Standard Test Methods for Pitting and Crevice Corrosion Resistance of Stainless Steels and Related Alloys by Use of Ferric Chloride Solution[1]

This standard is issued under the fixed designation G 48; 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 reappproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 These test methods cover procedures for the determination of the resistance of stainless steels and related alloys to pitting and crevice corrosion (see Terminology G 15) when exposed to oxidizing chloride environments. Six procedures are described and identified as Methods A, B, C, D, E, and F.

1.1.1 *Method A*—Ferric chloride pitting test.

1.1.2 *Method B*—Ferric chloride crevice test.

1.1.3 *Method C*—Critical pitting temperature test for nickel-base and chromium-bearing alloys.

1.1.4 *Method D*—Critical crevice temperature test for nickel-base and chromium-bearing alloys.

1.1.5 *Method E*—Critical pitting temperature test for stainless steels.

1.1.6 *Method F*—Critical crevice temperature test for stainless steels.

1.2 Method A is designed to determine the relative pitting resistance of stainless steels and nickel-base, chromium-bearing alloys, whereas Method B can be used for determining both the pitting and crevice corrosion resistance of these alloys. Methods C, D, E and F allow for a ranking of alloys by minimum (critical) temperature to cause initiation of pitting corrosion and crevice corrosion, respectively, of stainless steels, nickel-base and chromium-bearing alloys in a standard ferric chloride solution.

1.3 These tests may be used to determine the effects of alloying additives, heat treatment, and surface finishes on pitting and crevice corrosion resistance.

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

1.5 *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:*

A 262 Practices for Detecting Susceptibility to Intergranular Attack in Austenitic Stainless Steels[2]

D 1193 Specification for Reagent Water[3]

E 691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method[4]

E 1338 Guide for the Identification of Metals and Alloys in Computerized Material Property Databases[5]

G 1 Practice for Preparing, Cleaning, and Evaluating Corrosion Test Specimens[6]

G 15 Terminology Relating to Corrosion and Corrosion Testing[6]

G 46 Guide for Examination and Evaluation of Pitting Corrosion[6]

G 107 Guide for Formats for Collection and Compilation of Corrosion Data for Metals for Computerized Database Input[6]

3. Terminology

3.1 *Definition of Terms Specific to This Standard:*

3.1.1 *critical crevice temperature*, *n*—the minimum temperature (°C) to produce crevice attack at least 0.025-mm (0.001-in.) deep on the bold surface of the specimen beneath the crevice washer, edge attack ignored.

3.1.2 *critical pitting temperature*, *n*— the minimum temperature (°C) to produce pitting attack at least 0.025-mm (0.001-in.) deep on the bold surface of the specimen, edge attack ignored.

3.2 The terminology used herein, if not specifically defined otherwise, shall be in accordance with Terminology G 15.

[1] These test methods are under the jurisdiction of ASTM Committee G01 on Corrosion of Metals, and are the direct responsibility of Subcommittee G01.05 on Laboratory Corrosion Tests.

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[2] *Annual Book of ASTM Standards*, Vol 01.03.
[3] *Annual Book of ASTM Standards*, Vol 11.01.
[4] *Annual Book of ASTM Standards*, Vol 14.02.
[5] *Annual Book of ASTM Standards*, Vol 02.05.
[6] *Annual Book of ASTM Standards*, Vol 03.02.

Definitions provided herein and not given in Terminology G 15 are limited only to this standard.

4. Significance and Use

4.1 These test methods describe laboratory tests for comparing the resistance of stainless steels and related alloys to the initiation of pitting and crevice corrosion. The results may be used for ranking alloys in order of increasing resistance to pitting and crevice corrosion initiation under the specific conditions of these methods. Methods A and B are designed to cause the breakdown of Type 304 at room temperature.

4.2 The use of ferric chloride solutions is justified because it is related to, but not the same as, that within a pit or crevice site on a ferrous alloy in chloride bearing environments **(1, 2)**.[7] The presence of an inert crevice former of consistent dimension on a surface is regarded as sufficient specification of crevice geometry to assess relative crevice corrosion susceptibility.

4.3 The relative performance of alloys in ferric chloride solution tests has been correlated to performance in certain real environments, such as natural seawater at ambient temperature **(3)** and strongly oxidizing, low pH, chloride containing environments **(4)**, but several exceptions have been reported **(4-7)**.

4.4 Methods A, B, C, D, E, and F can be used to rank the relative resistance of stainless steels and nickel base alloys to pitting and crevice corrosion in chloride-containing environments. No statement can be made about resistance of alloys in environments that do not contain chlorides.

4.4.1 Methods A, B, C, D, E, and F were designed to accelerate the time to initiate localized corrosion relative to most natural environments. Consequently, the degree of corrosion damage that occurs during testing will generally be greater than that in natural environments in any similar time period.

4.4.2 No statement regarding localized corrosion propagation can be made based on the results of Methods A, B, C, D, E or F.

4.4.3 Surface preparation can significantly influence results. Therefore, grinding and pickling of the specimen will mean that the results may not be representative of the conditions of the actual piece from which the sample was taken.

NOTE 1—Grinding or pickling on stainless steel surfaces may destroy the passive layer. A 24-h air passivation after grinding or pickling is sufficient to minimize these differences **(8)**.

4.4.4 The procedures in Methods C, D, E and F for measuring critical pitting corrosion temperature and critical crevice corrosion temperature have no bias because the values are defined only in terms of these test methods.

5. Apparatus

5.1 *Glassware*—Methods A, B, C, D, E, and F provide an option to use either wide mouth flasks or suitable sized test tubes. Condensers are required for elevated temperature testing when solution evaporation may occur. Glass cradles or hooks also may be required.

5.1.1 *Flask Requirements*, 1000-mL wide mouth. Tall form or Erlenmeyer flasks can be used. The mouth of the flask shall have a diameter of about 40 mm (1.6 in.) to allow passage of the test specimen and the support.

5.1.2 *Test Tube Requirements*, the diameter of the test tube shall also be about 40 mm (1.6 in.) in diameter. If testing requires use of a condenser (described below), the test tube length shall be about 300 mm (about 12 in.); otherwise, the length can be about 150 to 200 mm (about 6 in. to 8 in.).

5.1.3 *Condensers, Vents and Covers*:

5.1.3.1 A variety of condensers may be used in conjunction with the flasks described in 5.1.1. These include the cold finger-type (see, for example, Practices A 262, Practice C) or Allihn type condensers having straight tube ends or tapered ground joints. Straight end condensers can be inserted through a bored rubber stopper. Likewise, a simple U tube condenser can be fashioned.

NOTE 2—The use of ground joint condensers requires that the mouth of the flask have a corresponding joint.

5.1.3.2 *U Tube Condensers*, fitted through holes in an appropriate size rubber stopper can be used in conjunction with the 300-mm test tube described in 5.1.2.

5.1.3.3 When evaporation is not a significant problem, flasks can be covered with a watch glass. Also, flasks as well as test tubes can be covered with loosely fitted stoppers or plastic or paraffin type wraps.

NOTE 3—Venting must always be considered due to the possible build up of gas pressure that may result from the corrosion process.

5.1.4 *Specimen Supports*:

5.1.4.1 One advantage of using test tubes is that specimen supports are not required. However, placement of the specimen does create the possible opportunity for crevice corrosion to occur along the edge.

NOTE 4—See 14.2 concerning edge attack.

5.1.4.2 When using flasks, specimens can be supported on cradles or hooks. Cradles, such as those shown in Fig. 1, eliminate the necessity for drilling a support hole in the test specimen. While the use of hooks requires that a specimen support hole be provided, the hooks, as contrasted to the cradle, are easier to fashion. Moreover, they create only one potential crevice site whereas multiple sites are possible with the cradle.

NOTE 5—A TFE-fluorocarbon cradle may be substituted for glass.

5.1.4.3 The use of supports for Methods B, D, and F crevice corrosion specimens is optional.

5.2 *Water or Oil Bath*, constant temperature.

5.2.1 For Methods A and B, the recommended test temperatures are 22 ± 2°C or 50 ± 2°C, or both.

5.2.2 For Methods C, D, E, and F, the bath shall have the capability of providing constant temperature between 0°C and 85°C ± 1°C.

5.3 *Crevice Formers—Method B*:

5.3.1 *Cylindrical TFE-fluorocarbon Blocks*, two for each test specimen. Each block shall be 12.7-mm (0.5 in.) in diameter and 12.7-mm high, with perpendicular grooves 1.6-mm (0.063 in.) wide and 1.6-mm deep cut in the top of each cylinder for retention of the O-ring or rubber bands. Blocks can be machined from bar or rod stock.

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

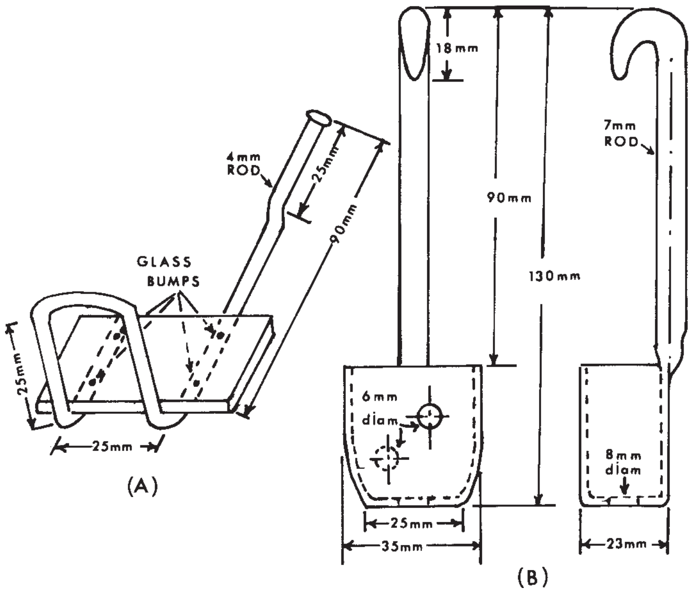


FIG. 1 Examples of Glass Cradles that Can Be Used to Support the Specimen

5.3.2 *Fluorinated Elastomers O-rings, or Rubber Bands,* (low sulfur (0.02 % max)), two for each test specimen.

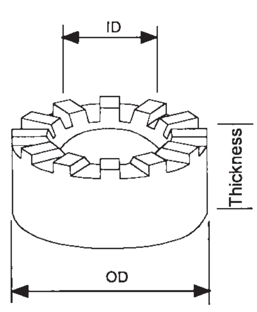
NOTE 6—It is good practice to use all O-rings or all rubber bands in a given test program.

5.3.2.1 O-rings shall be 1.75 mm (0.070 in.) in cross section; one ring with an inside diameter of about 20 mm (0.8 in.) and one with an inside diameter of about 30 mm (1.1 in.). Rubber bands shall be one No. 12 (38-mm (1.5-in.) long) and one No. 14 (51-mm (2-in.) long).

NOTE 7—Rubber bands or O-rings can be boiled in water prior to use to ensure the removal of water-soluble ingredients that might affect corrosion.

5.4 *Crevice Formers—Methods D and F*:

5.4.1 *A Multiple Crevice Assembly (MCA)*, consisting of two TFE-fluorocarbon segmented washers, each having a number of grooves and plateaus, shall be used. The crevice design shown in Fig. 2 is one of a number of variations of the multiple crevice assembly that is in use and commercially available.[8]



Crevice Washer Dimensions							
	ID		OD		Thickness		Number of Slots
Type	mm	in	mm	in	mm	in	
A	6.73	0.265	15.9	0.625	2.54	0.100	12
B	6.73	0.265	15.9	0.625	6.34	0.250	12
C	9.92	0.391	15.9	0.625	6.34	0.250	12

FIG. 2 TFE-fluorocarbon Crevice Washers

5.4.2 *Reuse of Multiple Crevice Assemblies*, when assembled to the specified torque, the TFE-fluorocarbon segmented washers should not deform during testing. Before reuse, each washer should be inspected for evidence of distortion and other damage. If so affected, they should be discarded. In some cases, the crevice formers may become stained with corrosion products from the tested alloy. Generally, this staining can be removed by immersion in dilute HCl (for example, 5-10% by volume) at room temperature, followed by brushing with mild detergent and through rinsing with water.

5.4.3 *Fasteners*, one alloy UNS N10276 (or similarly resistant alloy) fastener is required for each assembly. Each assembly comprises a threaded bolt and nut plus two washers. The bolt length shall be sized to allow passage through the mouth of the glassware described in 5.1.

5.5 *Tools and Instruments*:

5.5.1 A 6.35-mm (¼-in.) torque limiting nut driver is required for assembly of the Methods D and F crevice test specimen.

5.5.2 *Low Power Microscope*, (for example, 20× magnification) for pit detection.

5.5.3 *Needle Point Dial Depth Indicator or Focusing Microscope*, to determine the depth of pitting or crevice corrosion, or both.

5.5.4 *Electronic Balance* (optional), to determine specimen mass to the nearest 0.0001 g.

5.5.5 *Camera* (optional), to photographically record the mode and extent of any localized corrosion.

[8] The sole source of supply of the apparatus known to the committee at this time is Metal Samples Co., Inc., P.O. Box 8, Route 1 Box 152, Munford, AL 36268. If you are aware of alternative suppliers, please provide this information to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.