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22 December 1966
SUPERSEDING
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MILITARY SPECIFICATION

INSULATING COMPOUND, ELECTRICAL, CERAMIC, CLASS L

This specification is mandatory for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers class L, low dielectric constant (12 or under), ceramic, electrical, insulating compounds, for use in electronic, communications, and allied electrical equipments, and the grading thereof (see 6.1).

1.2 Classification. This specification shall cover only those insulating compounds characterized by combining the specific designators of 1.2.1 to 1.2.5, inclusive.

L	4	4	2	X6/04	T	B
Class(1.2.1)	Dielectric loss index (1.2.2.1)	Dielectric strength (1.2.2.2)	Flexural strength (modulus of rupture) (1.2.2.3)	X-band (when specified) (1.2.3)	Thermal conductivity (when specified) (1.2.4)	Finish (1.2.5)

1.2.1 Insulating compound designator. Insulating compounds shall be identified by the single letter designator "L".

1.2.2 Grade designators. Insulating compounds shall be further identified by three numbers (grade designators) following the above designator, the first representing dielectric loss index at one megahertz (MHz), the second dielectric strength, and the third flexural strength (modulus of rupture), as specified, i.e., L422-- (see 6.1 and 6.2).

1.2.2.1 Dielectric loss index at 1 MHz. The designator for dielectric loss index is determined by the maximum dielectric loss index at 1 MHz of the specimens tested, as follows:

Grade designator	Maximum dielectric loss index
2	0.070
3	.035
4	.016
5	.008
6	.004
7	.002
8	.001

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1.2.2.2 Dielectric strength. The designator for dielectric strength is determined by the average dielectric strength of the specimens tested, as follows:

Grade designator	Average dielectric strength volts/mil
1	180 to 199, incl
2	200 to 249, incl
3	250 to 299, incl
4	300 and above

1.2.2.3 Flexural strength (modulus of rupture). The designator for flexural strength (modulus of rupture) is determined by the average flexural strength (modulus of rupture) of the specimens tested, as follows:

Grade designator	Average flexural strength pounds/sq. in.
1	7,000 to 11,900, incl
2	12,000 to 19,900, incl
3	20,000 to 29,900, incl
4	30,000 to 34,900, incl
5	35,000 to 49,900, incl
6	50,000 and above

1.2.3 X-band designators. When insulating compounds are required for frequency applications from 100 MHz to 24 gigahertz (GHz), they shall be identified by the designator "X", followed by a one-digit number, a slant line, and a two-digit number. The one-digit number shall represent dielectric loss index measured at some X-band frequency in the range from 8.2 GHz to 12.4 GHz, using the table of grade designators of 1.2.2.1, and the two-digit number shall represent dielectric constant measured at some X-band frequency (see 1.2.3.1), as specified (see 6.1 and 6.2).

1.2.3.1 Dielectric constant at X band. The designator for dielectric constant is determined by the dielectric constant at some X band frequency in the range from 8.2 to 12.4 GHz of the specimens tested as follows:

Grade designator	Dielectric constant
12	11.6 - 12
11	10.6 - 11.5
10	9.6 - 10.5
09	8.6 - 9.5
08	7.6 - 8.5
07	6.6 - 7.5
06	5.6 - 6.5
05	4.6 - 5.5
04	3.6 - 4.5
03	2.6 - 3.5
02	1.6 - 2.5
01	1.0 - 1.5

1.2.4 Thermal conductivity designator. When high thermal conductivity (see 3.7) insulating compounds are required, they shall be identified by the designator "T", i.e., L422T-- or L422 X6/04T--. (See 6.1 and 6.2)

1.2.5 Finish designator. Insulating compounds shall be further identified by a single letter designator, "B," "W," or "C," to represent finish, i.e., L323B, L323 X/04B, L323TB or L323 X6/04TB. (See 6.1 and 6.2)

Symbol	Finish
B	Brown glaze. Glass and glass-bonded mica are not included.
W	White glaze. Glass and glass-bonded mica are not included.
C	Natural vitreous surface. Includes the fired ceramics, e.g., porcelain, steatite, and alumina; and the non-fired ceramics, e.g., glass and glass-bonded mica.

2. APPLICABLE DOCUMENTS

2.1 The following document, of the issue in effect on date of invitation for bids or request for proposal, forms a part of this specification to the extend specified herein.

STANDARDS

MILITARY

MIL-STD-202 - Test Methods for Electronic and Electrical Component Parts.

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

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

THE AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

D116 - Testing Vitrified Ceramic Materials for Electrical Applications.
D150 - A-C Capacitance, Dielectric Constant, and Loss Characteristics of Electrical Insulating Materials.
D2520- Complex Permittivity (Dielectric Constant) of Solid Electrical Insulating Materials at Microwave Frequencies and Temperatures up to 1650 degrees C.
C408 - Thermal Conductivity by the Cut Bar Appartus.

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

Resonant Rectangular Cavity Perturbation Method in Final Report U.S. Army Electronics Command Contract DA 36-039-AMC-00008(E), Task 701.

(Applications for copies should be addressed to Defense Documentation Center, Cameron Station, Alexandria, Virginia 22314, under number AD440-377).

3. REQUIREMENTS

3.1. Qualification. Insulating compounds furnished under this specification shall be of a product which has been tested and has passed the qualification tests specified in 4.4 and has been listed on or approved for listing on the applicable qualified products list (see 6.3).

3.2 Material. The material shall be natural or synthetic mineral (see 6.1), or combinations thereof, so compounded that, when pressed, extruded, or otherwise processed, then fused, or sintered by heat, it provides a body compound meeting the requirements of this specification.

3.2.1 Glaze. Polycrystalline body materials covered by this specification shall be either glazed or unglazed, as specified (see 6.2). When glazed body materials are specified, the glaze shall not exhibit pinholes, nor shall it be crazed or show any shivering (peeling). The body materials shall not be impregnated or otherwise treated with organic sealant or coating materials such as silicones, etc. Non-crystalline amorphous materials, such as glass, which, as molded, extruded, or otherwise processed, have a glass-like surface, shall be considered as glazed.

3.2.1.1 Color. Unless otherwise specified, the glaze on glazed body compounds shall be clear, white, or brown, as specified (see 6.2).

3.3 Dielectric constant and loss index at 1.0 MHz. When insulating compounds are tested as specified in 4.6.1.1, the dielectric constant shall not exceed 12, and the dielectric loss index shall not exceed the value cited in 1.2.2.1 for the grade specified.

3.3.1 Dielectric constant and loss index at X-band (when specified) (see 6.2). When insulating compounds are tested as specified in 4.6.1.2 the dielectric constant and loss index shall be in accordance with the grades specified in 1.2.3 and 1.2.3.1.

3.4 Dielectric strength. When insulating compounds are tested as specified in 4.6.2, the average dielectric strength shall not be less than the minimum value cited in 1.2.2.2 for the grade specified.

3.5 Flexural strength (modulus of rupture). When insulating compounds are tested as specified in 4.6.3, the average flexural strength (modulus of rupture) shall not be less than the minimum value cited in 1.2.2.3 for the grade specified.

3.6 Porosity. When insulating compounds are tested as specified in 4.6.4, there shall be no evidence of porosity.

3.7 Thermal conductivity (when specified) (see 6.2). When insulating compounds are tested as specified in 4.6.5, the average thermal conductivity shall be not less then $\frac{1608 \text{ BTU X IN}}{\text{HR X FT}^2 \text{ X } ^\circ\text{F}}$ at 100° F (37.8° C), and not less than $\frac{1200 \text{ BTU X IN}}{\text{HR X FT}^2 \text{ X } ^\circ\text{F}}$ at 257° F (125° C). The lowest value obtained for any one specimen shall not deviate from the average by more than 20 percent.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection.

4.1.1 Supplier. 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 Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to the prescribed requirements.

4.1.1.1 Test equipment and inspection facilities. Test equipment and inspection facilities shall be of sufficient accuracy, quality, and quantity to permit performance of the required inspection. The supplier shall establish calibration of test equipment to the satisfaction of the Government.

4.2 Classification of inspection. The examination and testing of insulating compounds shall be classified as follows:

(a) Qualification inspection (see 4.4).
(b) Quality conformance inspection (see 4.5).

4.3 Inspection conditions. Unless otherwise specified herein, all inspection shall be made in accordance with the general requirements of MIL-STD-202.

4.4 Qualification inspection. Qualification inspection shall be performed at a laboratory acceptable to the Government (see 6.3).

4.4.1 Sampling plan. Six specimens of the form and dimensions specified in the applicable method paragraph shall be submitted for each qualification test specified in table I, except for porosity and thermal conductivity (see 4.6.4 and 4.6.5). The specimens shall be molded or extruded, and glazed if required from production compounds by methods representative of production, or shall be machined from blanks which have been so prepared, except as required by the difference in form between the test specimens and the finished product.

TABLE I. Qualification testing.

Examination or test	Requirement paragraph	Method paragraph
Glaze (when applicable)	3.2.1	4.6.4
Dielectric constant and loss index at 1.0 MHz	3.3	4.6.1.1
Dielectric constant and loss index at X band (when specified)	3.3.1	4.6.1.2
Dielectric strength	3.4	4.6.2
Flexural strength (modulus of rupture)	3.5	4.6.3
Porosity	3.6	4.6.4
Thermal conductivity (when specified)	3.7	4.6.5

4.4.2 Extent of qualification. Qualification approval of a specific grade designation will constitute approval for other grades in which the individual designators for dielectric loss index, dielectric withstanding voltage, dielectric constant, and flexural strength (modulus of rupture) are numerically lower.

4.4.3 Retention of qualification. To retain qualification, the supplier shall forward, at 24-month intervals, to the qualifying activity, a summary of the results of batch-acceptance tests, indicating as a minimum the number of batches which passed and the number which failed, and a summary of the results of periodic-batch-check tests, including the number and type of any failures. The summary shall include those tests performed during that 24-month period. If the summary of the test results indicates nonconformance with specification requirements, action shall be taken to remove the failing product from the qualified products list. Failure to submit the summary shall result in loss of qualification for that product. In addition to the periodic submission of inspection data, the supplier shall immediately notify the qualifying activity at any time during the 24-month period that the inspection data indicates failure of the qualified product to meet the requirements of the specification.

4.5 Quality conformance inspection. Quality conformance inspection shall consist of batch-acceptance inspection (see 4.5.2) and periodic-batch-check inspection (see 4.5.3).

4.5.1 Batch. A batch shall consist of all the body compounds produced from essentially the same material under essentially the same conditions and offered for inspection in any three-month period.

4.5.2 Batch-acceptance inspection. Batch-acceptance inspection shall be made on each batch of compound of a particular product designation and shall be the basis on which acceptance or rejection of the batch is made. Batch-acceptance inspection shall consist of determination of dielectric constant and dielectric loss index and comparison with the specified value corresponding to the grade designator established for the product being inspected. (See 1.2.2 and 3.3.1).

4.5.2.1 Sampling plan. Four specimens of the form and dimensions specified in the applicable method paragraph shall be submitted for each batch acceptance test specified in 4.5.2. If one or more specimens fails to pass, the sample shall be considered to have failed.

4.5.3 Periodic-batch-check inspection. Periodic-batch-check inspection shall be made once every 2 years. Periodic-batch-check inspection shall consist of all the tests required by this specification (see table I).

4.5.3.1 Sampling plan. Four specimens of the form and dimensions specified in the applicable method paragraph shall be submitted for each periodic-batch-check test specified in 4.5.3, except for porosity and thermal conductivity (see 4.6.4 and 4.6.5). If one or more fails to pass, the sample shall be considered to have failed.

4.5.4 Rejected batches. If a batch is rejected as the result of failing batch-acceptance inspection or periodic-batch-check inspection, no further batches will be accepted for inspection until the supplier has taken corrective measures and has satisfied the Government that these measures will enable the compound to meet the requirements of this specification. Rejected batches may be reworked and resubmitted, but shall be kept separate from new batches.

4.6 Test methods.

4.6.1 Dielectric constant and loss index.

4.6.1.1 Measurement at 1.0 MHz (see 3.3). Dielectric constant and loss index shall be determined at 1 MHz as specified in ASTM Publication D150. Specimens shall be 1/4-inch-thick disks, at least 3 inches in diameter, or 1/4-inch-thick plates, at least 3 inches square. The specimens shall be immersed, before application of the electrodes, in distilled water at a temperature of 23° ±2° C for 48 +1, -0 hours. The specimens shall be removed from the distilled water one at a time, rinsed in fresh distilled water, and all surface moisture on the specimens shall be removed by drying with a clean, dry, absorptive cloth or paper. The electrodes shall be metal foil, applied with petrolatum. The lapsed time between removal of the specimens from the water and completion of the measurements shall not exceed 6 minutes.

4.6.1.2 Measurements at X band frequencies (when specified) (see 3.3.1). For microwave applications, dielectric constant and loss index shall be determined at some X band frequency in the range of 8.2 GHz to 12.4 GHz by either of the following methods.

4.6.1.2.1 Waveguide standing wave method. Measurements shall be performed as specified in ASTM Publication D2520. Specimen dimensions (except length) are critical, since a sliding push fit of the sample in the waveguide is desirable. Transverse dimensions of the specimen shall be 0.002 ± 0.001 inch (0.005 ± 0.0025 cm) less than those of the transmission line. The front and back faces shall be parallel within 0.0004 inch (0.001 cm) and perpendicular to the axis of the transmission line within 0.05 degree. The corners of the specimen may be rounded slightly so that the end surface seats flat against the termination with no airfilm between the surfaces. The length shall be suitable for the measurement; a length of 0.4 inch (1.0 cm) may be used in 0.4 x 0.9 inch (1.0 x 2.3 cm) rectangular waveguide.

4.6.1.2.2 Resonant rectangular cavity perturbation method. Measurements shall be performed as specified in final report, U. S. Army Electronics Command Contract DA 36-039-AMC-00008(E), Task 701. Specimen dimensions shall be 0.080 ± 0.003 inch diameter by 1.4 ± 0.1 inch length with taper less than 0.001 inch on the diameter.

4.6.2 Dielectric strength (see 3.4). Dielectric strength shall be determined as specified in ASTM Publication D116. Specimens shall be 1/4-inch-thick disks, at least 3 inches in diameter, or 1/4-inch-thick plates, at least 3 inches square. Specimens shall not be conditioned before test.

4.6.3 Flexural strength (modulus of rupture) (see 3.5). Flexural strength (modulus of rupture) shall be determined as specified in ASTM Publication D116. Specimens shall be rods 1/2 inch in diameter of 1/2-inch square, by 6 inches long.

4.6.4 Porosity (see 3.6). Porosity shall be determined in accordance with method C, Dye Penetration, of ASTM Publication D116.

4.6.4.1 Qualification inspection specimens. Specimens shall be at least three of the punctured dielectric-strength disks or plates (see 4.6.2) and, when available, at least three of the fractured flexural-strength (modulus of rupture) extruded rods (see 4.6.3).

4.6.4.2 Quality conformance inspection. Specimens shall be at least three insulators molded, pressed, or extruded from the batch of body compound being inspected.

4.6.4.3 Examination. At least four fragments shall be visually examined for penetration of dye (ASTM D116), and at least four glazed fragments, when applicable, and when available, shall be visually examined for pinholes, crazing, or shivering (peeling) of the glaze.

4.6.5 Thermal conductivity (when specified) (see 3.7). Thermal conductivity shall be determined at 100° F (37.8° C) and at 257° F (125.0° C) respectively, as specified in ASTM Publication C408 .

4.6.5.1 Specimens. Specimens shall be prepared so that they fit the thermodes of the test apparatus specified in ASTM Publication C408. Six specimens (2 only for beryllia) shall be prepared and submitted for qualification testing and six (2 only for beryllia) for quality conformance.

5. PREPARATION FOR DELIVERY

5.1 Preparation for delivery is not applicable to this specification.

6. NOTES

6.1 Intended use. The compounds covered by this specification are intended for use as electrical-insulating elements in components and parts, or as insulators in sub-assemblies and equipments. This specification established minimum requirements for these compounds, and grades them according to their performance. Because of the wide variety of ceramics available, including porcelain, steatite, glass, ceramoplastic, glass-bonded mica, cordierite, zircon, wollastonite, forsterite, alumina, and lithia procelain, a wide range of grades from L211 to L844 is possible. Currently, grade L221 is typical of porcelain, L422 of steatite, L431 of glass, L614 of alumina, and L423T of beryllia. Sufficient information is not yet available to establish grades typical of the other ceramics. Accordingly, before a grade is specified, the Qualified Products List should be refered to to determine availability of the grade desired. This specification is intended to be used as a subsidiary to drawings, specifications, and other procurement documents for components, parts, and elements.

6.1.1 Thermal shock. The various insulating materials covered by this specification differ in their resistance to thermal change or shock. Thermal-shock endurance of ceramics is dependent principally upon the following factors:

s = Tensile strength.
c = Thermal conductivity.
α = Coefficient of linear expansion.
E = Modulus of elasticity.

Comparative thermal-shock resistance (R) of different ceramics may be determined from the following relationship:

$$R \text{ is proportional to } \frac{s\sqrt{c}}{\alpha E}$$

$$R = \frac{s\sqrt{c}}{\alpha E}$$

This relationship should be kept in mind and should be considered when resistance to thermal-shock is an important factor in design. The following thermal-expansion data of various types of ceramic materials may be used as a guide toward establishing relative thermal-shock resistance of ceramics used in applications where thermal-shock characteristics are of prime importance:

Material	Coefficient of thermal expansion X 10-6 (25° to 300° C)
Lithia porcelain	-0.063 to 2.0
Devitrified glass	-0.7 to 2.0
Cordierite	2.36
Glass (pyrex)	3.2
Zircon	4.35
Porcelain	5.93
Alumina	6.85
Beryllia	7.69
Steatite	8.15
Forsterite	9.9
Wollastonite	10.0
Glass-bonded mica	10.7

6.2 Ordering data. Procurement documents should specify the following:

(a) Title, number, and date of this specification.
(b) Grade desired (see 1.2.2).
(c) Whether X-band insulating material is required (see 1.2.3 and 3.3.1).
(d) Whether high-thermal-conductivity insulating material is required (see 1.2.4 and 3.7).
(e) Color of glaze (see 1.2.5 and 3.2.1.1).
(f) Whether glazed or unglazed body compound is required (see 3.2.1).

6.3 Qualification. With respect to products requiring qualification, awards will be made only for products which are at the time set for opening of bids, qualified for inclusion in the applicable qualified products list whether or not such products have actually been so listed by that date. The attention of the suppliers is called to this requirement, and manufacturers are urged to arrange to have the products that they propose to offer to the Federal Government tested for qualification in order that they may be eligible to be awarded contracts or orders for the products covered by this specification. The activity responsible for the qualified products list is the U. S. Army Electronics Command, Fort Monmouth, N. J. 07703; however information pertaining to qualification of products may be obtained from the Defense Electronics Supply Center, ATTN: DESC-EQ, Dayton, Ohio 45401.

6.4 International standardization agreement. Certain provisions of this specification are the subject of international standardization agreement ABC-NAVY-STD-17C. When amendment, revision, or cancellation of this specification is proposed which will affect or violate the international agreement concerned, the preparing activity will take appropriate reconciliation action through international standardization channels including departmental standardization offices, if required.

6.5 Changes from previous issue. Asterisks are not used in this revision to identify changes with respect to the previous issue, due to the extensiveness of the changes.

Custodians:
Army - EL
Navy - SH
Air Force - 11

Review activities:
Army -
Navy -
Air Force - 11, 17, 85

User activities:
Army -
Navy -
Air Force - 14, 19

Preparing activity:
Army - EL

(Project 5970-0140)

Code "C"

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

INSTRUCTIONS

1. The preparing activity must complete blocks 1, 2, 3, and 8. In block 1, both the document number and revision letter should be given.

2. The submitter of this form must complete blocks 4, 5, 6, and 7.

3. The preparing activity must provide a reply within 30 days from receipt of the form.

NOTE: This form may not be used to request copies of documents, nor to request waivers, or clarification of requirements on current contracts. Comments submitted on this form do not constitute or imply authorization to waive any portion of the referenced document(s) or to amend contractual requirements.

I RECOMMEND A CHANGE:	1. DOCUMENT NUMBER MIL-I-10B	2. DOCUMENT DATE 22 December 1966

3. **DOCUMENT TITLE**

INSULATING COMPOUND, ELECTRICAL, CERAMIC CLASS L

4. NATURE OF CHANGE (Identify paragraph number and include proposed rewrite, if possible. Attach extra sheets as needed.)

5. REASON FOR RECOMMENDATION

6. SUBMITTER

a. NAME (Last, First, Middle initial)	b. ORGANIZATION	
c. ADDRESS (Include Zip Code)	d. TELEPHONE (Include Area Code) COMMERCIAL DSN FAX EMAIL	7. DATE SUBMITTED

8. PREPARING ACTIVITY

a. Point of Contact Carla Jenkins	b. TELEPHONE Commercial 703-767-6874 DSN 427-6874 FAX 703-767-6876 EMAIL carla_jenkins@hq.dla.mil
c. ADDRESS Defense Standardization Program Office (DLSC-J-330) 8725 John J. Kingman, Suite 4235 Fort Belvoir, VA 22060-6221	IF YOU DO NOT RECEIVE A REPLY WITHIN 45 DAYS, CONTACT: Defense Standardization Program Office (DLSC-J-330) 8725 John J. Kingman, Suite 2533 Fort Belvoir, VA 22060-6221 Telephone (703) 767-6888 DSN 427-6888