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

TO: E. L. Compere

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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% HNO_3, 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.

DISCLAIMER

In conjunction with the program in the Systems Development Section on the slurry mockup, the Reactor Materials Section prepared a set of coupon-corrosion specimens for field exposure in the mockup system during runs SM-6 through 9. The results of the examination of similar specimens which were exposed in runs SM-3, SM-4, and SM-5 have been reported previously.[1,2,3]

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% HNO_3, 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 O_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 ~1 to 800 g Th-U/kg H_2O.

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.

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

Type	Item No.	Finish	Condition	Vendor or Source	Analysis, wt % (Mfg. Certified)								Others
					Cr	Ni	Si	Mn	C	P	S	Fe	
347 SS	368	a	1, 2, 3	Republic Steel	18.86	10.75	0.57	1.41	0.054	0.029	0.008	Bal.	Cb-0.87
SA 212-B	542	a	1, 2, 3	Y-12		0.20[b]	0.23[b]	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.					<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

1 Hot rolled
2 Annealed
3 Pickled
4 Heat treated

Table 2. Summary of Operating Conditions for Runs SM 6 Through SM 9

(Conditions Not In Sequence)

Media	Temp. °C	Conc.	Pipeline Velocity fps 18.1	15.1	12.0	9.0	6.0	4.5	Total
HNO_3	60	5%	6.9						6.9
TSP	70	3%	4.3						4.3
Water	25		7.9						7.9
	200		97.4						97.4
Total			116.5						
Slurry	25	0-180	21.2						21.2
		300	14.0						14.0
		500	22.3						22.3
		750	22.2						22.2
	25-100	200	25.8						25.8
	25-225	~1	17.4						17.4
		500	73.4						73.4
	100	<70	174.3						174.3
		70	19.6						19.6
		500	16.2						16.2
	150	250	29.8		23.2		94.6	0.6	148.2
		375	155.7		43.3		70.3		269.3
		500	90.1	22.0	208.6	24.1	38.6		383.4
	200	250	52.6		50.6		56.6	0.6	160.4
		300	145.2						145.2
		375	190.9		20.2		25.7		236.8
		500	203.6	93.0	47.4	24.9	54.7		423.6
		800	5.8						5.8
	220	500	147.9						147.9
	225	300	99.8	1.0	2.4	1.6	0.7		105.5
		500	78.8						78.8
	250	300	9.0	1.5	2.0	0.6	1.3		14.4
		500	23.5						23.5
	275	300	24.0						24.0
		500	34.7						34.7
		800	114.1						114.1
	280	800	72.7						72.7
	300	300	34.5						34.5
		800	48.3						48.3
Slurry Total			1967.4	117.5	397.7	51.2	342.5	1.2	2877.5
Run Total									2994.0

TABLE 3

Specimen Corrosion Data, Run No. SM 6 thru 9

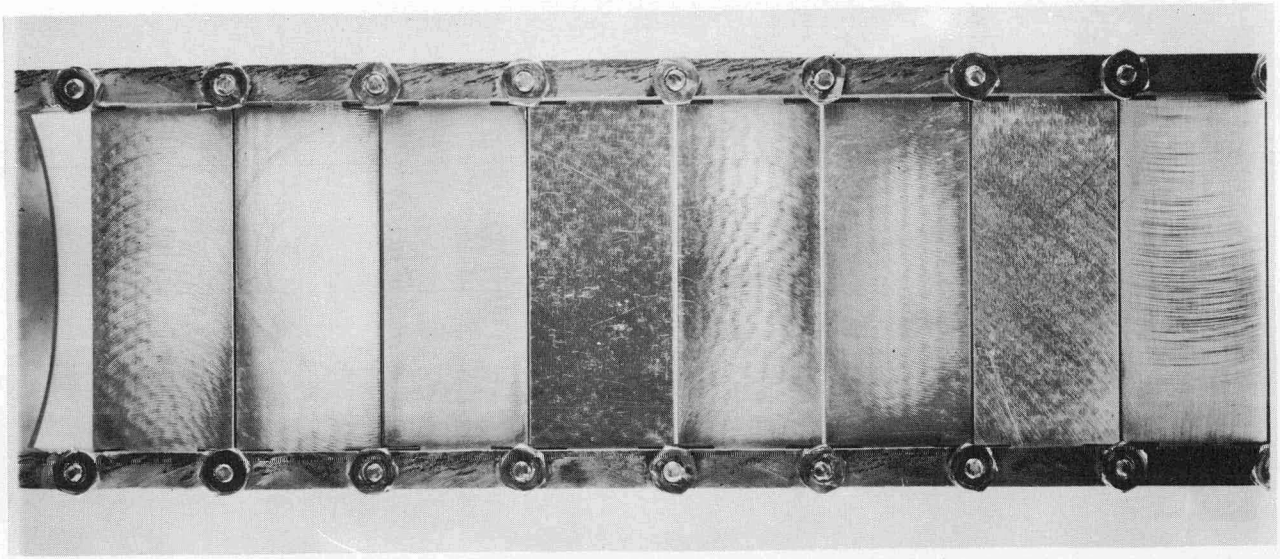
Time: 2877.5 **Hours**
ThO_2 Batch No.: Mixed MO, 8% U/Th
Avg. Conc.: 0-800 g
Additives: None
Temperature: 30-300 °C
Specimen Type: coupon — **Specimen Area** 30.3 cm^2
Flow, fps (±10%): 20 — 347 SS **Holder** _____ mpy

Velocity Lead Edge ft/sec or Position	Material	Hardness* Pre	Hardness* Post	Weight Change (mg) Scrubbed	Weight Change (mg) Defilmed	Weight Loss (mg/cm^2)	Defilmed Corrosion Rate (mpy)	Condition
A	347 SS **	81	82	- 109.44	- 110.20	3.31	0.5	Leading edge rounded. Dull. Grooves.
E	347 SS	81	84	- 48.27	- 49.92	1.65	0.3	Dull. Slight abrasion.
K	347 SS	81	84	- 41.91	- 45.25	1.49	0.2	Dull. Slight abrasion.
P	347 SS	81	85	- 48.25	- 49.60	1.64	0.2	Dull. Slight abrasion.
D	SA 212 B	61	4	- 37.10	- 575.48	18.99	2.9	Dull. Scaly, pitted.
G	SA 212 B	61	36	+ 12.75	- 576.31	19.02	2.9	Dull. Scaly, pitted.
J	SA 212 B	61	40	- 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	Dull. Scaly, pitted.
C	Ti-55A	86	85	- 4.52	- 4.87	0.16	<0.1	Dull. Discolored.
H	Ti-55A	86	88	+ 1.50	- 1.91	0.06	<0.1	Dull. Discolored.
L	Ti-55A	86	87	- 2.18	- 3.68	0.12	<0.1	Dull. Discolored.
O	Ti-55A	86	84	- 2.33	- 2.71	0.09	<0.1	Dull. Discolored. Slight abrasion.
B	Zircaloy-2	86	86	- 1.12	- 1.42	0.05	<0.1	Dull. Discolored.
F	Zircaloy-2	86	86	+ 1.39	+ 0.93	WG	WG	Dull. Discolored.
I	Zircaloy-2	86	86	+ 2.23	+ 1.88	WG	WG	Dull. Discolored.
N	Zircaloy-2	86	86	+ 1.53	+ 0.72	WG	WG	Dull. Discolored. App. two burnt streaks.

Loop Corrosion Rate _____ mpy

* Rockwell B
** Specimen Area 33.3 cm^2

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



b. Plate No. 4117-2
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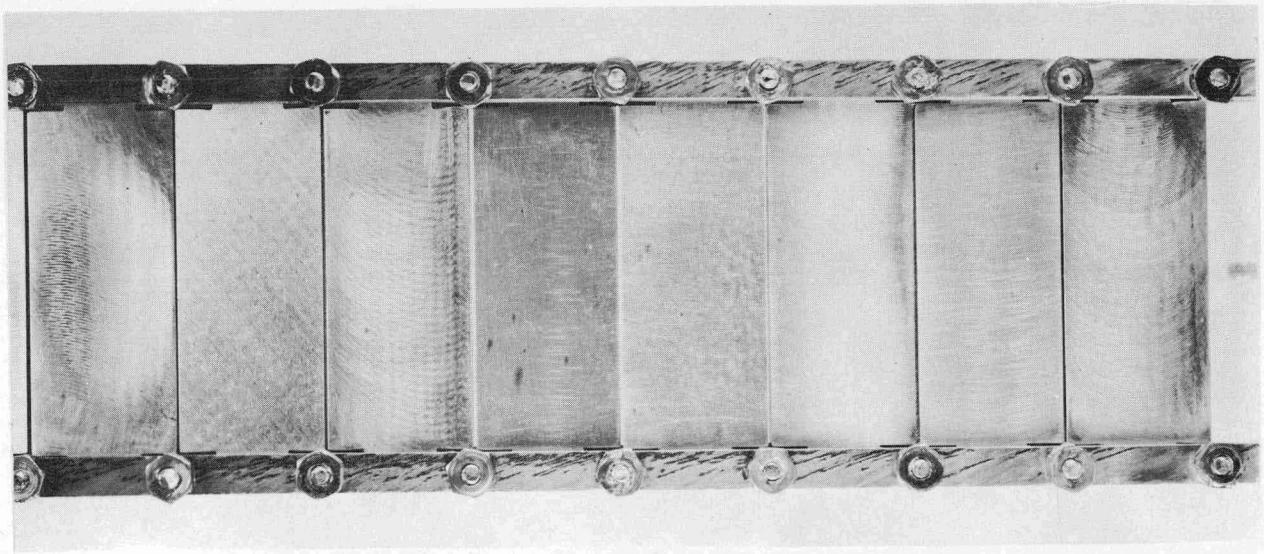

Fig. 1 Top Side of Corrosion Specimens Before Exposure in Runs SM-6 Through SM-9

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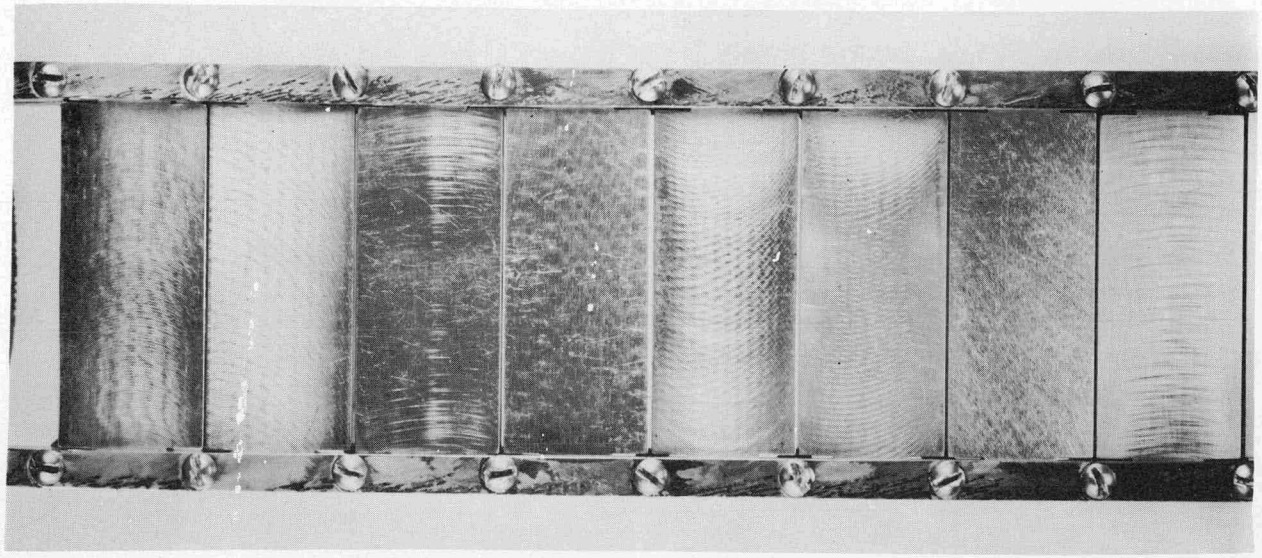
0.75X mag.



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

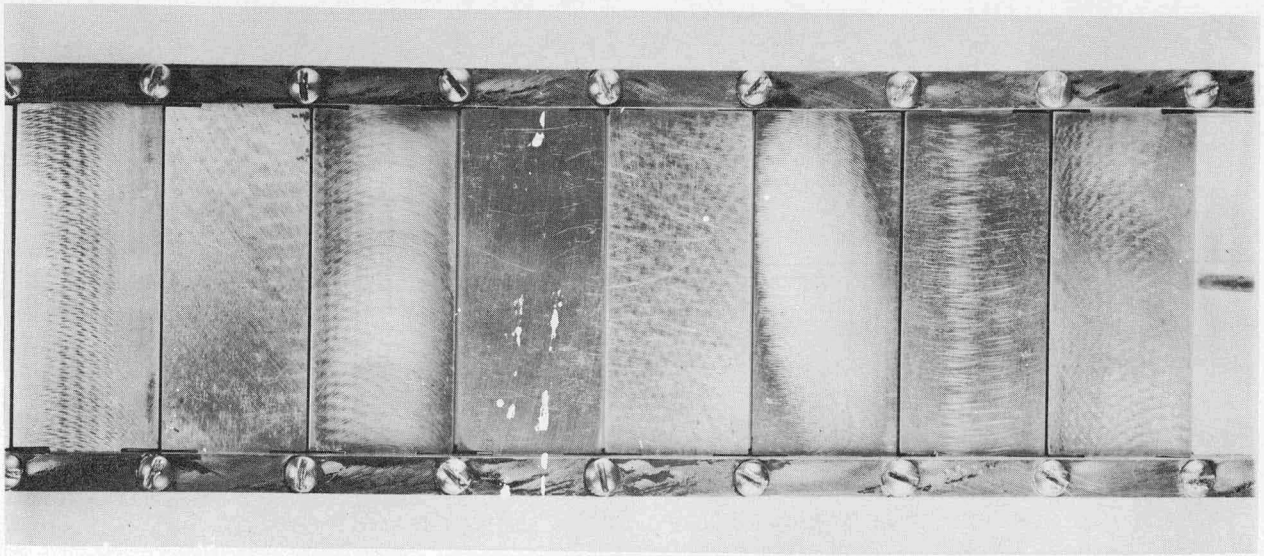


Fig. 2 Bottom Side of Corrosion Specimens Before Exposure in Runs SM-6 Through SM-9

Plate No. 35308
Unclassified
0.53X Mag.

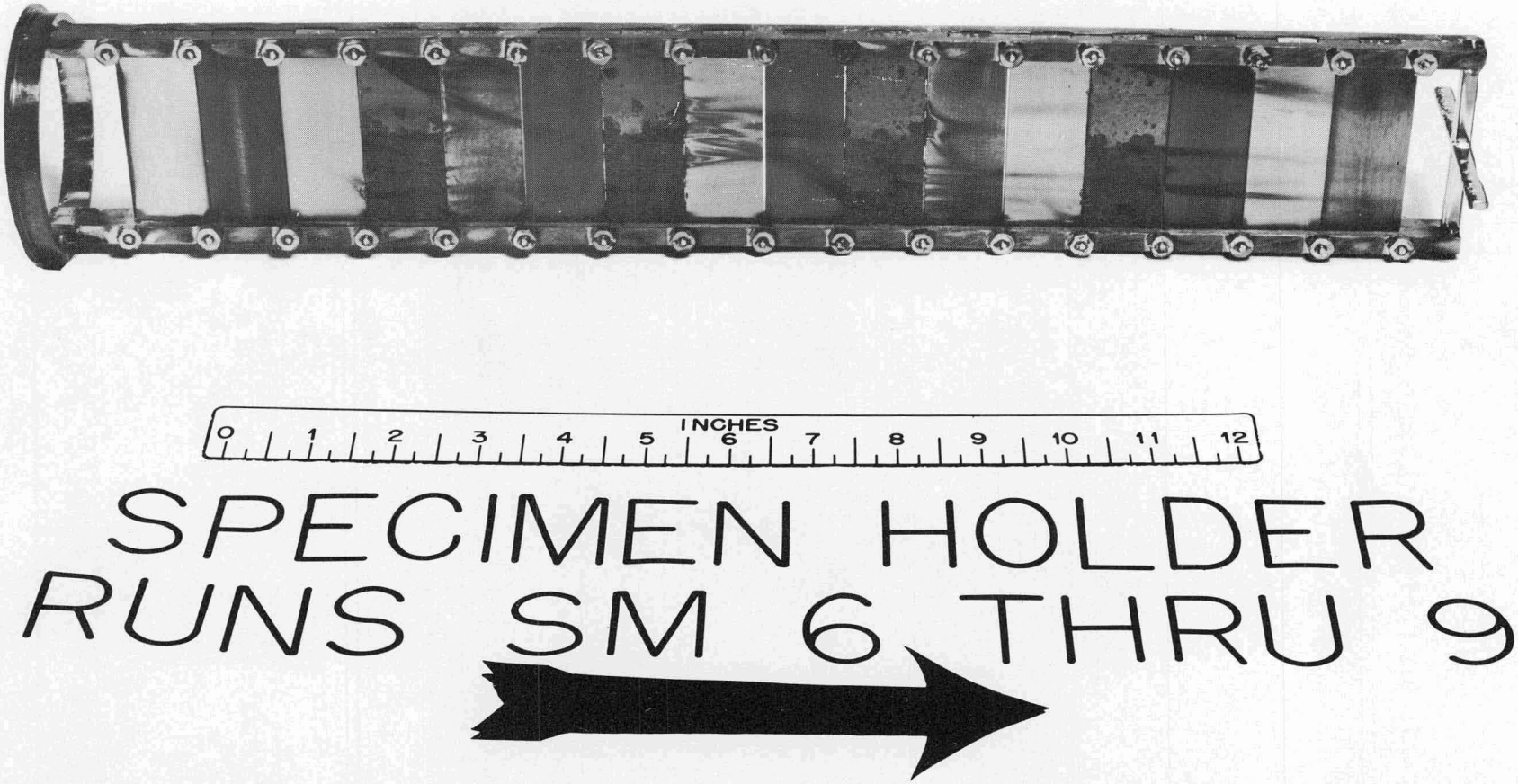
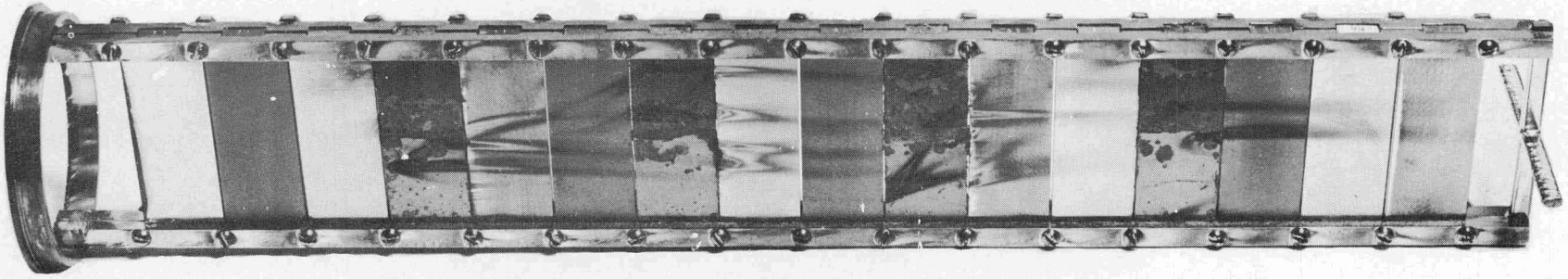
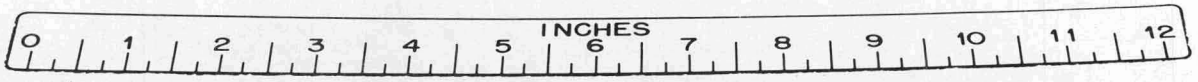


Fig. 3 Top Side of Corrosion Specimens After Exposure In Runs SM 6 Through SM 9.

Plate No. 35307
Unclassified
0.53X Mag.





SPECIMEN HOLDER
RUNS SM 6 THRU 9

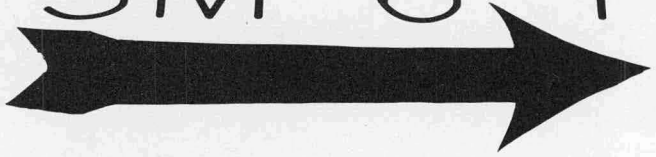


Fig. 4. Bottom side of Corrosion Specimens After Exposure In Runs SM 6 Through SM 9.

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UNCLASSIFIED

FIG. 5 SUMMARY OF SLURRY CONCENTRATION, VELOCITY, AND TEMPERATURE DURING RUNS SM-6 THROUGH SM-9

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1. S. A. Reed *et al.*, Summary of Specimen Corrosion Data from Slurry Blanket Mockup Run SM-3, ORNL CF-57-10-5.

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