

Standard Method of Test for Exfoliation Corrosion Susceptibility in 7XXX Series Copper-Containing Aluminum Alloys (Exco Test) (G34-72)¹

1. Scope

1.1 This method describes a procedure for constant immersion exfoliation (Note 1) corrosion testing of high strength 7XXX series aluminum alloys containing 1.2 to 2.8 % copper.

NOTE 1—The term exfoliation is used to describe that form of corrosion which proceeds laterally from the sites of initiation along planes, generally grain boundaries, parallel to the surface. The resulting corrosion products force the metal upwards giving rise to a layered appearance to the surface.²

1.2 This method applies only to wrought products such as sheet, plate, extrusions, and forgings.

1.3 This method of test can be used with any form of specimen or part that can be immersed in the test solution.

2. Summary of Method

2.1 This test involves continuous immersion of the specimens for 48 h at 25 ± 3 C (77 ± 5 F) in a solution containing 4 M sodium chloride, 0.5 M potassium nitrate, and 0.1 M nitric acid.

3. Significance

3.1 Use of this method should provide a reliable prediction of the exfoliation corrosion behavior of Al-Zn-Mg-Cu alloys in all types of service, including marine environments.

4. Apparatus

4.1 Any suitable glass, plastic, or similarly inert container can be used to contain the solution and specimens during the period of test. Depending upon the shape and size of the specimens, rods or racks of glass, plastic, or any inert substance shall be used to support the specimen above the bottom of the container. The container should be fitted with a loose-fitting cover to reduce evaporation.

5. Reagents

5.1 *Purity of Reagents*—The test solution shall be prepared with reagent grade sodium chloride (NaCl), potassium nitrate (KNO₃), and nitric acid (HNO₃).

5.2 *Purity of Water*—Distilled or deionized water conforming to ASTM Specification D 1193, for Reagent Water, Type II reagent water should be used to prepare the test solution.

5.3 A test solution of the following composition shall be used:

NaCl	(4.0 M)
KNO ₃	(0.5 M)
HNO ₃	(0.1 M)

Dissolve 234 g of NaCl, 50 g of KNO₃ in water, and add 6.3 ml of concentrated HNO₃ (70 weight percent). Dilute to 1 litre. This solution has an apparent pH of 0.4.

5.4 Solution shall be used in sufficient quantity to provide a volume to specimen surface area ratio of at least 50 ml/in.² (6.5 cm²). Unless the edges and the back of the specimens are masked, their area must be included in the determination of total surface area. Maskants must have good adherence to avoid crevice corrosion underneath the coating.

5.5 The solution shall be maintained at a temperature of 25 ± 3 C.

6. Test Specimens

6.1 Specimens may be of any practical size or shape. Nevertheless, for the results to be of most significance a minimum size of 2 by 4 in. (51 by 102 mm), or the equivalent, is recommended.

6.2 The edges of sawed specimens need not be machined but specimens obtained by blanking or shearing shall have edges dressed by machining or filing to a depth equal to the thickness of the specimen to remove cold worked metal.

7. Standardization

7.1 To ensure that some inadvertent change does not result in deviation from the correct test conditions, it is necessary to expose to the test at regular intervals a control specimen from a material of known resistance. This control should exhibit the same degree of exfoliation each time it is included in the test.

7.2 The control may be any material of the Al-Zn-Mg-Cu series that has a well-documented susceptibility to exfoliation corrosion.

8. Procedure

8.1 Degrease the specimens thoroughly prior to testing. No etching or other pretreatment is necessary.

8.2 Use fresh solution at the start of each test.

8.3 Immerse the specimens in the solution using rods or racks of inert material to support the specimens above the bottom of the container. The horizontal orientation of the test surface is preferred in order to prevent loss of corrosion products from the surface of the specimen.

8.4 Immerse the specimens for 48 h without change of solution. Inspect specimens (without cleaning) within 6 to 24 h, and discontinue the exposure of specimens showing definite exfoliation (Fig. 2) at that time.

8.5 Clean the specimens as soon as possible after removal from test by rinsing in water, soaking in concentrated HNO₃ for 30 min, rinsing again in water, and air drying.

¹ This method is under the jurisdiction of ASTM Committee G-1 on Corrosion of Metals.

² Ketcham, Sara J., and Jeffrey, Paul W., "Exfoliation Corrosion Testing of 7178 and 7075 Aluminum Alloys" (Report of ASTM G01.05 Interlaboratory Testing Program in Cooperation with the Aluminum Association); and Sprowls, D. O., Walsh, J. D., and Shumaker, M. B., "Simplified Exfoliation Testing of Aluminum Alloys," *Localized Corrosion—Cause of Metal Failure, ASTM STP 516*, Am. Soc. Testing Mats., 1972.

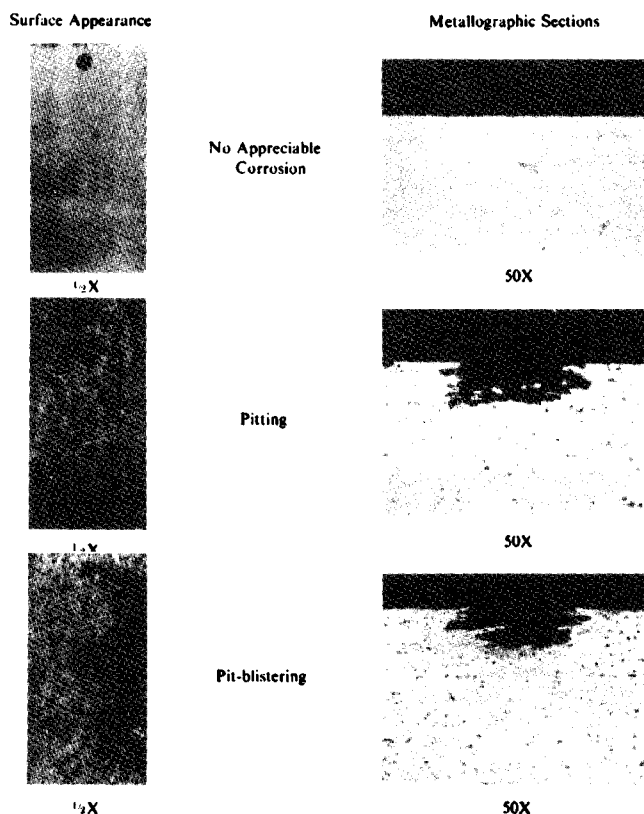


FIG. 1 Surface Appearance and Metallographic Sections of Specimens Not Susceptible to Exfoliation

9. Interpretation of Results

9.1 The following codes and classifications should be used when reporting the visual examination of corroded specimens:

Code	Classification
N	no appreciable attack
P	pitting
E	exfoliation

9.2 Descriptions of the various classifications, which are illustrated in Figs. 1 and 2,³ are as follows:

9.2.1 *N*—No appreciable attack: Surface may be etched or discolored (Fig. 1).

9.2.2 *P*—Pitting: Includes discrete pitting or pit-blistering. In the latter case, attack results in a slight undercutting of the surface. With this test such attack, pitting or pit-blistering, is to be expected on commercially produced alloys of the type under consideration. This type of attack should not be construed as exfoliation because it is essentially pitting with a slight tendency for blistering around the edges (Fig. 1).

9.2.3 *E*—Exfoliation: Visible lifting of the surface. A range of exfoliation can occur of varying degrees of severity, as shown in Fig. 2.

9.3 When it is difficult to classify a specimen it is advisable to place it in the category of greater susceptibility.

10. Report

10.1 The report should contain the following essential information:

- 10.1.1 Alloy identification,
 - 10.1.2 Product and temper of material tested, including reference to applicable product specification,
 - 10.1.3 Sampling procedure if other than that specified in referenced product specification,
 - 10.1.4 A rating of the test specimens using the “Code” and “Classification” given in 9.1, and
 - 10.1.5 Notation of any deviation in test procedure from that set forth in preceding paragraphs.
- 10.2 Other information that may be desirable for certain types of reports includes:
- 10.2.1 Size, type, and number of replicate specimens; method of edge preparation,
 - 10.2.2 Volume to surface ratio,
 - 10.2.3 Treatment used to clean the specimens before exposure, and
 - 10.2.4 Classification of the severity of exfoliation using the four categories illustrated in Fig. 2.

³ Enlarged glossy prints of Figs. 1 and 2 are available from ASTM Headquarters at a nominal charge. Request Adjunct No. 12-700340-00.

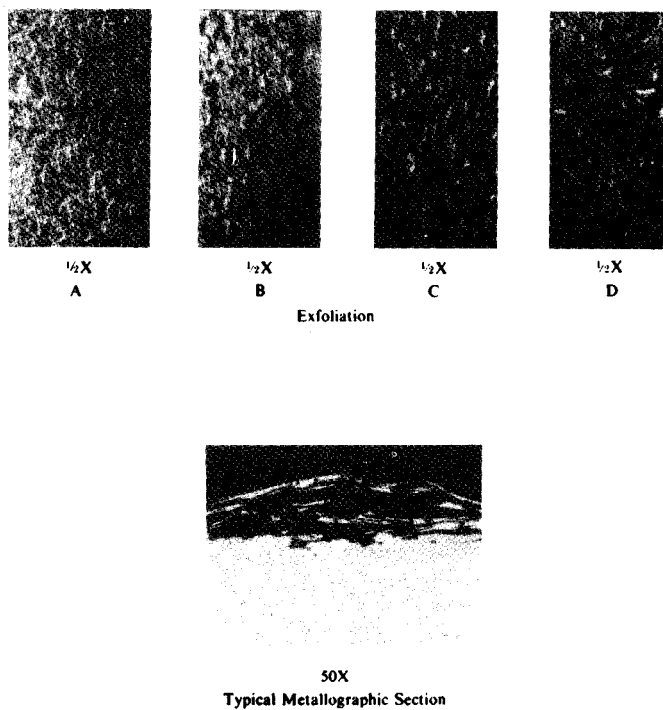


FIG. 2 Four Degrees of Severity of Exfoliation Corrosion

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