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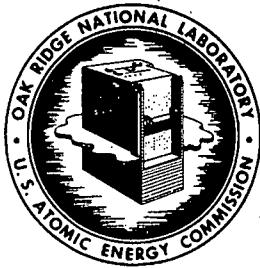
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SUBJECT: Summary of Specimen Corrosion Data from Slurry Blanket Mock-Up Run SM-3.

TO: E. G. Bohlmann

FROM: S. A. Reed and E. L. Compere

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SUMMARY

Examination of corrosion specimens from the 948 hour slurry blanket mock-up Run SM-3 indicated generally low attack rates on type 347 stainless steel, titanium -75A and Zircaloy-2. The upstream coupon of the array, of type 347 stainless steel, suffered moderate but more severe attack. Coupons of SA-212 grade B carbon steel were severely attacked. No stress corrosion cracking was noted on samples, placed in the pressurizer, of types 347 and AM 350 stainless steels, titanium aluminum-vanadium alloy, or Zircaloy-2.

In cooperation with the program of the Engineering Research Section on the slurry blanket mock-up, the Reactor Materials Section prepared corrosion specimens for field exposure during the experimental operation of this equipment.

One set of sixteen in-line coupon-type corrosion specimens and a set of eight stress specimens were exposed for a total period of 948 hr in Run SM-3 of the slurry blanket mock-up, which was shut down July 24, 1957.

The in-line specimens, which were exposed at relative velocity estimated as approximately 20 fps, consisted of four coupons each of type 347 stainless steel, SA-212-B carbon steel, titanium RC-55, and Zircaloy-2. The stress specimens, placed in the system pressurizer, consisted of two samples each of type 347 stainless steel, type AM 350 stainless steel, titanium AV and Zircaloy-2. One specimen of each of the materials was suspended in the gas-vapor space of the vertical pressurizer, while the comparison specimens were placed on the lower section of the specimen holder which was normally below the level of liquid in the pressurizer. Flow over these specimens was negligible. The coupons, contained in a type 347 stainless steel holder, were not insulated. The stress specimens were mounted, uninsulated, on a type 347 stainless steel holder using 347 stainless steel bolts.

Each coupon was machined to the dimensions 2.35" x 1.0" x 0.20" from special 1/4-in. plate stock from the controlled materials stores of the Reactor Materials Research Section. Projecting tabs were machined on both ends of each coupon for appropriate clamping in the specially built holder for insertion in the mock-up. The specimens and holder are described in drawing No. TD-4910.

The assembly is shown in Figures 1 and 2.

The in-line assembly was inserted in a flanged section of 3-in. sch-40 pipe in the main loop stream of the mock-up. The flow rate past the specimens was 360 gpm except for a 6-hr period during which time the circulating pump was operated at a slightly reduced speed using a motor generator set.

A brief operating summary of Run SM-3 is given in Table I. A description of the run is reported in ORNL-CF-57-10-2 by the Engineering Research Section¹.

As shown in Table I, the specimens were exposed for a period of 270 hr in oxygenated water before slurry charging was begun. Therefore, the specimens were exposed to slurry a total of 678 hr. During slurry loading and circulation,

¹ORNL CF-57-10-2. To be issued about Oct. 15, 1957.

loop temperatures varied from 170 to 200°C.

The slurry charges consisted of a number of batches of LO-series, 800°C-calcined thoria to which was added 3700 ppm SO_4 , based on thorium, as sulfuric acid.

As shown in Table II, corrosion rates, except for SA-212-B carbon steel, were low. A slightly higher rate was noted for the No. 1 lead coupon of type 347 stainless steel than specimens of the same alloy contained in the downstream positions of the specimen array. The higher attack of that coupon was attributed to entrance effects and increased abrasive attack by the slurry particles. The pattern of attack may be seen in Fig. 1 and 2, which depict the assembled specimens after removal from the test. Additional photographs of individual specimens are shown in Fig. 3 through 10.

Attack of type 347 stainless steel ranged from 0.18 to 0.28 mpy on 3 specimens, the fourth, the coupon at the entrance in the specimen array, showed 1.9 mpy; titanium RC-55 ranged from 0.16 to 0.26 mpy; Zircaloy-2 from 0.10 to 0.24 mpy; and SA-212-B carbon steel from 455 to 637 mpy. The high attack of SA-212-B steel appeared to be due, in part, to galvanic action between the uninsulated coupons and the stainless steel specimen holder. Both ends of each specimen were markedly corroded. It is also probable that the presence of sulfuric acid in the slurry contributed to the aggressive attack of the carbon steel.

The attack rates and the results of microscopic examinations of the stress specimens exposed in the mock-up pressurizer are presented in Table III. No evidence of stress cracking was observed with any of the specimens. One specimen of type 347 stainless steel, exposed in the gas-vapor space, and one specimen of type AM 350 stainless steel, which was immersed in the liquid, showed slight weight losses. Corrosion rates of these specimens were 0.11 and 0.47 mpy, respectively.

A series of photographs depicting the changes in appearance of each specimen are shown in Fig. 3 through Fig. 10.

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TABLE I

Operating Summary, Slurry Blanket Mock-Up Run SM-3^(a)

Circulation Hours	Loop Temperature (°C)	Pressurizer Temperature (°C)	Slurry Concentration (g Th/kg H ₂ O)	Atmosphere	Slurry pH	Sp. Conductivity of Supernatant mhos/cm X10 ⁵
0-270	Rm. temp to 200	Rm. temp to 240	0	O ₂		
270-430	170	200-210	Loading to 238	O ₂	5.4-5.8 ^(b)	8 ^(b)
430-570	170	200-210	238	O ₂	5.4-6.6	33
570-640	200	235-240	238	O ₂	5.7-6.3	7
640-676	170	200-210	Charging to 500	O ₂		
676-837	170	200-210	500	H ₂ ^(c)		
837-948	200	235-240	500	H ₂ ^(c)	6.1-6.3	8-9

(a) Furnished by L. F. Parsly, et. al., of the Engineering Research Section

(b) The slurry contained ~ 3700 ppm SO₄⁼ based on thorium, which was added as H₂SO₄.

(c) Hydrogen first appeared in gas samples at 780 hr.

TABLE II

In-Line Coupon Corrosion Rates at 20 fps
In Slurry Blanket Mock-Up Run SM-3

Material Type	Specimen Designation	Position In Holder	Weight Change, mg		Weight Loss mg/cm ² (b)	Corrosion Rate, mpy, Defilmed
			Scrubbed	Defilmed		
347 S Steel	347 (1)	1 (a)	- 106.2	- 108.4	2.99	1.91
Zircaloy-2	Z (1)	2	- 10.7	- 11.1	0.31	0.24
Titanium RC-55	R5 (1)	3	- 6.1	- 8.3	0.23	0.26
SA-212-Grade B Boiler Plate	SM (1)	4	- 35,635.0	-35,699.2	987	637
347 S Steel	347 (2)	5	- 10.2	- 16.0	0.44	0.28
Zircaloy-2	Z (2)	6	- 5.3	- 5.8	0.16	0.12
Titanium RC-55	R5 (2)	7	- 4.4	- 5.6	0.15	0.17
SA-212-Grade B Boiler Plate	SM (2)	8	- 27,041.3	-27,136.4	749	484
347 S Steel	347 (3)	9	- 5.9	- 10.5	0.29	0.18
Zircaloy-2	Z (3)	10	- 5.8	- 6.4	0.18	0.14
SA-212-Grade B Boiler Plate	SM (3)	11	- 25,116.8	-25,260.2	697	541
Titanium RC-55	R5 (3)	12	- 1.3	- 5.0	0.14	0.16
SA-212-Grade B Boiler Plate	SM (4)	13	- 25,376.0	-25,513.1	704	455
Titanium RC-55	R5 (4)	14	- 3.3	- 5.7	0.16	0.18
Zircaloy-2	Z (4)	15	- 3.8	- 4.5	0.12	0.10
347 S Steel	347 (4)	16	- 6.2	- 11.5	0.32	0.21

(a) Leading coupon, upstream position

(b) Exposed area, 36.22 cm²

(c) Machined specimens

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TABLE III

Corrosion Rates of Pressurizer Stress Specimens
Exposed in Slurry Blanket Mock-Up Run SM-3

Alloy	Position	Specimen Size (in.)	Stress (psi)	Strain (μ in.)	Weight Change, mg		Corrosion Rate, mpy	Microscopic Examination
					Scrubbed	Defilmed	Defilmed	
347 SS	gas-vapor space	1/16 x 3/8 x 3	30,400	1,200	+ 6.9	- 0.5	0.11	Very thin corrosion film, no cracks detected
347 SS	in liquid	1/16 x 3/8 x 3	30,400	1,200	+ 1.7	0.0		Very thin corrosion film, no cracks detected
AM 350 SS	gas-vapor space	1/16 x 3/8 x 3	28,000	1,100	+ 7.9	0.0		Dull gray film, no detectable cracks
AM 350 SS	in liquid	1/16 x 3/8 x 3	28,000	1,100	+ 2.9	- 2.4	0.47	Dull gray film, no detectable cracks
Ti AV	gas-vapor space	1/16 x 3/8 x 3	87,000	6,500	+ 6.4	+ 0.4	wt. gain	Light blue film, no detectable cracks
Ti AV	in liquid	1/16 x 3/8 x 3	87,000	6,500	+ 1.5	+ 0.4	wt. gain	Blue-pink film, no detectable cracks
Zircaloy-2	gas vapor space	1/8 x 3/8 x 3	9,500	1,300	+ 3.9	+ 1.3	wt. gain	Purple-pink film, no detectable cracks
Zircaloy-2	in liquid	1/8 x 3/8 x 3	9,500	1,300	+ 3.8	+ 1.4	wt. gain	Purple-pink film, no detectable cracks

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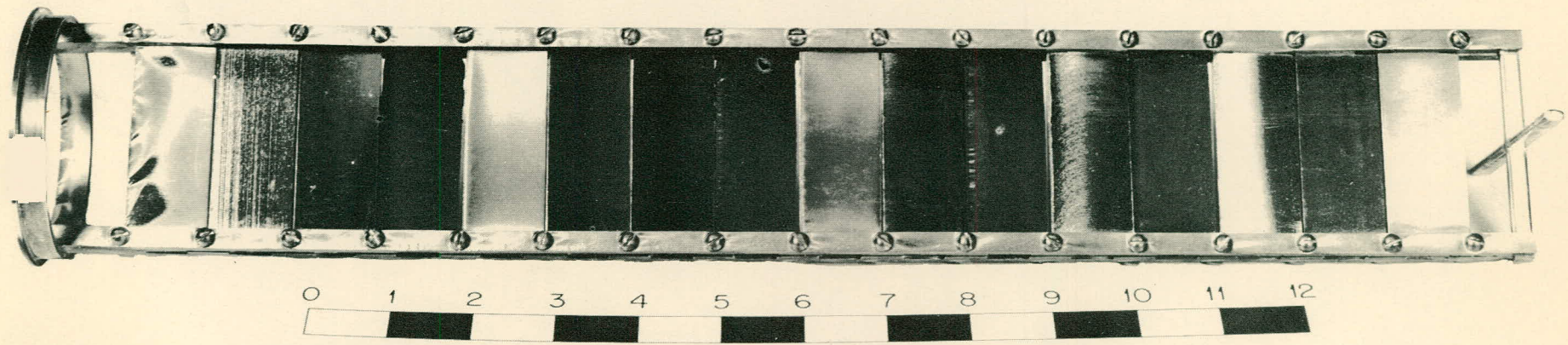


Fig. 1 In-Line Corrosion Specimens Removed from Slurry Blanket
Mock-Up Run SM-3 (Top View); Slurry Flow Left to Right.

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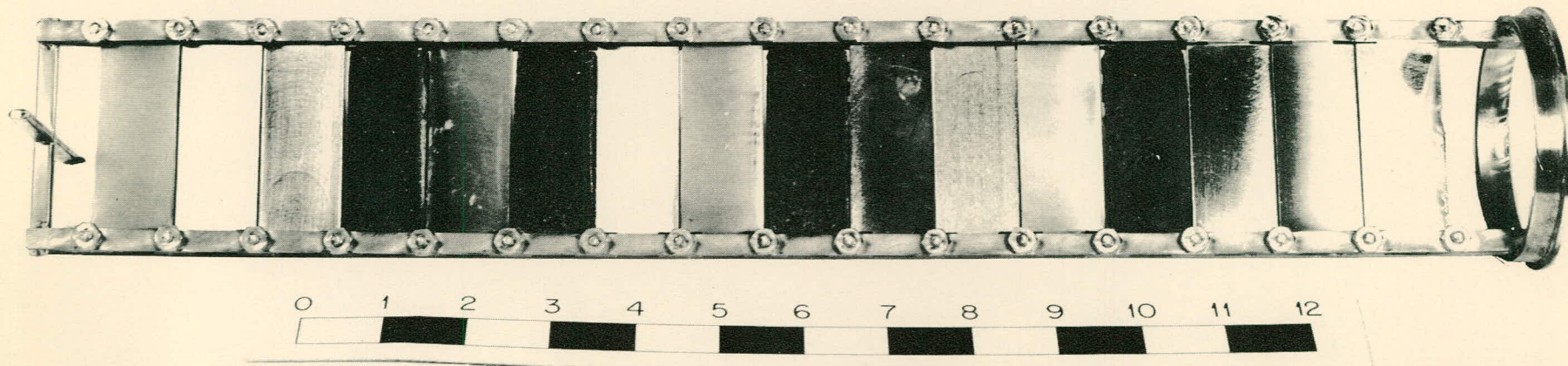


Fig. 2 In-Line Corrosion Speciment Removed from Slurry Blanket Mock-Up Run SM-3 (Bottom View); Slurry Flow Right to Left.

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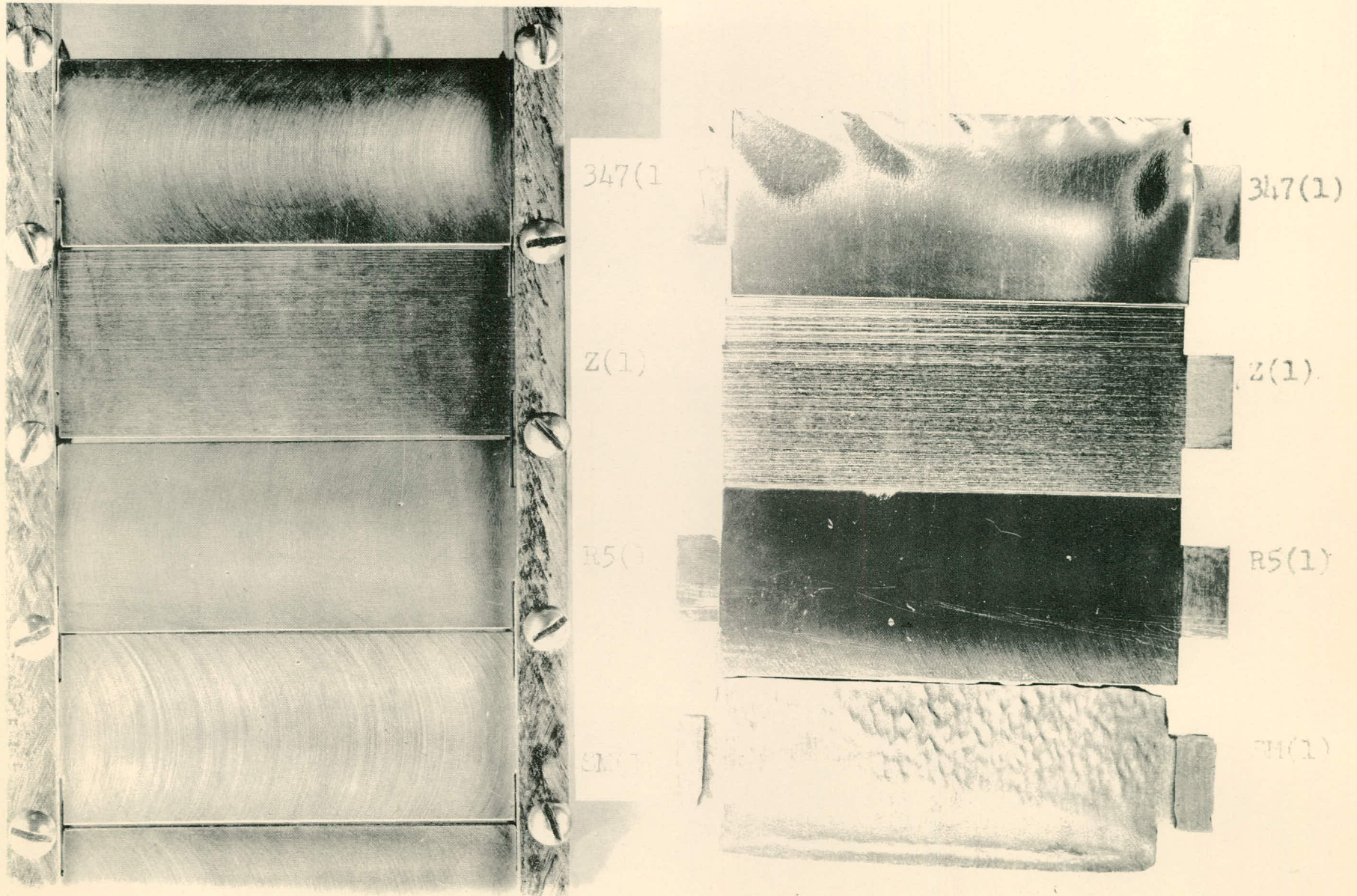


Fig. 3 In-Line Coupon Specimens from Run SM-3 Prerun (left) and Postrun (right); Specimen Positions 1-4. Flow Top to Bottom. Note Attack of Proturbances, Entrance Effect on No. 1 Specimen

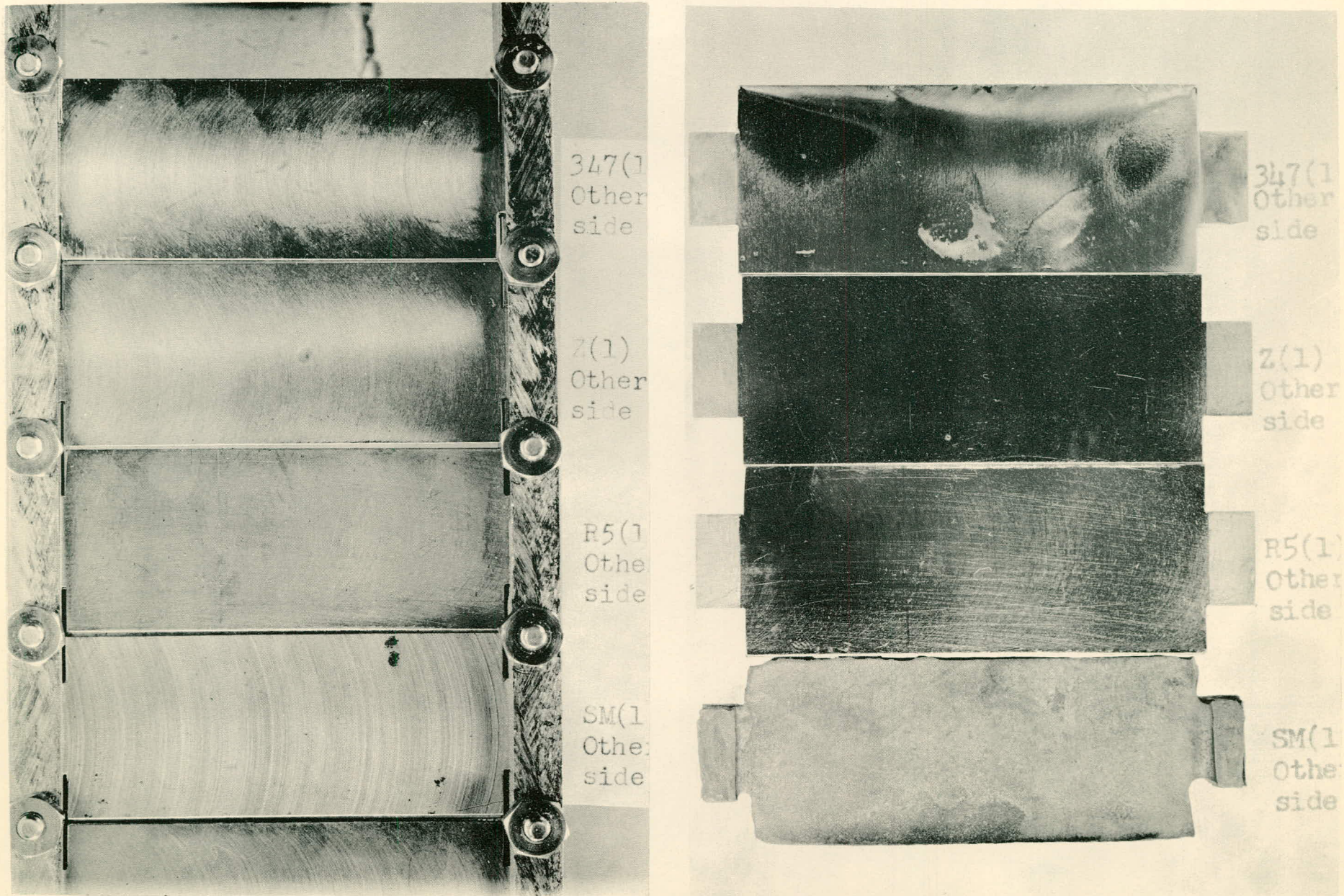


Fig. 4 In-Line Coupon Specimens from Run SM-3 Prerun (left) and Postrun (right); Specimen Positions 1-4.

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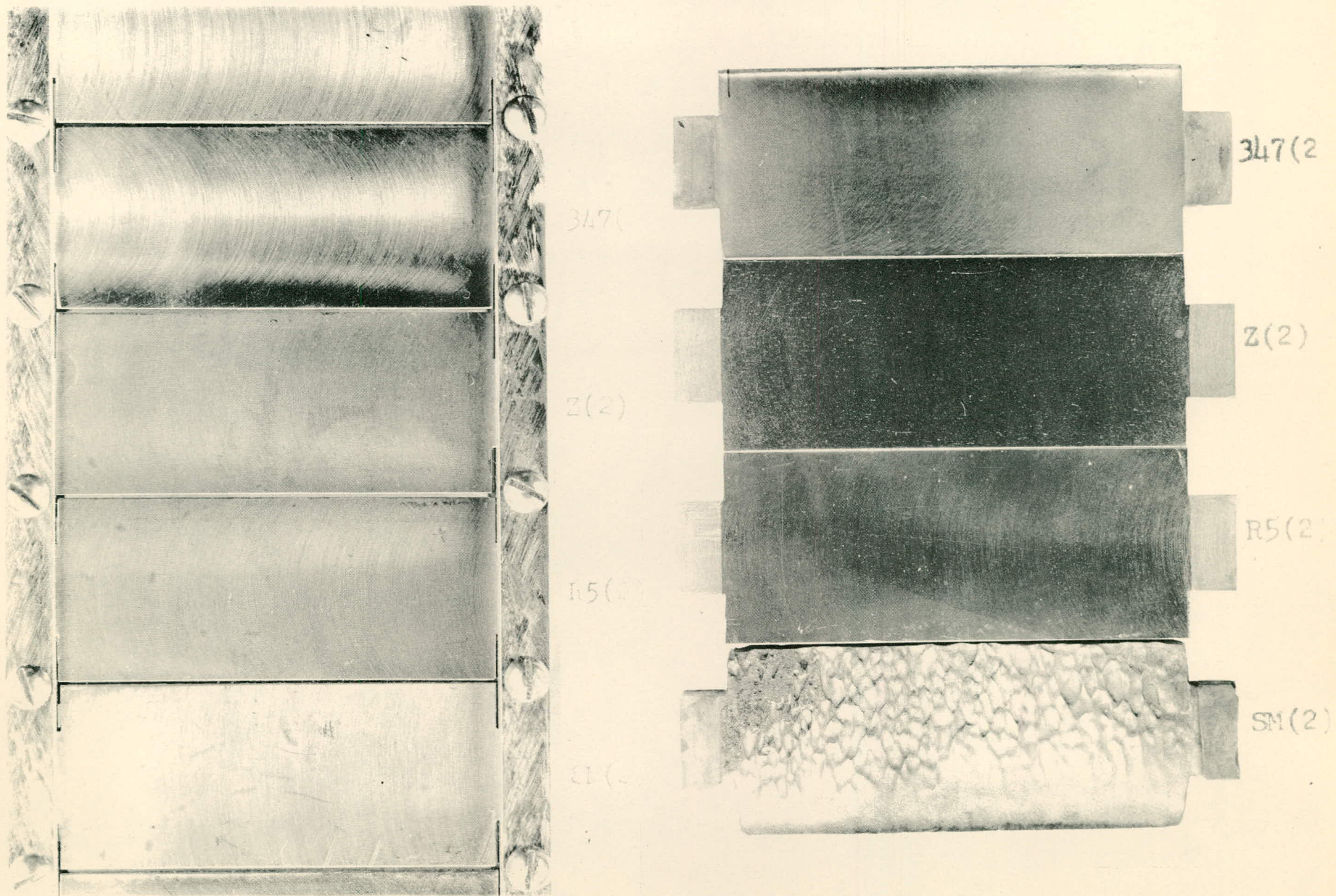


Fig. 5 In-Line Coupon Specimens from Run SM-3 Prerun (left) and Postrun (right); Specimen Positions 5-8. Flow top to bottom.

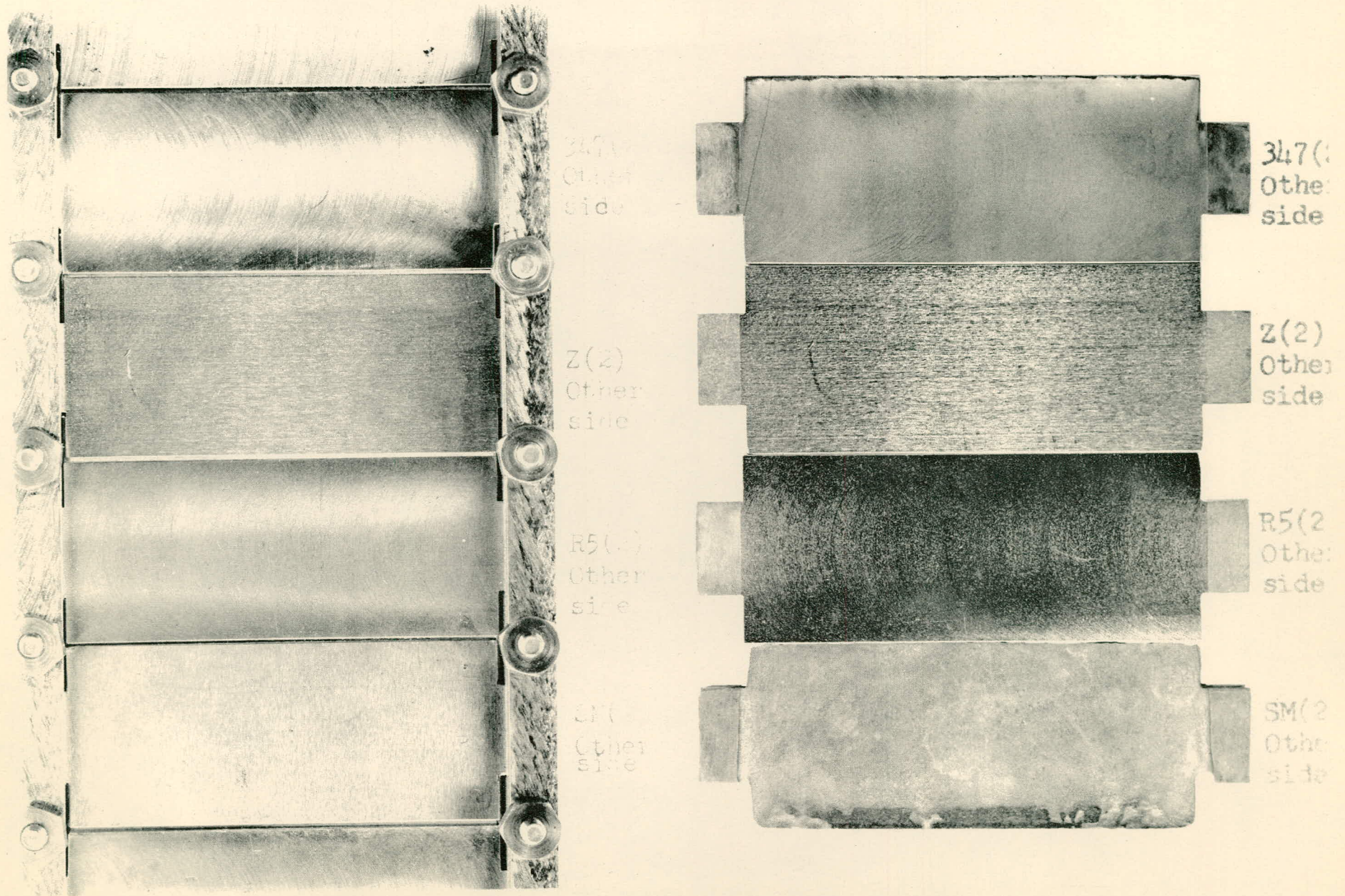


Fig. 6 In-Line Coupon Specimens from Run SM-3 Prerun (left) and Postrun (right); Specimen Positions 5-8.

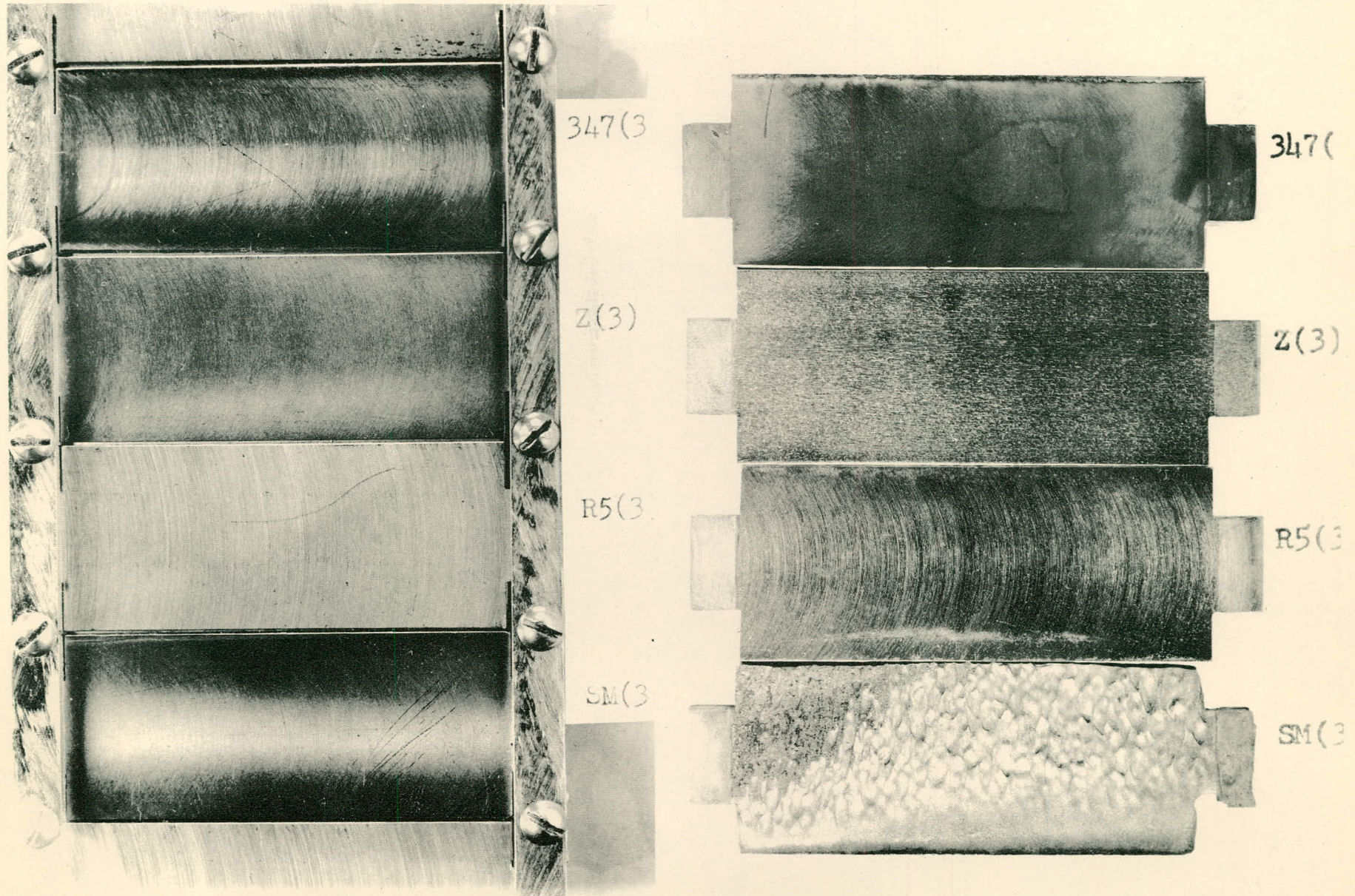


Fig. 7 In-Line Coupon Specimens from Run SM-3 Prerun (left) and Postrun (right); Specimen Positions 9-12. Flow top to bottom.

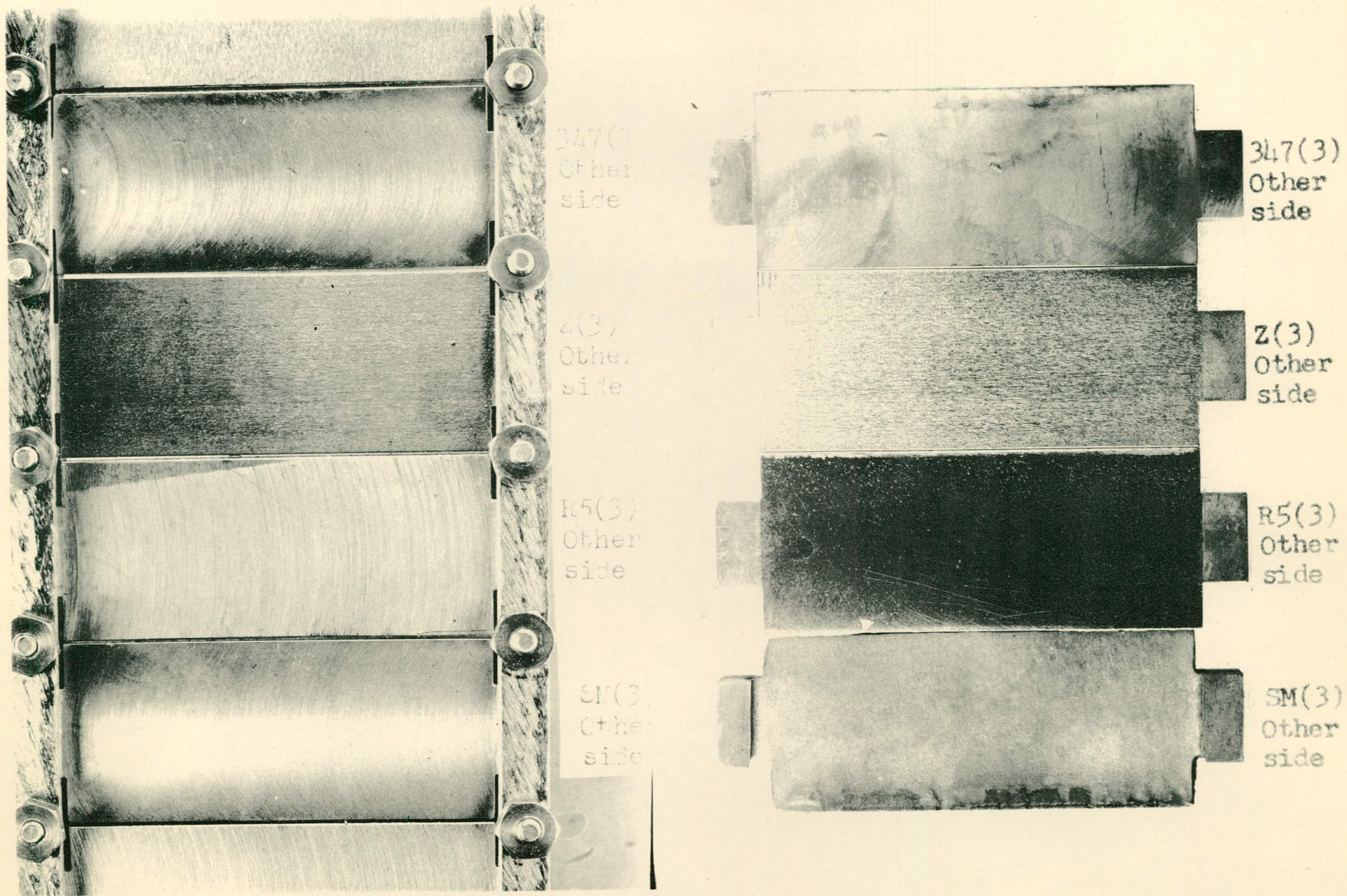


Fig. 8 In-Line Coupon Specimens from Run SM-3 Prerun (left) and Postrun (right); Specimen Positions 9-12.

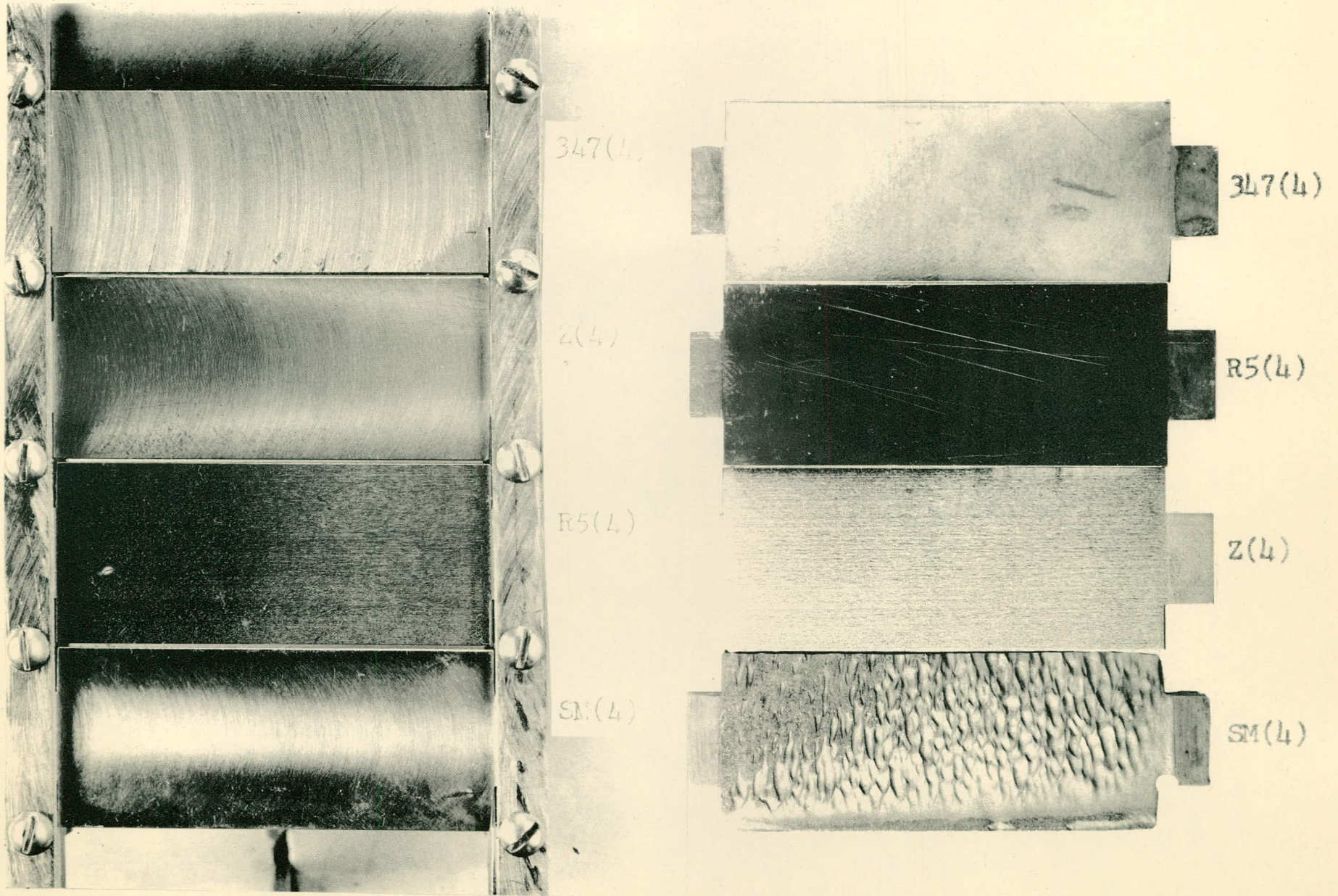


Fig. 9 In-Line Coupon Specimens from Run SM-3 Prerun (left) and Postrun (right); Specimen Positions 13-16. Flow Top to Bottom.

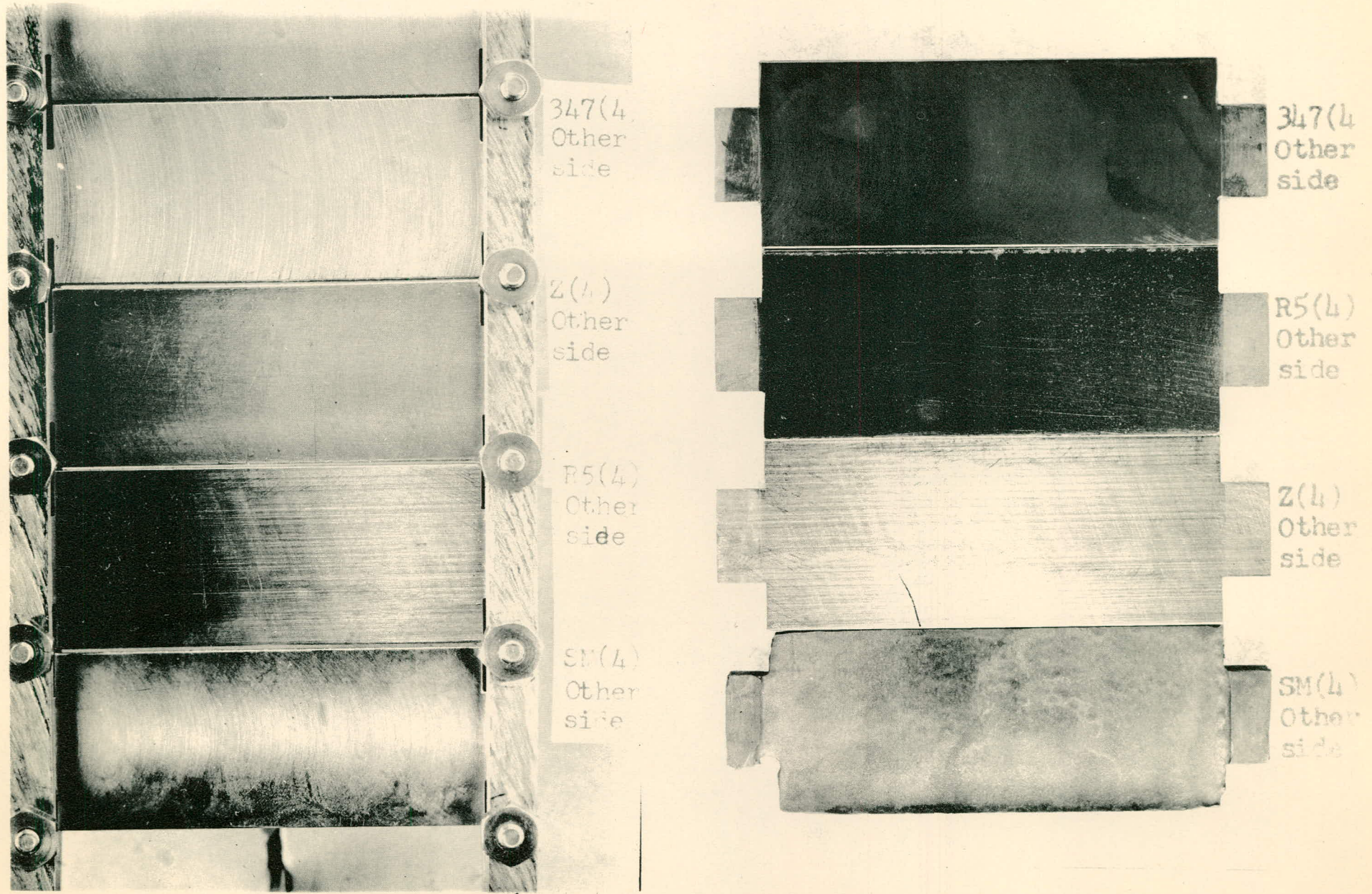


Fig. 10 In-Line Coupon Specimens from Run SM-3 Prerun (left) and Postrun (right); Specimen Positions 13-16.