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12/12/56

OAK RIDGE NATIONAL LABORATORY

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POST OFFICE BOX P
OAK RIDGE, TENNESSEE

EXTERNAL TRANSMITTAL AUTHORIZED

ORNL
CENTRAL FILES NUMBER

CF- 56-11-131

DATE: November 16, 1956

SUBJECT: 1. Summary of Runs, S56, 57, 73, 74, 78, 79, 80,
87, 88, 89 in Which Slurries Circulated at 300°C
in 100-A Loops Caked or Accumulated on Pipe Walls.

2. Summary of Runs T-52 Through T-75 in Which a
Bypass Line was Used in Parallel With Main Circulating
Loop

TO: Right Division

From: A. S. Kitzes, R. B. Gallaher, C. A. McLaughlin, R. P. Wichner

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Summary

Brief histories of the runs in which caking occurred are presented in Table I and Table II. In runs S-56 and S-57, the slurry was prepared from thorium oxide calcined at 650°C, whereas oxide calcined at 800°C was used in all the other runs. Sulfate as thorium sulfate was added to the slurry for each run except S-56. Although no sulfate was added in this run, a high sulfate content was found in the slurry, probably due to contamination from the previous run, S-55.

A hard cake was formed in appreciable quantity only in S-89. In this run, a hard, intractable cake, 0.4" thick with an average density of 4.75 was removed from the eye of the impeller. Most of the loop was also covered with a cake, 3/16" thick. However this cake was soft but sufficiently rigid to hold its form. The cake removed from under the loop cooler was only 3/32" thick.

Boiling was suspected in run S-89. Pump power fluctuations and cavitation noises could both be removed by raising the system pressure or lowering the loop temperature.

Twenty-four runs were completed in which slurry was circulated through a small diameter bypass line in parallel with the main circulating loop. The results of these runs are summarized in Table III and Table IV. In Table III a brief history of the runs is given and in Table IV the analytical data are presented.

In ten of the 24 runs, (T54, 55, 56, 59, 66, 67, 68, 70, 71, 72) the bypass line remained open during the entire duration of the run. In thirteen of the runs, (T53, 56, 57, 58, 60, 61, 62, 63, 64, 65, 73, 74, 75) the bypass plugged and once plugged it stayed that way for the remainder of the run. In run T-52, the bypass remained open for 52 hours at 290°C and then

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the loop was cooled to room temperature to repair a faulty instrument. On subsequent start ups, the bypass plugged each time. In run T-75, the bypass remained open for 3-1/2 hours at 290°C and then plugged. By lowering the loop temperature to 175°C, the bypass reopened and remained as such for 20 minutes and then plugged again at 175°C. On cooling the loop to room temperature, the bypass reopened again and remained open when the temperature was raised to 175°C and held there for 23.5 hours. Then, on raising the loop temperature to 290°C, the bypass plugged when the loop temperature reached 190°C. On lowering the temperature to 175°C, the flow through the bypass was indicated for 2 minutes before plugging was indicated again.

The bypass remained open in 5 of 6 runs in which fresh, unpumped oxide was used to prepare the slurry. Fresh oxide was used in runs T-52, 54, 55, 56 and 68, the runs in which the bypass did not plug. T-61 is the run in which the bypass plugged when using unpumped oxide. Using pumped slurries, the bypass plugged in 8 runs (T-52, 62, 63, 64, 65, 73, 74, 75) and remained open in 6 runs (T-59, 66, 67, 70, 71, 72).

The bypass plugged in only one run, T-53, in which the slurry concentration was as low as 400 mg Th/kg H₂O. The bypass plugged three times with 800 g/kg (T-63, 64, 65), twice with 900 g/kg (T-61, 62) and 6 times with 1000 g/kg slurries (T-56, 57, 60, 73, 74, 75).

No run was completed in which the bypass remained open when circulating 1000 g/kg slurry. The bypass remained open in 3 runs with 300 g/kg slurries (T-52, 54, 55), in 1 run (T-56) with a 400 g/kg slurry, in 5 runs (T-60, 66, 67, 68, 70) with 700 g/kg slurries, in 1 run (T-59) with a 800 g/kg slurry, and in two runs (T-71, T-72) with 900 g/kg slurries. In run T-56, the bypass did not plug with a 400 g/kg slurry but did plug when the concentration was increased to 1000 g Th/kg H₂O.

The effect of slurry treatment on formation of plugs in the bypass is seen from the following data. With pumped slurry, the bypass plugged 6 times when the loop temperature was 290°C , once when the temperature was 254°C and once at 190°C . With unpumped slurry, the bypass plugged once at 260°C and once at 150°C . Increasing the pressure drop across the bypass line helped to maintain flow through it in run T-53. However, in 16 other runs, the bypass plugged in 8 of the runs (61, 62, 63, 64, 65, 73, 74, 75) and remained open in the other 8 runs (59, 60, 66, 67, 68, 70, 71, 72) even though a pressure drop of 20 to 30 psi was maintained across the bypass. The addition of tetra-sodium pyrophosphate to the slurry did not prevent the bypass line from becoming plugged. However with each addition of pyrophosphate, the temperature at which the bypass plugged increased from 150°C to 235°C . The bypass line plugged instantaneously when the pyrophosphate content was increased to 0.015 M. Chemical and physical property data for the thorium oxide used in these runs are listed in Table VII.

The pump graphitar bearing usage is shown in Table VIII. Only the data for the front bearing are listed as the front bearing in the Westinghouse 100-A pump is the one which is most frequently replaced. Arbitrarily it has been established that the bearing is replaced when the internal diameter is 1.504" or greater. Normally, the internal diameter of the bearing is 1.502" when new.

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TABLE ISUMMARY OF OPERATIONAL HISTORY OF RUNS IN WHICH SLURRIES CIRCULATEDAT 300°C IN LOCA LOOPS CAKED OR ACCUMULATED ON PIPE WALLS

<u>Run No.</u>	<u>Purpose of Run</u>	<u>History of Run</u>	<u>Results or Remarks</u>
S-56	Demonstrate the pumpability at 300°C of a slurry containing 1000 g Th/kg H ₂ O. Slurry prepared from oxide calcined at 650°C which contained no sulfate.	10.5 kg ThO ₂ mixed with 11 l H ₂ O were charged to loop. 1. Loop reached 300°C 1 hour after pump was turned on. 2. Loop sampled 19 hours after start-up of run...Solids concentration low in loop sample and high in pressurizer sample	1. Run terminated because the solids accumulated in pressurizer. 2. No sulfate added to system; sulfate present in system as contaminant from previous run S-55.
S-57	Demonstrate pumpability at 300°C of a slurry containing 500 g Th/kg H ₂ O. Slurry prepared from oxide calcined at 650°C which contained no sulfate.	Six kilograms of oxide mixed in 11.5 liters of H ₂ O were loaded into loop. Operation normal at 300°C.	Run stopped because of erratic behavior of pump. Inspection of pump parts showed cracked front stellite 98M2 journal. No reason found for loss in solids concentration.
S-73	Same as S-56. Slurry prepared from oxide calcined at 800°C and contained 1000 ppm sulfate as added Th(SO ₄) ₂	13.6 kg of oxide and 24 g Th(SO ₄) ₂ were agitated together in 11 liter prior to loading into loop. Operation was normal at 300°C except for low pump power requirements.	Balancing holes in the impeller were plugged and hard cake found in the impeller channels. Chemical analysis of cake was not made.
S-74	Same as S-73.	1. Twenty-four grams of Th(SO ₄) ₂ blended into slurry containing 13.6 kg of oxide in 11 liters of H ₂ O for 32 hours with agitation prior to loading into loop. 2. Operation normal at 300°C except for low pump requirements.	Same as for S-73.

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TABLE I (continued)

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Run No.	Purpose of Run	History of Run	Results or Remarks
S-78	Same as S-57. Slurry prepared from oxide calcined at 800°C and contained 1000 ppm sulfate as added $\text{Th}(\text{SO}_4)_2$.	Six kilograms of oxide were blended with 24 g $\text{Th}(\text{SO}_4)_2$ in 11.5 liters of water prior to charging into loop. Operation normal at 300°C except for low pump power requirements.	Sample taken from loop sampling station contained no solids. No cakes found. Reason for slurry behavior unknown.
S-79	Evaluate qualitatively the effect of added fluoxide on the attack of metals at 300°C by a slurry containing 500 g Th/kg H_2O and 1000 ppm sulfate. Oxide calcined at 800°C was used to prepare slurry.	Six kilograms of oxide were blended with 24 g $\text{Th}(\text{SO}_4)_2$ and 0.5 g Th F_4 in 11.5 liters of H_2O prior to charging into loop. Operation normal at 300°C except for pump amperage which indicated low readings. Low pump power requirements is indicative of a decrease in slurry concentration.	Solids caked in impeller vanes only. Cause for decrease in concentration not known.
S-80	Same as S-78.	Six kilograms of oxide were mixed with 24 g $\text{Th}(\text{SO}_4)_2$ in 11.5 liters of H_2O prior to charging into loop. Operation appeared normal at 300°C. However, survey meter showed solids collecting in pressurizer 5 hours after start-up. Cooled to room temperature, bled off oxygen and then added only 10 liters of O_2 instead of normal 25 liters. Six hours after second startup, run terminated because samples contained no solids.	Loop samples contained no solids; therefore they were not submitted for analysis. Hard cake found in impeller vanes.

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TABLE I (continued)

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Run No.	Purpose of Run	History of Run	Results or Remarks
S-87	Check operation of pump with modified front bearing holder. Loop charged to circulate 1000 g/kg slurry at 300°C containing 1000 ppm SO_4 as added $\text{Th}(\text{SO}_4)_2$.	<ol style="list-style-type: none"> 1. Bearing modified by placing solid plate with only four-1/16" holes so that most of the cooling water had to pass through bearing annulus. Bearing operated satisfactory with water at 300°C for 82 hours. 2. Installed bypass, 3/8" tubing from venturi to pressurizer. Bypass approx. 8' long. 3. Loop charged with screened slurry containing 13.5 kg ThO_2 and 36 g $\text{Th}(\text{SO}_4)_2$ in 11.5 liters of H_2O. 4. By-pass plugged when loop temp. reached 120°C. Cooling did not unplug by-pass line. Run continued with by-pass plugged. 5. After 21 hours of circulation pump power fluctuations were observed; loop temp. then dropped to 290°C. 6. At this point pump began to vibrate so run was terminated. Run was in progress for 95 hours. 	<ol style="list-style-type: none"> 1. Pump wattmeter fluctuations indicated boiling. Pump also vibrated slightly. 2. Cake found in two impeller vanes and on a few areas in pump volute and thermal spacer. Cake also found on two titanium specimens headed on venturi rod. Cake appeared thin and looked glassy. Slurry velocity across two titanium specimens with cake estimated to be about 20 ft/sec.
S-88	Study effect of boiling in a sulfated slurry circulating at 300°C on cake formation. Slurry prepared from oxide calcined at 800°C and contained 750 ppm sulfate as added $\text{Th}(\text{SO}_4)_2$.	<p>Loop charged with 20.2 kg of screened slurry containing 13.5 kg ThO_2 and 20 g $\text{Th}(\text{SO}_4)_2$ in 11.5 liters of H_2O. Operation normal at 300°C when leak developed in back of pump.</p>	<ol style="list-style-type: none"> 1. In spite of leak which developed around plug in back plate of pump, no cake was found in impeller or pump scroll. 2. Soft deposit found on pipe walls which was removed by water flushing.

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TABLE I (continued)

<u>Run No.</u>	<u>Purpose of Run</u>	<u>History of Run</u>	<u>Results or Remarks</u>
S-89	Same as S-88	<p>Loop charged with 13.5 g ThO_2 in 11 liters of water.</p> <ol style="list-style-type: none">1. Start-up normal. Two hours after pump turned on, fluctuations in pump power were observed. Loop temp. was 285°C as indicated by one instrument and over 300°C by a check instrument.2. One and a half hours later, pump began to vibrate. Temp. still 285°C by one instrument and over 300°C by the other.3. Temp. lowered to 282° and 300°C as indicated by the same two instruments, pump vibrations still persisted.4. Pump turned off and loop cooled to room temp. after a total of 6 hours of circulation. Instruments checked; however loop was not drained.5. The second start-up was normal and everything appeared normal until loop temp. reached 250°C, at which time a sudden decrease in pump power was again observed. When temperature reached 280°C, the pump began to vibrate. To relieve the suspected boiling condition, system pressure was raised to 1700 psig, and as a result the vibrations ceased. A leak developed so run terminated.	<ol style="list-style-type: none">1. Boiling indicated by fluctuations in pump power.2. Pump vibrations caused Parker fitting to leak.3. Hard cake 0.4 inches thick formed in the eye of the impeller which had a density of 4.75.4. Loop also covered with a cake $3/16$" thick which was soft but rigid.5. Cake under loop cooler was only $3/32$" thick.

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TABLE II

SUMMARY OF RUNS IN WHICH THORIUM OXIDE SLURRIES CIRCULATED AT 300°C

IN 100A LOOPS ACCUMULATED ON PIPE WALLS OR IN PRESSURIZER

Run No.	Time hrs.	Th mg gm	← SOLIDS →								FILTRATE		← METALS IN SYSTEM →				Oxide	Additions
			Fe mg gm	Ni mg gm	Cr mg gm	Ti mg gm	SO ₄ mg gm	Cl mg gm	F mg gm	pH	pH	SO ₄ ppm	Imp.	Orifice Plate	Venturi Rod	Seal Rings in Pump		
S-56	(19) ^s																	
S-56-0	19	283	.099	.024	.022	.020	1.90	--	--	5.25	6.0	81	Ti	SS (83)***	SS (56)***	Ti 4 SS	D-10 10.5 kg oxide in 11 l H ₂ O	O ₂
-OP**		521	.106	.032	.040	.029	3.60	--	--	--	6.6	93						
S-57	(26)																	
S-57-0	18	179	.034	.005	.010	.02	--	--	--	5.72	5.9	--	Ti	SS (83)	SS (56)	Ti	D-10 6. kg oxide in 11.5 l H ₂ O	O ₂
-OP		36	.036	.005	.022	.02	--	--	--	6.0	6.0	--						
-1	24	180	.035	.008	.011	.02	--	--	--	6.1	7.0	--						
-1P		3	.006	.005	.005	.02	--	--	--	5.5	7.0	--						
S-73	(2)	No samples taken											SS	SS (83)	SS Ti Zr	Ti	D-25 13.6 kg oxide in 11 l H ₂ O	O ₂ 24 g Th(SO ₄) ₂

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TABLE II (continued)

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Run No.	Time hrs.	← SOLIDS →								FILTRATE		← METALS IN SYSTEM →				Oxide	Additions	
		Th <u>mg</u> <u>gm</u>	Fe <u>mg</u> <u>gm</u>	Ni <u>mg</u> <u>gm</u>	Cr <u>mg</u> <u>gm</u>	Ti <u>mg</u> <u>gm</u>	SO ₄ <u>mg</u> <u>gm</u>	Cl <u>mg</u> <u>gm</u>	F <u>mg</u> <u>gm</u>	pH	pH	SO ₄ <u>ppm</u>	Imp.	Orifice Plate	Venturi Rod			Seal Rings in Pump
S-74	(4)	No samples taken											SS	SS (83)	SS Ti Zr (56)	Ti	D-25 D-38 13.6 kg oxide in 11 l H ₂ O	O ₂ 24 g Th(SO ₄) ₂
S-78	(5)	No samples taken											SS	SS (80)	SS Ti Zr (51)	Ti	D-31 6 kg oxide 11.5 l H ₂ O	O ₂ 24 g Th(SO ₄) ₂
S-79	(55)												SS	SS (80)	SS Ti Zr (51)	Ti	D-31 6 kg oxide 11.5 l H ₂ O	O ₂ 24 g Th(SO ₄) ₂
S-79-0	2	271	.086	--	--	--	.61	--	--	7.0	7.2	10						
-1	6	125	.105	--	--	--	.41	--	.01	5.5	8.0	14						
-2	21	163	.48	--	--	--	.40	--	.01	5.6	8.3	23						
-3	55	125	.57	--	--	--	.29	--	.01	5.5	7.6	23						
S-80	(11)	No samples submitted for analysis											SS	SS (80)	SS Ti Zr (51)	Ti	D-31 6 kg oxide in 11.5 l H ₂ O	O ₂ 24 g Th(SO ₄) ₂

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TABLE II (continued)

Run No.	Time hrs.	SOLIDS								FILTRATE		METALS IN SYSTEM				Oxide	Additions	
		Th mg gm	Fe mg gm	Ni mg gm	Cr mg gm	Ti mg gm	SO ₄ mg gm	Cl mg gm	F mg gm	pH	pH	SO ₄ ppm	Imp.	Orifice Plate	Venturi Rod			Seal Rings in Pump
S-87	(95)												SS	SS (71)	SS Ti Zr (46)		LO-11	
S-87-0	6.6	396	.247	--	--	.02	.50	.02	.01	7.2	4.9	11					13.5 kg	36 g ⁰ ₂
-1	65	479	1.60	--	--	.178	.50	--	--	7.5	4.5	17					oxide	Th(SO ₄) ₂
-1P	--	--	--	--	--	--	--	--	--	--	5.7	6					11.5 l	
-2	94.5	502	2.54	--	--	.261	.52	--	--	7.3	6.7	22					H ₂ O	
-2P	--	--	--	--	--	--	--	--	--	--	5.8	7						
S-88	(2.5)	No samples submitted											Ti	SS (80)	SS Ti Zr (51)	Ti	LO-1	
																	13.5 kg	20 g ⁰ ₂
																	oxide	Th(SO ₄) ₂
																	11.5 l	
																	H ₂ O	
S-89	(8.4)												Ti	SS (80)	SS Ti Zr (51)	Ti	LO-1	
S-89-0	5.6	385	.088	--	--	0.21	0.26	--	--	9.2	8.3	11					13.5 kg	20 g ⁰ ₂
																	oxide	Th(SO ₄) ₂
																	11.5 l	
																	H ₂ O	

* Results reported as mg/gm slurry

** Sample marked with P taken from pressurizer

*** Number in parenthesis is velocity of slurry in feet per second through orifice plate and throat of venturi

a Number in parenthesis is total running time

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TABLE III

OPERATIONAL HISTORY AND RESULTS OF RUNS IN WHICH A BYPASS LINE
WAS USED IN PARALLEL WITH THE MAIN CIRCULATING LOOP

<u>Run No.</u>	<u>Purpose of Run</u>	<u>History of Run</u>	<u>Results or Remarks</u>
T-52	Study the accumulation of solids in the pressurizer as a function of the flow rate of water to back of pump	Loop included a by-pass line, 1/4" sch 80 pipe, from pump discharge to pressurizer. Operation normal at 250°C with fresh unpumped 300 g/kg slurry prepared from 650°C oxide until faulty instrument (Simplytrol) on the pressurizer heater circuit forced a shutdown after 52 hours of operation. After checking instrument, by-pass line plugged 30 minutes after the pump was started for second time. Cooled to room temperature, unplugged by-pass, and washed out line. By-pass plugged a second time 40 minutes after third start-up. After cleaning by-pass, 500 g ThO ₂ added to make up for losses in plugged lines. This time, by-pass plugged 80 minutes after startup. Run terminated.	<ol style="list-style-type: none"> 1. No hard cake found in by-pass lines after being unplugged. 2. With by-pass stream into pressurizer, solids concentration in loop essentially independent of flow of water to back of pump. These data obtained with gamma scintillation head and count rate meter at flow rates from 0.7 to 2.1/hr.

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TABLE III (continued)

Run No.	Purpose of Run	History of Run	Results or Remarks
T-53	Same as T-52	<ol style="list-style-type: none"> 1. System the same as for T-52 2. Operation normal at 250°C for 18 hours with unpumped 300 g/kg slurry prepared from 800°C oxide when by-pass plugged. 3. Cleaned by-pass. 4. By-pass plugged 2 hours after second start-up. Loop temp. was 220°C at time of plugging. 5. Cleaned by-pass and replaced 1-1/4" orifice in main circulating loop with 1-1/8" orifice plate to increase pressure drop across by-pass. Four hours after loop reached temp., the loop was cooled to room temperature to replace burned out calrod in by-pass heater. After making repair, system operated satisfactorily at 250°C for 97 hours. 6. Loop cooled to room temp. and the system was allowed to remain quiescent for 17 hours and then restarted. By-pass remained open and circulation at 250°C was for 3 hours before run terminated. 	<ol style="list-style-type: none"> 1. No cake found in by-pass line after it was unplugged. 2. Concentration in loop is essentially independent of flow of water to back of pump. The flow to the back of the pump was varied between 1 to 2.7 l/hr. 3. By-pass remained open after increasing pressure drop across it.

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TABLE III (continued)

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Run No.	Purpose of Run	History of Run	Results or Remarks																										
T-54	Study accumulations of solids in pressurizer with and without by-pass stream into pressurizer and at varying water flow rates to back of pump.	<ol style="list-style-type: none"> 1. System same as for T-52. 2. Loop operated at 250°C for 5 hours with fresh 300 g/kg slurry prepared from 650°C oxide and then cooled to increase concentration. One kilogram of 650°C fired ThO₂ oxide added. Pump purge water rates were varied from 0.95 to 1.75 liters/hr during the next 100 hours of operation before cooling to add an additional 750 g ThO₂. 3. When the loop was again at 250°C, the flow to the back of the pump was varied between 1.0 to 2.45 liters per hour. 4. After a total of 225 hours of circulation, the bypass was removed. 5. The system was then operated satisfactorily for an additional 67 hours without the bypass stream into pressurizer. Run terminated after a total of 308 hours of circulation. 	<p>a) With by-pass stream into pressurizer</p> <table border="1"> <tr> <td>Flow rate to back of pump cc/min</td><td>950</td><td>1750</td><td>1875</td><td>2250</td><td>1050</td><td>2450</td></tr> <tr> <td>Conc. in loop mg Th/g slurry</td><td>259</td><td>264</td><td>287</td><td>280</td><td>270</td><td>No sample taken</td></tr> </table> <p>b) With by-pass line removed from system</p> <table border="1"> <tr> <td>Flow rate to back of pump cc/min</td><td>2900</td><td>3900</td><td>1975</td><td>4500</td><td></td></tr> <tr> <td>Conc. in loop mg Th/g slurry</td><td>279</td><td>251</td><td>322</td><td>234</td><td></td></tr> </table> <p>Bypass line did not plug in this line.</p>	Flow rate to back of pump cc/min	950	1750	1875	2250	1050	2450	Conc. in loop mg Th/g slurry	259	264	287	280	270	No sample taken	Flow rate to back of pump cc/min	2900	3900	1975	4500		Conc. in loop mg Th/g slurry	279	251	322	234	
Flow rate to back of pump cc/min	950	1750	1875	2250	1050	2450																							
Conc. in loop mg Th/g slurry	259	264	287	280	270	No sample taken																							
Flow rate to back of pump cc/min	2900	3900	1975	4500																									
Conc. in loop mg Th/g slurry	279	251	322	234																									

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TABLE III (continued)

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Run No.	Purpose of Run	History of Run	Results or Remarks												
T-55	Same as T-54 except operation was at 300°C.	Operation was normal for 18 hours at 300°C with fresh 400 g/kg slurry prepared from 650°C oxide until sudden rise in pump amperage occurred at which time run was terminated.	Stellite 98M2 journal cracked causing the run to be terminated. By-pass did not plug in this run.												
T-56	Same as T-55	<p>1. Loop operated normally with unpumped 400 g/kg 800°C oxide slurry at 300°C for 49 hours before cooling to room temperature to determine if by-pass line would plug on a second start-up.</p> <p>2. After a 15 hour quiescent period at room temperature, the second start-up was attempted and all operations were normal for 22 hours thereafter. Bypass remained open.</p> <p>3. Loop cooled to room temperature to add 9 kg of fresh oxide to increase concentration to approximately 1000 g Th/kg H₂O. By-pass plugged 1-1/4 hours after pump turned on. Loop temperature was not noted when bypass plugged.</p> <p>4. With bypass plugged, system was operated as if there was no bypass in system for 200 hours.</p>	<p>With bypass line plugged</p> <table><tr><td>Flow of water to back of pump, ml/hr</td><td>875</td><td>1800</td><td>875</td><td>3350</td><td>1125</td></tr><tr><td>Conc. mg/gm slurry</td><td>449</td><td>451</td><td>500</td><td>410</td><td>437</td></tr></table> <p>1. The solids were not caked in by-pass line.</p> <p>2. At a concentration of 350-400 g/kg, the bypass was not plugged by the slurry which had previously been circulated at 300°C.</p> <p>3. The bypass did plug, however, when the concentration was increased to 1000 g/kg.</p>	Flow of water to back of pump, ml/hr	875	1800	875	3350	1125	Conc. mg/gm slurry	449	451	500	410	437
Flow of water to back of pump, ml/hr	875	1800	875	3350	1125										
Conc. mg/gm slurry	449	451	500	410	437										

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TABLE III (continued)

Run No.	Purpose of Run	History of Run	Results or Remarks
T-57	To determine the temperature at which plugging first occurs in bypass line from circulating loop to pressurizer	<ol style="list-style-type: none"> 1. Loop charged with 12 liters of unpumped slurry containing 972 g $\text{ThO}_2/\text{kg H}_2\text{O}$ and 2.5 liters H_2O. 800°C oxide used to prepare slurry. 2. Bypass plugged in 1-1/2 hours after pump was turned on. Loop temp. at the time of plugging was 150°C. 3. Run was continued at 300°C for total 19.5 hours and then terminated. 	<ol style="list-style-type: none"> 1. Bypass plugged when loop temp. reached 150°C and did not unplug when slurry was circulated at 300°C for 18 additional hours.
T-58	To determine temperature at which plugging first occurs in bypass line from circulating loop to pressurizer, using a slurry in which $\text{Na}_4\text{P}_2\text{O}_7$ was added as a dispersant.	<ol style="list-style-type: none"> 1. Slurry recovered from run T-57 was charged to loop with 35.6 g $\text{Na}_4\text{P}_2\text{O}_7$. H_2O was also added to make up volume. The bypass plugged 1.9 hours after the pump was turned on. Temp. at time of plugging was not noted. 2. Bypass cleaned and run continued by maintaining loop temperature at 150°C. Bypass remained open after 1 hour of circulation at 150°C. 3. Temperature then raised to 200°C and bypass plugged. 4. Bypass cleaned and an additional 35.6 g $\text{Na}_4\text{P}_2\text{O}_7$ and H_2O were added. Bypass plugged when loop temperature reached 235°C two hours after the pump was turned on. 5. Cleaned bypass and added an additional 35.6 g $\text{Na}_4\text{P}_2\text{O}_7$ and H_2O. Bypass plugged from start of run. After cleaning bypass, a second attempt was made to circulate the slurry and again the bypass was plugged from the start of the run. 	<ol style="list-style-type: none"> 1. The bypass remained open for 1 hour at 150°C with a slurry in which the solids were dispersed in 0.005 M $\text{Na}_4\text{P}_2\text{O}_7$. However, the bypass plugged at 200°C using the same slurry. 2. Increasing the $\text{Na}_4\text{P}_2\text{O}_7$ to .01 M raised the temp. at which plugging occurred to 235°C. 3. The bypass was plugged from the start of the run when the $\text{Na}_4\text{P}_2\text{O}_7$ was increased to 0.015 M.

T-58
T-57
T-56

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TABLE III (continued)

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Run No.	Purpose of Run	History of Run	Results or Remarks
T-59	To determine feasibility of pumping a concentrated, previously pumped slurry, through 3/8" tubing in parallel with the main circulating stream.	Loop charged with slurry previously pumped in "S" loop (S-71) at 300°C. Slurry prepared from 800°C calcined oxide and contained approximately 3000 ppm sulfate based on water. The loop included a 3/8" bypass line. Changed orifice in the discharge from pump from 1-1/8" to 1" in order to increase pressure drop across bypass circuit. Slurry circulated at 300°C for 237 hours with an average conc. of 800 g/kg.	No difficulty encountered. Bypass remained open during the entire run.
T-60	Same as T-59	<p>Loop charged with slurry previously pumped 311 hours in "S" loop (S-76) at 300°C. Slurry prepared from 800°C calcined oxide and contained approximately 1000 g/kg Th and 2000-2600 ppm sulfate. The system included a 3/8" bypass line from the pump discharge to pressurizer. Slurry circulated at 300°C for 205 hours (No samples taken)</p> <p>Bypass cleaned and slurry again circulated at 300°C for 508 hours. Sample T-60-0 taken</p> <p>Bypass cleaned. Slurry reloaded into loop and circulated for 152 hours at 300°C. Loop cooled to room temperature to add more slurry. Samples T-60-1 and T-60-2 were taken during these 152 hours of circulation.</p>	<p>Bypass plugged.</p> <p>Bypass plugged. Relatively hard plug was removed from about the middle of the bypass which is 92" long.</p> <p>Bypass was open during the entire time. Slurry concentration varied 715 to 930 g/kg during 152 hours of circulation.</p>

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TABLE III (continued)

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<u>Run No.</u>	<u>Purpose of Run</u>	<u>History or Run</u>	<u>Results or Remarks</u>
T-60 (continued)		Two liters of slurry from S-76 containing 1300 g ThO_2 were again added to loop to increase the concentration. Slurry circulated to 300°C for 47 hours before bypass plugged. During the cooling cycle, the pump was turned off for a while and then restarted. Loop temperature was not noted at time pump was turned on. Circulation was continued when it appeared that bypass was open. Run stopped 2.6 hours later because bypass plugged. No samples taken during this period.	Bypass plugged. Thermocouples on walls of bypass indicated flow through bypass when pump started after loop cooled below 160°C (estimated). Bypass plugged again 2 hours after pump was started. Temperature at which plugging occurred was not noted.
		Bypass cleaned and no additional solids added to the loop at this time. Slurry circulated at 300°C. Sample T-60-3 taken 3 hours after pump started and then loop cooled to change fitting which was leaking. Circulation was stopped for 14 hours to make repairs. After circulation was restarted, sample T-60-4 taken 100 hours later. Loop temperature was 300°C. Bypass plugged 20 hours later; pump turned off.	Bypass did not plug during shutdown and remained open after pump was restarted 14 hours later. Bypass remained open for 123 hours at 300°C before plugging.
		Two hours after the pump was turned off, the pump was turned on again; the temp. of the loop was not noted. After 2 hours of circulation at 200°C a leak was found so the loop was again cooled to room temperature. Leak repaired and the pump turned on once again.	Bypass appeared open. The thermocouples on the bypass indicated a temperature rise as the loop temperature increased. After repairing leak, bypass plugged within 10 minutes after circulation was started.

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TABLE III (continued)

<u>Run No.</u>	<u>Purpose of Run</u>	<u>History of Run</u>	<u>Results or Remarks</u>
T-60 (continued)		<p>Bypass cleaned again by brushing out the slurry. System recharged with same slurry; no fresh solids added. Slurry circulated for 58 hours at 300°C. Samples T-60-5 and T-60-6 taken during this period.</p> <p>Loop cleaned out completely; the pump was removed, checked and found satisfactory. There was no bearing wear. The loop was then reassembled and the same slurry drained from the loop was recharged. Sample T-60-7 was taken 5.5 hours after circulation was again started, the loop temperature being 300°C when the sample was taken. Forty-two hours later, the bypass plugged.</p> <p>Bypass cleaned by brushing and the system recharged with the same slurry. Sample T-60-8 was taken 21 hours after the pump was started. Operation was normal for 43 hours and then the pump began operating erratically; the power requirements increased. Run terminated.</p>	<p>Bypass remained open; however slurry concentration was only 630-752 mg Th/kg H₂O. A check with the portable gamma scintillation indicator revealed an accumulation of solids in the pressurizer. The solids were accumulated in the region between the main circulating loop and the point where the bypass ties into the pressurizer. Flow to the back of the pump was 15 cc/min.</p> <p>Bypass plugged after 42 hours of circulation at 300°C. The concentration of the slurry was 840 mg Th/kg H₂O at the time the plugging occurred.</p> <p>Bypass remained open. On inspecting the pump, the front stellite journal was found cracked which caused the erratic behavior of the pump. As a result, both back and front graphitar bearings were badly worn.</p>

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TABLE III (continued)

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Run No.	Purpose of Run	History of Run	Results or Remarks
T-61	To determine cause of plugging of bypass line at 300°C when using concentrated slurries prepared from sulfate-free oxide.	System similar to T-60. System charged with 900 g/kg slurry prepared from unpumped 800°C LO oxide. Flow to back of pump 15 cc/min. After run terminated the loop was partially drained and bypass cleaned.	Bypass plugged after 45 minutes of operation. Loop temperature was 260°C at time of plugging. Lowering temperature to 150°C did not unplug the bypass. Run terminated. Samples taken after bypass line plugged.
T-62	Same as T-61	System charged with slurry drained from T-61 which contained approximately 900 g Th/kg H ₂ O prepared from 800°C oxide.	Bypass plugged after 20 minutes operation. Loop temperature was 170°C when plugging occurred. Run terminated.
T-63	Same as T-61	Replaced 3/8" tubing used as bypass line with 1/4" schedule 80 pipe and installed pressure gauges, otherwise system similar to T-60. Charged slurry containing 800 g Th/kg H ₂ O drained from T-62 into loop. Maintained flow to the back of pump at 25 cc/min.	Bypass plugged after 2.6 hours of operation. Loop temperature at time of plugging was 245°C. Pressure drop across bypass line was 30 ± 10 psi which is equivalent to a shear at the wall of 2.7 lb/ft ² .
T-64	Same as T-61	Installed sampling station in place of gauge on upstream side (nearest pump) of bypass line, otherwise system similar to T-63. Slurry drained from T-63 charged to loop, concentration approximately 800 g Th/kg H ₂ O. Flow to the back of the pump, 25 cc/min.	Bypass plugged in 2 hours. Loop temperature at time of plugging was 190°C. Samples taken from the bypass sampling station showed essentially the same concentration as the loop sample before the bypass plugged. After plug had formed, the concentration of the sample taken from the bypass station showed an increase from approximately 420 to 472 mg/g slurry. Sample taken from loop at the same time showed a concentration of 424 mg Th/g slurry. However, a sample from the plug in the bypass gave a concentration of 628 mg Th/g slurry.

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TABLE III (continued)

Run No.	Purpose of Run	History of Run	Results or Remarks
T-65	Same as T-60 except that operation of loop was set for 150°C.	System similar to T-64. Loop charged with slurry drained from T-64, concentration approximately 800 g Th/kg H ₂ O. Flow to back of pump was maintained at 25 cc/min.	Samples taken 0.6 hours after start up showed that loop concentration was 420 mg Th per gram slurry, whereas bypass concentration was 397 mg/g. The concentration of the slurry circulating through bypass remained essentially the same for the next 22.5 hours of operation. After 23.1 hours of circulation, the bypass plugged. Concentration of plug was found to be 643 mg Th/g slurry. From the weight of slurry and its concentration, it was estimated that the plug completely filled the bypass line.
T-66	To determine the effect of temperature on forming plugs in the bypass line.	System similar to T-65 and loop charged with slurry containing approximately 700 g Th/kg H ₂ O which was drained from T-65. Loop was operated at 150°C. Samples T-66-0 and T-66-QBP, from the loop and bypass respectively, were taken 2.2 hours after the pump was turned on. Five hours later, difficulty was experienced in maintaining the system pressure at 1600 psig. Loop cooled to room temperature to check the pressurizer heater controller. Level in pressurizer was also checked and found 3 liters low. After adding 3 liters of water, operation was resumed at 150°C. Difficulty with pressurizer heater instrumentation again shut operation down after 11 hours of operation at 150°C. Instrumentation repaired and operation was resumed 13 hours after shutdown; the loop temperature was set for 150°C. System operated satisfactorily at 150°C for 63 hours.	Bypass remained open at all temperatures from 150°C to 250°C, even after two shutdowns and cooling to room temperature each time. Samples taken from the loop and bypass showed a decrease in concentration as the run progressed.

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TABLE III (continued)

Run No.	Purpose of Run	History of Run	Results or Remarks
T-66 (continued)		Samples T-66-1 and T-66-1BP were taken after a total of 81 hours of operation at 150°C. Loop temperature then raised to 290°C. When loop temperature reached 290°C, fluctuations in the pump power requirements were observed. Loop cooled to 285°C and then sampled (S-66-2 and 2BP). Run terminated after 21 hours circulation at 290°C and 285°C because the pump power fluctuations still persisted.	Fluctuations in pump power demand believed due to boiling. Bypass did not plug.
T-67	To study effect of temperature on the formation of plugs in the bypass line.	System the same as T-66. Loop charged with slurry from T-66 to give concentration of 700 g Th/kg H ₂ O. Loop was operated at 150°C for 35 hours and then at 250°C for 15 hours. Samples T-67-0 and T-67-0 BP from loop and bypass line respectively were taken after 19 hours of circulation; loop temperature was 150°C at time of sampling. Samples T-67-1 and T-67-1 BP were taken 31 hours after samples T-67-0 when loop temperature was 250°C.	Bypass remained open during the entire course of the run. Raising the temperature from 150°C to 250°C did not produce plug in bypass.
T-68	To determine the effect of the pipe diameter on the formation of plugs in bypass lines.	Replaced 1/4" schedule 80 bypass line with 3/8" schedule 80 pipe; otherwise the system the same as for T-67. Loop charged with slurry prepared from fresh, unpumped 800°C LO oxide to give concentration of 900 g Th/kg H ₂ O. Operation normal at 300°C. Flow to the back of the pump was maintained between 15 - 25 cc/min.	Run terminated after 25.7 hours of operation because of accumulation of solids in the pressurizer. Bypass did not plug. Sample T-68-0 taken from loop after 1.5 hours of operation showed only 709 g Th/kg H ₂ O instead of the expected 900 g Th/kg H ₂ O. Sample T-68-1 taken after 25 hours of circulation showed a further decrease to 608 g/kg. Liquid level approximately 1-1/2 low when checked.

TABLE III (continued)

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<u>Run No.</u>	<u>Purpose of Run</u>	<u>History of Run</u>	<u>Results or Remarks</u>
T-72	Same as T-68	Continuation of T-71 after repairing leak in fitting. No slurry additions were made while the loop was down. Run terminated to add slurry to increase concentration	Bypass remained open during shut-down and did not plug when circulation was resumed at 300°C for 44.6 hours. The concentration being circulated was between 428 and 438 mg Th/kg slurry.
T-73	Same as T-68	Continuation of T-72 after adding 3 kg unpumped ThO ₂ to increase concentration to 1000 g Th ² per kilogram of water... Erratic operation of pump after 6 to 7 hours of operation forced termination of run. Bypass line appeared plugged at end of run.	Inspection of pump revealed that Ti hubs on impeller came loose causing the erratic behavior of the pump. Plugging of bypass may have been also due to the erratic behavior of pump.
T-74	Same as T-73	Duplicate of run T-73. Slurry containing 1078 g Th/kg H ₂ O drained from T-73 was recharged into system. Loop temperature was 290°C. Run terminated after 66 hours of operation.	Bypass plugged after 66 hours of operation at 290°C. The loop was washed by circulating water. In this operation the bypass opened.

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TABLE III (continued)

<u>Run No.</u>	<u>Purpose of Run</u>	<u>History of Run</u>	<u>Results or Remarks</u>
T-75	To study effect of temperature on the formation of plugs in bypass lines	<p>System same as for T-68. Slurry from T-74 was used to charge loop. Operation at 290°C for 3-1/2 hours. Sampled loop after 1-1/2 hours of operation.</p> <p>Lowered loop temperature to 175°C.</p> <p>Loop cooled to room temperature with no circulation 11 hours after the run was started. System was allowed to remain quiescent for 8 hours; the bypass line was not cleaned. The pump was then turned on and flow in bypass line was indicated; the loop was sampled 1 hour later when the temperature reached 175°C. The loop was maintained at this temperature for 23.5 hours. Another sample was taken after 22 hours of operation at 175°C.</p> <p>Loop temperature then raised to 290°C.</p> <p>Lowered loop temperature to 175°C.</p> <p>Pulsafed 18 cc of 96% H₂SO₄ and 0.75 liters H₂O into loop in order to disperse plug in bypass line. Pressurizer heaters overheated melting out the aluminum around the calrods. Run terminated.</p>	<p>Concentration of slurry in loop when sampled was 517 mg Th/g slurry. Bypass plugged.</p> <p>Bypass became unplugged 6-1/2 hours after loop temperature was lowered and remained open for only 20 minutes and then plugged again.</p> <p>Concentration of first sample (T-75-1) was 499 mg Th/g slurry and 462 mg Th/g slurry for second sample (T-75-2). Bypass remained open during the course of the run at 175°C.</p> <p>Bypass plugged when temperature reached 190°C.</p> <p>Bypass opened 3 hours after loop temperature reached 175°C and then plugged 2 minutes later.</p> <p>Bypass did not unplug with the addition of the H₂SO₄. Solids accumulated in pressurizer. These solids were grainy but not caked and were removed with a scoop and by water flushing.</p>

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TABLE IV

ANALYTICAL DATA FOR RUNS T-52 THROUGH T-75

a) Runs T-52 through T-54 were made at 250°C.

b) Runs T-55 through T-75 were made at 300°C.

Run No.	Time hrs	← SOLIDS ^a →					FILTRATE		← METALS IN SYSTEM →			Oxide	Additions
		Th mg/gm	Fe mg/gm	Ti mg/gm	SO ₄ mg/gm	pH	pH	SO ₄ ppm	Lap.	Orifice Plate	Seal Rings		
T-52	(53.3) ^b								SS	SS	Ti	D-15	O ₂
T-52-0	4.2	226.5	.073	--	--	9.8	--	--	Ti	1-1/4"		5 kg	
T-52-1	22.7	222	.0815	--	--	9.5	--	--	Hubs	in.		14.5 l	
T-52-2	27.3	222.5	.1115	--	--	9.4	--	--		discharge		H ₂ O	
T-52-3		264	--	--	--	--	--	--		line and			
										3/4" in			
										suction			
										line			
T-53	(167.3)								SS	SS	Ti	D-26	O ₂
T-53-0	40.9	271	.254	--	--	8.9	--	--	Ti	1-1/8"		6 kg	
-1	63.8	274.5	.388	--	--	8.8	--	--	Hubs	in		14.4 l	
-2	134.5	285.5	.611	--	--	7.8	--	--		discharge		H ₂ O	
-3	140.3	283	.615	--	--	7.8	--	--		line and			
-4	157.8	278	.663	--	--	7.7	--	--		3/4" in			
-5	164.0	271	.644	--	--	7.6	--	--		suction			
-6	167.2	255	.612	--	--	8.1	--	--		line			

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TABLE IV (continued)

Run No.	Time hrs.	SOLIDS ^a					FILTRATE		METALS IN SYSTEM			Oxide	Additions
		Th mg/gm	Fe mg/gm	Ti mg/gm	SO ₄ mg/gm	pH	pH	SO ₄ ppm	Imp.	Orifice Plate	Seal Rings		
T-54	(308.3)								SS	SS	Ti	D-15	O ₂
T-54-0	4.0 ^c	222.5	--	--	--	8.5	--	--	Ti Hubs	Same Size as T-53		5 kg in 14.5 l H ₂ O	
-1	75.3	259	.522	--	--	8.05	--	--					
-2	81.5	263.5	.533	--	--	7.8	--	--					
-3	98.9	261	.550	--	--	8.05	--	--					
-4	128.5 ^d	286.5	.586	--	--	8.0	--	--					
-6	153.0	280	.615	--	--	8.0	--	--					
-7	224.4	270	.721	--	--	8.0	--	--					
-8	243.5	279	.765	--	--	7.5	--	--					
-9	267.2	251	.683	--	--	7.0	--	--					
-10	273.5	322	.878	--	--	7.3	--	--					
-11	291.4	234	.609	--	--	7.0	--	--					
T-55	(54.2)								SS	SS	Ti	D-15	O ₂
T-55-0	22.2	281	.781	--	--	8.35	--	--	Ti Hubs	Same Size as T-53			
T-56	(277.0)								SS	SS	SS	6 kg	O ₂
T-56-0	17.0	252	.219	--	--	8.8	--	--	Ti Hubs	1-1/8" in discharge line and 3/4" in suction line		D-26 in 14.5 l H ₂ O	
-1	71.2	275	.421	--	--	7.3	--	--					
-2	87.5	429	.475	--	--	7.0	--	--					
-3	105.2	449	.729	--	--	7.4	--	--					
-4	133.6	451	.99	--	--	7.2	--	--					
-5	225.8	500	2.13	--	--	6.2	--	--					
-6	249.6	410	1.80	--	--	5.0	--	--					
-7	273.5	437	2.27	--	--	5.1	--	--					

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TABLE IV (continued)

Run No.	Time hrs.	SOLIDS ^a					FILTRATE		METALS IN SYSTEM			Oxide	Additions
		Th mg/gm	Fe mg/gm	Ti mg/gm	SO ₄ mg/gm	pH	pH	SO ₄ ppm	Imp.	Orifice Plate	Seal Rings		
T-57	(19.5)	No samples submitted							SS Ti Hubs	SS Same Size as T-56	SS	D-26 12ℓ slurry containing 972 g ThO ₂ /kg H ₂ O and 2.5ℓ H ₂ O	O ₂
T-58	(10.6)								SS Ti Hubs	SS Same Size as T-56	SS	D-26 slurry recovered from T-57	O ₂ Na ₄ P ₂ O ₇
T-59	(237.2)								SS Ti Hubs	SS 1" in discharge line and 3/4" in suction line	Ti	800° ThO ₂ (D-31) slurry pumped in "S" loop as (S-71) at 1000 g/kg H ₂ O	O ₂
T-59-0	48.2	427	.871	--	--	7.5	6.9	--					
-1	73.3	418	.894	--	--	6.4	6.3	--					
-2	163.7	425	1.10	--	--	5.8	6.0	--					
-3	215.9	428	1.15	--	--	5.7	5.8	--					
-4	235.7	399	1.14	--	--	5.5	5.9	--					

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TABLE IV (continued)

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Run No.	Time hrs.	SOLIDS ^a					FILTRATE		METALS IN SYSTEM			Oxide	Additions
		Th mg/gm	Fe mg/gm	Ti mg/gm	SO ₄ mg/gm	pH	pH	SO ₄ ppm	Imp.	Orifice Plate	Seal Rings		
T-60	(633.5)								SS	SS	Ti	D-31	O ₂
T-60-0	26.2	475	.708	.204	1.20	6.7	6.1	45	Ti	Discharge			
-1	76.1	392	.640	.179	.94	6.0	5.8	50	Hubs	1"			
-2	222.9	449	.883	.226	.98	5.9	5.5	47		Suction			
-3	276.1	459	.873	--	1.26	6.2	7.9	63		3/4"			
-4	377.0	456	1.02	.238	.94	5.7	5.7	49					
-5	403.0	405	.874	--	1.10	5.7	7.9	48					
-6	414	365	.824	--	1.08	5.7	5.1	56					
-7	423	426	.909	.229	.78	6.4	6.7	21					
-8	490	420	.889	.235	.91	5.9	5.1	22					
T-61	(25.4)								SS	SS	Ti	LO 2	O ₂
T-61-1	2	447	--	--	--	--	--	--	Ti	Same			
-2	14	432	--	--	--	--	--	--	Hubs	Size as			
-3	25	465	--	--	--	--	--	--		T-59			
T-62	(1)								SS	SS	Ti	LO 2	O ₂
T-62	0.4	494	--	--	--	--	--	--	Ti	Same			
									Hubs	Size as			
										T-59			

TABLE IV (continued)

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Run No.	Time hrs.	SOLIDS ^a					FILTRATE		METALS IN SYSTEM			Oxide	Additions
		Th mg/gm	Fe mg/gm	Ti mg/gm	SO ₄ mg/gm	pH	pH	SO ₄ ppm	Lmp.	Orifice Plate	Seal Rings		
T-63	(9.4)								SS	SS	Ti	LO 2	O ₂
T-63-0-1	2.6	423	--	--	--	--	--	--	Ti	Same			
-0	3	408	--	--	--	--	--	--	Hubs	Size as T-59			
T-64	(2.5)								SS	SS	Ti	LO 2	None
T-64-OBP	.6	424	--	--	--	--	--	--	Ti	Same			
T-64-1BP	1.2	419	--	--	--	--	--	--	Hubs	Size as T-59			
-2BP	2	472*	--	--	--	--	--	--					
T-64-0	2	424	--	--	--	--	--	--					
T-64-3BP		628**	--	--	--	--	--	--					
T-65	(23.1)								SS	SS	Ti	LO 2	None
T-65-0	.6	420	--	--	--	--	--	--	Ti	Same			
-OBP ^e	.6	397	--	--	--	--	--	--	Hubs	Size as T-59			
-1BP	1.3	411	--	--	--	--	--	--					
-2BP	2.3	401	--	--	--	--	--	--					
-3BP	23.1	394	--	--	--	--	--	--					
-4BP		643**	--	--	--	--	--	--					

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TABLE IV (continued)

Run No.	Time hrs.	SOLIDS ^a					FILTRATE		METALS IN SYSTEM			Oxide	Additions
		Th mg/gm	Fe mg/gm	Ti mg/gm	SO ₄ mg/gm	pH	pH	SO ₄ ppm	Imp.	Orifice Plate	Seal Rings		
T-66	(102.8)								SS	SS	Ti	LO 2	None
T-66-0	2.2	387	--	--	--	--	--	--	Ti	Same			
-OBP	2.2	377	--	--	--	--	--	--	Hubs	Size as T-59			
-1	81	328	--	--	--	--	--	--					
-1BP	81	367	--	--	--	--	--	--					
-2	102	337	--	--	--	--	--	--					
-2BP	102	312	--	--	--	--	--	--					
T-67	(50.1)								SS	SS	Ti	LO 2	None
T-67-0	19	386	--	--	--	--	--	--	Ti	Same			
T-67-OBP	19	369	--	--	--	--	--	--	Hubs	Size as T-59			
-1	50	404	--	--	--	--	--	--					
-1BP	50	431	--	--	--	--	--	--					
T-68	(25.7)								SS	SS	Ti	LO 2	O ₂
T-68-0	1.5	393	--	--	--	--	--	--		Same			
-1	25	358	--	--	--	--	--	--		Size as T-59			
T-69	(1)	No samples taken							SS	SS	Ti	LO 2	O ₂
										Same Size as T-59			

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TABLE IV (continued)

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Run No.	Time hrs.	SOLIDS ^a					FILTRATE		METALS IN SYSTEM				
		Th mg/gm	Fe mg/gm	Ti mg/gm	SO ₄ mg/gm	pH	pH	SO ₄ ppm	Imp.	Orifice Plate	Seal Rings	Oxide	Additions
T-75	(46.8)								SS	SS	Ti	LO 2	O ₂
T-75-0	1.5	517	--	--	< .10	9.0	--	--		Same Size as T-59			
-1	14	499	--	--	< .10	8.9	--	--					
-2	36	462	--	--	.10	8.7	--	--					
-3	46.8	410	--	--	1.68	5.5	--	--					
T-75-PC-1***		652	--	--	.55	--	--	--					
-2		661	--	--	.14	--	--	--					
-3		607	--	--	.20	--	--	--					

- a) Results reported as mg/g slurry
b) () represents total running time
c) Added 1 kg of solids after this sample was taken
d) Added 750 g of solids after this sample was taken
e) BP signifies sample taken from bypass line
* Sample taken after bypass plugged
** Sample of plug
*** Sample of plug in pressurizer

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22
20

03
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Summary of Results

The runs in which ThO_2 cakes were found are summarized in Table V and the results of the runs with a bypass line in parallel with the main circulating stream are summarized in Table VI. The data are too limited insofar as these runs are concerned to permit evaluation of the various factors which are responsible for the formation of cakes or the plugging of the bypass lines.

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TABLE V

SUMMARY OF CAKING IN 100-A LOOPS

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RUNS 8-56 to 8-89

Observation	Frequency	Possible Cause	Runs	Loaded Concentration g Th/kg H ₂ O	Oxide Calcination, Temp., °C	Sulfate* Content ppm	Loop Temp. °C
Accumulation of solids in pressurizer	2	Sulfate content	8-56 T-75	1000	650 800	9000 650 to 2000	300
Loss of solids in circulating stream	1	Erratic operation of pump	S-57	500	650	unknown	300
Loss of solids in circulating stream	4	Erratic operation of pump due to solids caking in impeller vanes	S-73, 74, 79, 80	500 and 1000	800	1000	300
Loss of solids in circulating stream	1	unknown - no cake found	S-78	500	800	1000	300
Cakes in impeller vanes	4	unknown	S-73, 74, 79, 80	500 and 1000	800	1000	300
Cake found when boiling during circulation at 300°C was suspected	2	Boiling during circulation at 300°C	S-87 S-89	1000	800	750 - 1000	300
No cake found with leak in system	1	--	S-88	1000	800	750	300

* Results based on water

TABLE VI

SUMMARY OF RUNS IN WHICH BYPASS LINE WAS USED
IN PARALLEL WITH MAIN CIRCULATING STREAM

<u>Variable</u>	<u>Total Number of runs</u>	<u>Number of runs in which bypass plugged</u>	<u>Number of runs in which bypass remained open</u>
Calcination Temperature of oxide			
650°C	3	1	2
800°C	20	12	8
Temperature			
Below 200°C	4	4	--
200°C to 250°C	1	1	--
250°C to 300°C	18	8	10
Slurry Concentration			
300 g Th/kg H ₂ O	3	0	3
400 g Th/kg H ₂ O	2	1	1
700 g Th/kg H ₂ O	5	0	5
800 g Th/kg H ₂ O	4	3	1
900 g Th/kg H ₂ O	4	2	2
1000 g Th/kg H ₂ O	6	6	0
Previous Slurry History			
Pumped	10	5	5
Unpumped	16	8	8
Additives			
Sulfate	2	1	1
Na ₄ P ₂ O ₇	1	1	--
Thermal Cycling of Slurry	7	2	5

TABLE VII

CHEMICAL AND PHYSICAL DATA FOR ThO_2 USED IN PREPARING THE SLURRIES

Batch No.	ORNL D-10	ORNL D-15	ORNL D-25	ORNL D-26	ORNL D-31	ORNL LO-1	ORNL LO-2	ORNL LO-11
Calcination Temp. °C	650	650	800	800	800	800	800	800
Chemical Composition (mg/gm)								
Th	868	870	866	868	871	870	875	874
Fe	---	---	.026	<.005	.040	.015	.008	<.005
Ni	---	---	<.005	.009	.010	<.005	<.005	<.005
Cr	---	---	.006	.007	.014	.005	<.005	<.005
SO_4	<.10	.47	.30	.425	.77	<.10	<.10	<.10
NO_3	---	---	---	---	---	.025	.025	.012
PO_4	.016	---	---	---	---	.02	.02	<.02
CO_3	6.8	5.2	3.0	3.7	---	.34	1.7	1.4
F	---	---	---	<.01	---	<.01	<.01	.05
Cl	---	---	---	<.01	---	<.01	<.01	<.01
Na	---	---	---	---	---	.28	.17	.13
Mg	<.01	---	---	---	---	.017	.008	.02
Si	---	---	---	---	---	<.005	<.005	<.01
K	---	---	---	---	---	.32	.18	<.05
Al	<.01	---	---	---	---	.13	.17	.04
Physical Properties								
Surface Area m^2/gm	---	---	---	---	---	16	16	18.5
Average Crystallite Size, Å	---	---	---	---	---	242	245	214
Average particle Size, microns	---	---	---	---	---	2.2	2.9	---

TABLE VIII

PUMP BEARING HISTORY

Run No.	Total Service hr	Circulation Time of Run hrs	INTERNAL DIAMETER, in.		Reason for Replacement
			Start of Run	End of Run	
S-56	19	19	1.502	1.502	Bearing not replaced
S-57	45	26	1.502	1.502	Bearing not replaced
S-73	2	2	1.502	>1.504	Badly chipped
S-74	19	19	1.502	>1.504	Worn
S-78	339	5	Pump was not disassembled		---
S-79	372	33	Pump was not disassembled		---
S-80	383	11	Pump was not disassembled		---
S-87	85.4	85.4	1.5035	1.5055	Worn
S-88	21	21	1.502	1.502	Bearing O.K.
S-89	106	8.4	1.502	1.503	Bearing O.K.
T-52	55	55	1.502	1.506	Non-concentric
T-53	167	167	1.503	---	---
T-54	475	308	1.503	1.506	Worn
T-55	18	18	1.504	1.568	Cracked Journal
T-56	277	277	1.501	1.505	Worn
T-57	21	21	1.503	---	---
T-58	28	7	---	---	---
T-59	255	237	---	1.503	Bearing O.K.
T-60	888	633	1.503	1.586	Worn
T-61	15	15	1.502	--	--
T-62	16	1	Pump was not disassembled		---
T-63	25	9	Pump was not disassembled		---
T-64	28	2.5	Pump was not disassembled		---
T-65	51	23	Pump was not disassembled		---
T-66	154	103	Pump was not disassembled		---
T-67	204	50	---	1.504	Worn
T-68	44	44	1.502	Pump was not disassembled	---

TABLE VIII (continued)

Run No.	Total Service hr	Circulation Time of Run hrs	INTERNAL DIAMETER, in.		Reason for Replacement
			Start of Run	End of Run	
T-69	45	1	---	1.503	---
T-70	115	70	Pump was not disassembled		---
T-71	165	50	Pump was not disassembled		---
T-72	210	45	Pump was not disassembled		---
T-73	221	11	---	1.504	Worn
T-74	6	6	1.503	Pump was not disassembled	---
T-75	53	47	---	1.504	Worn

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[illegible]

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