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MSFC-SPEC-411
March 1, 1966

GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
SPECIFICATION
ADHESIVE, EPOXY RESIN

This specification has been approved by the George C. Marshall Space Flight Center (MSFC) and is available for use by MSFC and associated contractors.

1. SCOPE

1.1 Scope. - This specification establishes the requirements for epoxy resin adhesives intended for structural bondings on printed circuit boards, components, and connectors.

1.2 Classification. - Adhesives covered by this specification shall be of the following types, as specified (see 6.2).

- (a) Type I. - Room temperature setting (20 to 30 degrees Celsius (°C)); transparent.
- (b) Type II. - Intermediate temperature setting (31 to 75 °C); opaque and unfilled.
- (c) Type III. - High temperature setting (above 75 °C); filled.

2. APPLICABLE DOCUMENTS

2.1 The following documents form a part of this specification to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposals shall apply.

STANDARDS

Federal

FED-STD-406

Plastics; Methods of Testing.

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Military

MIL-STD-129

Marking for Shipment and Storage.

PUBLICATIONS

National Aeronautics and Space Administration

NPC 200-2

Quality Program Provisions for Space System Contractors.

NPC 200-3

Inspection System Provisions for Supplier of Space Materials, Parts, Components, and Services.

(Copies of specifications, standards, drawings, and publications required by contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

2.2 Other publications. - The following documents form a part of this specification to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposals shall apply.

American Society for Testing and Materials

D570-63

Test for Water Absorption of Plastics.

D952-51

Test for Bond Strength of Plastics and Electrical Insulating Materials.

D1002-64

Test for Strength Properties of Adhesives in Shear by Tension Loading (Metal to Metal).

(Application for copies should be addressed to the American Society for Testing and Materials, 1916 Race St., Philadelphia, Pennsylvania 19103.)

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3. REQUIREMENTS

3.1 Qualification. - The materials shall constitute a product that has been tested, has passed the qualification tests specified herein, and has been listed or approved for listing on the applicable qualified products list.

3.2 Samples.

3.2.1 Preproduction. - The preproduction sample, when required (see 6.2), shall be capable of meeting the requirements of this specification.

3.2.2 Acceptance. - The acceptance sample shall meet all the requirements of this specification.

3.3 Materials. - The adhesive material shall be of two parts or more, having an activator separate from the base adhesive. The basic ingredient shall contain a thermosetting resin of the epoxy type. An amine type material may be used as the activator. The activator can be formulated to give a fast or slow reacting time. The activator reacting time will determine the application life of the adhesive, as specified in table I. The adhesives shall be noncorrosive to the surfaces being bonded and shall meet the requirements specified herein.

3.3.1 Filler. - If necessary, a suitable filler may be incorporated in the adhesive. This filler shall be readily dispersible throughout the adhesive during the entire usable storage life, shall be highly resistant to moisture and corrosion, and shall withstand the maximum curing temperature.

3.4 Performance and product characteristics.

3.4.1 Texture. - The activated material shall be free of lumps and coarse particles and shall be capable of being readily applied.

3.4.2 Application life. - When the adhesive is mixed at a temperature of 24 ± 2 °C, the application life shall be as follows:

(a) With use of a fast activator.

(1) Type I - 10 minutes minimum.

(2) Type II - 30 minutes minimum.

(3) Type III - 40 minutes minimum.

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Table I. Physical and electrical properties.

Properties	Requirements		
	Type I	Type II	Type III
Application life (fast activator) (slow activator)	10 minutes (min) 2 hours (min)	30 minutes (min) 2 hours (min)	40 minutes (min) 2 hours (min)
Bond strength (aluminum to aluminum) (fiberglass to fiberglass)	1200 psi (min) 3000 psi (min)	1200 psi (min) 3000 psi (min)	2000 psi (min) 3000 psi (min)
Dielectric constant (1 kHz to 1 MHz)	5.0 (max)	4.0 (max)	5.0 (max)
Dielectric strength	500 volts/ mil (min)	450 volts/ mil (min)	350 volts/ mil (min)
Dissipation factor (1 kHz to 1 MHz)	.01 (max)	.01 (max)	.01 (max)
Hardness (shore D)	80 ±5	90 ±5	90 ±5
Mositure absorption	0.6% (max)	0.6% (max)	0.6% (max)
Nonvolatile content	99% (min)	99% (min)	99% (min)
Shear strength (aluminum to aluminum) (fiberglass to fiberglass)	800 psi (min) 1200 psi (min)	1000 psi (min) 1200 psi (min)	1250 psi (min) 1500 psi (min)
Specific gravity	1.2 (max)	1.2 (max)	1.6 (max)
Surface resistivity	3×10^{12} ohms/cm ² (min)	3×10^{14} ohms/cm ² (min)	3×10^{12} ohms/cm ² (min)

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Table I. Physical and electrical properties (continued).

Properties	Requirements		
	Type I	Type II	Type III
Thermal conductivity	4×10^{-4} cal/sec/ cm ² /°C/cm (min)	1.5×10^{-4} cal/sec/ cm ² /°C/cm (min)	6×10^{-4} cal/sec/ cm ² /°C/cm (min)
Thermal expansion	150×10^{-6} cm/cm/°C (max)	95×10^{-6} cm/cm/°C (max)	100×10^{-6} cm/cm/°C (max)
Viscosity (activated material)	15 poises ±10%	65 poises ±10%	200 poises ±10%
Volume resistivity	4.6×10^{15} ohms/cm/ cm ² (min)	4×10^{15} ohms/cm/ cm ² (min)	4×10^{15} ohms/cm/ cm ² (min)

NOTE: Abbreviations used in this table are defined as follows:

cal	calorie
cm	centimeter
kHz	kilohertz
max	maximum
mHz	megahertz
min	minimum
psi	pounds per square inch
sec	second

(b) With use of a slow activator.

- (1) Type I - 2 hours minimum.
- (2) Type II - 2 hours minimum.
- (3) Type III - 2 hours minimum.

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3.4.3 Storage life. - The adhesive components shall be capable of meeting the requirements of this specification when stored at 24 ± 2 °C for 1 year.

3.4.4 Toxicity. - The materials shall contain no benzene, chlorinated solvents, or other highly toxic materials, either initially or as a product of the curing reaction.

3.4.5 Nonvolatile content. - The minimum nonvolatile content of the material shall be 99 percent by weight.

3.4.6 Appearance. - The activated material shall be homogeneous and free from lumps and coarse particles. There shall be no separation of pigment that cannot be readily dispersed.

3.5 Physical and electrical properties. - The compound shall be capable of meeting the requirements specified in table I when tested in accordance with the applicable test methods of section 4.

3.6 Product marking. - The compound shall be marked as specified in Standard MIL-SID-129.

4. QUALITY ASSURANCE PROVISIONS

4.1 The supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified, the supplier may utilize his own or any other inspection facilities and services acceptable to the procuring activity that are covered by an inspection or quality control plan as required by the applicable NASA Quality Publication NPC 200-2 or NPC 200-3 as referenced in the contract (see 6.2). Unless otherwise specified, the inspection plan as required by NASA Quality Publication NPC 200-3 shall be submitted for review with the supplier's bid or proposal. Inspection and test records shall be kept complete and, upon request, made available to the procuring activity or its designated representative in accordance with NASA Quality Publication NPC 200-2, NPC 200-3, or other provisions of the contract or procurement document. The procuring activity, or its designated representative, reserves the right to perform any or all of the inspections set forth in the specification to ensure that the end item conforms to the prescribed requirements.

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4.2 Lot. - A lot shall consist of adhesive of one type, manufactured at one time in one batch, forming part of one contract or order, and submitted for inspection at the same time and place. A batch shall be that quantity of material that has been subjected to some unit chemical or physical mixing process intended to make the final product substantially uniform.

4.3 Samples.

4.3.1 Preproduction sample. - When preproduction tests are required, the preproduction sample shall consist of two 1-pint kits representative of the identical material and manufacturing process to be used in production. Preproduction sample examinations and tests shall be performed by the contractor under MSFC surveillance, or as directed by the procuring activity, at the installation designated by the contract or order (see 6.2).

4.3.1.1 Preproduction sample rejection. - If any specimen of the preproduction sample fails to meet the requirements of any inspection specified herein, the preproduction sample shall be rejected. Before a new preproduction sample is submitted, a detailed report shall be forwarded to the procuring activity covering the rejection and the action taken to prevent recurrence of the defect causing failure. A reworked preproduction sample shall not be submitted. Production lots will not be considered for acceptance until the preproduction sample has been approved.

4.3.2 Quality assurance sample. - The quality assurance sample shall be selected at random from the lot submitted for MSFC acceptance at any one time. The number of quality assurance samples to be submitted shall be specified in the contract or order. Quality assurance sample examinations and tests shall be performed by the contractor under MSFC surveillance, or as directed by the procuring activity, at the installation designated by the contract or order (see 6.2).

4.3.2.1 Quality assurance sample rejection. - If any specimen of the quality assurance sample fails any inspection specified herein, the entire lot represented by the sample shall be rejected. Before the rejected lot can be resubmitted for acceptance, a detailed report shall be forwarded to the procuring activity covering the rejections and the action taken to prevent recurrence of the defect causing failure. The defect causing failure and the corrective action taken will be the basis for permitting resubmittal. Any reworked lot must be accompanied by a detailed report concerning the previous rejection and corrective action taken.

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4.3.3 Acceptance inspection. - Unless otherwise specified by the procuring activity, an acceptance inspection shall be performed on all lots submitted for acceptance at any one time. The acceptance inspection shall consist of all examinations and acceptance tests specified herein.

4.3.3.1 Acceptance inspection rejection. - Any lot that fails any acceptance inspection shall be rejected. Rejected lots may be resubmitted at the discretion of the procuring activity, after corrective action has been taken. The number and type of defects shall be the basis for permitting resubmittal. Any reworked lots shall be accompanied by a detailed report concerning previous rejection and corrective action taken.

4.4 Test procedures. - Unless otherwise specified by the contract, detailed test procedures including schematic diagrams of test setups and a list of equipment to be utilized for test shall be submitted by the contractor and approved by the procuring activity prior to accomplishment of tests.

4.4.1 Standard test conditions. - Standard test conditions shall be 24 ± 2 °C with 50 ± 5 percent relative humidity. Unless otherwise specified, tests shall be conducted at standard conditions.

4.4.2 Qualification test. - The qualification test shall consist of all the tests specified herein.

4.4.3 Preproduction tests. - The preproduction tests, when required, shall consist of all the acceptance tests specified herein and the following tests. The items submitted to these tests shall be considered unserviceable but may be retained for examination by the procuring activity. All preproduction tests shall be performed on specimens prepared from the preproduction sample.

4.4.3.1 Specific gravity. - The test specimen shall be tested in accordance with method 5012 of Standard FED-STD-406.

4.4.3.2 Dielectric strength. - Five specimens, 4 inches in diameter and 0.050 mil thick, shall be prepared as specified in 4.3.1. The test shall be conducted in accordance with method 4031 of Standard FED-STD-406.

4.4.3.3 Dielectric constant. - Three specimens, 2 inches in diameter and 125 mils thick, shall be cured at standard conditions. The tests shall be conducted in accordance with method 4021 of Standard FED-STD-406.

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4.4.3.4 Volume and surface resistivity. - Three specimens, 4 inches in diameter and 125 mils thick, shall be prepared as specified in 4.3.1. The tests shall be conducted in accordance with method 4041 of Standard FED-STD-406.

4.4.3.5 Moisture absorption. - The moisture absorption test shall be in accordance with procedure A of ASTM D570-63.

4.4.3.6 Bond strength. - The test specimen shall be tested in accordance with ASTM D952-51.

4.4.3.7 Shear strength. - The test specimen shall be tested in accordance with ASTM D1002-64.

4.4.4 Acceptance tests. - Unless otherwise specified by the procuring activity, acceptance tests shall be conducted on all lots submitted for MSFC acceptance.

4.4.4.1 Nonvolatile content. - Fresh adhesion compound shall be transferred immediately to tared containers 1 3/4 inches in diameter and 1/2 inch deep. The compound shall be leveled with the top of the dish. The dish shall be weighed and then exposed to 82 ± 2 °C for 24 ± 1 hours. At this point, weigh to determine conformance to 3.4.5. The percent of nonvolatile content equals the weight of compound after heating times 100 divided by the weight of compound before heating.

4.4.4.2 Viscosity. - A 250-gram sample of mixed compound, consisting of the base material with the addition of a curing agent, shall be used to determine the viscosity. A standard 236 cubic centimeter (1/2-pint) can with its retaining flange removed shall be utilized for testing in conjunction with a Brookfield Viscometer, Model RVF, with a number 7 spindle, operated at 10 revolutions per minute, or with approved equivalent equipment. Viscosity determinations on the mixed compound shall be made within 3 minutes after mixing. The base material and the viscometer shall be at a uniform temperature of 24 ± 2 °C during the test. The base material shall be thoroughly stirred immediately before testing. Readings shall be taken when the pointer first assumes a steady position after release of the clutch to determine conformance to 3.5.

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4.4.4.3 Application life. - The sample of mixed compound used in 4.4.4.2 shall be used to determine the application life of the adhesive as follows:

- (a) If the sample contains a slow activator or if the sample is type II or III with a fast activator, the application life determination shall begin when the viscometer pointer assumes a steady position in 4.4.4.2. Readings shall then be made at 10-minute intervals until a reading of 300 poises is attained. This reading shall be considered as the end of the application life.
- (b) If the sample is type I and contains a fast activator, the application life determination shall begin when the viscometer pointer assumes a steady position in 4.4.4.2. The pointer shall then be observed continuously until a reading of 300 poises is attained. This reading shall be considered as the end of the application life.

4.4.4.4 Hardness. - The hardness tests shall be performed in accordance with method 1083 of Standard FED-STD-406.

5. PREPARATION FOR DELIVERY

5.1 Packaging. - Packaging shall be in accordance with the generally accepted practice of the manufacturer.

5.2 Packing. - All exterior shipping containers shall be of uniform size and shall be designed to ensure that damage to the packaging is prevented during handling and shipping.

5.3 Marking.

5.3.1 Packaging container. - Each packaging container shall display the following information:

- (a) Manufacturer's name and address.
- (b) Name of the product.
- (c) Classification (see 1.2).
- (d) Date of manufacture.
- (e) Quantity of container.

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- (f) Necessary supplemental ingredients.
- (g) Toxic precautions (see 3.4.4).

5.3.2 Packing container. - Each packing container shall be marked as follows:

- (a) Manufacturer's name and address.
- (b) Name and type of product (see 1.2).
- (c) Number of units contained.

6. NOTES

6.1 Intended use. - This specification is intended for use in qualifying adhesive compounds for structural bonding on printed circuit boards, components, and connectors.

6.2 Ordering data. - Procurement documents should specify the following:

- (a) Title, number, and date of this specification.
- (b) Types of adhesives required (see 1.2).
- (c) Whether preproduction sample is required (see 3.2.1).
- (d) Numbers and types of resins required for preproduction sample (see 4.3.1).
- (e) Where preproduction sample test will be accomplished (see 4.3.1).
- (f) Whether quality assurance samples are required (see 4.3.2).
- (g) Where quality assurance tests will be accomplished (see 4.3.2).
- (h) Whether special preservation, packaging, packing and marking is required (see 5.1, 5.2, and 5.3).
- (i) What provisions of the NASA Quality Publications are applicable (see 4.1).

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6.3 Provisions for qualification. - With respect to products requiring qualification, awards shall be made only for such products as have, prior to the bid opening date, been tested and approved for inclusion into the applicable qualified products list whether or not such products have actually been listed by that date. The supplier's attention is called to this requirement. Manufacturers should have the products to be offered to the procuring activity tested for qualification so they may be eligible to be awarded contracts or orders for the products covered by this specification. Requests for information pertaining to qualification of products covered by this specification should be addressed to:

Astrionics Laboratory
George C. Marshall Space Flight Center
Huntsville, Alabama

6.4 Changes, deviations, or waivers. - No technical changes, deviations, or waivers will be made to the requirements of this document without the approval of the cognizant design engineering activity of MSFC. All changes, deviations, or waivers will be submitted to the Technical Writing and Editing Section of the Propulsion and Vehicle Engineering Laboratory (R-P&VE-VNW) for coordination with the cognizant design activity.

Notice. - When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

Custodian:

NASA - George C. Marshall Space
Flight Center

Preparing activity:

George C. Marshall Space
Flight Center

MSFC-SPEC-411
AMENDMENT 1
March 10, 1969

GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SPECIFICATION

ADHESIVE, EPOXY RESIN

This amendment forms a part of the George C. Marshall Space Flight Center (MSFC) Specification MSFC-SPEC-411, dated March 1, 1966, and has been approved by MSFC and is available for use by MSFC and associated contractors.

- (1) Page 6, paragraph 3.4.3: Delete and substitute.

"3.4.3 Storage life. - The adhesive components shall be capable of meeting the requirements of this specification when stored at 24 ± 2 °C for 1 year. Compounds stored longer than the time specified shall be tested within 168 hours prior to actual use for conformance to the acceptance inspection test requirements which shall be the basis for approval or rejection."

- (2) Page 8, paragraph 4.3.3: Delete and substitute:

"4.3.3 Acceptance inspection. - Unless otherwise specified by the procuring activity, an acceptance inspection shall be performed on all lots submitted for acceptance at any one time. The acceptance inspection shall consist of the following tests: Specific gravity (4.4.3.1), nonvolatile content (4.4.4.1), viscosity (4.4.4.2), application life (4.4.4.3), hardness (4.4.4.4), and shear strength (aluminum to aluminum) (4.4.3.7)."

Custodian:

NASA - George C. Marshall Space
Flight Center

Preparing activity:

George C. Marshall Space
Flight Center

MSFC DOCUMENTATION REPOSITORY - DOCUMENT INPUT RECORD

I. GENERAL INFORMATION

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6. DOCUMENT/DRAWING TITLE: Adhesive, Epoxy Resin			7. REPORT TYPE:	
8. CONTRACT NUMBER / PERFORMING ACTIVITY:	9. DRD NUMBER:	10. DPD / DRL / IDRD NUMBER:		
11. DISPOSITION AUTHORITY (Check One): <input checked="" type="checkbox"/> Official Record - NRRS <u>8/121A</u> <input checked="" type="checkbox"/> Reference Copy - NRRS 8/5/A/3 (destroy when no longer needed)	12. SUBMITTAL AUTHORITY:	13. RELEASING AUTHORITY: <u>10/30/02</u> <u>Gail H Gordon</u>		
14. SPECIAL INSTRUCTIONS:				
15. CONTRACTOR/SUBMITTING ORGANIZATION, ADDRESS AND PHONE NUMBER: Nonmetallic Materials and Processes Group Materials, Processes, and Manufacturing Department		16. ORIGINATING NASA CENTER: Marshall Space Flight Center		
		17. OFFICE OF PRIMARY RESPONSIBILITY: ED34, Nonmetallic Materials and Processes Group		
18. PROGRAMMATIC CODE (5 DIGITS):			19. NUMBER OF PAGES:	

II. ENGINEERING DRAWINGS

20. REVISION:	21. ENGINEERING ORDER:	22. PARTS LIST:	23. CCBD:
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III. REPORTS, SPECIFICATIONS, ETC.

24. REVISION:	25. CHANGE: <u>1</u>	26. VOLUME:	27. BOOK:	28. PART:	29. SECTION:
30. ISSUE:	31. ANNEX:	32. SCN:	33. DCN:	34. AMENDMENT:	
35. APPENDIX:	36. ADDENDUM:	37. CCBD:	38. CODE ID:	39. IRN:	

IV. EXPORT AND DISTRIBUTION RESTRICTIONS

- Privacy Act (see MWI 1382.1)

 EAR (see MPG 2220.1)
- Proprietary (see MPD 2210.1)

 Other ACI (see NPG 1620.1 and MPG 1600.1) _____
- Patent (see MPG 2220.1)

 No statutory or institutional restrictions applicable -- material may be electronically distributed to user in the NASA domain
- ITAR (see MPG 2220.1)

V. ORIGINATING ORGANIZATION APPROVAL

40. ORG. CODE: ED34	41. PHONE NUMBER: (256) 544-2726	42. NAME: Gail H. Gordon	43. SIGNATURE/DATE: <u>Gail H Gordon</u> <u>10/30/02</u>
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VI. TO BE COMPLETED BY MSFC DOCUMENTATION REPOSITORY

44. RECEIVED BY: <u>Jammy Wise</u>	45. DATE RECEIVED: <u>10-15-03</u>	46. WORK ORDER:
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