



Standard Test Method for Measurement of Hydrogen Embrittlement Threshold in Steel by the Incremental Step Loading Technique¹

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INTRODUCTION

Hydrogen embrittlement is caused by the introduction of hydrogen into steel that can initiate fracture as a result of residual stress or in service when external stress is applied (**1**).² The hydrogen can be generated during cleaning or plating processes or the exposure of cathodically protected steel parts to a service environment including fluids, cleaning treatments, or maintenance chemicals that may contact the surface of steel components. This method can be used to rapidly determine the effects of residual hydrogen in a part caused by processing or quantify the relative susceptibility of a material under a fixed set of hydrogen-charging conditions.

The combined residual and applied stress above which time-delayed fracture will occur (finite life) or below which fracture will never occur (infinite life) is called the threshold stress or threshold stress intensity (K) for precracked specimens. Historically, sustained load time-to-failure tests have been conducted on notched bars to determine the threshold stress for the onset of hydrogen stress cracking. This technique may require 12 to 14 specimens and several high-load capacity machines. For precracked specimens, the run-out time can be as long as four to five years per U.S. Navy requirements for low-strength steels at 33 to 35 HRC. In Test Method **E1681**, more than 10 000 h (> one year) are specified for low-strength steel (< 175 ksi) and 5000 h for high-strength steel (> 175 ksi).

This standard provides an accelerated method to measure the threshold stress or threshold stress intensity as defined in Test Method **E1681** for the onset of hydrogen stress cracking in steel within one week on only one machine. The specific application of this standard to hydrogen embrittlement testing of fasteners is described in **Annex A1**.

1. Scope

1.1 This test method establishes a procedure to measure the susceptibility of steel to a time-delayed failure such as that caused by hydrogen. It does so by measuring the threshold for the onset of subcritical crack growth using standard fracture mechanics specimens, irregular-shaped specimens such as notched round bars, or actual product such as fasteners (**2**) (threaded or unthreaded) springs or components as identified in SAE J78, J81, and J1237.

1.2 This test method is used to evaluate quantitatively:

1.2.1 The relative susceptibility of steels of different composition or a steel with different heat treatments;

1.2.2 The effect of residual hydrogen in the steel as a result of processing, such as melting, thermal mechanical working, surface treatments, coatings, and electroplating;

1.2.3 The effect of hydrogen introduced into the steel caused by external environmental sources of hydrogen, such as fluids and cleaners maintenance chemicals, petrochemical products, and galvanic coupling in an aqueous environment.

1.3 The test is performed either in air, to measure the effect if residual hydrogen is in the steel because of the processing (IHE), or in a controlled environment, to measure the effect of hydrogen introduced into the steel as a result of the external sources of hydrogen (EHE) as detailed in ASTM STP 543.

1.4 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 This test method is under the jurisdiction of ASTM Committee **F07** on Aerospace and Aircraft and is the direct responsibility of Subcommittee **F07.04** on Hydrogen Embrittlement.

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² The boldface numbers in parentheses refer to the list of references at the end of this standard.

NOTE 1—The values stated in metric units may not be exact equivalents. Conversion of the inch-pound units by appropriate conversion factors is required to obtain exact equivalence.