NATIONAL BUREAU OF STANDARDS REPORT

9942

HYDROGEN EMBRITTLEMENT OF CHROMIUM PLATED PRINTING PLATES

To

Electrolytic Section
Bureau of Engraving and Printing
Washington, D. C.

U.S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

NATIONAL BUREAU OF STANDARDS

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The Bureau comprises the Institute for Basic Standards, the Institute for Materials Research, the Institute for Applied Technology, and the Center for Radiation Research.

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Reactor Radiation—Linac Radiation—Applied Radiation—Nuclear Radiation.

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[1] Headquarters and Laboratories at Gaithersburg, Maryland, unless otherwise noted; mailing address Washington, D. C. 20234.
[2] Located at Boulder, Colorado 80302.
[3] Located at 5285 Port Royal Road, Springfield, Virginia 22151.

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By

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Hydrogen Embrittlement of Chromium Plated Printing Plates

It has been suggested that hydrogen embrittlement may occur during the chromium plating of printing plates and may contribute to their premature failure. The results of an investigation inquiring into whether printing plates can incur hydrogen embrittlement and into the benefits to be obtained from a baking treatment intended to alleviate this condition are presented in this report.[1]

Test Material and Procedure: Two types of tests were employed in this investigation. One type involved "delayed failure" tests on thin, notched specimens, Figure 1. The other involved guided bend tests on specimens 0.180 inch thick, 1.0 inch wide and 6.0 inch long. Specimens for both types of tests were cut from the same virgin Moltrup plate. The long axes of the specimens were aligned in the plate rolling direction. Chromium plating was applied on as-received polished surfaces. Case hardening, tempering, and chromium plating were conducted by the Bureau of Engraving and Printing using their established procedures. Designated specimens were baked at 400°F for four hours at NBS.

In the delayed failure tests plated notched tensile specimens were loaded statically at 70 percent of the notch tensile strength of an unplated notched specimen. Guided bend tests involved bending of specimens around a mandrel 0.75 inch thick.

Delayed Failure Test Results: Delayed failure test results are given in Table 1. Failure of unbaked plated specimens occurred after they were loaded for one-half hour at a stress equal to 70 percent of the notched tensile strength of unplated specimens. Failure of baked specimens similarly loaded was delayed for 200 hours.

Bend Test Results: All of the case-hardened and case-hardened and plated bend test specimens fractured in the bend tests. A typical fracture surface is shown in Figure 2. It is composed of a thin flat area which coincides with the case on the outside of the bent portion and a more extensive fibrous area largely coinciding with the core. These fractographic features indicate that fracture was initiated in a brittle manner in the case and then propagated in a quasi-ductile manner through the core.

[1] This report covers only part of the investigation concerned with the hydrogen embrittlement of printing plates. The effects of hydrogen embrittlement and of a baking treatment on fatigue properties will be discussed in a forthcoming report.

The bend test results, Table 2, reveal the loss in ductility that occurs at various stages of printing plate processing. They indicate that case hardening lowers plate ductility and that chromium plating has an additional adverse effect on this property.

Discussion and Conclusions: Hydrogen embrittlement often manifests itself in the form of delayed, brittle failures which are characterized by failure at relatively low applied loads. Accordingly, delayed failure tests were employed in this investigation to detect possible hydrogen embrittlement. The fact that specimens baked for hydrogen embrittlement relief withstood a load equal to 70 percent of the notched tensile strength of the material for 200 hours while unbaked specimens failed in only one-half hour would seem to indicate that hydrogen embrittlement occurs during the chromium plating of printing plates.

The case formed in case-hardening is incapable of appreciable plastic deformation. It cracked early in the bend tests initiating fractures. It is believed that the hard, brittle case is the chief factor in reducing over-all plate ductility as measured by the bend tests.

The delayed failure test, which provides a more positive indication of hydrogen embrittlement than a bend test of the type employed, revealed that hydrogen embrittlement of printing plates occurs during chromium plating. It is our opinion that baking of plates at 400°F for 4 hours be applied to obtain relief from hydrogen embrittlement. Baking should take place as soon after plating as possible.

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Table 1. Delayed Failure Test Results

Specimen	Condition	Notched Tensile Strength (NTS) psi	Duration of Test at 70% of NTS (130,900 psi) hr	Duration of Test at 90% of NTS (168,300 psi) hr
B	Case hardened and tempered	187,000	-	-
C-1	Case hardened, tempered and chromium plated	-	0.5[1]	-
C-2	Case hardened, tempered and chromium plated	-	0.5[1]	-
Average	Case hardened, tempered and chromium plated	-	0.5[1]	-
D-1	Case hardened, tempered, chromium plated and baked	-	200	0[2]
D-2	Case hardened, tempered, chromium plated and baked	-	200	0[2]
Average	Case hardened, tempered, chromium plated and baked	-	200	0[2]

[1] Failed at slot in grip end under load.

[2] Failed at slot in grip end while loading.

Table 2. Bend Test Results

Specimen	Condition	Load to Crack (Pounds)	Deflection Before Base Metal Cracked (Degrees)	Remarks
A	As received	-	-	Bent 180° without cracking. Maximum load 4800 pounds.
B-1	Case hardened and tempered	3400	44	-
B-2	Case hardened and tempered	3600	48	-
Average		3500	46	-
C-1	Case hardened, tempered and chromium plated	3700	24	Chromium plating cracked at 5° deflection.
D-1	Case hardened, tempered, chromium plated and baked.	3800	26	Chromium plating cracked at 5° deflection.
D-2	Case hardened, tempered, chromium plated and baked.	3500	26	Chromium plating cracked at 5° deflection.
Average		3650	26	

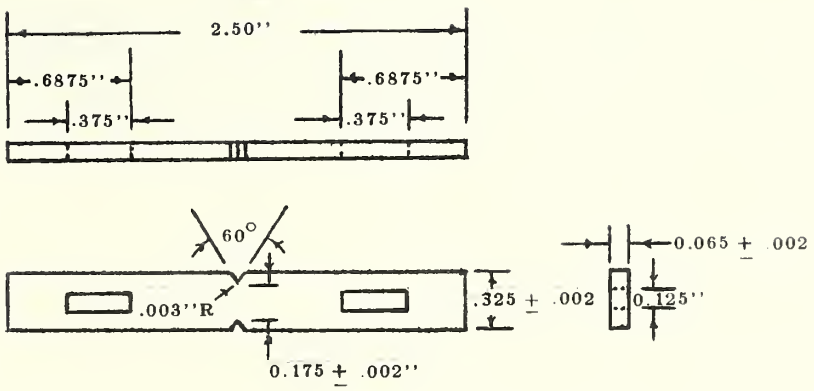

Figure 1. Dimensions of test specimen used in determining susceptibility to delayed failure resulting from hydrogen embrittlement.

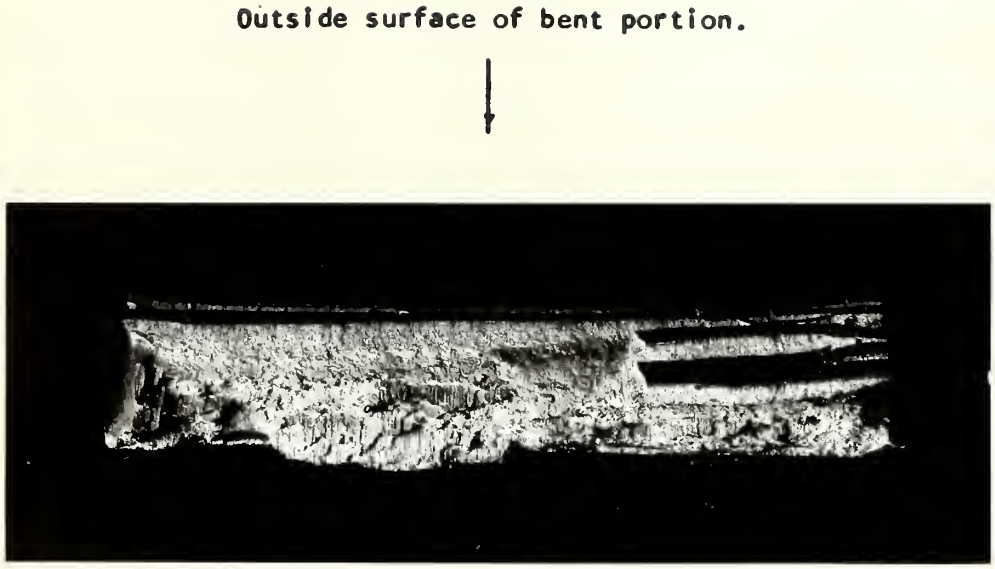

Figure 2. Fracture surface of bend test specimen, D-2. Note the flat brittle fracture surface of the case (area adjacent to outside surface of bent portion). The fracture surface of the core is fibrous. The core accounted for any of the ductility observed. This fracture surface is typical of that obtained on all of the case-hardened and case-hardened and plated bend test specimens. X 3


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