



Designation: D 6412/D 6412M – 99

# Standard Specification For Epoxy (Flexible) Adhesive For Bonding Metallic And Nonmetallic Materials<sup>1</sup>

This standard is issued under the fixed designation D 6412/D 6412M; 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 reappraisal. A superscript epsilon (ε) indicates an editorial change since the last revision or reappraisal.

## 1. Scope

1.1 The specification covers a two-part modified epoxy paste adhesive for bonding metallic and nonmetallic materials. The adhesive should be suitable for forming bonds that can withstand environmental exposure to temperatures from –184 to 82 °C (–300 to 180 °F) when exposed to an expected combination of stress, temperature, and relative humidity to be encountered in service.

NOTE 1—When coordinated through the Department of Defense (DoD) and the National Aeronautics and Space Administration (NASA), this practice will be a direct replacement of MIL-A-82720 (OS), MIS-26872, and MSFC-SPEC-2037.

1.2 The values stated in SI units or inch-pound units are to be regarded separately as standard. Within the text, the inch-pound units are shown in brackets. The values stated in each system are not exact equivalents; therefore, each system must be used independently of the other. Combining values from the two systems may result in nonconformance with this specification.

1.3 The following precautionary statement pertains to the test method portion only, Section 8, of this specification: *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 109 Specification for Steel, Strip, Carbon (0.25 Maximum Percent), Cold Rolled<sup>2</sup>
- A 167 Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip<sup>2</sup>
- B 209 Specification for Aluminum and Aluminum Alloy Sheet and Plate<sup>3</sup>

<sup>1</sup> This specification is under the jurisdiction of ASTM Committee D-14 on adhesives and is the direct responsibility of subcommittee D14.80 on Metal Bonding adhesives.

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<sup>2</sup> Annual Book of ASTM Standards, Vol 01.03.

<sup>3</sup> Annual Book of ASTM Standards, Vol 02.02.

D 907 Terminology of Adhesives<sup>4</sup>

D 1002 Test Method for Apparent Shear Strength of Single-Lap-Joint Adhesively Bonded Metal Specimens by Tension Loading (Metal-to-Metal)<sup>4</sup>

D 1876 Test Method for Peel Resistance of Adhesives (T-Peel Test)<sup>4</sup>

D 2240 Test Method for Rubber Property Durometer Hardness<sup>5</sup>

D 2651 Guide for Preparation of Metal Surfaces for Adhesive Bonding<sup>4</sup>

D 3951 Practice for Commercial Packaging<sup>6</sup>

D 4142 Guide for Testing Epoxy Resins<sup>7</sup>

E 595 Test Method for Total Mass Loss and Collected Volatile Condensable Materials from Outgassing in a Vacuum Environment<sup>8</sup>

2.2 National Aeronautics and Space Administration (NASA):<sup>9</sup>

JSC Sp-R-0022 General Specification, Vacuum Stability Requirement of Polymeric Material for Spacecraft Application

MSFC-HDBK-527/JSC-09604 Material Selection List for Hardware Systems

GSFC RP 1124 Outgassing Data for Selecting Spacecraft Materials

NOTE 2—Copies of specifications, standards, drawings and publications required by suppliers in connection with specific purchases should be obtained from the purchaser or as directed by his contracting officer.

## 3. Terminology

3.1 Definitions—Many terms in this specification are defined in Terminology D 907.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 epoxy-polyamide high viscosity adhesive, n—an epoxy paste base (B) and a modified amide paste accelerator (A) when mixed in a proper ratio results in a viscous paste.

<sup>4</sup> Annual Book of ASTM Standards, Vol 15.06.

<sup>5</sup> Annual Book of ASTM Standards, Vol 09.01.

<sup>6</sup> Annual Book of ASTM Standards, Vol 15.09.

<sup>7</sup> Annual Book of ASTM Standards, Vol 06.03.

<sup>8</sup> Annual Book of ASTM Standards, Vol 15.03.

<sup>9</sup> Unless otherwise indicated, copies of the above documents are available from ant NASA installation library or document repository.

3.2.2 *epoxy-polyamide low viscosity adhesive, n*—an epoxy liquid base (B) and a modified amide liquid accelerator (A) when mixed in a proper ratio results in a viscous liquid.

#### 4. Significance and Use

4.1 *General*—This specification provides testing procedures and specimen requirements to differentiate between the physical and adhesive bonding properties of two types of epoxy-polyamide adhesive.

#### 5. Classification

5.1 The epoxy-polyamide adhesive shall be furnished as one of the following types:

5.1.1 *Type I*—Consists of two-part kits of Part B, base and Part A, accelerator.

5.1.1.1 *Grade 1*—The high viscosity adhesive system is composed of an epoxy base (B) and a modified polyamide accelerator (A).

5.1.1.2 *Grade 2*—The low viscosity adhesive system is composed of an epoxy liquid base (B) and a modified polyamide liquid accelerator (A).

5.1.2 *Type II*—Consists of premixed, frozen, Type I, Grade 1 or Type I, Grade 2.

#### 6. Ordering Information

6.1 *Procurement Documents*—Purchasers may select any of the desired options offered herein and the procurement documents should specify the following:

6.1.1 Title, number and dated revision letter of this specification,

6.1.2 Adhesive type and grade numbers,

6.1.3 Amounts and unit quantities of adhesive required,

6.1.4 Curing conditions,

6.1.5 Level of Packaging and packing required, and

6.1.6 Whether or not qualification (see 6.2) is necessary.

6.2 *Qualification*—In the case the adhesives for which the purchaser requires qualification, the procurement documents should state that the awards will be made only for adhesives that are qualified at the time set for opening of bids.

#### 7. Test Requirements

7.1 *Material*—The adhesive shall be thermosetting and, when tested using the tests described in Section 8 shall meet the strength requirements of this specification. The adhesive shall not have a detrimental effect on the surfaces being bonded over the range of temperatures at which the adhesives will be used.

7.2 *Qualification*—The adhesive shall be qualified at the time for opening of bids. The qualification shall only apply to the formulation on which the qualification tests have been made (see 6.2). Any changes by the manufacturer in formulation or in the method of manufacturing, shall be cause of designating the adhesive as a new product.

7.3 *Processing*—Methods of specimen surface preparation, that is, cleaning and etching adherends, cure time, temperature and pressure shall be in accordance with the manufacturer's recommendation.

7.4 The physical, mechanical and outgassing properties of the adhesive shall meet the requirements specified in Table 1.

Although, it is not listed in Table 1, Type II materials shall meet the same requirements as Type I materials.

#### 8. Test Methods

8.1 *Qualification Tests*—For qualification, the adhesive shall be tested using the tests described in this section. Test methods and requirements are included in Table 1.

8.2 *Preparation of Test Specimens:*

8.2.1 *Tensile Shear:*

8.2.1.1 *Adherend*—The metal bonded shall be 6061-T6 or 2024-T3 aluminum alloy.

NOTE 3—The use of steel substrates for the evaluation and lot acceptance of the material is optional at the discretion of the procuring agency. Use A 109 Grade 2 Steel or A 167, Type 302 corrosion resistant steel.

8.2.1.2 *Surface Treatment*—Adherend surfaces shall be cleaned and etched in accordance with Test Method D 2651.

8.2.1.3 *Cure*—Cure time, temperature and pressure shall be in accordance with the adhesive manufacturer's recommendation.

NOTE 4—Test panels or specimens, or both, other than the breakaway type shall be cut in such a manner that minimum vibration or heat is generated during the cutting operation.

NOTE 5—Adhesive bondline thickness for tensile shear specimens shall be 0.05 to 0.13 mm [0.002 in. to 0.005 in.] and 0.25 to 0.43 mm [0.010 to 0.017 in.] for T-Peel specimens. Control of bondline thickness shall be accomplished by placing two lengths of appropriate diameter stainless wire [0.13 mm for tensile shear and 0.43 mm for T-Peel] in the lengthwise direction on the specimen bond area during the adhesive bonding operation; the use of the same diameter glass beads approximately 0.5 % by weight, thoroughly mixed in the adhesive may also be used to maintain uniform bondline thickness.

8.2.2 *Hardness* specimens shall be prepared using a mixture of resin and catalyst for Type I Grades 1 or 2 in the ratios specified by the manufacturer or Type II premixed. Pour the thoroughly mixed material into an aluminum foil cup approximately 7.6 cm [3.0 in.] in diameter to a minimum thickness of 6.3 mm [0.25 in.]; cure per manufacturer's recommendation.

8.3 *Test Procedures:*

8.3.1 *Room-Temperature Tensile Shear*—Subject at least five specimens to a tensile shear test at normal temperature  $25 \pm 3^\circ\text{C}$  [ $77 \pm 5^\circ\text{F}$ ] in accordance with Test Method D 1002.

8.3.2 *High-Temperature Tensile Shear*—Test at least five specimens at  $60 \pm 3^\circ\text{C}$  [ $140 \pm 5^\circ\text{F}$ ] and  $82 \pm 3^\circ\text{C}$  [ $180 \pm 5^\circ\text{F}$ ] in accordance with Test Method D 1002. Bring the specimen to temperature as indicated by a temperature at the bondline and stabilize for 10 min. Stabilize the chamber at the test temperature for 45 min prior to testing.

8.3.3 *Low-Temperature Tensile Shear*—Test at least five specimens at  $55 \pm 3^\circ\text{C}$  [ $-67 \pm 5^\circ\text{F}$ ] in accordance with Test Method D 1002. Bring the specimen to temperature as indicated by a thermocouple at the bondline and stabilize for 10 min. Stabilize the chamber at the test temperature for 45 min prior to testing.

8.3.4 *Room-Temperature T-Peel*—Test at least five specimens in accordance with Test Method D 1876 constructed from 2024-T3 alclad aluminum alloy or 6061-T6 aluminum 0.8 mm [0.032 in.] thick. T-peel specimens shall be etched per D 2651.