



Standard Test Method for Process Control Verification to Prevent Hydrogen Embrittlement in Plated or Coated Fasteners¹

This standard is issued under the fixed designation F 1940; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers a procedure to prevent, to the extent possible, internal hydrogen embrittlement (IHE) of fasteners by monitoring the plating or coating process, such as those described in Specifications F 1137 and F 1941. The process is quantitatively monitored on a periodic basis with a minimum number of specimens as compared to qualifying each lot of fasteners being plated or coated. Trend analysis is used to ensure quality as compared to statistical sampling analysis of each lot of fasteners. This test method consists of a mechanical test for the evaluation and control of the potential for IHE that may arise from various sources of hydrogen in a plating or coating process.

1.2 This test method applies to externally threaded tensile fasteners that can also be loaded in bending during installation.

1.3 This test method is limited to evaluating hydrogen induced embrittlement due only to processing (IHE) and not due to environmental exposure (EHE, see Test Method F 1624).

1.4 This test method is not intended to measure the relative susceptibility of steels to either IHE or EHE.

1.5 This test method is limited to ferrous fasteners that are susceptible to time-delayed fracture caused by the diffusion of hydrogen under stress.

1.6 This test method uses a notched square bar specimen that conforms to Test Method F 519, Type 1e, except that the radius is increased to accommodate the deposition of a larger range of platings and coatings. For the background on Test Method F 519 testing, see publications ASTM STP 543² and ASTM STP 962.³ The stress concentration factor is at a $K_t = 3.1 \pm 0.2$. The sensitivity is demonstrated with a constant imposed cathodic potential to control the amount of hydrogen. Both the sensitivity and the baseline for residual hydrogen will be established with tests on bare metal specimens in air.

1.7 The sensitivity of each lot of specimens to IHE shall be demonstrated. A specimen made of AISI E4340 steel heat treated to a hardness range of 50 to 52 HRC is used to produce a “worst case” condition and maximize sensitivity to IHE.

1.8 A notched four-point bend specimen undergoes sustained load and slow strain rate testing by using incremental loads and hold times under displacement control to measure a threshold stress in an accelerated manner in accordance with Test Method F 1624. The test is an accelerated (≤ 24 h) incrementally increasing step load test method that measures the threshold for hydrogen stress cracking that is used to quantify the amount of residual hydrogen in the specimen.

1.9 In this test method, bending is used instead of tension because it produces the maximum local limit load tensile stress in a notched bar of up to 2.3 times the yield strength as measured in accordance with Test Method E 8. A fastener that is unintentionally exposed to bending on installation may attain this maximum local tensile stress.

1.10 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.11 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:

- D 1193 Specification for Reagent Water⁴
- E 4 Practices for Force Verifications of Testing Machines⁵
- E 8 Test Methods for Tension Testing of Metallic Materials⁵
- E 18 Test Methods of Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials⁵
- E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications⁶
- E 177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods⁶

¹ This test method is under the jurisdiction of ASTM Committee F16 on Fasteners and is the direct responsibility of Subcommittee F16.93 on Quality Assurance Provisions for Fasteners.

Current edition approved April 10, 2001. Published July 2001. Originally published as F 1940 – 98. Last previous edition F 1940 – 99.

² *Hydrogen Embrittlement Testing*, ASTM STP 543, American Society for Testing and Materials, 1974.

³ *Hydrogen Embrittlement; Prevention and Control*, ASTM STP 962, American Society for Testing and Materials, 1985.

⁴ *Annual Book of ASTM Standards*, Vol 11.01.

⁵ *Annual Book of ASTM Standards*, Vol 03.01.

⁶ *Annual Book of ASTM Standards*, Vol 14.02.