Designation: G157 – 98 (Reapproved 2018)

Standard Guide for Evaluating Corrosion Properties of Wrought Iron- and Nickel-Based Corrosion Resistant Alloys for Chemical Process Industries[1]

This standard is issued under the fixed designation G157; 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 guide covers an evaluation approach that is designed to provide information on the corrosion properties of wrought iron- and nickel-based alloys for the chemical process industries. This guide incorporates test conditions for general corrosion measurements in a variety of environments, crevice corrosion resistance in chloride environments, and stress corrosion cracking resistance in chloride environments.

1.2 The values stated in SI units are to be regarded as 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, health, and environmental practices and to determine the applicability of regulatory limitations prior to use.*

1.4 *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

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

G15 Terminology Relating to Corrosion and Corrosion Testing (Withdrawn 2010)[3]

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

G36 Practice for Evaluating Stress-Corrosion-Cracking Resistance of Metals and Alloys in a Boiling Magnesium Chloride Solution

G46 Guide for Examination and Evaluation of Pitting Corrosion

G48 Test Methods for Pitting and Crevice Corrosion Resistance of Stainless Steels and Related Alloys by Use of Ferric Chloride Solution

G123 Test Method for Evaluating Stress-Corrosion Cracking of Stainless Alloys with Different Nickel Content in Boiling Acidified Sodium Chloride Solution

3. Terminology

3.1 Terms such as *crevice corrosion, stress corrosion cracking*, and *corrosion rate* are defined in Terminology G15.

4. Significance and Use

4.1 This guide is intended to provide a series of evaluations that will assist engineers dealing with chemical environments in selecting appropriate alloys (**1-3**). In chemical environments, an important issue for determining general corrosion resistance is the temperature at which an alloy transitions from corrosion at a low rate to corrosion at a much higher rate. Other important concerns include the tendency towards crevice corrosion and stress corrosion cracking resistance, especially in hot chloride-containing aqueous environments.

4.2 This guide is also intended for alloy developers to assist them in choosing environments and test methods that are of particular interest to the chemical process industries.

4.3 The use of this approach will allow direct comparisons to be made among alloys from various suppliers and, thereby, to assist engineers in selecting the most appropriate materials for further testing to determine suitability in their application.

[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.

5. General Corrosion Resistance

5.1 The general corrosion resistance of nickel- and iron-based alloys is determined in 14 test solutions at various temperatures to determine the lowest temperature at which the corrosion rate exceeds 0.13 mm/y (5 mpy). The test solutions are listed in Table 1. A suggested procedure is provided in Appendix X1. The test is run on three coupons of metal for each environment. The tests are run for two 48-h exposures with one specimen exposed for the total 96 h. Welded specimens may be used if results are required on weldments.

5.2 The corrosion rates are based on mass loss measurements with appropriate conversion to thickness loss as shown in Appendix X1.

5.3 The results of the tests in each solution should be reported on a summary results sheet. A typical format is shown in Fig. 1 and Fig. 2.

6. Six Percent Ferric Chloride Solution Critical Crevice Corrosion Temperature

6.1 The crevice corrosion resistance of each alloy is to be evaluated as described in Test Methods G48, Method D. The standard exposure period of 72 h is to be used. Mass loss results are also to be obtained and reported in this environment.

6.2 The results of this test are to be reported as discussed in Test Methods G48. The results should also be entered on the summary results sheet shown in Fig. 3.

7. Chloride Stress Corrosion Resistance

7.1 The resistance to chloride stress corrosion cracking is an important characteristic of alloys used in the chemical process industries. Two environments are provided to evaluate and report chloride stress corrosion cracking behavior—acidified sodium chloride and magnesium chloride. The magnesium chloride environment is highly acidic and, as a consequence, tends to cause many suitably resistant alloys to fail. The acidified sodium chloride environment gives results closer to experience in cooling water and process water environments.

7.2 *Acidified Sodium Chloride Test*—Test Method G123 should be used to evaluate all alloys for resistance to chloride stress corrosion cracking. The specimen design suggested in Test Method G123 should be used, if possible. This design is based on the Practice G30 U-bend and the tests should be carried out with at least triplicate specimens for a period of 1000 h. The results are to be reported as described in Test Method G123 and entered on the summary results sheet. See Fig. 3.

7.3 *Magnesium Chloride Test, Optional*—Alloys that do not crack in the acidified sodium chloride environment may be tested in a magnesium chloride test. The test environment is described in Practice G36. U-bend specimens similar to those suggested in Test Method G123 should be used with triplicate replication. The test should be run for 30 days or until cracking is observed. The specimens should be removed at convenient intervals not to exceed three days during exposure and examined for cracking. The time to first crack is reported. Metallographic sectioning is to be carried out on at least one of each set of replicates at the end of the exposure to document the crack morphology or, in the case of surviving specimens, that no microcracks are present. The result of this test is to be reported on the summary results sheet (Fig. 3).

8. Report

8.1 The results of these tests are to be reported as specified in the test method referenced. The summary results sheets

TABLE 1 Fourteen Environments for Evaluating General Corrosion Resistance

Corrodent	Formula	Concentration, %[A]
Hydrochloric Acid	HCl	0.2, 1.0, 5.0
Sulfuric Acid	H_2SO_4	10, 60, 96[B]
Nitric Acid	HNO_3	10, 70[B]
Phosphoric Acid	H_3PO_4	85[B]
Formic Acid	HCOOH	50
Acetic Acid	CH_3COOH	80
Sodium Hydroxide	NaOH	50
Hydrochloric Acid + Ferric Chloride	HCl + $FeCl_3$	1.0 HCl + 0.3 $FeCl_3$[C]
Acetic Acid + Acetic Anhydride	$CH_3COOH + (CH_3CO)_2O$	50/50

[A] All chemicals are ACS reagent grade mixed with Specification D1193 Type 4 reagent water.
[B] Undiluted reagent grade acid may be used.
[C] Ferric chloride concentration calculated on anhydrous basis.

Commercial Designation UNS Number
Heat Treatment Designation

Manufacturer:	XXX
Common Trade Designations:	XXX
Nominal Composition - Mass %	Cr Ni Mo etc.
Mechanical Properties:	
Yield Strength	MPa (ksi)
Tensile Strength	MPa (ksi)
Elongation	%
Reduction in Area	%
Hardness	
Analysis of Specimen	
Test Condition - (Heat Treatment)	

FIG. 1 Summary Results Form - Alloy Description

Corrodent	Material: % (mass/mass)	Temp.[A] °C	Corrosion Rates, mm/y (mpy) 0 - 48 h	48 - 96 h	0 - 96 h	Remarks
HCl	0.2					
	1.0					
	5.0					
HCl + $FeCl_3$	1.0 0.3					
H_2SO_4	10					
	60					
	96					
HNO_3	10					
	70					
H_3PO_4	85					
HCOOH	50					
CH_3COOH	80					
CH_3COOH + $(CH_3CO)_2O$	50 50					
NaOH	50					

[A] An entry to be made for each environment where the corrosion rate is below 0.13 mm/y and at the next higher temperature where the corrosion rate exceeds 0.13 mm/y

FIG. 2 Summary Results Form - General Corrosion Resistance