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SUBJECT: Examination of Corrosion Specimens from Slurry Blanket Mockup Runs SM-6 Through SM-9

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SUMMARY

Low attack rates (0.1 to 0.5 mpy) were displayed by coupon specimens of type 347 stainless steel, titanium RC-55, and Zircaloy-2 which were exposed for 2877.5 hr in an oxygenated slurry of Th-8% U oxide, 116.5 hr in water, 6.9 hr in 5% HNO₃, and 4.3 hr in 3% trisodium phosphate during runs SM-6 through SM-9 in the slurry blanket mockup. The leading coupon of type 347 stainless steel showed a slightly higher rate than the other stainless steel coupons due to entrance effects. Specimens of SA-212-B carbon steel displayed average attack rates of 2.9 mpy.

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A set of sixteen coupon-type corrosion specimens, placed in the main line of the mockup loop, were exposed for a period of 2994.0 hr, consisting of 116.5 hr in water, 6.9 hr in 5% HNO3, 4.3 hr in 3% trisodium phosphate, and 2877.5 hr in slurry.

The slurry charged to runs SM-6 through 9 consisted of a composite of batches of MO-series, 1050° C-calcined Th-8% U oxide with no additives. An oxygen overpressure was added (<250 cc 0_2 /liter).

The coupons, secured in a type 347 stainless steel holder, were not insulated. The coupon array consisted of four specimens each of type 347 stainless steel, SA-212-B boiler plate (carbon steel), titanium RC-55, and Zircaloy-2. Chemical composition of each material is shown in Table 1. Each specimen was machined to the dimensions 2.35 x 1.0 x 0.20 in. from special 1/4 in. plate stock from the controlled materials stores of the Reactor Materials Research Sections.¹

A brief summary of the operating conditions for the entire period is presented in Table 2 and Fig. 5. These were compiled from data supplied by the Systems Development Section.⁴ The flow velocity across the specimens varied from an estimated 18.1 to 4.5 fps as a result of varying flow rates in the system while the pump was operated from a variable frequency generator. The system was calibrated with water at room temperature with the pump operated with 60 cps current. Temperatures were varied from ambient to 300°C. Slurry concentrations ranged from~l to 800 g Th-U/kg H₂O.

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Attack rates, calculated from defilmed weight loss measurements, for each specimen exposed are shown in Table 3. The rates for Ti-RC 55 and Zircaloy-2 were very low, <0.1 mpy. Type 347 stainless steel was mildly attacked, 0.2 to 0.5 mpy. The attack rates were in close agreement with those rates observed in the previous runs.

The average attack rate for SA-212-B mild steel was 2.9 mpy. Some scale and pitting attack was observed; however, corrosion rates were generally lower, by a factor of approximately 100, than rates observed on specimens exposed in previous runs in which no oxygen overpressure was used.

Figs. 1 and 2 show the specimens loaded in the holder prior to insertion in the loop. Figs. 3 and 4 show the specimens in the holder after exposure. The sample positions, A through G, were numbered from left to right on the photographs with the flow in the same direction.

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Table 1. Composition of Materials Tested, Runs SM 6 Through SM 9

Type	Item No.	Finish	Condition	Vendor or Source	Analysis, wt % (Mfg. Certified)								
					Cr	Ni	Ni Si Mn		C P		S	Fe	Others
347 SS	368	a	1,2,3	Republic Steel	18.86	10.75	0.57	1.11	0.054	0.029	0.008	Bal.	Сь-0.87
SA 212-B	542	a	1, 2, 3	Y-12		0.20b	0.23	0.59 ^b	0.17 ^b	0.015 ^b	0.029 ^b	Bal. ^b	Cu-0.09 ^b , Se-0.003 ^b
Ti-55A	48	a	2	Rem-Cru-Ti Co.				4	<0.1				N-<0.03, Ti-Bal.
Zr-2	62	a	1,2	Jessop Steel Co.	0.093 ^a	0,05 ^a			0.01 ^a		·	0.12 ^a	Zr-97.79 ^a , Sn-1.60 ^a Al-0.07 ^a , H ₂ -0.006 ^a O ₂ -0.14 ^a , N ₂ -0.005 ^a

a_{Machine} finish b_{ORNL}

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1 Hot rolled

2 Annealed

3 Pickled

4 Heat treated

é.

Table 2.	Summary of	Operating	Conditions	for
	Runs SM 6	Through SN	19	

			(Conditions	Not In Sec	uence) _			·	
Media	Temp. °C	Conc.	Pipeline Velocity							
			18.1	15.1	12.0	9.0	6.0	4.5		
HNO3	60	5%	6.9						6.9	
TSP	70	3%	4.3			Y.			4.3	
Water	25 200		7.9 97.4						7.9 97.4	
Tota	1		116.5			•				
Slurry	25	0-180 300 500 750	21.2 14.0 22.3 22.2				• •		21.2 14.0 22.3 22.2	
	25-100	200	25.8				•	x	25.8	
-	25-225	~1 500	17.4 73.4		·				17.4 73.4	
•	100	<70 70 500	174.3 19.6 16.2						174.3 19.6 16.2	
	150	250 375 500	29.8 155.7 90.1	22.0	23.2 43.3 208.6	24.1	94.6 70.3 38.6	0.6	148.2 269.3 383.4	
	200	250 300 375 500 800	52.6 145.2 190.9 203.6 5.8	93.0	50.6 20.2 47.4	24.9	56.6 25.7 54.7	0.6	160.4 145.2 236.8 423.6 5.8	
	220	500	147.9						147.9	
- :	225	300 500	99.8 78.8	1.0	2.4	1.6	0.7		105.5 78.8	
	250	300 500	9.0 23.5	1.5	2.0	. 0.6	1.3		14.4 23.5	
	275	300 500 800	24.0 34.7 114.1				• .		24.0 34.7 114.1	
v	280	800	72.7					• •	72.7	
- \$	300	300 800	34.5 <u>48.3</u>						34.5 <u>48.3</u>	
Slurry T	Slurry Total			117.5	3 97•7	51.2	342.5	1.2	2877.5	
Run Tota	1						,		2994.0	

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TABLE 3

Specimen Corrosion Data, Run No. SM 6 thru 9

2877.5 Hours Time: ThO, Batch No .: Mixed MO, 8% U/Th 0-800 g Avg. Conc.: Additives: None 30-300 °C. Temperature: Specimen Area 30.3 cm Specimen Type: coupon Flow, fps (+10%): 20 347 SS Holder mpy Velocity Lead Edge ft/sec Weight Change Weight Defilmed (mg) Loss or Hardness* Corrosion Position Material Post Scrubbed Defilmed (mg/cm⁻) Rate (mpy) Pre Condition 347 SS ** 81 82 - 109.44 - 110.20 3.31 Leading edge rounded. Dull. Grooves. 0.5 81 84 48.27 Ε 347 SS 49.92 1.65 . 0.3 . Dull. Slight abrasion. 347 SS 84 K 81 41.91 45.25 -• 1.49 0.2 Dull. Slight abrasion. 81 85 48.25 Ρ 347 SS 49.60 1.64 -Slight abrasion. 9 0.2 Dull SA 212 B 61 18.99 D 4 37.10 - 575.48 2.9 Dull. Scaly, pitted. -36 G SA 212 B 61 12.75 - 576.31 +19.02 2.9 Dull Scaly, pitted. 61 40 Ĵ SA 212 B 42.30 - 611.93 -20.19 3.1 Dull Scaly, pitted. M SA 212 B 61 23 18.97 - 568.47 18.76 2.8 Scaly, pitted. . Dull 86 85 C Ti-55A 4.52 4.87 <0.1 0.16 -.... Dull. Discolored. 86 88 1.50 H Ti-55A 1.91 0.06 Discolored. + -<0.1 Dull 86 87 2.18 3.68 L Ti-55A -..... 0.12 <0.1 Dull Discolored. 0 86 84 2.33 Ti-55A . ت 2.71 Discolored. . 0.09 < 0.1 Dull Slight abrasion. B 86 86 Zircaloy-2 1.12 ----1.42 0.05 Dull. Discolored. -<0.1 F Zircaloy-2 86 86 ŴG 1.39 0.93 + + WG Dull. Discolored. 86 1.88 Т Zircaloy-2 86 2.23 + WG WG Dull. + Discolored. Zircaloy-2 86 86 Ν 1.53 + 0.72 WG WG Discolored. + Dull App. two burnt streaks.

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Loop Corrosion Rate ____ mpy

* Rockwell B ** Specimen Area 33.3 cm²

TY-2131

a. Plate No. 4117-1 Unclassified 0.75X mag.



b. Plate No. 4117-2 Unclassified 0.75X mag.



Fig. 1 Top Side of Corrosion Specimens Before Exposure in Runs SM-6 Through SM-9

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a. Plate No. 4117-3 Unclassified 0.75X mag.



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b. Plate No. 4117-4 Unclassified 0.75X mag.



Fig. 2 Bottom Side of Corrosion Specimens Before Exposure in Runs SM-6 Through SM-9



Plate No. 35308 Unclassified 0.53X Mag.



Fig. 3 Top Side of Corrosion Specimens After Exposure In Runs SM 6 Through SM 9.

Plate No. 35307 Unclassified 0.53X Mag.

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SPECIMEN HOLDER RUNS SM 6 THRU 9

Fig. 4. Bottom side of Corrosion Specimens After Exposure In Runs SM 6 Through SM 9.



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REFERENCES

- 1. S. A. Reed et al., Summary of Specimen Corrosion Data from Slurry Blanket Mockup Run SM-3, ORNL CF-57-10-5.
- 2. S. A. Reed et al., <u>Examination of Corrosion Specimens from Slurry Blanket</u> <u>Mockup Run SM-4</u>, ORNL CF-58-6-59.
- 3. S. A. Reed et al., Examination of Corrosion Specimens from Slurry Blanket Mockup Run SM-5, ORNL CF-58-8-83.
- 4. L. F. Parsley et al., ORNL CF-60-4-92.

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