Designation: G67 – 24

Standard Test Method for Determining the Susceptibility to Intergranular Corrosion of 5XXX Series Aluminum Alloys by Mass Loss After Exposure to Nitric Acid (NAMLT Test)[1]

This standard is issued under the fixed designation G67; 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 test method, also known as the Nitric Acid Mass Loss Test (NAMLT), covers a procedure for constant immersion intergranular corrosion testing of 5XXX series aluminum alloys.

1.2 This test method is applicable only to wrought products.

1.3 This test method covers type of specimen, specimen preparation, test environment, and method of exposure.

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

1.6 *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

E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

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

G16 Guide for Applying Statistics to Analysis of Corrosion Data

3. Summary of Test Method

3.1 This test method consists of immersing test specimens in concentrated nitric acid at 30 °C (86 °F) for 24 h and determining the mass loss per unit area as a measure of susceptibility to intergranular corrosion.

4. Significance and Use

4.1 This test method provides a quantitative measure of the susceptibility to intergranular corrosion of Al-Mg and Al-Mg-Mn alloys. The nitric acid dissolves a second phase, an aluminum-magnesium intermetallic compound (βAl-Mg), in preference to the solid solution of magnesium in the aluminum matrix. When this compound is precipitated in a relatively continuous network along grain boundaries, the effect of the preferential attack is to corrode around the grains, causing them to fall away from the specimens. Such dropping out of the grains causes relatively large mass losses of the order of 25 mg/cm^2 to 75 mg/cm^2 (160 mg/in.^{2} to 480 mg/in.^{2}), whereas, samples of intergranular-resistant materials lose only about 1 mg/cm^2 to 15 mg/cm^2 (10 mg/in.^{2} to 100 mg/in.^{2}). When the βAl-Mg compound is randomly distributed, the preferential attack can result in intermediate mass losses. Metallographic examination is required in such cases to establish whether or not the loss in mass is the result of intergranular attack.

4.2 The precipitation of the second phase in the grain boundaries also gives rise to intergranular corrosion when the material is exposed to chloride-containing natural environments, such as seacoast atmospheres or sea water. The extent to which the alloy will be susceptible to intergranular corrosion depends upon the degree of precipitate continuity in the grain boundaries. Visible manifestations of the attack may

[1] This test method 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. This method was developed by a joint task group with The Aluminum Association, Inc.

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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.

be in various forms such as pitting, exfoliation, or stress-corrosion cracking, depending upon the morphology of the grain structure and the presence of sustained tensile stress.[3]

5. Interferences

5.1 If all loose particles are not removed during cleaning after exposure, the mass loss will be low relative to the amount of corrosion that actually occurred.

6. Apparatus

6.1 *Nonmetallic Container*—A suitable inert, nonmetallic container should be used to contain the nitric acid and specimens during the period of the test. The use of individual beakers for each specimen is recommended; however, the immersion of multiple specimens in the same container is acceptable.

6.1.1 The specimens should be situated in the container so that none of the major surfaces is in total contact with the walls of the container. Also, specimens should be isolated electrically from one another. A recommended method of positioning the specimens is to incline them so that the edges rest on the bottom and side wall of the container. See Figs. 1 and 2 for an example of the recommended configuration, using a 100 mL non-fluted beaker and a watchglass cover for each specimen with the beakers immersed in a water bath. This method is considered to be the optimal configuration for this test method.[4]

6.1.2 The container should have a loose fitting cover to reduce evaporation and to confine any fumes evolved by the acid.

6.2 *Laboratory-Grade Water Bath*—This test method requires precise temperature control (see 8.2 for tolerances on test temperature). It is highly recommended that a laboratory-grade water bath be used. An ideal configuration of specimens and water bath are shown in Figs. 1 and 2.

6.3 *Temperature Measuring Device*—Given the extreme sensitivity to temperature fluctuations, it is recommended that the temperature be measured continuously with a recording temperature measurement device.

6.4 *Ultrasonic Bath*—The corroded specimens will be cleaned using an ultrasonic cleaning bath (see 11.7). Such ultrasonic cleaning baths are available from all of the common laboratory supply companies and typically have an operating frequency of 40 kHz and 15 W⁄L to 50 W⁄L ultrasonic power.

7. Reagents

7.1 *Purity of Reagents*—The nitric acid (HNO_3) test solution shall be reagent grade within the range of 69 w⁄w % to 70 w/w %. The sodium hydroxide (NaOH) solution used for etching and the HNO_3 (67 w⁄w % to 70 w⁄w %) used for desmutting shall also be reagent grade.

FIG. 1 Recommended Configuration for Specimen Exposure; A 100 mL Non-fluted Beaker and Watchglass

7.2 *Purity of Water*—Use water conforming to Specification D1193 Type IV to prepare the NaOH solution and for rinsing and ultrasonic cleaning purposes.

8. Test Solution

8.1 Use sufficient test solution to fully immerse the specimens and constitute a volume to specimen surface area ratio of at least 30 L/m^2 (19 mL/$in.^2$).

8.2 Maintain the test solution temperature at 30 °C ± 0.1 °C (86 °F ± 0.2 °F).

9. Sampling

9.1 The specific location of samples in a mill product, the number of samples that should be tested, and so forth, are outside the scope of this standard.

[3] Craig, H. L. Jr., "Nitric Acid Weight Loss Test for the H116 and H117 Tempers of 5086 and 5456 Aluminum Alloys," *Localized Corrosion—Cause of Metal Failure, ASTM STP 516*, ASTM, 1972, pp. 17–37.

[4] Aluminum Association Technical Report T1, "Exfoliation Corrosion Testing of Aluminum Alloys 5086 and 5456," T.J. Summerson, D.O. Sprowls. Published circa 1975. Currently out-of-print. Hard copies can be acquired from the Aluminum Association.