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Ending February 16, 1957

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SUMMARY OF CORROSION DATA FOR HRT MOCKUP
OPERATION PERIOD ENDING FEBRUARY 16, 1957

The HRT mockup was shut down February 16, 1957 after operating for 576 hr on high concentration uranyl sulfate. At this time, all corrosion samples in the system were removed and replaced, and the wire extending through the letdown heat exchanger was removed for examination.

I. General

During the reported period of mockup operation, December 9, 1956 to February 16, 1957, a total of 576 hr of operation was completed with 1.3 m UO_2SO_4 at 260°C and 1400 psi pressure; the oxygen concentration was about 500 ppm during most of the run. In addition to the operating time under the above conditions, over 400 hr of operation was made on water and more dilute uranyl sulfate solutions. The run was actually made in two periods of operation. The system was started up on water containing 150 ppm Cr(VI) added as CrO_3 , and the uranyl sulfate concentration was then gradually built up to a concentration of 1.3 to 1.4 m. Sulfuric acid was also added during this build-up period, reaching a final value of 2 - 5 mole percent of the uranyl sulfate. After 200 hr of operation had been completed at full concentration, the system was shut down by pump trouble. A second run was then made in the same manner for a total of 376 hr with 1.3 m UO_2SO_4 . The system corrosion rate based on nickel analysis was 17.3 mpy for the first period of operation and 12.1 mpy for the second period, an average of 13.9 mpy for all operation on 1.3 m UO_2SO_4 .

II. Samples

The corrosion samples were of the same type as previously exposed in the mockup. A titanium holder in the suction side of the main circulating line contained coupons of titanium 75A, Zircaloy-2, and types 309 SCb and 347 stainless steel. All coupons contained a heavy, glossy, black paint-like scale. Type 347 stainless steel coupons were also mounted on a stainless steel bar that extended through the vertical leg of the pressurizer. The coupons exposed to the vapor phase and

water region of the vertical leg had black films, while those coupons exposed in the soup region had heavy deposits of an orange to yellow precipitate mixed with black scale. Samples of the scale from the bottom of the holder and from the water-soup interface were analyzed spectrographically and by x-ray diffraction. Results of these analyses are shown in Table IV. The horizontal header into which the bottom coupons extended contained 150 g of black solids. Type 347 stainless steel coupons mounted in the same manner as those extending through the vertical leg of the pressurizer were also mounted in the pressurizer heater leg. These coupons which should be exposed only to water, had a rusty film with a trace of yellow precipitate on the bottom of the holder. These samples had been in the mockup for a total of 5376 hr. Corrosion data for all samples are presented in Tables I through III.

Photographs of the coupons before the run and after defilming are shown in Figures 1 through 62. Figures 1 through 36 show the main circulating line samples in the as machined condition. Figures 37 through 48 show these same coupons after defilming at the end of the run. Figures 49 through 54 show the pressurizer vertical leg samples as machined. Figures 55 through 58 show these same coupons after defilming, and Figures 59 through 62 show the pressurizer heater leg samples after defilming.

The appendix contains a tabulation of the negative plate numbers of all photographs. A similar array of new samples has been inserted in the mockup for the next period of operation.

III. Letdown Heat Exchanger Wire Specimen

The corrosion specimen wire which had been installed in the letdown heat exchanger just prior to this run period was removed for examination at this time. The wire was approximately 1/8-in. diameter and extended through the feed stream pipe of the letdown heat exchanger. On dismantling the mockup, the letdown heat exchanger discharge pipe was plugged with a yellow solid. The solid material was uranyl sulfate left by the manner in which the system was dumped on shut down and could easily be dissolved with water.

Micrometer readings had been taken along the length of the corrosion wire before installing it in the letdown heat exchanger. However, on pulling it from the pipe, the wire was badly stretched and deformed, making further measurements of its thickness to determine the extent of corrosion on the wire useless. Visual observation showed pitting attack along the first two feet of wire in the discharge end of the feed stream. This portion of the wire was exposed to 1.3 m UO_2SO_4 at a temperature in the region around 225°C. The extent of corrosion was estimated to be about 50 mpy. The remainder of the wire appeared to be in good condition with no evidence of localized corrosion attack. Huey tests run on a section of this wire before exposure to the uranyl sulfate solution, gave values of 1.9 and 2.1 mils/mo on duplicate samples. A short section of wire was inserted in the feed stream of the letdown heat exchanger for the next period of operation.

IV. Main Circulating Line Orifice Flange

The flange and O-ring on the discharge side of the main circulating line showed severe corrosion. A titanium orifice plate was bolted to the upstream flange at this point, and the flow of solution was channeled out around the orifice plate, causing severe corrosion damage to the stainless steel flange and O-ring. Both the corroded areas and the flow pattern shown by the orifice plate showed areas of heavy corrosion to be located symmetrically between the bolts which held the orifice plate against the flange. Areas adjacent to the bolts showed no corrosion attack. The O-ring showed a weight loss of 43 g out of a total weight of 650 g and was corroded to within approximately 1/16 in. of the line of seal of the O-ring.

TABLE I
MAIN LINE SAMPLES

Coupons		Coupon Position From Flange End of Holder	Sample Area cm ²	Weight Change, mg/cm ²		Defilmed Corrosion Rate, mpy	Appearance
No.	Type			Scrubbed	Defilmed		
H-146	347 SS	3	20.7	+ 6.93	- 0.50	0.38	Heavy glossy black, paint-like scale
H-147	347 SS	6	20.7	+ 7.97	- 0.38	0.29	Heavy glossy black, paint-like scale
H-204	309 SCb	4	20.7	+11.68	- 0.29	0.22	Heavy glossy black, paint-like scale
H-205	309 SCb	5	20.7	+ 6.76	- 0.06	0.05	Heavy glossy black, paint-like scale
H-174	Ti-75A	1	20.7	+ 4.63	+ 0.14	0.20*	Heavy glossy black, paint-like scale
H-175	Ti-75A	8	20.7	+ 7.95	+ 0.38	0.53*	Heavy glossy black, paint-like scale
H-235	Zircaloy-2	2	20.7	+ 3.96	+ 0.24	0.91*	Heavy glossy black, paint-like scale
H-236	Zircaloy-2	7	20.7	+ 7.96	+ 0.30	1.14*	Heavy glossy black, paint-like scale

* Corrosion rate figured on the assumption that all the weight gain on these samples was due to their respective oxides.

Exposed for 576 hr to 300-350 g U/1 UO₂SO₄

TABLE II
PRESSURIZER VERTICAL LEG SAMPLES

Coupons		Coupon Position From Top of Holder	Sample Area cm ²	Weight Change, mg/cm ²		Defilmed Corrosion Rate, mpy	Appearance
No.	Type			Scrubbed	Defilmed		
H-261	347 SS	1	16.1	+ 0.06	- 0.09	0.07	Black to brown film
H-262	347 SS	2	16.1	- 0.01	- 0.15	0.11	Black to brown film
H-263	347 SS	3	16.1	+ 0.01	- 0.16	0.12	Black to brown film
H-264	347 SS	4	16.1	- 0.09	- 0.25	0.19	Black to brown film
H-265	347 SS	5	16.1	+ 0.02	- 0.14	0.11	Black to brown film
H-266	347 SS	6	16.1	+11.89	- 0.20	0.15	Orange deposit. Easy to remove
H-267	347 SS	7	16.1	+ 8.73	- 0.11	0.08	Orange deposit. Easy to remove
H-268	347 SS	8	16.1	+78.03	- 1.01	0.76	Yellow and black de- posit. Could be washed off. Heavy black film underneath
H-269	347 SS	9	16.1	+88.72	- 1.96	1.48	Yellow and black de- posit. Could be washed off. Heavy black film underneath.

Exposed for 576 hr to 300-350 g U/1 UO₂SO₄

TABLE III

PRESSURIZER HEATER LEG SAMPLES

Coupons		Coupon Position From Top of Holder	Sample Area cm ²	Weight Change, mg/cm ²		Defilmed Corrosion Rate, mpy	Appearance
No.	Type			Scrubbed	Defilmed		
MK-10	347 SS	1	16.1	- 0.07	- 0.47	0.07	Rust colored scale
MK-11	347 SS	2	16.1	+ 0.01	- 0.37	0.05	Rust colored scale
MK-12	347 SS	3	16.1	+ 0.01	- 0.53	0.08	Rust colored scale
MK-13	347 SS	4	16.1	0	- 0.40	0.06	Rust colored scale
MK-14	347 SS	5	16.1	+ 0.05	- 0.37	0.05	Rust colored scale
MK-15	347 SS	6	16.1	+ 0.05	- 0.37	0.05	Rust colored scale
MK-16	347 SS	7	16.1	+ 0.03	- 0.37	0.05	Rust colored scale
MK-17	347 SS	8	16.1	- 0.02	- 0.32	0.05	Rust colored scale
MK-18	347 SS	9	16.1	- 0.04	- 0.25	0.04	Rust colored scale. Small amount of yellow precipitate.

Exposed for 5376 hr.

TABLE IV
ANALYSIS OF SAMPLE SCALES

<u>Analysis</u>	<u>Weight Percent</u>			
	<u>Sample X^a</u>		<u>Sample Y^b</u>	
	<u>Spec</u>	<u>X-Ray^c</u>	<u>Spec</u>	<u>X-ray</u>
Fe	.2		> 10	
Cr	< .1		> 5	
Zr			.2	
Ni			.05	
Ti			.5	
Mo			.3	
Nb			1	
U	> 10		10	
Fe ₂ O ₃ ^d				> 90

- a) Scale removed from interface region of pressurizer vertical leg sample holder.
- b) Scale removed from bottom of pressurizer vertical leg sample holder.
- c) Sample could not be identified by x-ray analysis.
- d) Solid solution of Cr₂O₃ in Fe₂O₃.

APPENDIX

Sample Photographs*

<u>Sample Number</u>	<u>Holder</u>	<u>Corrosion Lab. Plate Number</u>
H-146	Main Line	1768, 1857
H-147	Main Line	1768, 1858
H-174	Main Line	1655, 1858
H-175	Main Line	1774, 1857
H-204	Main Line	1656, 1858
H-205	Main Line	1696, 1857
H-235	Main Line	1719, 1858
H-236	Main Line	1719, 1857
H-261	Pressurizer Vertical Leg	1662, 1861
H-262	Pressurizer Vertical Leg	1780, 1861
H-263	Pressurizer Vertical Leg	1780, 1861
H-264	Pressurizer Vertical Leg	1780, 1861
H-265	Pressurizer Vertical Leg	1780, 1861
H-266	Pressurizer Vertical Leg	1780, 1862
H-267	Pressurizer Vertical Leg	1781, 1862
H-268	Pressurizer Vertical Leg	1781, 1862
H-269	Pressurizer Vertical Leg	1781, 1862
MK-10	Pressurizer Heater Leg	1859
MK-11	Pressurizer Heater Leg	1859
MK-12	Pressurizer Heater Leg	1859
MK-13	Pressurizer Heater Leg	1859
MK-14	Pressurizer Heater Leg	1859
MK-15	Pressurizer Heater Leg	1860
MK-16	Pressurizer Heater Leg	1860
MK-17	Pressurizer Heater Leg	1860
MK-18	Pressurizer Heater Leg	1860

* Photographic plates are on file with J. L. English of the Materials Research Section, Reactor Experimental Engineering Division, Oak Ridge National Laboratory.

Sample Photographic Figures

<u>Figure Number</u>	<u>Corrosion Lab. Plate Number</u>
1, 2, 3, 4, 5, 6	1768
7, 8, 9, 10, 11, 12	1656
13, 14, 15, 16, 17, 18	1696
19, 20, 21, 22, 23, 24	1655
25, 26, 27, 28, 29, 30	1774
31, 32, 33, 34, 35, 36	1719
37, 38, 39, 40, 41, 42	1857
43, 44, 45, 46, 47, 48	1859
49, 50	1662
51, 52	1780
53, 54	1781
55, 56	1861
57, 58	1862
59, 60	1859
61, 62	1860

Figure 2: As Machined

Figure 1: As Machined

Figure 4: As Machined

Figure 3: As Machined

Figure 6: As Machined

Figure 5: As Machined

14

Figure 7: As Machined 25X

Figure 8: As Machined 25X

15

Figure 9: As Machined 25X

Figure 10: As Machined 25X

Figure 12: As Machined 25X

Figure 11: As Machined 25X

17

Figure 13: As Machined

Figure 14: As Machined

18

Figure 15: As Machined

Figure 16: As Machined

Figure 18: As Machined

Figure 17: As Machined

20

Figure 19: As Machined 25X

Figure 20: As Machined 25X

21

Figure 21: As Machined 25X

Figure 22: As Machined

Figure 24: As Machined 25X

Figure 23: As Machined 25X

Figure 26: As Machined

Figure 25: As Machined

Figure 28: As Machined

Figure 27: As Machined

Figure 30: As Machined

Figure 29: As Machined

26

Figure 31: As Machined

Figure 32: As Machined

27

Figure 33: As Machined

Figure 34: As Machined

Figure 36: As Machined

Figure 35: As Machined

Figure 38: Defilmed

Figure 37: Defilmed

Figure 39: Defilmed

Figure 40: Defilmed

Figure 42: Defilmed

Figure 41: Defilmed

Figure 44: Defilmed

Figure 43: Defilmed

Figure 46: Defilmed

Figure 45: Defilmed

Figure 48: Defilmed

Figure 47: Defilmed

35

Figure 49: As Machined 2.5X

Figure 50: As Machined 2.5X

Figure 52: As Machined

Figure 51: As Machined

Figure 54: As Machined

Figure 53: As Machined

Figure 56: Defilmed

Figure 55: Defilmed

Figure 58: Defilmed

Figure 57: Defilmed

Figure 60: Defilmed

Figure 59: Defilmed

Figure 62: Defilmed

Figure 61: Defilmed