37,750		50 g/l SS, 2.8 $\underline{M}$ Na_2SO_4						183,500	5	?
AlW Bl**	?	?	?	1,950	.323						
CPPD	41,230		50 g/l SS						127,500	5	?
EBR-1 Ax Bl				583	.155						
NMSR	51,200	209	50 g/l SS, 2.8 $\underline{M}$ Na_2SO_4	1,085	.155	12,800	52.3	200 g/l SS			

Table 2 (continued)

Reactor	Sulfex Neutralized Cladding Solution or Declad Al Fuels			Purex Neutralized 1AW		Darex-Purex 1AW			Aluminum Fuels and U-Mo Fuels		
	Volume (l/core)	Volume (l/kg U^{235})	Composition	Volume (l/core)	Volume (l/kg U)	Volume (l/core)	Volume (l/kg U^{235})	Composition	Volume (l/core)	Volume (l/kg U)	Composition
EBWR											
Core 1**	29,700		.5 M Zr	1,795	.323						
Rural Co-op*			50 g/l SS	4,770							
(without ends)	1,980	13.2	2.8 M Na_2SO_4	10,640		496	3.3	200 g/l SS			
Consolidated			50 g/l SS	19,640							
Edison*	119,750	172.2	2.8 M Na_2SO_4	43,800		29,950	43.1	200 g/l SS			

*Th-SS fuels - 1AW Volume figured two ways
1. Thorex 1.3 l/kg Th
2. Int 23 2.9 l/kg Th

**Zirconium clad fuels - zirflex used

***Volumes from CF-58-12-142

Table 3

Volume and Heat Generation Totals

	Cumulative Totals			Volume Produced Each Year			Cumulative Totals		
	Fuels Committed to ORNL	High Enrichment SS Fuels	Fuels ORNL may get some part of	Fuels Committed to ORNL	High Enrichment SS Fuels	Fuels ORNL may get some part of	Fuels Committed to ORNL	High Enrichment SS Fuels	Fuels ORNL may get some part of
Year	Btu/hr	Btu/hr	Btu/hr	Liters*	Liters*	Liters*	Liters*	Liters*	Liters*
	Lower Heat Generating Fuels[1]								
1960	3,121	49,140		2,032	21,286		2,032	21,286	
1961	16,754	115,110		14,916	82,966		16,948	104,252	
1962	21,651	48,860		18,566			35,514	104,252	
1963	21,968	32,317	62,880	10,566		5,494	46,080	104,252	5,494
1964	29,633	20,535	23,240	26,566			72,646	104,252	5,494
1965	70,643	15,996	12,860	202,066			274,712	104,252	5,494
	Higher Heat Generating Fuels[2]								
1960									
1961									
1962	91,000		888,350	496		117,800	496		117,800
1963	1,096,150		368,900	29,950			30,446		117,800
1964	870,600		931,800	55,796		43,700	86,242		161,500
1965	2,161,650		444,800	81,706			167,948		161,500

* SS fuels figured by Darex method except as noted below
EBWR, Commonwealth Edison, AlW, figured on Zirflex since clad is Zircaloy,
EBR figured on Sulfex since SS data sparse, HTRE 1, 2, and 3
Volumes from CF-58-12-142

[1] MTR U^{233}, OMRE, VBWR, SRE, APPR, SPERT-3, BORAX-4, Foreign RR, PRDC, EBWR Core 1, AlW

[2] Rural Co-op., Commonwealth Edison, Yankee, EBWR Core 3, Consolidated Ed., NMSR, CPPD, Florida West Coast

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