Designation: G142 – 98 (Reapproved 2022)

Standard Test Method for Determination of Susceptibility of Metals to Embrittlement in Hydrogen Containing Environments at High Pressure, High Temperature, or Both[1]

This standard is issued under the fixed designation G142; 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 for determination of tensile properties of metals in high pressure or high temperature, or both, gaseous hydrogen-containing environments. It includes accommodations for the testing of either smooth or notched specimens.

1.2 This test method applies to all materials and product forms including, but not restricted to, wrought and cast materials.

1.3 The values stated in SI units are to be regarded as standard. The values given in parentheses after SI units are provided for information only and are not considered standard.

1.4 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D1193 Specification for Reagent Water

E4 Practices for Force Calibration and Verification of Testing Machines

E8/E8M Test Methods for Tension Testing of Metallic Materials

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

G15 Terminology Relating to Corrosion and Corrosion Testing (Withdrawn 2010)[3]

G111 Guide for Corrosion Tests in High Temperature or High Pressure Environment, or Both

G129 Practice for Slow Strain Rate Testing to Evaluate the Susceptibility of Metallic Materials to Environmentally Assisted Cracking

2.2 *Military Standard:*[4]

MIL-P-27201B Propellant, Hydrogen

3. Terminology

3.1 *Definitions:*

3.1.1 *control test, n*—a mechanical test conducted in an environment that does not produce embrittlement of a test material.

3.1.2 *hydrogen embrittlement, n*—hydrogen induced cracking or severe loss of ductility caused by the presence of hydrogen in the metal.

3.1.3 Other definitions and terminology related to testing can be found in Terminology G15.

4. Summary of Test Method

4.1 Specimens of selected materials are exposed to a gaseous hydrogen containing environment at high pressure or high temperature, or both, while being pulled to failure in uniaxial tension. The susceptibility to hydrogen embrittlement is evaluated through the determination of standard mechanical properties in tension (that is, yield strength, ultimate tensile strength, notched tensile strength, reduction in area or elongation, or both). Comparison of these mechanical properties determined in a hydrogen-containing environment to those determined in a non-embrittling environment (control test) provides a general index of susceptibility to cracking versus the material's normal mechanical behavior.

[1] This test method is under the jurisdiction of ASTM Committee G01 on Corrosion of Metals and is the direct responsibility of Subcommittee G01.06 on Environmentally Assisted Cracking.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] The last approved version of this historical standard is referenced on www.astm.org.

[4] Available from DLA Document Services, Building 4/D, 700 Robbins Ave., Philadelphia, PA 19111-5094, http://quicksearch.dla.mil.

5. Significance and Use

5.1 This test method provides a reliable prediction of the resistance or susceptibility, or both, to loss of material strength and ductility as a result of exposure to hydrogen-containing gaseous environments. This test method is applicable over a broad range of pressures, temperatures, and gaseous environments. The results from this test method can be used to evaluate the effects of material composition, processing, and heat treatment as well as the effects of changes in environment composition, temperature, and pressure. These results may or may not correlate with service experience for particular applications. Furthermore, this test method may not be suitable for the evaluation of high temperature hydrogen attack in steels unless suitable exposure time at the test conditions has taken place prior to the initiation of tensile testing to allow for the development of internal blistering, decarburization or cracking, or both.

6. Apparatus

6.1 Since this test method is intended to be conducted at high pressures and may also involve high temperatures, the apparatus must be constructed to safely contain the test environment while being resistant to the embrittling effects of hydrogen. Secondly, the test apparatus must be capable of allowing introduction of the test gas, removal of air from the test cell, and accurate performance of the tension test on the test specimen. In cases where the tests are conducted at elevated temperatures, the apparatus must provide for heating of the specimen and the test environment in direct contact with the specimen.

6.2 Fig. 1 shows a schematic representation of a typical test cell designed to conduct HP/HT gaseous hydrogen embrittlement experiments.[5] The typical components include:

6.2.1 *Metal Test Cell*—The test cell should be constructed from materials that have proven to have high resistance to hydrogen embrittlement under the conditions. A list of potential materials of construction is shown in Fig. 2.[6] Materials with high values of tensile ratios (environment versus a control environment) should be used. Materials with low values of this parameter should be avoided.

6.2.2 *Closure and Seal*—To facilitate operation of the test cell and tension testing, the closure should provide for rapid opening and closing of the test cell and reliable sealing capabilities for hydrogen. This can include either metallic or nonmetallic materials with high resistance to hydrogen embrittlement and degradation.

6.2.3 *Gas Port(s)*—The gas port should be designed to promote flow and circulation of the gaseous test environments, inert gas purging and evacuation as required to produce the intended test environment. Usually two ports are used so that flow-through capabilities are attained to facilitate these functions.

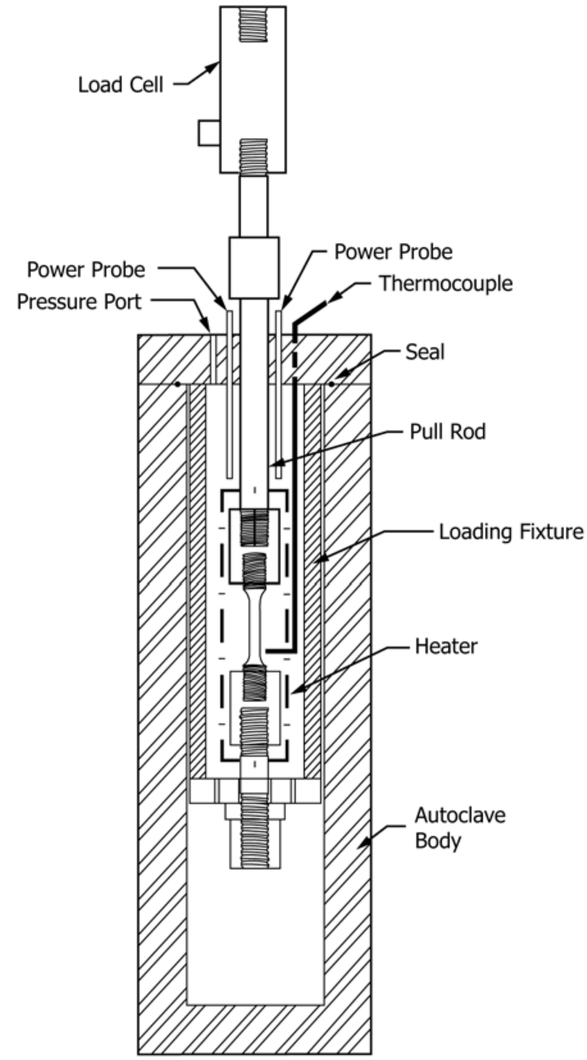

FIG. 1 Hydrogen Tensions Test Autoclave for Various Alloys in Hydrogen versus Air

6.2.4 *Electrical Feed-Throughs*—If very high temperature conditions are required it may be advantageous to utilize an internal heater to heat the test specimen and the gaseous environment in the immediate vicinity of the specimen. Therefore, a feed-through would be needed to reach an internal resistance or induction heater. These feed-throughs must also provide electrical isolation from the test cell and internal fixtures, and maintain a seal to prevent leakage of the test environment. If external heaters are used, no electric feed-throughs would be required for testing.

6.2.5 *Tensile Feed-Through(s)*—To apply tensile loading to the test specimen it is necessary to have feed-through(s) which provide linear motion and transmission of loads from an external source. Care must be taken to design such feed-throughs to have low friction to minimize errors due to friction losses when using externally applied loads. These are usually designed to incorporate thermoplastic or elastomeric materials, or both. If elevated temperature tests are being conducted, then

[5] Kane, R. D., "High Temperature and High Pressure," *Corrosion Tests and Standards*, Baboian, Robert, editor, ASTM, West Conshohocken, PA.

[6] *Metals Handbook, Vol 9, Corrosion*, 9th Edition, ASM International, Metals Park, OH, 1987, p. 1104.