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SUBJECT: EVALUATION OF LOOP COMPONENTS AND ADMIXED THORIUM-3%
URANIUM OXIDE SLURRY IN 200A LOOP (Summary of Run 200A-10)

TO: Distribution

FROM: R. B. Gallaher, A. S. Kitzes and C. F. VandenBulck

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EVALUATION OF LOOP COMPONENTS AND ADMIXED THORIUM-3% URANIUM OXIDE SLURRY
IN 200A LOOP (SUMMARY OF RUN 200A-10)

SUMMARY

A slurry addition system, a venturi in the circulation loop, and two types of sampling systems were tested with 500 and 800 g Th/kg H₂O slurries in the 200 gpm loop at 250°C and 1000 psig. The addition system worked satisfactorily while the venturi gave erratic readings during part of the run. Both the capillary and in-line sampling systems proved satisfactory with the capillary sampler being much easier and more convenient to operate. The addition of uranium to the slurry had no appreciable effect on the handling characteristics, the attack rate on 347 SS, the particle size and crystallite size of the thorium oxide. The attack rate was found to be 1 mpy during the first 100 hours of circulation and decreased to 0.4 mpy at the end of the run.

INTRODUCTION

Run 200A-10 was programmed to check the operation of several new components in the 200A loop at 250°C and 1000 psig and to determine qualitatively the handling characteristics of a sulfated thorium oxide slurry containing uranium. The new components included: (a) a capillary tube sampler, (b) an in-line sampling system, (c) a venturi flowmeter, and (d) a slurry addition system. The run was terminated on January 2, 1957 after 777 hours of operation at 250°C. This report summarizes the results of the run.

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Modifications to the Loop

A. In-Line Sampler

A recirculating sample bomb, shown in Fig. 1, through which a portion of the main stream circulates, was installed across the pump discharge and suction as an in-line sampler. After the slurry circulates through the system for a few minutes, a 300 ml sample is isolated in the bomb, cooled to room temperature, and withdrawn into a bottle.

B. Capillary Tube Sampler

A capillary tube sampling system which could be used to sample any one of three locations on the pressurizer and one position on the loop was installed as shown in Fig. 2. In this system a tube 0.060 in. ID and 30 ft long is coiled inside a cooling water jacket to minimize flashing as the pressure is reduced to atmospheric during withdrawal of the sample at room temperature. The sampler was designed so that 90% of the pressure drop is taken across the capillary tube and the remaining 10% across the throttle valve. For 2000 psi operation, slurry with a density of 2 can be withdrawn at a rate of 6 cc/sec which is equivalent to a maximum velocity of 10 ft/sec through the tube.

C. Slurry Addition System

A two-liter tank was installed to permit the addition of slurry to the loop while the system is at operating temperature and pressure (Fig. 3). Water can also be removed from the system through this tank if the liquid level in the pressurizer becomes too high. The operation of the addition system is as follows:

1. Slurry is drawn into the tank by means of a vacuum.

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Fig. 1

IN-LINE RECIRCULATING SAMPLE SYSTEM

ORNL-LE-176-22188
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4

Fig. 2

PRESSURIZER CAPILLARY TUBE SAMPLE SYSTEM

ORNL-IR-DWG.-22189
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Fig. 2

Fig. 2

ORNL-LR-Dwg.-22190
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Fig. 3

ADDITION SYSTEM (200A LOOP)

2. The tank is brought to pressure by slowly opening the valves between the purge water tank and the addition tank.

3. The valves between the addition system and the loop are then opened, and the purge water flow is adjusted to the desired rate by a throttle valve using a rotameter to determine the flow rates. A Lapp pulsafeeder, shown in Fig. 3, can be used to augment the flow of the purge water if additional head is needed to move the slurry.

D. Venturi Flowmeter

A venturi, shown in Fig. 4, was installed in the loop to measure the slurry flow through the 3 in. pipe. To retard the diffusion of slurry into the Barton differential pressure cell, a continuous flow of purge water obtained by condensing steam from the pressurizer is maintained through the manometer lines with the pulsafeeder.

Run History

A preliminary oxygenated water run was made for 63 hours at 250°C and 1000 psig to check the operation of the pump. Since the run was being made at 1000 psig, the main pump flanges were not seal-welded.

After the water run, the loop was drained and charged (time meter reading - TM 1616.6) with 32.7 kg of thorium oxide, batch LO-10, 220 g $\text{Th}(\text{SO}_4)_2$, 71 liters of water, and 75 liters of oxygen to give a circulating concentration of 500 g Th/kg H_2O containing 3400 ppm of sulfate based on the thorium oxide and 500 ppm of oxygen. Chemical data for the oxide are listed in Table I.

After 72 hours of circulation at 250°C and 1000 psig, the loop was cooled to room temperature (TM 1688.6), to repair a valve which failed

Fig. 4

VENTURI SYSTEM WITH PURGE WATER FOR MANOMETER LINES

ORNL-LE-DWG.-22191
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Fig. 4

TABLE I
CHEMICAL COMPOSITION OF THORIUM OXIDE USED IN 200A-10

Batch No.	Specifications	ORNL LO-10
Source of Nitrate	--	Lindsay
Calcination Temp. °C	--	800°
Specific Surface Area		18.4 m/g
Chemical Composition mg/g		
Th	872 min.	872
Fe } Ni } Cr }	0.05 max.	<0.005 <0.005 <0.005
Al		0.04
SO ₄	0.50 max.	<0.10
CO ₃	3.00 max.	2.3
Cl } F }	0.01 max.	<0.01 <0.01
NO ₃	0.01 max.	<0.005
PO ₄	0.01 max.	<0.02
Pb	0.01 max.	<0.01
Si	0.01 max.	0.02
Ca } Ba } Mg }	0.10 max.	0.37 -- 0.047
K } Na }	0.01 max. 0.01 max.	0.08 0.26

during sampling. The slurry was not drained from the system. A vacuum was therefore maintained on the system to prevent the slurry from draining from the loop while the valve stem was replaced. Operating conditions were restored and the run continued for 40 hours before the circulating concentration was increased from 500 to 800 g Th/kg H_2O (TM 1728.6) over the next 116 hour interval by adding 24.8 kg of unpumped, sulfated thorium oxide, batch L0-10, stepwise in 7 kg increments. Approximately 1.5 kg of oxide were added per charge.

During one of the additions (TM 1776.3) a drip was noticed at a 1/4-in. Parker tubing connector located in the purge water line downstream of the condenser. As the loop and pressurizer were cooled, the leak was investigated when the pressure was approximately 400 psig and found to be due to a crack in the purge water condenser jacket. Since the location of the leak was not considered hazardous to the operation of the condenser, the jacket was not repaired at this time and the loop was reheated to 250°C. The run was continued for 181 hours at the increased thorium level.

To determine the effect of uranium on the handling characteristics of the slurry, 2080 g of $UO_3 \cdot H_2O$ were added in three steps over a 51 hour period to give a final uranium concentration of 3% based on the thorium oxide in the system. The first addition of uranium started at TM 2009.5. With the last addition of $UO_3 \cdot H_2O$, 2.28 kg of unpumped, sulfated, thorium oxide were added to partially replace the solids which had been withdrawn during sampling. The admixed thorium-uranium oxide slurry was circulated at 250°C for 308 hours without incident.

Approximately 100 hours before the scheduled shutdown (TM 2317.7), a high pressure water leak was found in the head of the purge water pulsafeder

which could not be repaired while the loop was at pressure. The pulsafeeder was therefore isolated from the high pressure system for the remainder of the run, stopping the purge water flow to the manometer lines.

The run was terminated at Th 2393.1 for scheduled inspection of the loop and the pump after a total of 777 hours of operation at 250°C and 1000 psig.

Results

A. Capillary Sampler

The capillary tube sampling system proved very satisfactory and no difficulties were encountered in its operation. The samples were cool when collected and the rate of sample withdrawal could be easily controlled by the throttle valve with no tendency toward plugging even with slurry of a concentration of 1500 g Th/kg H₂O.

B. In-Line Sampler

After the first sample was taken, leaky block valves hindered the operation of the in-line sampling system from then on. To continue testing of the sampler, freeze plugs were established when sampling to back-up the leaky valves and to isolate the bomb from the high pressure system. Approximately 30 minutes were required to form the freeze plugs with dry ice. Since the sample remained in the isolation bomb during this period, the solids tended to settle to the bottom of the bomb, which often plugged the outlet valve.

A comparison of the capillary tube and in-line samplers is shown in Table II. Referring to Table II it can be seen that the concentration of the samples taken by the two methods check within $\pm 10\%$ which is good agreement considering that there is a $\pm 2\%$ error in the chemical analysis for thorium and a 10% error in obtaining a representative aliquot of the sample for the chemical analysis.

TABLE II
COMPARISON OF SAMPLES WITHDRAWN THROUGH THE IN-LINE
AND THE CAPILLARY TUBE SAMPLERS

Sample No.	Circulating Time Hours	In-Line Sampler <u>mg Th</u> <u>gm slurry</u>	Capillary Sampler <u>mg Th</u> <u>gm slurry</u>
200A-10-2	70.1	316	299
-4	130.1	294	328
-6	224.3	405	374
-7	248.5	391	414
-11	392.4	412	407
-13	416.3	423	435
-14	441.7	408	421
-15	464.7	381	401
-16	487.6	394	391
-17	608.1	407	417
-18	679.6	407	421
-19	774.8	400	448

Pump power vs density of the circulating slurry is shown in Fig. 5 and Table III. The solid line shown in Fig. 5 was determined from water data and slurry run 200A-11 using the method of least squares to determine the best line. These points are shown as solid circles. Comparing these data with the data obtained by sampling it can be seen that the slurry concentration indicated by the pump power is consistently 10 to 15% higher than that determined by sampling and chemical analysis. This bias is probably due to the uncertainties in sampling two phase flow.

Venturi System

The venturi flow meter appeared to function satisfactorily during part of this run. Purge flow through the manometer lines was maintained without difficulty as long as the pulsafeeder operated. At the beginning of the run the flow meter indicated a flow of 208 gpm assuming a circulating concentration of 585 gm Th/kg H_2O (sample 200A-10-1R). The d/p cell responded proportionately to the first addition of thorium oxide. However the readings became erratic with subsequent additions of slurry as seen in Table IV for samples 200A-10-6 through 11. After the first uranium addition was made, the readings increased to 96% of full scale, or to a value corresponding to a flow of 220 gpm for a slurry containing 810 gm Th/kg H_2O at 250°C (sample 200A-10-12). The flow meter readings remained relatively constant for the rest of the run, responding to the concentration changes as indicated in Table IV. No satisfactory explanation has been found for the unexpectedly erratic behavior of the venturi.

13

Fig. 5

Fig. 5

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TABLE III

DENSITY OF SAMPLES AT 250°C

Sample No.	Circulating Time hr	In Line Sampler		Capillary Sampler		Pump Power kw
		Concentration <u>mg Th</u> <u>gm slurry</u>	Density* <u>gm</u> <u>ml</u>	Concentration <u>mg Th</u> <u>gm slurry</u>	Density* <u>gm</u> <u>ml</u>	
200A-10-0	17.3	255.5	1.090	--	--	11.7
-1	35.0	250	1.262	--	--	11.7
-2	70.1	316	1.187	299	1.159	11.6
-3	87.7	--	--	306.5	1.177	11.5
-4	130.1	293.5	1.150	327.5	1.212	11.7
-5	153.0	--	--	360	1.282	12.4
-6	224.3	404.5	1.382	373.5	1.310	12.7
-7	248.5	391	1.350	414	1.417	13.1
-8	255.8	--	--	--	--	13.0
-9	278.6	--	--	410	1.405	13.0
-10	296.7	421	1.425	568.5	1.978	13.0
-11	392.4	412	1.41	406.5	1.387	12.8
-12	398.3	--	--	450	1.514	13.4
-13	416.3	423	1.433	435	1.463	13.4
-14	441.7	407.5	1.391	420.5	1.423	13.2
-15	464.7	380.5	1.323	400.5	1.372	13.0
-16	487.6	393.5	1.354	391	1.35	12.9
-17	608.1	407	1.389	416.5	1.417	13.4
-18	679.6	406.5	1.387	421	1.425	13.5
-19	774.8	400	1.370	448	1.503	14.0

* At 250°C.

TABLE IV
LOOP FLOW

Sample Number	Slurry Concentration		Venturi Reading %	Indicated flow* using slurry concentration based on	
	Avg. of Chemical Analysis mg Th <u>gm slurry</u>	Indicated by Pump Power mg Th <u>gm slurry</u>		Chemical Analysis <u>gpm</u>	Pump Power <u>gpm</u>
200A-10-0	255.5	358	73	226	207
-1	350	358	73	208	207
-2	307.5	350	74	218	210
-3	306.5	345	74	218	211
-4	310.5	358	78	224	214
-5	360	406	78	214	205
-6	389	427	65.5	188	180
-7	402.5	450	75	201	198
-8	--	445	56	--	163
-9	410	445	46	153	148
-10	421	445	44	148	144
-11	409	404	64	182	178
-12	450	463	88	208	204
-13	429	463	88	213	204
-14	414	455	92	221	211
-15	390.5	445	96	234	218
-16	392	438	95	230	220
-17	412	463	99	230	218
-18	414	472	>100	--	--
-19	424	495	>100	--	--

* A flow of 208 gpm was measured with water at room temperature
using a calibrated orifice.

Addition System

With the addition system, slurry could be added to the loop at a rate of approximately 1-1/2 kg of thorium oxide per 40 minutes without difficulty while at operating conditions. At higher concentrations than 800 g Th/kg H₂O, the lines connecting the addition tank to the loop tended to plug and the pulsafeeder was needed to develop sufficient head to move the settled bed.

Generalized Attack

The total iron contamination in the slurry, a measure of the attack on stainless steel, is shown in Fig. 6. Samples were taken according to the schedule shown in Table V.

Referring to Fig. 6, the iron build-up showed the characteristic rapid initial attack followed by a much lower attack. For the first 95 hours of circulation, the attack rate was 1 mpy. The attack rate decreased slightly during the period the slurry concentration was increased from 500 to 800 g/kg and appeared to be leveling off at 0.5 mpy when the uranium additions were made. The addition of uranium had little effect on the attack rate--the rate was 0.4 mpy for the 325 hour interval in which the thorium-uranium slurry was circulated at 250°C. Similar results were reported for a thorium-uranium slurry circulated in a 100A loop.¹

A greater localized attack occurred in areas of high velocity, as evidenced by the rates of attack listed in Table VI for the stainless steel orifice plates and the titanium impeller; however, these localized rates are comparable to those obtained with the pure thorium oxide slurry.²

17

FIG. 6

Fig. 6

TABLE V

CHEMICAL DATA, PUMP POWER REQUIREMENTS AND VENTURI READINGS FOR RUN 200A-10

Sample Number	Time, hr	SOLIDS (based on slurry)									FILTRATE			PUMP POWER	
		Th mg/g	Th g/kg H ₂ O	U mg/g	Fe mg/g	Ni mg/g	Cr mg/g	Ti mg/g	SO ₄ mg/g	pH	pH	SO ₄ ppm	U ppm	Amps.	kw
0 R	17.3	255.5	360	--	0.018	<0.005	<0.005	<0.02	0.97	6.7	6.2	8	--	16.8	11.7
0 BP	--	5.7	6	--	--	--	--	--	--	5.4	6.2	7	--	--	--
0 TP	--	--	--	--	--	--	--	--	--	--	6.8	<5	--	--	--
1 R	35.0	350	585	--	0.036	0.006	0.008	<0.02	1.30	7.3	6.2	10	--	16.8	11.7
1 BP	--	--	--	--	--	--	--	--	--	--	5.1	<5	--	--	--
1 TP	--	--	--	--	--	--	--	--	--	--	6.5	<5	--	--	--
2 R	70.1	316	496	--	0.045	0.008	0.008	<0.02	1.04	6.1	6.1	6	--	16.8	11.6
2 L	--	299	455	--	0.053	0.008	0.010	<0.02	1.19	5.9	6.1	8	--	--	--
2 BP	--	--	--	--	--	--	--	--	--	--	5.1	<5	--	--	--
2 TP	--	--	--	--	--	--	--	--	--	--	6.7	<5	--	--	--
3 L	87.7 112	306.5 Added 3.2 kg ThO ₂	472	--	0.050	0.007	0.009	<0.02	1.20	5.6	6.9	6	--	16.7	11.5
4 R	130.1	293.5	443	--	0.053	0.005	0.009	<0.02	1.15	5.9	6.2	6	--	17.0	11.7
4 L	--	327.5	525	--	0.056	0.008	0.013	<0.02	1.25	6.0	6.4	6	--	--	--
4 BP	--	--	--	--	--	--	--	--	--	--	5.1	<5	--	--	--
4 TP	--	--	--	--	--	--	--	--	--	--	5.6	5	--	--	--
	133	Added 7.8 kg ThO ₂													
5 L	153.0	360	614	--	0.077	0.014	0.013	0.02	1.53	6.0	5.1	6	--	17.8	12.4
5 TP	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	165	Added 7.0 kg ThO ₂													
6 R	224.3	404.5	755	--	0.084	0.012	0.018	0.03	1.35	6.0	6.3	<5	--	18.1	12.7
6 L	--	373.5	654	--	0.083	0.013	0.010	0.02	1.25	5.7	6.2	<5	--	--	--
6 TP	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	228	Added 6.8 kg ThO ₂													

Table V (continued)

19

Sample Number	Time, hr	SOLIDS (based on slurry)									FILTRATE			PUMP POWER	
		Th mg/g	Th g/kg H ₂ O	U mg/g	Fe mg/g	Ni mg/g	Cr mg/g	Ti mg/g	SO ₄ mg/g	pH	pH	SO ₄ ppm	U ppm	Amps.	kw
7 R	248.5	391	710	--	0.071	0.014	0.020	0.02	1.26	6.0	6.3	<5	--	18.8	13.1
7 L	--	414	790	--	0.089	0.014	0.020	0.03	1.46	5.9	6.1	<5	--	--	--
7 BP	--	--	--	--	--	--	--	--	--	--	5.6	<5	--	--	--
7 TP	--	--	--	--	--	--	--	--	--	--	5.3	<5	--	--	--
8 L	255.8	Sample Lost		--	--	--	--	--	--	--	--	--	--	18.8	13.0
9 L	278.6	410	776	--	0.091	0.013	0.019	0.02	1.56	5.9	6.5	5	--	18.8	13.0
9 TP	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
10 R	296.7	421	816	--	0.099	<0.005	0.012	0.03	1.57	5.9	6.2	6	--	18.3	13.0
10 L	--	568.5	1640	--	0.138	<0.005	0.026	0.04	1.47	5.6	6.2	7	--	--	--
10 BP	--	--	--	--	--	--	--	--	--	--	4.5	<5	--	--	--
10 TP	--	--	--	--	--	--	--	--	--	--	5.1	8	--	--	--
11 R	392.4	412	783	--	0.130	0.012	0.024	0.03	1.59	5.8	7.1	9	--	18.5	12.8
11 L	--	406.5	766	--	0.122	0.007	0.026	0.04	1.63	5.8	6.4	10	--	--	--
11 BP	--	--	--	--	--	--	--	--	--	--	4.7	<5	--	--	--
11 TP	--	--	--	--	--	--	--	--	--	--	5.9	13	--	--	--
	393	Added 300 gm UO ₃ ·H ₂ O													
12 L	398.3	450	932	2.8	0.128	0.028	0.020	--	1.55	5.2	6.0	10	--	19.4	13.4
13 R	416.3	423	823	2.6	0.124	0.015	0.015	0.04	1.53	5.2	6.1	8	--	19.2	13.4
13 L	--	435	870	2.8	0.134	0.026	0.026	0.05	1.60	5.2	5.7	10	--	--	--
13 BP	--	--	--	--	--	--	--	--	--	--	4.6	<5	--	--	--
13 TP	--	--	--	--	--	--	--	--	--	--	4.8	16	--	--	--
	420	Added 740 gm UO ₃ ·H ₂ O													
14 R	441.7	407.5	768	7.47	0.123	0.032	0.033	0.04	1.37	4.5	4.9	17	--	19.0	13.2
14 L	--	420.5	815	7.60	0.129	0.025	0.036	0.03	1.53	4.5	5.0	16	--	--	--
14 BP	--	--	--	--	--	--	--	--	--	--	4.2	5	--	--	--
14 TP	--	--	--	--	--	--	--	--	--	--	4.5	11	--	--	--
	444	Added 1000 gm UO ₃ ·H ₂ O and 2.28 kg ThO ₂													

18-a

Table V (continued)

20

Sample Number	Time, hr	SOLIDS (based on slurry)									FILTRATE			PUMP POWER	
		Th mg/g	Th g/kg H ₂ O	U mg/g	Fe mg/g	Ni mg/g	Cr mg/g	Ti mg/g	SO ₄ mg/g	pH	pH	SO ₄ ppm	U ppm	Amps.	kw
15 R	464.7	380.5	677	14.9	0.130	0.036	0.016	0.03	1.35	4.2	4.3	105	234	18.5	13.0
15 L	--	400.5	744	14.9	0.125	0.039	0.019	0.05	1.43	4.2	4.3	102	219	--	--
15 BP	--	541.5	1441	10.2	0.150	0.039	0.020	0.07	1.90	4.6	5.0	11	5	--	--
15 TP	--	--	--	--	--	--	--	--	--	--	3.5	33	17	--	--
16 R	487.6	393.5	718	11.5	0.130	0.036	0.030	<0.02	1.50	4.0	3.9	84	137	18.7	12.9
16 L	--	391	710	11.5	0.122	0.035	0.032	0.06	1.56	4.0	4.1	56	100	--	--
16 BP	--	554.5	1528	17.8	0.174	0.050	0.027	0.06	1.90	4.1	4.2	48	71	--	--
17 R	608.1	407	766	12.7	9.135	0.037	0.033	0.06	1.91	3.7	3.8	65	--	19.2	13.4
17 L	--	416.5	800	12.4	0.155	0.045	0.036	0.06	0.79	3.6	4.0	56	--	--	--
17 BP	--	--	--	--	--	--	--	--	--	--	3.9	19	19	--	--
17 TP	--	--	--	--	--	--	--	--	--	--	2.4	199	52	--	--
18 R	679.6	406.5	764	12.9	0.196	0.064	0.031	0.04	1.69	4.0	4.3	53	55	19.5	13.5
18 L	--	421	816	14.2	0.192	0.039	0.036	0.05	1.57	3.9	4.1	43	47	--	--
18 BP	--	--	--	--	--	--	--	--	--	--	3.5	23	24	--	--
18 TP	--	--	--	--	--	--	--	--	--	--	2.6	199	90	--	--
19 R	774.8	400	741	12.2	0.180	0.051	0.037	0.05	1.88	4.4	4.2	53	--	20.1	14.0
19 L	--	448	923	14.4	0.202	0.055	0.044	0.06	1.34	4.5	4.1	51	--	--	--
19 BP	--	--	--	--	--	--	--	--	--	--	4.1	8	<2	--	--
19 TP	--	--	--	--	--	--	--	--	--	--	2.7	314	135	--	--

R In line recirculating sampler
 L Loop sample station
 BP Bottom pressurizer sample point
 TP Top pressurizer sample point

21

TABLE VI
LOCALIZED ATTACK ON COMPONENTS

Component	Slurry Velocity (fps)	Attack Rate, mpy	
		Th-U Slurry	ThO ₂
Stainless steel orifice plate 1	37	36	30
Stainless steel orifice plate 2	65	246	132
Titanium impeller	--	5	--

22

Handling Characteristics

There was no difficulty in handling the admixed thorium-uranium oxide slurry. It pumped well and no cakes or accumulations were found upon draining the loop at the end of the run. Approximately 97% of the thorium oxide charged to the loop was recovered. If spheres were present in the pure or admixed slurries they were too small to be clearly identified within the resolution of the microscope used. Particle size data determined by sedimentation in xylene with oleic acid as the dispersant are shown in Table VII. According to these data, the particles were degraded so that 70% of them were less than 2 microns in diameter after 17 hours of circulation at 250°C. The addition of uranium oxide to the slurry did not affect the particle size distribution; approximately 70% of the admixed solids were still less than 2 microns in diameter.

Surface area and X-ray crystallite size data, shown in Table VIII, indicate no changes occurred in the crystallite dimensions. However, there was an increase in the surface area of the pure oxide, determined by N₂ absorption, as the particles were degraded during the first 88 hours of the run; the surface area increased from 18.0 to 25.0 square meters per gram. Also, there appears to be a slight decrease in surface area with the addition of uranium. However, additional data are needed to corroborate these observations.

Pump History

When the pump was opened, the impeller and thermal barrier appeared to have sustained very little wear as seen in Figures 7 and 8, however, the surfaces exposed to high turbulence acquired a minor polish. The titanium

23

TABLE VII

PARTICLE SIZE AS DETERMINED IN SEDIMENTATION IN
XYLENE AND OLEIC ACID WITHOUT WARING BLENDING

Sample No.	Time hr	<7 μ	<5 μ	<3 μ	<2 μ	<1.5 μ
0 R	17.3	94	92	84	75	32
1 R	35.0	100	99	95	83	41
2 R	70.1	99	98	93	87	82
2 L	--	97	95	94	87	57
3 L	87.7	94	93	90	77	61
4 R	130.1	93	91	82	72	63
4 L	--	95	92	86	78	--
5 L	154.0	96	93	90	73	--
6 R	224.3	98	97	95	90	53
6 L	--	96	96	91	88	75
7 R	248.5	98	96	92	92	74
7 L	--	100	93	93	90	78
8 L	255.8	98	94	88	81	70
9 L	278.6	99	97	96	90	87
10 R	296.7	100	99	97	91	85
10 L	--	100	100	100	87	84
11 R	392.4	97	98	96	95	68
11 L	--	99	98	96	93	81
12 L	398.3	99	98	98	79	47
13 R	416.3	98	98	95	94	58
13 L	--	100	98	96	95	93
13 BP	--	97	95	94	65	31
14 R	441.7	95	94	92	89	41
14 L	--	94	92	90	80	54

24

Table VII (continued)

Sample No.	Time hr	<7 μ	<5 μ	<3 μ	<2 μ	<1.5 μ
15 R	464.7	97	96	94	76	45
15 L	--	97	94	91	78	51
16 R	487.6	99	98	95	80	44
16 L	--	98	97	95	71	41
16 BP	--	98	97	94	41	18
16 BP (re-run)	--	98	96	91	83	36
17 R	608.1	99	98	96	54	23
17 L	--	98	96	92	78	45
18 R	679.6	96	95	89	74	25
18 L	--	98	95	89	58	32
19 R	774.8	98	96	92	87	61
19 R (re-run)	--	94	90	88	69	34
19 L	--	96	96	96	91	77
19 L (re-run)	--	89	89	87	82	45

R In line recirculating sample
 L Loop sample point
 BP Bottom pressurizer sample point

25

TABLE VIII
SURFACE AREA AND X-RAY CRYSTALLITE SIZE DATA

Sample No.	Circulating Time Hours	Surface Area M ² /gm	Crystallite Size Å
Original oxide	0	18	220
0 R	17	22.8	218
3 L	88	25.0	227
11 R	392	23.5	239
13 L	416	23.0	228
14 L	442	22.5	232
17 L	608	21.6	230
19 L	775	22.1	230

26

Photo-27820
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Fig. 7 Run 200A-10 Impeller

27

Photo-27821
UNCLASSIFIED

Fig. 8 Run 200A-10 Thermal Barrier

28

impeller was not pitted although it lost 3.5 g in weight and was highly polished. The front hub was worn 0.001". The stainless steel seal rings in the thermal barrier were not worn whereas the titanium seal rings in the volute liner wore 0.018 inches.

Several small cracks were found in the upper stellite 19 journal of the rotor in a 1/4-in. band which extended around the journal 3/4 inches from its upper end. This band was discolored, indicating overheating as the possible cause for the cracking. The upper graphitar radial bearing failed in a ring corresponding to the area of failure for the journal. The lower graphitar radial bearing showed a tapered wear of 0.004 inches maximum with the wear occurring at the lower end; the lower stellite 19 journal showed no wear. The Kingsbury graphitar thrust runner and stellite 19 shoes appeared to be in good condition.

29

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