INCH-POUND
MIL-I-24718
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MILITARY SPECIFICATION

INSULATING RESINS, SOLVENTLESS, VACUUM-PRESSURE-IMPREGNATING; GENERAL SPECIFICATION FOR

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

1. SCOPE

1.1 Scope. This specification covers solventless insulating resins of various compositions and classes for treating and impregnating electrical equipment by the vacuum-pressure-impregnation (VPI) process.

1.2 Classification. Insulating resins shall be provided in the following compositions and classes, as specified (see 6.2).

1.2.1 Composition. Solventless impregnating resins shall be identified by chemical family and rheological properties, as defined by the individual specification sheets. The composition description shall identify all primary reactants in the resin formulation (for example, epoxy-Lewis acid, polyester diallyl phthalate, and so forth) and the rheology required for its end-use application (for example, thixotropic, slightly thixotropic, low viscosity, and so forth). Each specification sheet describes a unique composition.

1.2.2 Classes. Each composition shall be of one of the following class designations. Class is an indication of the thermal endurance (see 4.6.15.1). Class is determined from the temperature index rating in degrees Celsius (°C) at 20,000 hours.

Thermal class	Temperature index range
Class 105	105 up to but less than 130
Class 130	130 up to but less than 155
Class 155	155 up to but less than 180
Class 180	180 up to but less than 200
Class 200	200 up to but less than 220

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commander, Naval Sea Systems Command, SEA 55Z3, Department of the Navy, Washington, DC 20362-5101 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

AMSC N/A FSC 5970

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation (see 6.2).

SPECIFICATIONS

FEDERAL

J-W-1177	- Wire, Magnet, Electrical, General Specification.
P-D-220	- Detergent, General Purpose.
PPP-F-320	- Fiberboard: Corrugated and Solid, Sheet Stock (Container Grade), and Cut Shapes.
PPP-P-1892	- Paint, Varnish; Lacquer, and Related Materials; Packaging, Packing and Marking of.

MILITARY

MIL-L-17331	- Lubricating Oil; Steam Turbine and Gear, Moderate Service.
MIL-H-17672	- Hydraulic Fluid, Petroleum, Inhibited.
MIL-L-19140	- Lumber and Plywood, Fire-Retardant Treated.
MIL-I-24718/1	- Insulating Resins, Solventless, Vacuum-Pressure-Impregnating Epoxy-Lewis Acid, Slightly Thixotropic.
MIL-I-24718/2	- Insulating Resins, Solventless, Vacuum-Pressure-Impregnating Replenishment Resin, Epoxy-Lewis Acid, Slightly Thixotropic.
MIL-I-24718/3	- Insulating Resins, Solventless, Vacuum-Pressure-Impregnating Polyester Diallyl Phthalate, Slightly Thixotropic.
MIL-I-24718/4	- Insulating Resins, Solventless, Vacuum-Pressure-Impregnating Replenishment Resin, Polyester Diallyl Phthalate, Slightly Thixotropic.
MIL-C-81302	- Cleaning Compound, Solvent, Trichlorotrifluoroethane.

STANDARDS

FEDERAL

FED-STD-141	- Paint, Varnish, Lacquer and Related Materials: Methods of Inspection, Sampling and Testing.
FED-STD-313	- Material Safety Data, Transportation Data and Disposal Data for Hazardous Materials Furnished to Government Activities.

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from the Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.)

2.2 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents which are DOD adopted are those listed in the issue of the DODISS cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS are the issues of the documents cited in the solicitation (see 6.2).

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

D 93 - Standard Test Methods for Flash Point by Pensky-Martens Closed Tester. (DoD adopted)

D 149 - Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies. (DoD adopted)

D 150 - Standard Test Methods for A-C Loss Characteristics and Permittivity (Dielectric Constant) of Solid Electrical Insulating Materials. (DoD adopted)

D 323 - Standard Test Method for Vapor Pressure of Petroleum Products (Reid Method). (DoD adopted)

D 374 - Standard Test Methods for Thickness of Solid Electrical Insulation.

D 609 - Standard Methods for Preparation of Steel Panels for Testing Paint, Varnish, Lacquer, and Related Products. (DoD adopted)

D 618 - Standard Methods of Conditioning Plastics and Electrical Insulating Materials for Testing. (DoD adopted)

D 823 - Standard Test Methods for Producing Films of Uniform Thickness of Paint, Varnish, and Related Products on Test Panels. (DoD adopted)

D 1963 - Standard Test Method for Specific Gravity of Drying Oils, Varnishes, Resins, and Related Materials at 25/25°C.

D 2196 - Standard Test Methods for Rheological Properties of Non-Newtonian Materials by Rotational (Brookfield) Viscometer. (DoD adopted)

D 2240 - Standard Test Method for Rubber Property - Durometer Hardness. (DoD adopted)

D 2436 - Standard Specification for Forced-Convection Laboratory Ovens for Electrical Insulation.

D 2519 - Standard Test Method for Bond Strength of Electrical Insulating Varnishes by the Helical Coil Test.

D 3056 - Standard Test Method for Gel Time of Solventless Varnishes.

D 3145 - Standard Test Method for Thermal Endurance of Electrical Insulating Varnishes by the Helical Coil Method.

D 3850 - Standard Test Method for Rapid Thermal Degradation of Solid Electrical Insulating Materials by Thermogravimetric Method.

F 74 - Standard Recommended Practice for Determining Hydrolytic Stability of Plastic Encapsulants for Electronic Devices.

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

(Non-Government standards and other publications are normally available from the organizations that prepare or distribute the documents. These documents also may be available in or through libraries or other informational services.)

2.3 Order of precedence. In the event of a conflict between the text of this document and the references cited herein (except for related specification sheets), the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 Specification sheets. The individual item requirements shall be as specified herein and in accordance with the applicable specification sheet. In the event of any conflict between the requirements of this specification and the specification sheet, the latter shall govern.

3.2 First article. When specified (see 6.2), a sample shall be subjected to first article inspection (see 6.4) in accordance with 4.3.

3.3 Materials. The impregnating resin shall be of a chemically curing composition consisting of either one or two components. When there are two components, they shall be completely compatible with only mild stirring. The output of the stirring propeller shall be so that the tanker resin can be stirred within 15-30 minutes. The catalyzed resin shall be designed to provide minimum void in coils processed for vacuum-pressure-impregnation. The product shall cure (having maximum dielectric strength) completely at a temperature of not more than 200°C in a time period of no more than 16 hours, and shall meet all requirements defined on the individual specification sheet.

3.3.1 Recovered materials. Unless otherwise specified herein, all material incorporated in the products covered by this specification shall be new and may be fabricated using materials produced from recovered materials to the maximum extent practicable without jeopardizing the intended use. The term "recovered materials" means materials which have been collected or recovered from solid waste and reprocessed to become a source of raw materials, as opposed to virgin raw materials. None of the above shall be interpreted to mean that the use of used or rebuilt products is allowed under this specification unless otherwise specifically specified.

3.3.2 Fillers and additives. Fillers and additives may be incorporated by formulators into the product to obtain the properties defined by this specification. Fillers shall be sized to meet the minimum voids requirement and be evenly dispersed throughout the total volume of resin. Fillers shall not irreversibly settle during storage of the product. The fillers shall not settle during application or cure. Phase separation of the additives or of the catalyst from the resin shall not occur.

3.3.3 Purity and uniformity. On visual inspection of the packaged components, they shall be free from all foreign substances, such as grit, dirt, oil, and water. The material shall show no gel particles, skin, ingredient lumps, or agglomerates.

3.3.4 Toxic products. The material shall have no adverse effect on the health of personnel when used for its intended purpose. Questions pertinent to this effect shall be referred by the contracting activity to the appropriate departmental medical service who will act as an advisor to the contracting agency.

3.3.5 Prohibited material. Asbestos and organic silicone shall not be used in the formulation (see 4.5.4).

3.3.6 Unreactive volatiles. The products purchased under this specification shall contain no unreactive volatile constituents (see 4.5.5). Conformance to this requirement may be verified by the Navy using vacuum distillation and gas chromatography methods.

3.3.7 Surface properties. The product shall cure in smooth, thin films. Unmagnified visual examination of the cured film on steel foil, prepared in accordance with 4.6.1.4, shall show no surface defects such as blisters, cracks, pinholes, or other irregularities that may trap moisture or particulate matter. Lack of adhesion of the top coat shall not occur when the curved surface is coated with common resinous materials.

3.4 Material safety data sheet (MSDS). The contracting activity shall be provided a material safety data sheet at the time of contract award. The MSDS shall be provided in accordance with the requirements of FED-STD-313. The MSDS shall be included with each shipment of the material covered by this specification (see 6.7).

3.5 Performance. Material performance shall be as specified in 3.5.1 through 3.5.17.

3.5.1 Catalyzed storage life. Catalyzed storage life shall be as specified (see 3.1 and 4.6.2).

3.5.2 Vapor pressure. Vapor pressure shall be as specified (see 3.1 and 4.6.3).

3.5.3 Weight loss on cure. Weight loss on cure shall be as specified (see 3.1 and 4.6.4).

3.5.4 Flash point. Flash point shall be as specified (see 3.1 and 4.6.5).

3.5.5 Gel point. Gel point shall be as specified (see 3.1 and 4.6.6).

3.5.6 Viscosity. Viscosity shall be as specified (see 3.1 and 4.6.7).

3.5.7 Build. Build shall be as specified (see 3.1 and 4.6.8).

3.5.8 Resin retention. Resin retention shall be as specified (see 3.1 and 4.6.9).

3.5.9 Specific gravity. Specific gravity shall be as specified (see 3.1 and 4.6.10).

3.5.10 Dielectric strength. Dielectric strength shall be as specified (see 3.1 and 4.6.11).

3.5.11 Dissipation factor and dielectric constant. Dissipation factor and dielectric constant shall be as specified (see 3.1 and 4.6.12).

3.5.12 Hardness. Hardness shall be as specified (see 3.1 and 4.6.13).

3.5.13 Bond strength. Bond strength shall be as specified (see 3.1 and 4.6.14).

3.5.14 Thermal endurance. Thermal endurance shall be as specified (see 3.1 and 4.6.15).

3.5.15 Saltwater proof. Saltwater proof shall be as specified (see 3.1 and 4.6.16).

3.5.16 Hydrolytic stability. Hydrolytic stability shall be as specified (see 3.1 and 4.6.17).

3.5.17 Chemical resistance. Chemical resistance shall be as specified (see 3.1 and 4.6.18).

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the contractor is responsible for the performance of all inspection requirements (examinations and tests) as specified herein. Except as otherwise specified in the contract or purchase order, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in this specification where such inspections are deemed necessary to ensure supplies and services conform to prescribed requirements.

4.1.1 Responsibility for compliance. All items shall meet all requirements of sections 3 and 5. The inspection set forth in this specification shall become a part of the contractor's overall inspection system or quality program. The absence of any inspection requirements in the specification shall not relieve the contractor of the responsibility of ensuring that all products or supplies submitted to the Government for acceptance comply with all requirements of the contract. Sampling inspection, as part of the manufacturing operations, is an acceptable practice to ascertain conformance to requirements, however, this does not authorize submission of known defective material, either indicated or actual, nor does it commit the Government to accept defective material.

4.1.2 Toxicological formulations. The contractor shall have the toxicological product formulations and associated information available for review by the contracting activity to evaluate the safety of the material for the proposed use.

4.2 Classification of inspections. The inspection requirements specified herein are classified as follows:

(a) First article inspection (see 4.3).
(b) Quality conformance inspection (see 4.4).

4.3 First article inspection. First article inspection shall consist of the inspections and tests specified in table I.

TABLE I. First article tests.

Characteristics	Requirement	Test
Catalyzed storage life	3.5.1	4.6.2
Vapor pressure	3.5.2	4.6.3
Weight loss on cure	3.5.3	4.6.4
Flash point	3.5.4	4.6.5
Gel point	3.5.5	4.6.6
Viscosity at 2 r/min	3.5.6	4.6.7
at 20 r/min		4.6.7
Shear thinning		4.6.7
Build	3.5.7	4.6.8
Resin retention	3.5.8	4.6.9
Specific gravity	3.5.9	4.6.10
Dielectric strength	3.5.10	
96/23/50		4.6.11
96/23/96		4.6.11
24/23/water		4.6.11
Dissipation factor	3.5.11	4.6.12
at 25°C		4.6.12
at 150°C		4.6.12
Dielectric constant	3.5.11	4.6.12
at 25°C		4.6.12
at 150°C		4.6.12
Hardness	3.5.12	4.6.13
Bond strength	3.5.13	4.6.14
at 25°C		4.6.14
at 150°C		4.6.14
Thermal endurance	3.5.14	4.6.15
Saltwater proof	3.5.15	4.6.16
Hydrolytic stability	3.5.16	4.6.17
Chemical resistance	3.5.17	4.6.18

4.3.1 First article samples. First article samples shall consist of two 1-gallon cans of the resin and an appropriate amount of catalyst, as required.

4.4 Quality conformance inspection. The product sample selected shall be subjected to the tests specified in table II as applicable to the particular composition and class involved (see 6.3). Criteria for determining lot acceptance are defined in the individual specification sheet.

TABLE II. Quality conformance tests.

Characteristics	Requirement	Test
Weight loss on cure	3.5.3	4.6.4
Gel point	3.5.5	4.6.6
Viscosity at 2 r/min percent change in viscosity from qualification value	3.5.6	4.6.7
Build	3.5.7	4.6.8
Resin retention	3.5.8	4.6.9
Specific gravity percent change in gravity from qualification value	3.5.9	4.6.10
Dielectric strength 24/23/50	3.5.10	4.6.11
Hardness	3.5.12	4.6.13
Bond strength at 25°C	3.5.13	4.6.14

4.4.1 Lot. A lot shall consist of resin from one process batch or numerous process batches, uniformly blended together in a tank and offered for delivery at one time. If the resin cannot be identified by batch or tank, a lot shall consist of not more than 1,000 gallons blended together and offered for delivery at one time. Catalyst, if required, shall be treated in the same way.

4.4.2 Samples for quality conformance tests. The sample shall be made as representative as possible by agitation or circulation of the lot before sampling. From each lot, a representative sample consisting of two 1-quart containers of the resin and appropriate amount of catalyst shall be selected in accordance with method 1031 of FED-STD-141.

4.4.2.1 Lot rejection. If any sample is found to be not in conformance with the requirements of this specification, the lot represented by the sample shall be rejected.

4.5 Conditioning, tolerances, designations, and apparatus.

4.5.1 Temperature and humidity tolerances. Unless otherwise specified, temperature and relative humidity shall be maintained within the tolerances at all times shown in table III.

TABLE III. Tolerances.

Temperature		Relative humidity	
(°C)	Tolerance (± °C)	(Percent)	Tolerance (absolute) (± percent)
0 to 180	2	50	5
181 to 300	3	95	2
301 to 325	4	--	-
326 to 500	5	--	-

4.5.2 Conditioning designations. Preconditioning, conditioning, curing, and aging conditions shall be designated in accordance with the format defined in ASTM D 618.

4.5.3 Chambers and ovens. Chambers and ovens shall be as specified in 4.5.3.1 through 4.5.3.2.

4.5.3.1 High humidity chamber. The chamber shall be a non-corroding container of a standard size, large enough for the apparatus intended to be processed, and the relative humidity shall be maintained as specified in ASTM F 74 using a saturated salt solution of potassium sulfate.

4.5.3.2 Oven. The oven shall be an electrically heated, forced convection type as specified in ASTM D 2436.

4.5.4 Test for prohibited material. Tests for prohibited materials (see 3.3.5), when specified, shall be conducted by a Navy designated laboratory using analytical chromatographic or spectroscopic methods for analysis.

4.5.5 Test for unreactive volatiles. Acceptable verification of conformance to 3.3.6 shall be accomplished using vacuum distillation and gas chromatography methods. When specified, testing may be done by a Navy designated laboratory.

4.6 Test procedures. Tests shall be conducted in accordance with 4.6.1 through 4.6.18.

4.6.1 Preparation of test specimens. The number and type of test specimens shall be as specified in the applicable test methods and table IV.

TABLE IV. Standard specimens for first article and quality conformance tests.

Property	Requirement	Test	Substrate and dimensions (inches)	Resin coats	Specimens tested
Catalyzed storage life	3.5.1	4.6.2	---	---	1/
Vapor pressure	3.5.2	4.6.3	---	---	1
Weight loss on cure	3.5.3	4.6.4	---	---	3
Flash point	3.5.4	4.6.5	---	---	1
Gel point	3.5.5	4.6.6	---	---	3
Viscosity	3.5.6	4.6.7	---	---	2
at 2 r/min		4.6.7	---	---	2
at 20 r/min		4.6.7	---	---	2
Shear thinning		4.6.7	---	---	---
Build	3.5.7	4.6.8	Steel 5 x 3 x 0.032	1	5
Resin retention	3.5.8	4.6.9	Steel 5 x 3 x 0.032	1	5
Specific gravity	3.5.9	4.6.10	---	---	1
Dielectric strength	3.5.10				
96/23/50		4.6.11	Steel 5 x 3 x 0.032	2	3
96/23/96		4.6.11	5 x 3 x 0.032	2	3
24/23/water		4.6.11	5 x 3 x 0.032	2	3
Dissipation factor	3.5.11				
at 25°C		4.6.12	---		1
at 150°C		4.6.12	---	---	1
Dielectric constant	3.5.11				
at 25°C		4.6.12	---	---	1
at 150°		4.6.12	---	---	1
Hardness	3.5.12	4.6.13	---	---	1
Bond strength	3.5.13				
at 25°C		4.6.14	2/ M2 and K2	1	3/ 5
at 150°C		4.6.14	2/ M2 and K2	1	3/ 5
Thermal endurance	3.5.14	4.6.15	2/ M2 and K2	1	1/
Saltwater proof	3.5.15	4.6.16	Brass 0.59 x 5.9	2	1/
Hydrolytic stability	3.5.16	4.6.17	2/ M2	1	5
Chemical resistance	3.5.17	4.6.18	2/ M2	1	30

1/ As required by the test paragraph.
2/ Size 18 AWG magnet wire, in accordance with J-W-1177.
3/ In accordance with magnet wire type.

4.6.1.1 Liquid resin. The product shall be brought to laboratory temperature in a closed container at least 24 hours before use. Two-part products shall be brought to temperature as described above, mixed thoroughly with catalyst, and allowed to stand in a closed container for 24 to 48 hours prior to use. Other than catalyst, no additions shall be made to the as-received resin.

4.6.1.2 Curing of test specimens. Preparation of specimens shall be in accordance with the manufacturer's instructions, including curing time and temperature and, if required, catalyst and catalyst/resin ratio. Specimens for all property measurements shall be cured identically.

4.6.1.3 Cast specimens. Cast specimens shall be made by preparing the liquid product in accordance with 4.6.1.1, pouring into a 2- to 3-inch diameter aluminum weighing dish, and curing as specified in 4.6.1.2 in a preheated oven. Sufficient product shall be used to achieve a casting thickness of 0.125 ± 0.031 inch.

4.6.1.4 Panel specimens. The catalyzed product shall be coated onto steel panels and cured.

4.6.1.4.1 Materials. The liquid product shall be prepared in accordance with 4.6.1.1, brought to 24 ± 1°C and poured slowly into a suitable container so as not to trap air in the resin. Vapor degreased, cold rolled steel panels, 3 ± 0.25 inches in width by 5 ± 0.25 inches in length, shall conform to the type I standard specified in ASTM D 609.

4.6.1.4.2 Apparatus. A device as specified in ASTM D 823 shall be used to withdraw the steel panel from the liquid product at 4 ± 0.25 inches per minute. A water bath or conditioned room shall be provided to maintain the liquid product at 24 ± 1°C.

4.6.1.4.3 Procedure. The panel shall be tested as follows. Lower the test panel slowly into the product. Place the container with the liquid and panel in a constant temperature water bath or in a conditioned room held at 24 ± 1°C. Allow to stand without vibration in this condition for 60 plus 5, minus 0 minutes. At the end of 60 minutes, move the specimen under the dip coater which has been previously adjusted to withdraw the specimen at a rate of 4 ± 0.25 inches per minute. Attach the specimen without disturbing the jar or panel. When the panel has been raised from the resin, stop the dip coater and allow the specimen to drain 30 plus 2, minus 0 minutes. Laboratory conditions during draining shall be 24 ± 1°C and 50 ± 5 percent (absolute) relative humidity. Move the container away from the specimen so that it can hang free without detriment to the coating. Place specimen in a preheated oven and cure in accordance with 4.6.1.2. The specimen shall not be vibrated during draining or in the curing oven before the product gels. For dielectric test specimens, two steel panels may be taped back-to-back so that only one side is coated; the uncoated side provides an electrode surface. The number of cured coats per specimen shall be as specified.

4.6.1.5 Helical coil specimens. The specimens shall be prepared in accordance with ASTM D 2519, with the exception that the product shall be prepared as specified in 4.6.1.1 and only one coat shall be applied. Film insulated magnet wire shall be heavy build, size AWG 18 and of a composition as specified.

4.6.1.6 Saltwater proof test coil specimens. The coil, shall be made from a continuous length of the wire. Use standard M1 magnet wire size 18 AWG to make a simple race track shaped coil by wrapping 50 feet of this wire around two mandrels (3 inches in diameter) and positioned on 7-inch centers. After winding on the mandrels, four plastic ties shall be attached and evenly spaced on the straight portion of the coil to form it and hold it to a cylindrical bundle. Such a coil will be approximately 11 inches in length and 4 inches wide. The diameter of a cross section of the wire bundle is approximately 1/4 inch. The coil shall be wound in such a manner that the beginning and end shall extend approximately 8 inches beyond the coil proper. These extended ends can be twisted slightly together for the purpose of supporting the coils for the impregnation process (see 4.6.1.7).

4.6.1.7 Impregnation of test coils. The solventless resin to be evaluated, prepared as specified in 4.6.1.1, shall be used to impregnate the coils using the VPI process. The test coils shall be VPI'd with a 30-minute dry vacuum of 2mm Hg (minimum) followed by a wet vacuum for 1 hour at the same vacuum level. Both for the wet vacuum and the pressure cycle, the coil shall be submerged a minimum of 3 inches under the surface of the resin being evaluated. After the 1-hour wet vacuum the coil is subjected to a pressure cycle of 50 lb/in^2 (minimum) for an additional hour. The temperature for the VPI process shall be according to the manufacturer's instructions as intended for normal shop use of the product. No special conditions shall be used. After the VPI process the coils are drained and cured according to the manufacturer's instructions. After cooling the test coil specimens are ready for the saltwater proofness test (see 4.6.16).

4.6.2 Catalyzed storage life. The catalyzed product shall have storage life such that all of the requirements shall be met after storage in a closed container at 20°C for the time period required (see 3.5.1).

4.6.3 Vapor pressure. Vapor pressure of the catalyzed product, prepared as specified in 4.6.1.1, shall be measured and recorded in accordance with ASTM D 323 (Reid method).

4.6.4 Weight loss on cure. Weight loss on cure shall be tested as follows. Prepare catalyzed product as specified in 4.6.1.1. Transfer a specimen weighing 2 to 4 grams to a weighed aluminum drying dish which was previously heated for 30 minutes at 150°C and cooled in a desiccator to laboratory temperature. Weigh and place the dish with specimen in a forced-convection oven in accordance with ASTM D 2436, preheated to the curing temperature, and cure in accordance with 4.6.1.2. After cure, allow the dish and specimen to cool in a desiccator to laboratory temperature before weighing. Calculate the percent weight loss using the following formula:

$$\text{Percent weight loss on cure} = 100 \times \frac{A-B}{A-C}$$

Where: A = weight of uncured resin plus dish
B = weight of cured resin plus dish
C = weight of dish

Three resin specimens shall be tested.

4.6.5 Flash point. Flash point of the catalyzed product shall be measured and reported in accordance with ASTM D 93, method B.

4.6.6 Gel point. Gel time shall be measured on three catalyzed product specimens in accordance with ASTM D 3056. Bath temperature of either 100, 125 or 150°C shall be employed. The temperature shall be chosen to give a gel time between 10 and 60 minutes.

4.6.7 Viscosity. Viscosity shall be measured as follows at 24 ± 1°C on catalyzed product prepared in accordance with 4.6.1.1. Viscosity shall be determined at spindle speeds of 2 and 20 revolutions per minute (r/min) in accordance with method B of ASTM D 2196. The product shall be placed in a 1-quart container to within 1 inch of the top. Using a water bath, adjust the sample to 24 ± 1°C. After reaching the required temperature, wait 90 plus 5, minus 0 minutes before the first measurement is made at 2 r/min. The 20-r/min measurement shall then be made immediately after the 2-r/min measurement. Test two specimens and record the average of two readings, provided the deviation of a single measurement from the average is not greater than 10 percent. If greater than 10 percent, recalibrate the viscometer and repeat the tests with different samples a minimum of three times, if needed. A shear thinning index shall be calculated as follows:

$$\text{Shear thinning index} = \frac{\text{Average viscosity at 2 r/min}}{\text{Average viscosity at 20 r/min}}$$

4.6.8 Build. Build, or thickness of a single coat of cured product on a steel panel, shall be determined using five specimens as specified in 4.6.1.4. Thickness measurements shall be made, after cure, on the 1-inch center width section of a steel strip, 5 by 3 by 0.031 inch, to avoid edge effects. Thickness measurements shall be made with micrometers in accordance with ASTM D 374, method A. The average of the thickness at points 2 and 4 inches from the top of the steel strip, with the average thickness of the steel subtracted and remainder divided by 2, shall be taken as the film build per specimen.

4.6.9 Resin retention. Resin retention shall be measured as follows on five specimens prepared as specified in 4.6.1.4. Pre-weighed test panels are coated with the resin and are permitted to drain into the resin containers for 30 minutes as in 4.6.1.4.3. The coated test panels are placed into a room temperature baking oven and clean pre-weighed aluminum pans are positioned under each of the panels. After the oven is energized and the temperature begins to rise the pans collect the run-off resin. After the test panels of resin are cured in the baking oven according to the time and temperature recommended by the manufacturer, the panels and aluminum pans are permitted to cool to room temperature and are then weighed. Calculate the percent resin retention as follows:

$$\text{Percent resin retention} = \frac{(C-D)}{(C-D) + (A-B)}$$

Where:
A = weight of pan plus cured collected resin
B = weight of clean, empty pan
C = weight of steel panel and cured coating
D = weight of clean, uncoated steel panel

4.6.10 Specific gravity. Specific gravity shall be measured at 25°C in accordance with ASTM D 1963. Individual values are required for each component, if a two-part system.

4.6.11 Dielectric strength. The voltage gradient at which dielectric failure of the resin occurs shall be measured as follows on specimens as described in 4.6.1.4, except reverse dip the steel panel for a total of two coats. The test specimens shall be prepared by placing two steel panels together and sealing the edges so that a coating is obtained on one side of the panel only. Three test strips shall be subjected to each of the following conditions in accordance with ASTM D 618 after cure:

96/23/50
96/23/96
24/23/distilled water

Breakdown voltage measurements shall be made using an electrode set, 0.250 inch in diameter with edges rounded to a radius of 0.031 inch. Circular gaskets shall be placed over the end of each electrode to prevent flashover. After carefully placing the test specimens between the electrodes connected to a suitable test apparatus, increase the voltage from zero to breakdown at a rate of 500 volts per second in accordance with ASTM D 149. Make a minimum of 5 voltage breakdown determinations per panel. Test points shall be no less than 0.5 inch from the edge of the sample and no more than 1.250 inches from a prior test point. Make thickness measurements using a micrometer that has a maximum opening of 0.5 inch, in accordance with ASTM D 374, near the breakdown area (point) and also measure the average thickness of the uncoated panel. Use the differences in these measurements in calculating breakdown volts per mil.

4.6.12 Dissipation factor and dielectric constant. Dissipation factor and dielectric constant shall be measured on a cast and cured specimen prepared in accordance with 4.6.1.3 and conditioned 96/23/50. Measurements shall be made at 23 and 150°C in accordance with the two-terminal system as specified in ASTM D 150. Testing shall be at 60 hertz (Hz).

4.6.13 Hardness. Hardness measurements shall be made on a cast sample, prepared in accordance with 4.6.1.3 and tested, in accordance with ASTM D 2240 (type D), at 23°C.

4.6.14 Bond strength. The bond strength test shall be conducted in accordance with ASTM D 2519 with the exception that the specimen shall be prepared as specified in 4.6.1.5. The magnet wire shall be types M2 and K2 of J-W-1177. Specimens of each magnet wire type shall be conditioned at 96/23/50 and then tested at temperatures of 23 and 150°C. Five identical helical coil specimens shall be tested for each variation in magnet wire and test temperature.

4.6.15 Thermal endurance. Thermal endurance shall be tested as specified in 4.6.15.1 through 4.6.15.2.

4.6.15.1 Thermal class. The thermal class rating shall be determined by using the helical coil method, as specified in ASTM D 3145. The specimens shall be prepared in accordance with 4.6.1.5. Thermal indices shall be measured on

specimens made with type M2 and K2 magnet wire of J-W-1177. The individual thermal index shall be indicated for each wire type. The end point, determining thermal life, shall be as specified in ASTM D 3145. The straight line shall be extrapolated to 20,000 hours.

4.6.16 Saltwater proof. Nine VPI test coils, prepared in accordance with 4.6.1.7, shall be preconditioned at 24/23/50. These test coils shall be suspended in saltwater (3-1/2 percent sodium chloride by weight) in such a manner as to completely submerge the coil loop. Approximately 2 inches of the beginning and end of the wire shall be scrapped free of enamel and varnish, to bare the copper and act as leads. These leads are twisted together and extended out of the saltwater solution to provide one side of the electrical circuit. Direct current voltage (120 volts) shall be applied with the impregnated coil as a cathode and a nichrome wire suspended in the salt solution as an anode. The electrodes shall be connected to the power supply with one lead in series with a standard 7.5 watt incandescent lamp to indicate breakdown of the coil insulation. The coils shall be energized while completely submerged in the saltwater for 100 hours at 23°C. Breakdown prior to the 100 hours shall be indicated in number of hours to failure. Results obtained in the saltwater proof test shall be recorded as follows:

(a) No more than six of nine coils fail - Pass.
(b) Seven or more of nine coils fail - Retest (nine additional coils shall be prepared for retest).
(c) On retest, a total of no more than 12 of 18 coils fail - Pass.
(d) On retest, a total of 13 or more of 18 coils fail - Reject.

4.6.17 Hydrolytic stability. Moisture resistance shall be determined by measuring the percent change in helical bond strength due to conditioning for 200 hours at 97°C and 95 percent relative humidity in the humidity chamber specified in 4.5.3.1. Helical bond specimens, five per test condition, shall be made from only type M2 magnet wire of J-W-1177 and tested at 23°C, in accordance with 4.6.14, after the following conditioning:

96/23/50
200/97/95

After humidity aging, specimens shall be allowed to equilibrate at 23 ± 2°C and 50 ± 5 percent (absolute) relative humidity for a minimum of 1 hour and a maximum of 2 hours before testing. Procedures specified in ASTM F 74 shall apply.

4.6.18 Chemical resistance. Chemical resistance shall be measured by the change in helical bond strength caused by 168 hours immersion in various chemical media at 23°C. Helical bond specimens, five per test condition, shall be made from only type M2 magnet wire of J-W-1177 and tested at 23°C, in accordance with 4.6.14, after exposure to 96/23/50 and after 168 hours immersion in the following liquids at 23°C:

(a) Hydraulic fluid in accordance with MIL-H-17672.
(b) Lubricating oil in accordance with MIL-L-17331.

(c) Cleaning fluid in accordance with MIL-C-81302 (1, 1, 2 trichloro-1, 2, 2-trifluoroethane).
(d) Distilled water.
(e) Detergent solution in accordance with P-D-220; mixed 1 pound of detergent to 2.25 gallons of distilled water.

The immersed specimens shall be tested within 3 minutes after removal from the immersion medium. The first article inspection shall include wire identity, immersion medium, immersion temperature, time of immersion, average pounds of breaking force, and percent change from 96/23/50 to after immersion in each medium. The specimens shall also show no sign of resin softening or tackiness, as determined by gently wiping the surface of the helical coil specimen with cotton prior to physical testing. No cotton fibers shall be retained on the surface of the specimen.

4.7 Inspection of packaging. Sample packs, and the inspection of the preservation, packing and marking for shipment, stowage, and storage shall be in accordance with requirements of section 5 and the documents specified therein.

5. PACKAGING

(The packaging requirements specified herein apply only for direct Government acquisition.)

5.1 Packaging requirements. The insulating resins shall be preserved level A, or commercial, packed level A, B, or commercial as specified (see 6.2), and marked in accordance with PPP-P-1892 and shall include bar codes and applicable packaging acquisition options therein as specified (see 6.2). Packaging shall be in 1-gallon pails, 5-gallon pails, or 55-gallon drums, as specified (see 6.2). In addition, for Navy acquisitions, the following applies:

(a) Navy fire-retardant requirements.

(1) Lumber and plywood. Unless otherwise specified (see 6.2), all lumber and plywood including laminated veneer material used in shipping container construction members, blocking, bracing, and reinforcing shall be fire-retardant treated material conforming to MIL-L-19140 as follows:

Levels A and B - Type II - weather resistant.
Category 1 - general use.

Level C - Type I - non-weather resistant.
Category 1 - general use.

(2) Fiberboard. Unless otherwise specified (see 6.2), fiberboard used in the construction of class-domestic, non-weather resistant fiberboard and cleated fiberboard boxes including interior packaging forms shall meet the flamespread and the specific optic density requirements of PPP-P-320 amendments thereto.

5.2 Marking. In addition to the markings required by PPP-P-1892, each unit container, intermediate and shipping container shall be permanently marked with the following information:

Manufacturer's trade name or formula number
Shelf life and storage conditions
"CAUTION: This resin may not be compatible with resin in the storage tank. Check identity before use."

The method of marking shall be by stenciling, painting, printing, or other method that will not degrade visually during normal shipping, storage, and handling. Marking shall also be in accordance with federal statutes and regulations (for example, Federal Hazardous Substance Labeling Act, and so forth) and as specified in 5.2.1.

5.2.1 Marking of hazardous material. Hazardous materials, which may cause personal injury, property damage, or environmental deterioration through transportation, use or disposal, shall be marked in accordance with the requirements of public law and regulations and PPP-P-1892.

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Intended use. The insulating products covered by this specification are intended for impregnation and complete void fill of all types of electrical coils and windings. They should be rated for continuous operation at the maximum operating temperature specified for each class. Products may also be used at temperatures lower than the thermal class. Products covered by this specification are intended for use in the VPI process. The primary purpose of the impregnant is to protect the coils from the operating environment.

6.1.1 Evaluation of toxicity. Questions regarding the effect of compounds procured with this specification on the health of personnel involved in its utilization should be referred by the contracting activity to the Naval Medical Command (NAVMEDCOM). NAVMEDCOM will act as an advisor to the contracting activity when requested (see 3.3.4).

6.2 Acquisition requirements. Acquisition documents must specify the following:

(a) Title, number, and date of this specification.
(b) Issue of DoDISS to be cited in the solicitation, and if required, the specific issue of individual documents referenced (see 2.1.1 and 2.2).
(c) Types of insulating resins required (see 1.2).
(d) Whether first article inspection is required (see 3.2).
(e) Part number as defined on the specification sheet.
(f) Size of containers required (insulating resin should be purchased by volume, the unit being a U.S. gallon at 15.6°C) (see 5.1).
(g) Levels of preservation and packing required (see 5.1).

(h) Special marking required (see 5.1).
(i) When fire-retardant materials are not required (see 5.1).

6.3 Consideration of data requirements. The following data requirements should be considered when this specification is applied on a contract. The applicable Data Item Descriptions (DID's) should be reviewed in conjunction with the specific acquisition to ensure that only essential data are requested/provided and that the DID's are tailored to reflect the requirements of the specific acquisition. To ensure correct contractual application of the data requirements, a Contract Data Requirements List (DD Form 1423) must be prepared to obtain the data, except where DoD FAR Supplement 27.475-1 exempts the requirement for a DD Form 1423.

Reference Paragraph	DID Number	DID Title	Suggested Tailoring
4.4	DI-T-2072	Reports, test	-----

The above DID's were those cleared as of the date of this specification. The current issue of DoD 5010.12-L, Acquisition Management Systems and Data Requirements Control List (AMSDL), must be researched to ensure that only current, cleared DID's are cited on the DD Form 1423.

6.4 First article. When first article inspection is required, the contracting officer should provide specific guidance to offerors whether the item(s) should be a preproduction sample, a first article sample, a first production item, a sample selected from the first production items, a standard production item from the contractor's current inventory (see 3.2), and the number of items to be tested as specified in 4.3. The contracting officer should also include specific instructions in acquisition documents regarding arrangements for examinations, approval of first article test results, and disposition of first articles. Invitations for bids should provide that the Government reserves the right to waive the requirement for samples for first article inspection to those bidders offering a product which has been previously acquired or tested by the Government, and that bidders offering such products, who wish to rely on such production or test, must furnish evidence with the bid that prior Government approval is presently appropriate for the pending contract. Bidders should not submit alternate bids unless specifically requested to do so in the solicitation.

6.5 Definitions.

6.5.1 Electrical insulating resin, solventless. A solventless electrical insulating resin is 100 percent reactive without non-reactive volatile ingredients. Catalysts, co-reactants and inorganic fillers may be included. When applied and cured on electrical components, the deposit provides mechanical, electrical, environmental protection, and improves the heat dissipation of the unit.

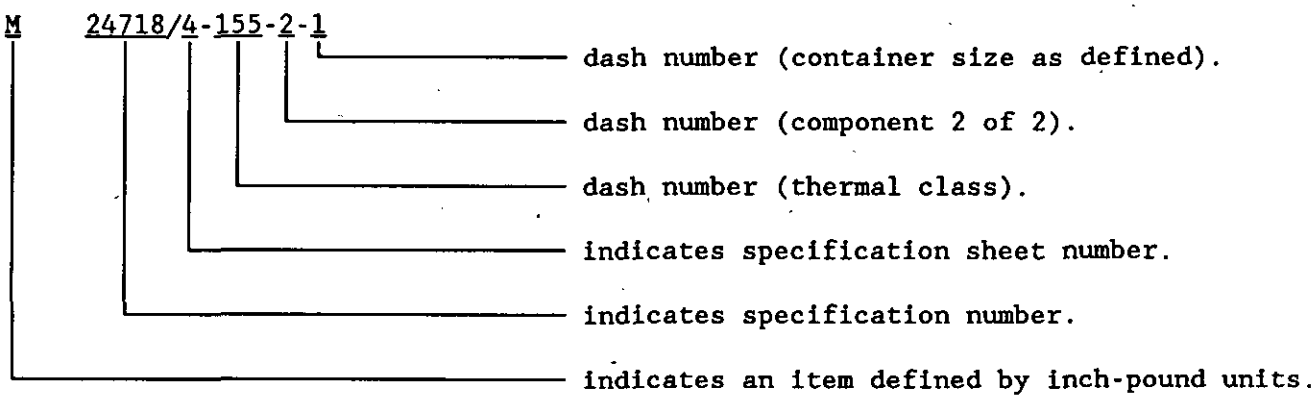
6.5.2 VPI. In the VPI process, all solid-porous insulating material in an electrical coil is treated by heat and vacuum to remove practically all gas and vapor and then is impregnated under pressure by a liquid resin. Prior to impregnation, the resin is generally under vacuum in the storage tank to remove entrapped air and water. After impregnation, the coil is transferred to a curing oven.

6.5.3 Product. Product is defined as a distinct resin and catalyst system, either one or two part, manufactured from a specific formula.

6.6 Compatibility. Resins of the same composition and class may not be compatible with one another. Mixing of different products should be avoided, unless specifically approved by NAVSEA. An individual specification sheet exists for replenishment VPI resins. The unique requirements for this product will assure compatibility with the resin currently in a storage tank.

6.7 Material safety data sheets. Contracting officers will identify those activities requiring copies of completed Material Safety Data Sheets prepared in accordance with FED-STD-313. The pertinent Government mailing addresses for submission of data are listed in FED-STD-313.

6.8 Part or Identifying Number (PIN). The PIN to be used for insulating resins acquired to this specification is created as follows:



6.9 Subject term (key word) listing.

Epoxy-Lewis acid
Impregnating electrical equipment
Thixotropic

Custodians:
Army - ER
Navy - SH
Air Force - 20

Preparing activity:
Navy - SH
(Project 5970-1002)

Review activities:
Army - MI, AR
Navy - EC, YD, OS
Air Force - 99
DLA - GS, DS

User activities:
Army - ME
Navy - MC, AS

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	2. DOCUMENT DATE (YYMMDD)
	MIL-I-24718	

3. DOCUMENT TITLE
INSULATING RESINS, SOLVENTLESS, VACUUM-PRESSURE-IMPREGNATING: GENERAL SPECIFICATION FOR

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) (1) Commercial (2) AUTOVON (If applicable)	7. DATE SUBMITTED (YYMMDD)

8. PREPARING ACTIVITY

a. NAME	b. TELEPHONE (Include Area Code) (1) Commercial	(2) AUTOVON
Technical Point of Contact (TPOC): Mr. C.Y. Lu (SEA 56Z24) PLEASE ADDRESS ALL CORRESPONDENCE AS FOLLOWS:	TPOC: 703-602-3123	8-332-3123
c. ADDRESS (Include Zip Code) Commander, Naval Sea Systems Command Department of the Navy Washington, DC 20362-5101	IF YOU DO NOT RECEIVE A REPLY WITHIN 45 DAYS, CONTACT: Defense Quality and Standardization Office 5203 Leesburg Pike, Suite 1403, Falls Church, VA 22041-3466 Telephone (703) 756-2340 AUTOVON 289-2340	

DD Form 1426, OCT 89 — Previous editions are obsolete. — 198/290