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Standard Test Method for Determination of the Susceptibility of Metallic Materials to Hydrogen Gas Embrittlement (HGE)[1]

This standard is issued under the fixed designation F1459; 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 the quantitative determination of the susceptibility of metallic materials to hydrogen embrittlement, when exposed to high pressure gaseous hydrogen.

1.2 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.3 *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:*

E384 Test Method for Knoop and Vickers Hardness of Materials

3. Summary of Test Method

3.1 A thin disk metallic specimen is subjected to an increasing gas pressure at constant rate until failure (bursting or cracking of the disk). The embrittlement of the material can be evaluated by comparing the rupture pressures of identical disk specimens in hydrogen (P_{H2}) and in a reference inert gas such as helium (P_{He}) (**1, 2**).[2]

3.2 The ratio P_{He}/P_{H2} can be used to evaluate the susceptibility of the metallic material to gaseous hydrogen embrittlement. The ratio is dependent on the pressurization rate. A ratio of 1 or less indicates the material is not susceptible to hydrogen embrittlement. A ratio greater than 1 indicates that the material is susceptible to hydrogen embrittlement and the susceptibility increases as the ratio increases.

4. Significance and Use

4.1 This test method will provide a guide for the choice of metallic materials for applications in high pressure hydrogen gas.

4.2 The value of the P_{He}/P_{H2} ratio will be a relative indication of the severity of degradation of the mechanical properties to be expected in hydrogen.

5. Apparatus

5.1 A basic test system shall consist of the following items:

5.1.1 *Test Cell,* consists of two flanges as shown schematically in Fig. 1.

5.1.1.1 The test cell shall befabricated from materials such as 316 stainless steel in the annealed condition that are not susceptible to HGE (**3, 4**).

5.1.1.2 The seals shall be elastomer O-rings for helium testing and hydrogen testing at rates of 10 bar/min (145 psig/min) or higher. For hydrogen tests at a lower rate, indium O-rings shall be used.

5.1.1.3 An evaluation port (Item 1 in Fig. 1) on the lower flange is used to check gas purity and adjust pressurization rate.

5.1.2 The test cell is pressurized with hydrogen or helium through a pneumatic system. Fig. 2 schematically illustrates the pneumatic system.

5.1.2.1 The pressurization rate shall be adjustable in the system. A throttle valve is used to adjust the pressurization rate in Fig. 2.

6. Gases

6.1 *Helium,* purity 99.995 minimum, 6000-psig (41 400-kPa) or higher pressure source.

6.2 *Hydrogen,* purity 99.995 minimum, 6000-psig (41 400-kPa) or higher pressure source.

7. Specimen Preparation

7.1 Fifteen (15) specimens with identical dimensions and temper conditions shall be prepared for each test program. Six (6) specimens are to be tested in helium and nine (9) specimens are to be tested in hydrogen. One specimen is to be tested at the predetermined pressurization rate in helium or hydrogen as prescribed in 8.2.3.

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[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.