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in HRT Dump and Sampler Lines
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In the present HRT design, cooling jackets are shown on the dump and sampler lines. There is a danger that uranium peroxide may be precipitated in these lines if the highly radioactive fuel is cooled below 70°C soon after leaving the main circulating loop. Calculations have been made to determine the beta and gamma power density as a function of temperature which will cause peroxide to precipitate and also the power densities to be expected from the absorption of beta particles in the HRT fuel.

The chemistry of peroxide decomposition is discussed, and a procedure for calculating permissible power densities is given by Silverman, Watson, and McDuffie.⁽¹⁾

The power density at which uranium peroxide will begin to precipitate is given by

$$PD = k \left[\frac{C_{ss}}{.0052 \times G} \right]$$

where PD = power density, Kw lt⁻¹

k = decomposition rate constant, min⁻¹

C_{ss} = solubility of peroxide, moles lt⁻¹

The decomposition rate constant obtained from measurements on natural uranyl sulfate solution which had been circulated in the HRE (Preparation C, Table 2, p. 47, TID-2010) is plotted in Figure 1 as a function of temperature. As the HRT fuel solution will contain CuSO₄ (.005 M), the decomposition rate constant given in Figure 1 was increased by a factor of four to take into account the promoter action⁽¹⁾ of the copper on the

(1) M. D. Silverman, G. M. Watson, and H. F. McDuffie, "The Radiation Chemistry of Aqueous Reactor Solutions, Part 2," Reactor Science and Technology, Vol. 3, No. 3, Sept. 1953, TID-2010

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catalytic effect of the iron ions that will be present from corrosion. The solubility of uranium peroxide was taken as 0.0039 M. A value of $G = 0.40$ molecules H_2 per 100 ev of beta and gamma radiation absorbed in 10 gm U/Kg D_2O uranyl sulfate solution was used.⁽²⁾ The answer obtained should be conservative for higher concentrations of uranium as the G value decreases with increasing concentration of uranium.

The beta or gamma power density at which uranium peroxide will begin to precipitate is shown in Figure 2. The power density to be expected at various times after removal of fuel from the main circulating loop was obtained from data given by J. W. Hill.⁽³⁾ In Figure 7, p. 17 of his memo, the rate of energy release in the HRT core from fission products is given as a function of decay time after saturation at 5 Mw and 10 Mw. The power density was obtained by dividing Hill's values by the core volume, 290 liters. As most of the gamma particles emitted in the dump line and sampler will escape from the solution, it was assumed that only the power density from beta particle absorption contributes to the peroxide formation. The beta power density was obtained from Hill's values by multiplying by .526, the ratio of fission product beta energy to total fission product beta and gamma energy.⁽⁴⁾

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- (2) C. J. Hochanadel, et al, "Radiation-Induced Decomposition," Reactor Science and Technology, Vol. 3, No. 1, p. 32, March 1953, TID-2008
- (3) J. W. Hill, Jr., "HRT Power and Fuel Temperature after Fuel Circulation Stops," ORNL CF 54-9-64, September 9, 1954
- (4) K. Way and E. P. Wigner, Phys. Rev. 73, 1318 (1948)

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TABLE I

Beta Power Density in HRT Fuel After ∞ Operation

Decay Time sec.	Beta Power Density	
	5 Mw Core Power Kw/lt	10 Mw Core Power Kw/lt
10	.27	.54
100	.16	.33
1000	.10	.20

It is evident from Figure 2 that the HRT fuel solution cannot immediately be cooled below 70°C after removal from the main circulating loop without a possibility of peroxide precipitation occurring if the operating level is 10 Mw. In order to prevent precipitation in the sampler lines and isolation chamber, it is recommended that a means be provided for maintaining the temperature of the fuel solution at ~80°C for 15-30 minutes, after a sample is isolated. The sample could then be cooled to 60°C and removed. As the reactor cell temperature will be 60°C, it is marginal whether or not precipitate will form in the dump line if no cooling water is circulated through the cooling jacket during operation. For a safe design, it is recommended that a few pounds steam pressure be applied to the cooling jacket on the dump line. A provision for turning off the steam and turning on cooling water to the jacket would be necessary if the jacket is to be used as a cooler during a dump.

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Fig. 2. Beta Power Density Which Will Cause Peroxide Precipitation in HRT Fuel Solution.