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METALLOGRAPHIC EXAMINATION OF GALVANIZED SHEET

by

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PHYSICAL METALLURGY DIVISION

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SUMMARY OF RESULTS

The Armco and Weirton steels had typical aluminum-containing coatings but the latter had many coating defects, which were attributed to the steel preparation prior to galvanizing.

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INTRODUCTION

On May 10, 1961, two galvanized samples from the Ford Motor Company were received at the Physical Metallurgy Division, from Mr. J.M. Diebold, Manager, Welding Development Department, Manufacturing Engineering and Development Office, Detroit, Michigan. One sample had shown good welding tip life, whereas the second had given poor welding tip life. Attempts were made to determine differences in the metallurgical characteristics of the coatings as they may have affected the weldability.

METALLOGRAPHIC EXAMINATION

Metallographic examination revealed a significant difference in the amount of iron-zinc alloy at the coating-steel interface of the two materials. The Armco sheet (48) showed a thin and uniformly continuous fringe of crystals next to the steel surface, whereas the Weirton steel (4A) had practically no alloy formation. The Armco sheet had minor galvanizing faults caused by mechanical surface defects on the steel but the Weirton material had fine cracks and many non-metallic inclusions present in the coating.

These two coatings are shown in Figures 1 and 2, respectively. A typical surface lamination in the Armco coating is shown in Figure 3. During galvanizing the molten zinc penetrated the pickled cavity caused by the removal of oxide. The formation of alloy undermined and raised the edge of the lamination on the steel surface.

The Armco material had only minor variations in coating thickness as one would expect, but the Weirton coating thickness was less uniform. The local thinning of the latter left areas with only a thin fringe of zinc, as shown in Figure 4 (a), (b) and (c).

The most serious coating defect on Weirton steel is evident in Figures 5 and 6. It appeared that the rolling scale was partially reduced to iron during the annealing process, and that this sponge iron was not tightly adherent to the base sheet. During galvanizing, this sponge iron was converted to "hard zinc", i.e., a complex zinc-iron compound. These compounds also appear to be associated with scale which, presumably, was not eliminated by the annealing or pickling treatments. These inclusions were lifted by the force of the molten zinc, to be distributed in various areas in the zinc coating.

COATING ANALYSIS

As a matter of interest, coating weight stripping tests and analyses for iron, aluminum, and lead in the coating were conducted by the Analytical Chemistry Subdivision of the Mineral Sciences Division. The test results as listed in Table 1 were reported in the Mineral Sciences Division Internal Reports MS-61-150 and MS-61-300.

The coating weight and iron content of the coating were in agreement with the thickness and the alloy observed in the microstructure. The lead content is essentially the same for both coatings but the aluminum content in the Weirton material was higher by a factor of three.

CONCLUSIONS

From the metallographic examination, it appears likely that the major factor affecting the observed differences in the weldability of Armco and Weirton coatings was the numerous inclusions in the zinc layer of the latter. These inclusions could conceivably alter the resistivity of the coating during welding, causing more zinc to be torn away as the electrodes retract, and may also contribute to mechanical failure.

It is possible that other factors such as iron-zinc alloy at coating-steel interface, coating thickness and coating composition could affect the electrode tip life, but these differences were not so apparent in the two samples examined.

TABLE 1

Coating Analyses

Steel	Coating Weight oz/sq ft-sheet	Thickness (by conversion) mils	Iron Content mg/sq ft	Aluminum %	Lead %
Weirton (4A)	0.88	0.73	105	0.50	0.27
"	0.89	0.74	85	0.47	0.26
"	0.85	0.71	99	0.45	-
Armco (48)	0.99	0.82	136	0.16	0.23
"	1.00	0.83	142	0.16	0.24
"	1.01	0.84	136	0.11	0.27

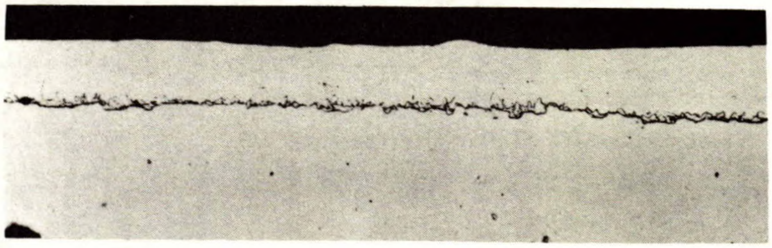


Figure 1 - Typical microstructure of Armco coating showing a thin, uniformly continuous fringe of crystals next to steel interface.
(X500, nitramyl etch)

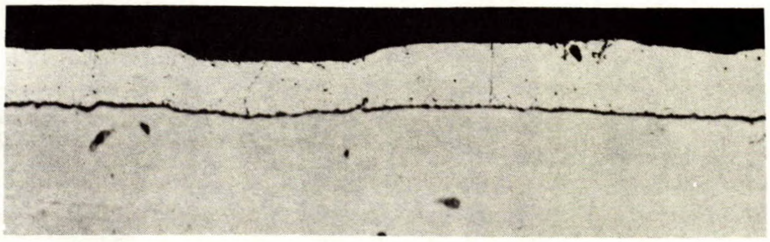


Figure 2 - Typical microstructure of Weirton coating showing practically no alloy at steel interface. Numerous fine cracks and non-metallic inclusions are present in the zinc layer.
(X500, nitramyl etch)

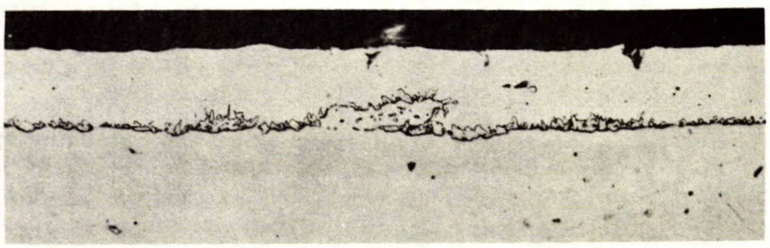
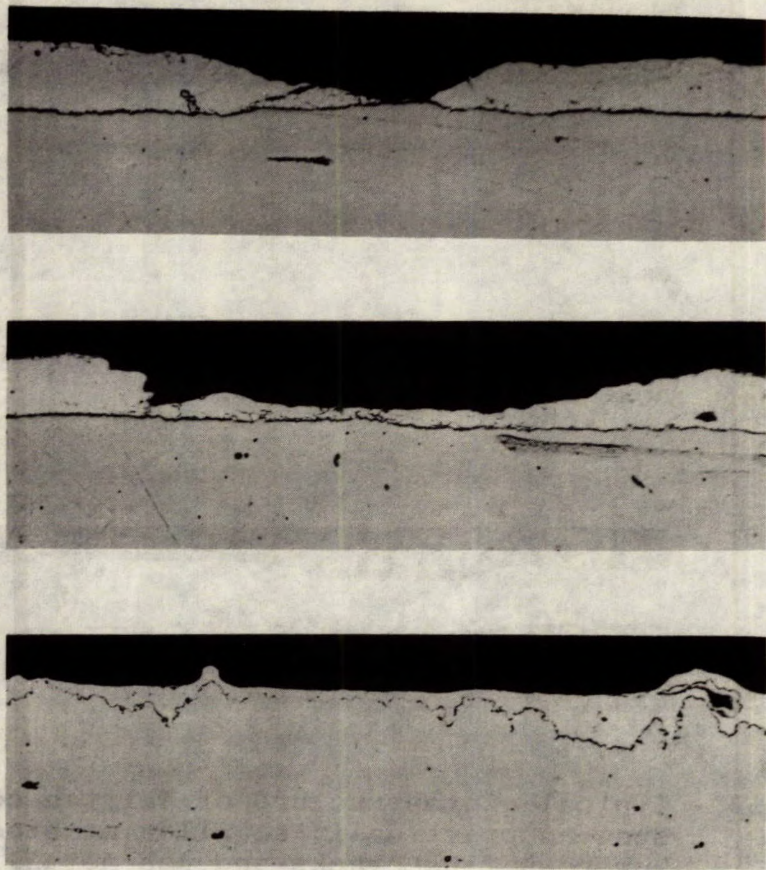


Figure 3 - Minor defect in Armco coating showing the alloy growth undermining and raising the edge of a lamination on the steel surface.
(X500, nitramyl etch)



(a)

(b)

(c)

Figure 4 - Microstructures of Weirton coating defects showing variations in thickness of the zinc coating by (a) pore formation (b) local thinning of zinc and (c) irregular steel surface. (X500, nitramyl etch)

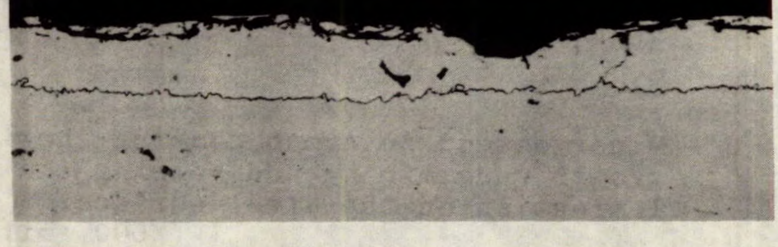
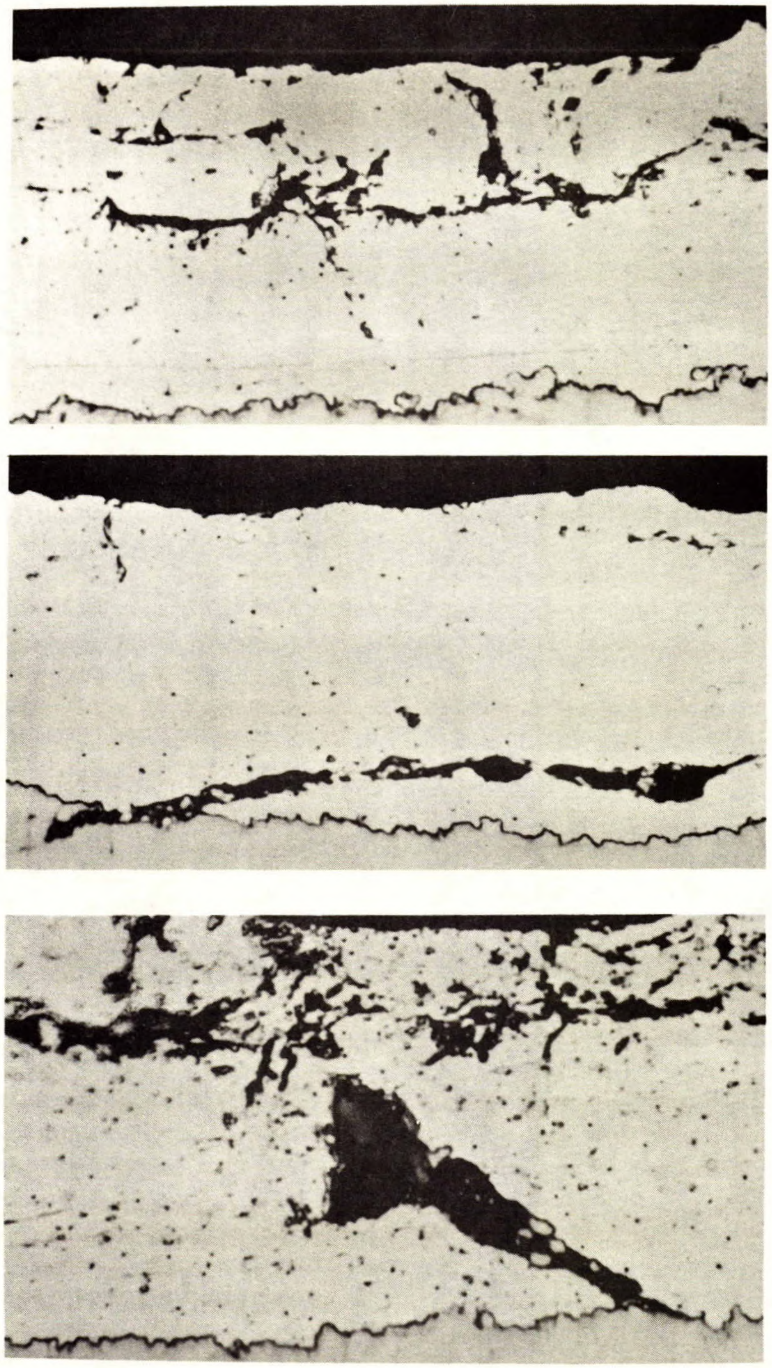


Figure 5 - Microstructure of Weirton coating defect containing a mixture of "hard zinc" and scale at or near the outer zinc edge. (X500, nitramyl etch)



(a)

(b)

(c)

Figure 6 - Similar defect to Figure 5 at higher magnification.
(a) "hard zinc" - scale inclusion floating in zinc layer
(b) "hard zinc" - scale inclusion initially embedded in the steel sheet
(c) combination of (a) and (b)
(X2000, nitramyl etch)