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Standard Specification For Silicone Rubber Room Temperature Vulcanizing Low Outgassing Materials[1]

This standard is issued under the fixed designation D6411/D6411M; 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 The specification covers a two-part flowable space grade room temperature vulcanizing (RTV) silicone rubber adhesive or compound. The material is specifically designed for applications requiring extreme low temperature, low outgassing and minimal volatile condensibles under extreme operating conditions. The RTV silicone rubber should be suitable for withstanding environmental exposure to temperatures from –115 to 200°C (–175 to 392°F). The material should also withstand the combination of stress, temperature, and relative humidity expected to be encountered in service. The RTV silicone rubber may be used as a sealing, caulking, potting or bonding material for applications on metal, plastics, rubber, glass, and ceramic products. Types I and II are often used as coatings.

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 refers 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:*[2]

B209 Specification for Aluminum and Aluminum-Alloy Sheet and Plate

D149 Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies

D150 Test Methods for AC Loss Characteristics and Permittivity (Dielectric Constant) of Solid Electrical Insulation

D257 Test Methods for DC Resistance or Conductance of Insulating Materials

D412 Test Methods for Vulcanized Rubber and Thermoplastic Elastomers—Tension

D792 Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement

D907 Terminology of Adhesives

D1002 Test Method for Apparent Shear Strength of Single-Lap-Joint Adhesively Bonded Metal Specimens by Tension Loading (Metal-to-Metal)

D1084 Test Methods for Viscosity of Adhesives

D2240 Test Method for Rubber Property—Durometer Hardness

D2651 Guide for Preparation of Metal Surfaces for Adhesive Bonding

D3951 Practice for Commercial Packaging

E595 Test Method for Total Mass Loss and Collected Volatile Condensable Materials from Outgassing in a Vacuum Environment

2.2 *National Aeronautics and Space Administration (NASA):*

JSC SP-R-0022 General Specification, Vacuum Stability Requirement of Polymeric Material for Spacecraft Application[3]

MSFC-HDBK-527/JSC-09604 Material Selection List for Hardware Systems[3]

GSFC RP 1124 Outgassing Data for Selecting Spacecraft Materials[3]

NOTE 1—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:*

[1] This specification is under the jurisdiction of ASTM Committee D14 on Adhesives and is the direct responsibility of subcommittee D14.80 on Metal Bonding Adhesives.

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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] Unless otherwise indicated, copies of the above documents are available from a NASA installation library or document repository.

3.1.1 Many terms in this specification are defined in Terminology D907.

3.1.2 *lot, n*—a specific material that can be identified by the place of manufacture, quantity and type of raw materials and process conditions used.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *RTV, adj*—room temperature vulcanizing.

3.2.2 *RTV Silicone Rubber Compound, n*—a silicone resin base (*A*) and a silicone resin curing agent (*B*) when mixed in a proper ratio results in a rubbery compound. A RTV silicone rubber compound that is manufactured by a unique combination of raw silicone materials and manufacturing process that conforms to a given set of physical and performance properties and is identified by specific name, number, or alphanumeric designation.

NOTE 2—A "curing agent" is commonly used with this type of silicone rubber compound. The term "accelerator" or "catalyst" is synonymous with "curing agent."

4. Significance and Use

4.1 *General*—This specification provides material requirements and testing procedures to differentiate between the physical, mechanical, electrical, adhesive bonding properties of three types of RTV silicone rubber compounds.

4.2 The physical, mechanical and electrical properties of the RTV silicone rubber are tested and measured to provide specific data on requirements for qualification and lot acceptance of separate ingredients comprising the RTV silicone rubber compounds and the properties resulting from the cured mixture.

NOTE 3—Because of the many number of adherend materials bonded with RTV silicone rubber material, testing by this specification will only evaluate the RTV silicone rubber material under a given set of conditions.

5. Classification

5.1 The RTV low volatile silicone rubber compounds shall be furnished as one of the following types:

5.1.1 *Type I*—A low viscosity, two-part system consists of a silicone resin base (*A*) and a liquid curing agent (*B*) when mixed and cured results in a Shore A hardness of 60.

5.1.2 *Type II*—A medium viscosity, two-part system consists of a silicone resin base (A) and a liquid curing agent (B) when mixed and cured results in a Shore A hardness of 40.

5.1.3 *Type III*—A medium viscosity thixotropic, two-part system consists of a silicone resin base (A) and a liquid curing agent (B) when mixed and cured results in a minimum Shore A hardness of 40.

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 of this specification,

6.1.2 RTV silicone rubber material type and number,

6.1.3 Amounts and unit quantities of RTV rubber compound required,

6.1.4 Curing conditions,

6.1.5 Level of packaging and packing required,

6.1.6 Whether or not qualification is necessary, and

6.1.7 Storage conditions.

6.2 *Qualification*—In case the RTV silicone rubber compound(s) that are qualified/approved at the time set for opening of bids, the procurement documents should state that the awards will be forthcoming.

7. Test Requirements

7.1 *Material*—The RTV silicone rubber compound, when tested per Section 8, shall meet the physical, mechanical and electrical, and outgassing requirements as specified in Table 1. The silicone rubber compound shall not have a detrimental effect on surfaces being in contact or bonded over the range of temperatures at which the RTV silicone rubber compounds will be used.

7.2 *Qualification*—Qualification shall only apply to the formulation on which the qualification tests have been made; any changes by the manufacturer in formulation or method of manufacturing, shall be cause of designating the RTV silicone rubber compound as a new product. The new product shall be given a new code number and shall be requalified and approved until it has been shown to meet the requirements of this specification.

7.3 *Working Characteristics:*

7.3.1 *Application*—The RTV silicone rubber compound shall be suitable for application to surfaces in accordance with the manufacturer's instructions.

7.3.2 *Curing*—The time, temperature, and pressure used to cure the RTV silicone rubber compound shall be in accordance with the manufacturer's recommendation.

8. Test Methods

8.1 *Qualification Tests*—For qualification, the RTV silicone rubber compound shall be tested using the tests described in this section. All tests specified in Table 1 shall be performed at room temperature, 25 ± 3°C [77 ± 5°F] with the exception of the outgassing test.

8.2 *Preparation of Test Specimens*—Prepare at least ten specimens for each separate test as follows:

8.2.1 *Tensile Shear Strength Specimens:*

8.2.1.1 *Adherend*—The metal substrate shall be 6061-T6 or 2024-T3 aluminum alloy in accordance with Specification B209.

8.2.1.2 *Surface Preparation*—Clean and etch in accordance with Practice D2651.

8.2.1.3 *Cure*—Time and temperature for curing the RTV silicone rubber material shall be in accordance with the manufacturer's recommendations.

NOTE 4—Control of bondline thickness shall be accomplished by placing two lengths of 0.13 mm (0.005 in.) diameter stainless wire 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 can also be used to maintain uniform bondine thickness.

NOTE 5—When applying or bonding the RTV rubber compound, care should be taken to avoid air entrapment. When practical, it is suggested that applying be done under vacuum or that the application area be

TABLE 1 Property Requirements for the RTV Silicone Rubber Compounds

Test[A]	Test Method	Requirement		
		Type I	Type II	Type III
Uncured Property				
Specific Gravity @ 25 ± 3°C [77 ± 5°F]	D792			
Part A		1.46-1.52	1.04-1.08	1.08
Part B		1.15	. . .	. . .
Resin Weight, kg/L (lb/gal)				
Part A		1.49 [12.42]	1.02 [8.50]	1.08 [9.00]
Part B		1.15 [9.59]	. . .	. . .
Viscosity, CPS @ 25 ± 3°C [77 ± 5°F]	D1084			
Part A		33 000-58 000	7000-10 000	Non-Slump[B]
Part B		N/A	N/A	
Work (Pot) Life, h		1.5	1	4 to 6
Cured Property (Cured at 25 ± 3°C (77 ± 5°F) @ 50 % Relative Humidity for 24 h for Type I and Seven Days for Types II and III)				
Durometer, Shore A	D2240	60 ± 5	40 ± 5	40 min.
Tensile Shear Strength on Primed Aluminum, MPa [PSI]	D1002	3.21 [465]	. . .	. . .
Tensile Strength, MPa [PSI]	D412	3.45 [500] min	3.45 [500] min	6.20 [900]
Elongation, %	D412	120	80 min	100
Dielectric Strength, kv/mm [v/mil]	D149	21.2 [540]	22.3 [570]	22.3 [570]
Dielectric Constant	D150			
@ 1 kHZ		3.9	2.75	2.75
@ 100 kHZ		. . .	2.73	2.73
Volume Resistivity, Ohm-cm	D257	2×10^{14}	6.9×10^{13}	6.9×10^{13}
Outgassing Characteristics	E595			
Total Mass Loss (TML), %		≤ 1.0	≤ 1.0	≤ 1.0
Volatile Condensible Material (VCM), %		≤ 0.1	≤ 0.1	≤ 0.1
Storage Life	. . .	*C*	*C*	*C*

[A] All values as stated are typical unless otherwise indicated. The values as stated are the minimal to be met by the averages of the results for the specimens tested.
[B] The mixture of Part "A" and Part "B" will not flow or run when used in a vertical position.
[C] The storage life at the maximum recommended temperature and under the recommended storage conditions shall be stated in the manufacturer's data sheet.

evacuated afterward to remove any entrapped air. For bonding metals, a primer recommended by the manufacturer shall be used.

8.2.2 *Tensile Strength and Elongation Test Specimens*—Tensile strength and elongation test specimens shall be prepared for test in accordance with Test Method D412.

8.2.3 *Hardness Tests*—For Shore A hardness measurement, prepare a mixture of resin and curing agent in ratios specified by the manufacturer. Pour the thoroughly mixed material into an aluminum foil cup approximately 7.6 cm [3.0 in.] in diameter and a minimum thickness of 0.64 cm [0.25 in.]; cure per manufacturer's recommendations.

8.3 *Test Procedures:*

8.3.1 All tests listed in Table 1 (except outgassing) shall be performed at 25 ± 3°C [77 ± 5°F]

9. Inspection

9.1 *Responsibility for Inspection*—Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or purchase order, the supplier may use his own or any other facility suitable for the performance of inspection requirement specified herein. The purchaser has the right to perform any of the inspections set forth in this specification where such inspections are deemed necessary to ensure compliance with the requirements.

9.2 *Classification of Inspections*—The inspection requirements specified are classified as follows:

9.2.1 Qualification inspection (see 9.3), and

9.2.2 Quality conformance inspection (see 9.4).

9.3 *Qualification Inspection:*

9.3.1 *Qualification Test*—Unless otherwise specified by the purchaser (see 6.2), RTV silicone rubber compound that has not passed the qualification tests, must be tested against this specification and proved to meet all its requirements.

9.3.1.1 At the option of the purchaser, qualification tests may be performed at any time.

9.3.1.2 *Data Sheet*—A dated, coded, and title data sheet stating the RTV silicone rubber material property data and

procedures for mixing, curing, bonding, storage and shelf life, etc., shall be supplied by the manufacturer for the initial purchase order. Reorders of the same material do not require a duplicate copy of the data sheet unless otherwise required. The data sheet shall be forwarded with the test report (see 9.3.2) when requesting qualification.

9.3.2 *Test Report*—In addition to the qualification test samples, the manufacturer shall furnish a certified and dated and numbered report, giving the results of all tests listed in Section 8. The individual and average values for each test shall be reported. The test report shall cover all the requirements of Section 7. The Type of adherends, surface preparation (including cleaning, etching and primer, if required) assembly conditions, pressure, temperature and time of curing used in the preparation of the test panels shall be reported. The report shall certify that the preparation of the material and test specimens conformed to the description given in the data sheet.

9.4 *Quality Conformance Inspection*—Samples of each lot of material delivered on contract or purchase order shall be subjected to the following quality conformance tests: Test reports shall be furnished for all quality conformance test specimen in this specification, and shall be signed by an authorized representative of the laboratory making the tests.

NOTE 6—Acceptance or approval of material during the course of manufacture shall not be construed as a guarantee of the acceptance of the finished products.

9.4.1 *Room-Temperature Adhesive Tensile Shear Strength*—The room temperature adhesive tensile shear strength shall be as specified in Table 1.

9.4.2 Room temperature tensile strength, elongation and Shore A hardness shall be as specified in Table 1.

9.4.3 *Outgassing Characteristics*—Outgassing characteristics shall meet the outgassing requirements of NASA/JSC specification SP-R-0022A when tested in accordance with Test Method E595 (see Table 1).

10. Rejection

10.1 If the results of test do not conform to the requirements prescribed in this specification, the lot shall be rejected.

11. Product Safety

11.1 A copy of the Materials Safety Data Sheet (MSDS) of the RTV silicone rubber material shall be supplied by the manufacturer along with the material data sheet for the initial purchase order. For future purchase orders, additional MSDS copies accompanying the data sheet may be obtained upon request.

12. Packaging

12.1 *Packaging*—Packaging, packing and marking shall be in accordance with Practice D3951.