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Standard Guide for Conducting Exfoliation Corrosion Tests in Aluminum Alloys[1]

This standard is issued under the fixed designation G112; 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 differs from the usual ASTM standard in that it does not address a specific test. Rather, it is an introductory guide for new users of various standard exfoliation test methods with consideration for specific aluminum alloy families (see Terminology G193 for definition of exfoliation).

1.2 This guide covers aspects of specimen preparation, exposure, inspection, and evaluation for conducting exfoliation tests on aluminum alloys in both laboratory accelerated environments and in natural, outdoor atmospheres. The intent is to clarify any gaps in existent test methods.

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]

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

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

G50 Practice for Conducting Atmospheric Corrosion Tests on Metals

G66 Test Method for Visual Assessment of Exfoliation Corrosion Susceptibility of 5XXX Series Aluminum Alloys (ASSET Test)

G85 Practice for Modified Salt Spray (Fog) Testing

G92 Practice for Characterization of Atmospheric Test Sites

G193 Terminology and Acronyms Relating to Corrosion

2.2 *ASTM Adjunct:*[3]

Illustrations of Appearance Classifications (6 glossy photos)

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *panel, n*—a flat, rectangular specimen normally taken with the test surface parallel to the longitudinal and long-transverse dimensions of fabricated product. For thin sheet and extrusions, the thickness may be the full thickness of the part.

3.1.2 *sample, n*—a portion of a large piece, or an entire piece out of a group of many pieces, that is submitted for evaluation and considered representative of the larger piece or population. For castings and forgings, this may be an extra portion or prolongation, or in the case of small parts, an entire extra piece taken from a specific lot.

3.1.3 *specimen, n*—the actual test piece to be corrosion tested. Frequently this has a specific shape with prescribed dimensional tolerances and finishes.

3.1.4 *test plane, n*—the plane in the thickness of the sample that is being tested. Generally this is the fabricated surface or some specified interior plane. Interior planes typically used are: (*a*) T/10 = 10 % of the thickness removed, (this is representative of a minimal machining cut to obtain a flat surface), (*b*) T/4 = quarter plane, 25 % of the thickness removed, and (*c*) T/2 = midplane, 50 % of the thickness removed.

4. Significance and Use

4.1 Although there are ASTM test methods for exfoliation testing, they concentrate on specific procedures for test methodology itself. Existent test methods do not discuss material variables that can affect performance. Likewise they do not address the need to establish the suitability of an accelerated test for alloys never previously tested nor the need to correlate

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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] Available from ASTM International Headquarters. Order Adjunct No. ADJG003402-E-PDF. Original adjunct produced in 1980.

results of accelerated tests with tests in outdoor atmospheres and with end-use performance.

4.2 This guide is a compilation of the experience of investigators skilled in the art of conducting exfoliation tests and assessing the degree and significance of the damage encountered. The focus is on two general aspects: guides to techniques that will enhance the likelihood of obtaining reliable information, and tips and procedures to avoid pitfalls that could lead to erroneous results and conclusions.

4.3 The following three areas of testing are considered: the test materials starting with the "as-received" sample up through final specimen preparation, the corrosion test procedures including choice of test, inspection periods, termination point, and rating procedures, and analyses of results and methods for reporting them.

4.4 This guide is not intended as a specific corrosion test procedure by which to evaluate the resistance to exfoliation of an aluminum alloy product.

4.5 This guide is not intended as a basis for specifications, nor as a guide for material lot acceptance.

5. Sample

5.1 *Sample Size*—Most exfoliation tests do not require any particular specimen size but, when beginning a new investigation, it is best to obtain considerably more material than the minimum amount needed. About 50 % to 100 % overage is recommended. This avoids the need of procuring a second sample, that may have a different response, to complete any confirmatory retests or extensions to a specific program.

5.2 *Sample Reproducibility*—The specific location of samples in a mill product, and the number of samples to take are beyond the scope of this guide. When testing large production items, a typical procedure is to test at both ends (front and rear), and to test at the side and at the mid-width if the product is 0.6 m (2 ft) or more in width. Thick products should be tested at various planes through the thickness.

5.2.1 In addition, some assessment should be made of the uniformity of a large sample, or of numerous small samples. Typical quick check methods would be to measure electrical conductivity or hardness. If the material variability has a pattern, for example, a difference between front and rear of a long extrusion, then this should be noted and the specimens segregated accordingly. If the variability is random, then multiple test specimens should be randomized.

5.3 *Sample Microstructure*—The directionality of the grain structure of aluminum alloys will markedly affect the susceptibility to exfoliation. When a product shape and alloy are being tested for the first time, it is advisable to macroetch full thickness by longitudinal and by transverse slices to establish the directionality and uniformity of the grain structure. Test panels are normally positioned such that the test surface is parallel to the plane in the product with the most elongated grain structure. Complex shaped parts, such as certain extrusions or die forgings, may have several categories of grain structures and grain flow that do not necessarily follow the part geometry. Grain structure of such parts must be determined by macroetching or from prior experience.

5.3.1 For a given temper condition, unrecrystallized, pancake-shaped grains, that are long and wide but relatively thin, are the most susceptible. Pancake-shaped recrystallized grains, as in sheet, are the next most susceptible. This is followed by the long, rod-shaped grains found in extruded or rolled rod and bar with a symmetrical cross section, for example, circle, square, hex, or a rectangle with the width not more than twice the thickness. An equiaxed grain structure is the least susceptible to exfoliation, especially if the grain size is large. Often the recrystallized surface layer on products such as extrusions, forgings, or sheet will not exfoliate, even though it corrodes intergranularly.

5.4 *Sample Temper*—When a large sample is obtained as a stock item for use over a long time period, the extra material should be stored in a stable temper and at a low enough temperature so that no further precipitation will occur to alter the starting condition of the metal. The unaged W temper of 7XXX alloys is not stable and will continue to age harden at room temperature. Room temperature storage of such material should be limited to a couple of months at most. Natural aging of these alloys can be retarded almost completely by storing the material in a freezer at −40 °C (−40 °F) or colder. This factor is of even more importance in determination of mechanical properties than the investigation of corrosion resistance. An alternative practice is to use a standard first-step age that will stabilize the material and allow for variations in the subsequent second and third aging steps.

6. Selection of an ASTM Test Method

6.1 Selection of the appropriate ASTM test method(s) to use will depend primarily on the type of alloy and on the end-use environment. When testing a new alloy or temper, a test method known to be applicable to the most similar commercial alloy is normally selected. The user is cautioned, however, that even small changes in alloy chemical composition, or changes in processing method (for example, rapid solidification processes) can markedly effect resistance of an alloy and the appropriateness of a test method. Normally exfoliation tests are conducted on ingot metallurgy alloys, that tend to have the elongated grain structure prone to exfoliate. The known alloy applicability of the ASTM test methods are listed below. Included are some observed instances where a test method was found to be inappropriate, or at least produced results different than those observed on the initial qualification alloys.

6.1.1 It is advisable to initially employ more than one laboratory test method and determine whether they agree; or if not, which method is the most discriminating. One procedure for doing this is to apply different fabrication procedures to the metal that are known to generally affect resistance to exfoliation and determine which of the test methods best detects differences in the corresponding resistance to exfoliation.