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Standard Guide for Corrosion Tests in High Temperature or High Pressure Environment, or Both[1]

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1. Scope

1.1 This guide covers procedures, specimens, and equipment for conducting laboratory corrosion tests on metallic materials under conditions of high pressure (HP) or the combination of high temperature and high pressure (HTHP). See 3.2 for definitions of high pressure and temperature.

1.2 Tests conducted under HP or HTHP by their nature have special requirements. This guide establishes the basic considerations that are necessary when these conditions must be incorporated into laboratory corrosion tests.

1.3 The procedures and methods in this guide are applicable for conducting mass loss corrosion, localized corrosion, and electrochemical tests as well as for use in environmentally induced cracking tests that need to be conducted under HP or HTHP conditions.

1.4 The primary purpose for this guide is to promote consistency of corrosion test results. Furthermore, this guide will aid in the comparison of corrosion data between laboratories or testing organizations that utilize different equipment.

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

1.6 *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:*[2]

E8 Test Methods for Tension Testing of Metallic Materials

G1 Practice for Preparing, Cleaning, and Evaluating Corrosion Test Specimens

G3 Practice for Conventions Applicable to Electrochemical Measurements in Corrosion Testing

G5 Reference Test Method for Making Potentiodynamic Anodic Polarization Measurements

G15 Terminology Relating to Corrosion and Corrosion Testing (Withdrawn 2010)[3]

G30 Practice for Making and Using U-Bend Stress-Corrosion Test Specimens

G31 Guide for Laboratory Immersion Corrosion Testing of Metals

G34 Test Method for Exfoliation Corrosion Susceptibility in 2XXX and 7XXX Series Aluminum Alloys (EXCO Test)

G38 Practice for Making and Using C-Ring Stress-Corrosion Test Specimens

G39 Practice for Preparation and Use of Bent-Beam Stress-Corrosion Test Specimens

G46 Guide for Examination and Evaluation of Pitting Corrosion

G49 Practice for Preparation and Use of Direct Tension Stress-Corrosion Test Specimens

G59 Test Method for Conducting Potentiodynamic Polarization Resistance Measurements

G78 Guide for Crevice Corrosion Testing of Iron-Base and Nickel-Base Stainless Alloys in Seawater and Other Chloride-Containing Aqueous Environments

G106 Practice for Verification of Algorithm and Equipment for Electrochemical Impedance Measurements

3. Terminology

3.1 *Definitions*—The definitions of terms given in Terminology G15 shall be considered as applying to this guide.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *high pressure*—a pressure above ambient atmospheric pressure that cannot be contained in normal laboratory glassware. Typically, this is greater than 0.07 MPa (10 psig).

[1] This guide is under the jurisdiction of ASTM Committee G01 on Corrosion of Metals and is the direct responsibility of Subcommittee G01.05 on Laboratory Corrosion Tests.

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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.

3.2.2 *high temperature*—temperatures above ambient laboratory temperature where sustained heating of the environment is required.

4. Summary of Guide

4.1 This guide describes the use of corrosion coupons, stressed SCC specimens, and electrochemical electrodes in HP and HTHP environments. It also includes guidelines for the use of high pressure test cells with these specimens to conduct reproducible, accurate corrosion test data.

4.2 Typically, HP and HPHT tests involve exposure of test specimens to a liquid (aqueous or non-aqueous), gaseous or multiphase environment, or both, in an appropriate test cell. The test cell must be able to resist corrosion and environmental cracking in the test environment while containing the pressurized, heated environment. Furthermore, the test specimens in the HP or HPHT test, or both, can be exposed in either stressed or unstressed condition in either the free corroding state or under electrochemical polarization.

5. Significance and Use

5.1 HP and HTHP corrosion tests are commonly used to evaluate the corrosion performance of metallic materials under conditions that attempt to simulate service conditions that involve HP or HTHP in combination with service environments. Examples of service environments where HP and HTHP corrosion tests have been utilized include chemical processing, petroleum production and refining, food processing, pressurized cooling water, electric power systems and aerospace propulsion.

5.2 For the applications of corrosion testing listed in 5.1, the service involves handling corrosive and potentially hazardous media under conditions of high pressure or high temperature, or both. The temperature and pressure usually enter directly into the severity of the corrosion process. Consequently, the laboratory evaluation of corrosion severity cannot be performed in conventional low pressure glassware without making potentially invalid assumptions as to the potential effects of high temperature and pressure on corrosion severity.

5.3 Therefore, there is a substantial need to provide standardized methods by which corrosion testing can be performed under HP and HTHP. In many cases, however, the standards used for exposure of specimens in conventional low pressure glassware experiments cannot be followed due to the limitations of access, volume and visibility arising from the construction of high pressure test cells. This guide refers to existing corrosion standards and practices as applicable and then goes further in areas where specific guidelines for performing HP and HTHP corrosion testing are needed.

6. Apparatus

6.1 The test cell shall be constructed to applicable standards and codes so that it will have an adequate pressure rating to safely handle the test pressure.

6.2 The test cell shall be made of materials that are corrosion resistant and effectively non-reactive with the test environment.

6.2.1 The term effectively non-reactive shall mean that the test cell shall be free of significant mass loss or localized corrosion, SCC or other embrittlement phenomena in the test environment, not contaminate the test environment with corrosion or other reaction products, and not consume or absorb reactive chemical species from the test environment.

6.3 The test cell shall have a seal mechanism that can withstand both the pressures, temperatures, and corrosive environment to be used in the test. Periodic hydrostatic testing of the test cell is recommended to ensure pressure capabilities.

6.4 The test cell shall be designed to have the necessary inlet and outlet ports to allow the test environment to be established in a controllable manner, monitored and sampled during the exposure period, released in a controlled manner at the completion of the test, and if over temperature or pressure conditions may occur, adequate over pressure release and over temperature control equipment should be utilized.

6.5 In cases where external loading fixtures are used for stressing specimens in the HP and HTHP test environment, specially designed feed-throughs shall be used which provide for a minimum of friction force.

6.6 Test cell feed-throughs required for external stressing may be designed to balance the internal pressure in the test vessel.

6.7 Any frictional or pressure forces (or thermal expansion) acting on the specimen through the stressing fixtures must be taken into account when determining the actual load on the specimen.

6.8 Stressing and electrode feed-throughs shall be designed so that the electrodes or stressing rods and specimens cannot be ejected from the test cell under pressure. Furthermore, they shall provide for electrical isolation of the specimen from the test cell unless galvanic coupling is specifically desired.

6.9 Gripping devices shall be designed such that they are in compliance with Test Method E8 where application of load to the specimen is required.

7. Reagents

7.1 In corrosion testing, providing a reproducible chemical environment in which to expose the corrosion test specimens is necessary.

7.2 In cases where the test environment is established by the mixing of chemicals in the laboratory, chemicals of reagent grade purity with known contaminant levels are recommended. Simulations of service environments can be formulated in which laboratory corrosion tests can be conducted.

7.3 In HP/HTHP corrosion testing, a common practice is to conduct tests in environments that have been sampled and retrieved from field or plant locations. In both cases described in 7.2 and 7.3, detailed information as to the chemical composition of the environment should be obtained. Particular attention should be given to the levels of impurities and contaminants that may be in the environment. Furthermore, under some conditions, these environments may be prone to changes after sampling or during testing which can affect the corrosion test results.