Standards Topics

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Hydrogen Embrittlement Standards

Metal finishing standards frequently provide procedures for eliminating the disastrous effects of hydrogen embrittlement in plated parts, particularly high-strength steel parts. I have not been able to identify the first such standard to specify a procedure to eliminate hydrogen embrittlement, but we can state that a one-hr heat treatment at 300° to 500° F was being practiced at the Watervliet and Frankford Arsenals in early 1942.

The best information I have been able to obtain is that federal specifications, issued by the General Services Administration of the U.S. government, began to include requirements for heat treatment for hydrogen embrittlement or stress relief, starting in the 1940s and 1950s. These specifications were patterned after the ASTM/AES standards that did not include heat treatment.

The first industry standard to contain recommendations for hydrogen embrittlement relief treatment was ASTM B242, *Standard Practice for the Preparation of High Carbon Steel for Electroplating*. This standard was issued in 1949 and revised in 1954, and was incorporated into the other ASTM Plating Standards by reference.

The ASTM B08 Committee received a number of communications, starting in 1973, from users commenting that the treatment recommended in B242 was not always adequate. Subcommittee B08.02 on Substrate Preparation formed a working group, Section 14, to address these comments concerning hydrogen embrittlement and stress relief treatments. I was named chairman of the Section, in part because I was already working on the problem for my employer at that time (IBM Corporation). In time, we had a number of very active participants. One of the first things that the Section did was to establish a liaison with ASTM F07.04, the Aerospace and Aircraft Subcommittee on Hydrogen Embrittlement. The Subcommittee chairman, Dr. Louis Raymond, welcomed the cooperation and invited us to attend their symposium on hydrogen embrittlement testing.

In 1974, the B08.02.14 Section began to catalog the various relief treatments documented in specifications or detailed on engineering drawings. Cooperating were the major aircraft manufacturers, the military, bearing manufacturers, tool manufacturers, plating shops, fastener manufacturers, and other interested companies.

By the spring of 1979, we had catalogued some 61 treatments for embrittlement relief and 34 treatments for stress relief. The embrittlement relief treatment temperatures ranged from 300° to 470° F; the treatment duration ranged from one to 24 hr. The stress relief treatment temperatures ranged from 265° to 445° F, with treatment duration ranging from one to 24 hr.

International Standard Proposed

At the 1980 meeting of ISO/TC 107/SC 3, the United Kingdom proposed an international standard for hydrogen embrittlement relief and for stress relief. After the work being done in the U.S. was presented, it was decided to have an ISO working group that would bring together experts from all over the world to prepare the standards. The chairmanship of the ISO working group was given to the U.S. It was agreed that parallel documents would be balloted in ASTM and in ISO.

The ISO working group held its first meeting in June of 1982 in Berlin. Dr. G. Paul Ray of the British Ministry of Defense undertook to rationalize the large number of embrittlement relief and stress relief treatments that had been documented. His initial effort reduced the treatments to four for stress relief and eight for embrittlement relief. In time, these were increased to the current nine and 18 treatments.

At the 1985 ASTM F07.04 Symposium on Hydrogen Embrittlement: Prevention and Control, three draft standards were presented. The first was *Embrittlement Relief Treatment of Steels and Alloys After Electroplating and Autocatalytic Plating Processes*.The second was *Stress Relief Heat Treatment of Steels Prior to Electroplating, Conversion Coating, Autocatalytic and Chemical Treatment*. The third was *Test for Residual Embrittlement in Metallic-Coated Externally Threaded Articles, Fasteners and Rod, Inclined-Wedge Method*.

Publication of the drafts in ASTM STP 962 in 1986 resulted in a large number of useful comments. It also resulted in a small but organized opposition determined to block the publication of the documents. The objections were never on the grounds of technical inaccuracy. Rather, they were on the grounds that the purchaser should not have the right to specify the treatment he wanted. Finally, after numerous rewrites to overcome various objections, the documents were balloted, approved and published in ASTM as B839-94, *Test Method for Residual Embrittlement in Metallic-Coated, Externally Threaded Articles, Fasteners and Rod, Inclined-Wedge Method*; B849-94, *Pre-Treatments of Iron or Steel for Reducing Risk of Hydrogen Embrittlement*; and B850-94, *Post-Coating Treatments of Iron or Steel for Reducing Risk of Hydrogen Embrittlement*. The corresponding ISO Standards are undergoing final votes as ISO/DIS 10587, ISO/DIS 9587, and ISO/DIS 9588.

ASTM B839-ISO/DIS 10587 is a test method for determining if any residual embrittlement remains in threaded fasteners or articles. Three levels of test confidence are provided.

ASTM B849-ISO/DIS 9587 provides eight standard stress relief treatments, SR-0 through SR-8, from which the purchaser may select.

ASTM B850-ISO/DIS 9588 provides 17 standard embrittlement relief treatments, ER-0 through ER-17, from which the purchaser may select. These two standards are based on the premise that only the part designer and the manufacturing engineer have sufficient knowledge of the part's functional requirements and the material it is fabricated from to correctly select the treatments to be used.

ASTM B851-94, *Automated Controlled Shot-Peening of Metallic Articles Prior to Nickel, Autocatalytic Nickel or Chromium Plating, or as a Final Finish* and its companion, ISO/DIS 12686, provide a standard shot-peening treatment to control any reduction in fatigue properties that occurs from plating.

Standards developed by ASTM Subcommittee F07.04 are F326-78, *Test Method for Electronic Hydrogen Embrittlement Test for Cadmium*

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