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OVERHAUL ELECTRICAL ROTATING MACHINES

1. SCOPE

1.1 Scope. This standard specification describes the requirements for the Contractor to overhaul electrical rotating machines onboard Coast Guard vessels.

1.2 Applicability. The work specified in this standard specification applies to auxiliary motors and generators, and ship service and emergency generators, but not to electric propulsion rotating machines.

1.3 Appendices. The following appendices apply to this standard specification:

TITLE	APPENDIX
Table for Round Film Insulated Magnet Wire (J-W-1177)	A
Table for Square and Rectangular Film Insulated Magnet Wire (J-W-1177)	B
Table for Flexible Insulation Sheet	C
Table for Insulating Sleeving	D
Table for Laminated Uninsulated Sheet (U/I LB)	E
Table for Lacing and Tying Tape	F
Table for Insulation Tape (U/I Roll)	G
Table for Lead Wire (MIL-DTL-16878)	H
Table for Varnish Insulation	I
Table for Slot Wedge Insulation	J

2. APPLICABLE DOCUMENTS

Commercial Item Description (CID) A-A-52083, Feb 2004, Tape,

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Lacing and Tying, Glass

Commercial Item Description (CID) A-A-52084, Jun 2003, Tape, Lacing and Tying

Commercial Item Description (CID) A-A-59133, Nov 1997, Cleaning Compound, High Pressure (Steam) Cleaner

MIL-I-631, Insulation, Electrical, Jun 1987, Synthetic Resin Composition, Non-Rigid

MIL-I-695, Nov 1972, Insulation, Electrical, Paper (Slot Cell

MIL-I-3190, Insulation Sleeving, Aug 1993, Electrical, Flexible, Coated, General Specification for

MIL-I-3505, Oct 1960, Insulation Sheet and Tape, Electrical, Coil and Slot, High Temperature

MIL-I-15126, Apr 2003, Insulation Tape, Electrical, Pressure Sensitive Adhesive and Pressure Sensitive Thermosetting Adhesive

MIL-DTL-16878, Wire, Electrical, Aug 2000, Insulated, General Specification for

MIL-I-19166, Oct 1988, Insulation Tape, Electrical, High Temperature, Glass Fiber, Pressure Sensitive

MIL-I-21070, May 1966, Insulation Sheet and Tape, Electrical, Reinforced Mica Paper

MIL-I-22834, Apr 1998, Insulation, Electrical, Dielectric Barrier, Laminated, Plastic Film and Synthetic Fiber Material

MIL-I-24092, Sept 1993, Insulating Varnishes and Solventless Resins for Application by the Dip Process

MIL-I-24204, Aug 2002, Insulation, Electrical, High Temperature, Bonded Synthetic Fiber Paper

MIL-I-24391, Aug 1991, Insulation Tape, Electrical, Plastic, Pressure Sensitive

MIL-I-24718, Jun 1993, Insulation Resins, Solventless, Vacuum-Pressure-Impregnation; General Specification for

MIL-I-24768, Dec 1992, Insulation, Plastics, Laminated, Thermosetting; General Specification for

MIL-I-24768/1, Dec 1992, Insulation, Plastic, Laminated, Thermosetting, Glass-Cloth, Melamine-Resin(GME)

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MIL-I-24768/17, Feb 1992, Insulation, Plastic, Laminated, Thermosetting, Glass-Cloth, Silicone-Resin (GSG)

MIL-STD-2037, Oct 1991, Procedure to Obtain Certification for Electric Motor Sealed Insulation Systems

MIL-T-713, Apr 1989, Twine, Fibrous: Impregnated, Lacing and Tying

MIL-Y-1140, Sep 1985, Yarn, Cord, Sleeving, Cloth and Tape-Glass

National Electrical Manufacturers Association (NEMA) MW-1000, 2003, Magnet Wire

3. REQUIREMENTS

3.1 Advance notice for inspections. The Contractor shall notify the Coast Guard Inspector at least 24 hours before performing each test and inspection specified in this standard.

3.2 Insulation resistance test. When specified in other parts of this standard, the Contractor shall perform insulation resistance (IR) test by applying a test voltage across the insulation system between circuits and/or ground, using a 500V DC megger; measure and document all IR test readings.

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WARNING!

When one winding is being measured, all other windings must be connected to ground.

3.2.1 Correct the measured IR readings to 77 degrees Fahrenheit (25 degrees Celsius), using the Resistance Temperature Nomograph in Figure 4 herein. Document the corrected readings.

3.2.2 Submit all IR readings (measured and corrected) to the COR, within 24 hours after completion of IR test.

NOTICE!

Minimum acceptable insulation resistance readings for windings are provided in Table I below.

3.3 Initial insulation resistance (IR) test. The Contractor shall perform an initial IR test for each circuit listed in Table I, as applicable, for use as benchmark (see 3.2 (Insulation resistance test)).

TABLE I. MINIMUM ACCEPTABLE RESISTANCE READINGS

MOTORS AND GENERATORS		INSULATION RESISTANCE (Megohm)
AC	Stator circuit	2.0
	Rotor circuit of wound rotor induction motors	1.0
	Field circuit of generators or synchronous motors	4.0
DC	Complete shunt field circuits	2.5
	Complete armature circuit	1.0
	Armature alone	2.0
	Armature circuit less armature	2.0

NOTICE!

The complete armature circuit of a DC machine includes armature, brush rigging, connections to machine terminals, and any fields which carry armature current, such as commutating field, compensating field, and series field. The stator circuit of polyphase generators and motors and the rotor circuit of form wound rotor induction motors include all phases. If the machine has three phases and a single phase is isolated, its insulation resistance must be at least three times the value given in Table I.

3.3 Overhaul particulars. The Contractor shall accomplish the following tasks for each designated electrical rotating machine, as applicable:

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3.3.1 Disassembly. Completely disassemble the machine in a suitable repair facility.

3.3.2 Cleaning. Perform detergent cleaning of the stator and rotor as follows.

- Vacuum all loose accessible carbon, dirt, and other foreign particles or debris from the windings.

- Clean all mechanical parts with lint free cloths dampened with a suitable solvent.

WARNING!

Ensure that solvent does not come in contact with varnished surfaces or commutators.

- Prepare an appropriate quantity of cleaning solution, (depending on size of machine being cleaned), by mixing 15 to 20 pounds of steam cleaning compound, conforming to CID A-A-59133 and one quart of butyl alcohol per 1000 gallons of fresh water. Heat the solution to a temperature of 185-190 degrees Fahrenheit and maintain this temperature throughout the cleaning.

- Completely immerse the windings in the tank with the hot cleaning solution. Place rotors in the tank with the commutator (slip ring end up). Circulate water through the windings and through commutator risers, using an air agitator to stir. Continue cleaning for eight to ten hours, depending on the condition of the windings.

- Thoroughly flush the windings with clean hot water after cleaning with solution. Remove surface moisture with a clean cloth to minimize the amount of water that soaks into the insulation.

3.3.3 Drying. Immediately after completion of cleaning, thoroughly dry the windings in an oven for a minimum of eight hours. Slowly increase the oven temperature to a maximum of 221 degrees Fahrenheit (105 degrees Celsius), without exceeding 167 degrees Fahrenheit (75 degrees Celsius) for the first hour.

3.3.3.1 Before drying the DC armatures, loosen the studs that hold together the commutator V-rings to allow water or condensation under the commutator to escape during drying. After complete drying, re-tighten the V-ring studs to the required torque value for the machine in accordance with the manufacturer's instructions.

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3.3.3.2 After drying in the oven for the minimum eight hours, record megger readings of the windings again. Continue drying until four consecutive megger readings of the same value have been obtained. Submit a CFR for final megger readings.

3.3.3.3 Allow the windings to cool to within ten degrees Celsius of ambient temperature.

3.3.4 Inspection. Conduct a complete inspection of all parts as follows:

- Check all connections, including wedges, binding bands, soldered connections, and bolted connections; tighten where necessary.

- Examine all field windings and connections for cracks in taped surfaces, brittle condition, crystallization, and loose connections.

- Inspect rotor shaft journal areas, bearings, and bearing housings.

- Measure and record diameters of all journals, commutators, and slip rings.

3.3.5 Electrical tests. Perform the following tests to determine if winding faults exist:

3.3.5.1 Voltage surge comparison. Perform a surge comparison test to simultaneously test turn-to-turn, coil-to-coil, and coil-to-ground insulation. Ensure that the tester features voltage variation capabilities to smoothly increase voltage from zero up to the maximum as indicated in Table II.

3.3.5.2 Surge tester. Use an electronic surge tester capable of applying a surge voltage stress between turns of a coil, between phases, from the windings to ground, and to detect short-circuited turns in windings under test. Apply a repetitive surge waveshape to the turn and phase insulation in opposite directions and refer to Figure 2 to determine the condition of winding insulation. See paragraphs 5.4 (Surge tester), 5.5 (Tracing), and 5.6 (Three-phase machine fault detection).

3.3.5.3 Armature testing. Apply surge voltage across one brush span and observe the voltage at the middle of the span as the armature is rotated. A typical test connection is shown in Figure 3 (A). Use the bar-to-bar voltage measuring circuit as shown in Figure 3 (B) for cross-connected or wave-wound machines.

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3.3.5.4 Two-coil comparison. Test coils of various sizes as shown in Figure 3 (C). Test DC field coils or delta-connected AC stator windings using these connections and comparing one coil or phase of the winding to the other coil or phase.

3.3.5.5 Three-phase machine tests. Test three-phase motors and generators with the technique shown in Figure 3 (D).

3.3.5.6 Test voltage. Apply the test voltage to the wound component 1.4 times the value specified in Table II.

3.3.5.7 Curve evaluation. Evaluate the results of the trace curves, using Figure 2 as guidance, through a qualified technician, who is familiar with the trace curve analysis.

TABLE II. TEST VOLTAGES FOR RECONDITIONED AND REWOUND/REPLACED CIRCUITS

NOTE	CIRCUITS					
	RECONDITIONED			REWOUND/REPLACED		
	Armature AC/DC	Field AC	Shunt Field DC	Armature AC/DC	Field AC	Shunt Field DC
A	$\frac{2}{3}$(2E+1000)	7E*	$\frac{2}{3}$(2E+1000)	2E+1000	10E**	2E+1000
B	600V	600V	600V	900V	900V	900V
C	400V	-	400V	600V	-	600V

Notes:

A :Generators and motors, including propulsion generators and motors, but excluding all machines listed in notes "B" and "C".
B :Generators and motors of not more than 250 volts and not more than 0.25 kilowatts (generators) or 0.5 horsepower (motors), except machines listed in note "C".
C :Bracket fan motors.
E =Machine's rated voltage.
V =Volt.
*** =In no case less than 1000V nor more than 2300V.**
****=In no case less than 1500V nor more than 3500V.**

3.3.6 Report. Submit a CFR after completion of all inspections and tests.

3.3.7 Rewinding. When stated in the work item, or if a Change Request has been released and authorized by the KO, rewind the designated machine as follows:

3.3.7.1 Review and documentation. Review all available information concerning the machine before starting the work; this includes reviewing the appropriate drawings and technical manuals. Carefully record all winding dimensions including the length, thickness, inside and outside diameters, and winding flares.

3.3.7.2 Armature/stator stripping. Strip out the old winding keeping careful records of the coil data, size and type of magnet

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wire, number of turns per coil, coils per pole, pitch, number of poles, number of slots, connections, and similar data. After stripping, clean the armature or stator, removing all dirt, grease, rust and scale. Varnish dip and bake the cleaned armature or stator using a dilute varnish. See paragraph 3.3.7.8 (Varnishing).

3.3.7.3 Rewind material. Rewind using insulation materials in accordance with Tables III and IV. If rewinding kits are available from the manufacturer, the kits may be used in lieu of materials in Tables III and IV.

3.3.7.4 DC high potential tests. Conduct DC high potential tests after the rewind procedure. Ensure that the test voltage is 2/3(2E+1000), where "E" is the machine's rated voltage. Apply DC voltage in steps (i.e. 10% increments of maximum test voltage) and record the leakage current (microamperes) through the insulation. Should a sharp rise in leakage current occur at any point, stop the test and notify the Coast Guard Inspector.

3.3.7.4.1 Voltage tester. Ensure that the DC high voltage tester features voltage variation capabilities to smoothly increase voltage from zero up to the maximum required and contain a protective current relay that can be set to trip at any given percentage of the micro-ammeter scale, and the micro-ammeter has sufficient ranges to provide readings from less than one to at least 2500 microamperes. Attach the positive terminal of the tester to the copper and the negative terminal to the iron.

3.3.7.4.2 Test voltage. Calculate the maximum DC test voltage using the appropriate formula stated in Table II. Apply approximately 25 percent of the calculated maximum test voltage and record the leakage current. Set the protective current relay of the tester to approximately four times the recorded leakage current. Gradually adjust the current relay upward for rising current values.

3.3.7.4.3 Recorded leakage. Gradually increase the DC voltage in steps (points) up to the calculated maximum test voltage. Stop at a minimum of eight points and allow leakage current to stabilize. Record the leakage current and the machine's temperature for each voltage. See Figure 1.

3.3.7.4.4 Insulation resistance test - new windings. Perform an IR test for the new windings, as specified in paragraph 3.2 (Insulation resistance test).

3.3.7.4.5 Discharging. After the test, ground the copper until the machine is completely discharged.

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3.3.7.4.6 Plotting. Plot on cross-section paper the various voltage and the current values; use the shape of the resultant curve to check the cleanliness and moisture content of the machine. Plot a curve for each test, all on one sheet of cross-section paper. Plot megger readings taken in paragraph 3.3.7.4.4 (Insulation resistance test – new windings). Submit a CFR.

3.3.8 Varnishing. When stated in the work item, or if a Change Request has been released and authorized by the KO, twice treat the rotor, stator, and coils with varnish dip and bake treatments in accordance with Tables III and V. Perform a third varnish treatment, limiting immersion time to one minute. Subject windings using Class H or N insulation to an additional eight hours of baking at 450 degrees Fahrenheit (232 degrees Celsius).

TABLE III. VARNISH TREATMENT CLASSIFICATION

	COMPLIANCE (MIL-I-24092)		
CLASS OF INSULATED EQUIPMENT	**GRADE**	**CLASS**	**COMPOSITION**
A, B, F	Clear, Solvent, Baking, Flexible (CB)	155	I
H, N	Clear, Solvent, Baking, Silicone (CBS)	200	I

3.3.8.1 Viscosity. Maintain the proper varnish viscosity using either the No. 1 Demmler cup or the No. 2 Zahn cup in accordance with the varnish manufacturer's recommended procedures. Maintain the temperature of the varnish in the dip tank between 77 and 99 degrees Fahrenheit (25 to 32 degrees Celsius).

3.3.8.2 Dipping. Dip DC armatures with the commutator end down and drain with the commutator end up. If the assembled winding, armature, or stator cannot be immersed, it may be rotated slowly in a horizontal position in a shallow pan, allowing the varnish to flow into the windings. Soak all winding parts well during immersion. Make at least two complete revolutions, each one lasting ten minutes.

3.3.8.3 Baking time. Be aware that baking time is based on the time at temperature; therefore make allowances for time needed to bring equipment to temperature. Time required to bring windings up to proper temperature shall not be included. Bake DC armatures with the commutator end up, if possible.

3.3.8.4 Binding treatment. Bind the windings using the materials shown in Table IV. Varnish dip and bake the winding materials in accordance with Table V.

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TABLE IV. INSULATION MATERIALS FOR RANDOM WINDINGS (Note 1)

ITEM	INSULATION CLASS MATERIALS (See Notes 2,3,7)	
	F(155°C)	H(180°C) N(200°C)
Lead Wire	MIL-DTL-16878, EPDM	MIL-DTL-16878,PTFE or Silicone Rubber
Sleeving, leads and connections	MIL-I-3190, Class 155	MIL-I-3190, Class 200
Slot wedges, flat (Machine to shape)	MIL-I-24768/1, GME (Glass-Melamine)	MIL-I-24768/17, GSG
Varnish-solvent (Dip & Bake)	MIL-I-24092, Class 155 Grade CB Composition I	MIL-I-24092, Class 200 Silicone
Varnish-solvent (VPI only)	MIL-I-24718	MIL-I-24718
Armor tape	Dacron (Note 4)	MIL-Y-1140 (Untreated glass) (Note 6)
Adhesive tape	MIL-I-15126, TYPE gft	MIL-I-19166
Coil side separator	MIL-I-24204 (polyamide paper) or MIL-I-24768 (Glass)	
Varnish-solventless (dip & bake)	MIL-I-24092/5	
Slot wedges, U shape	MIL-I-24204 (polyamide paper)	
Band Insulation (Note 5)	MIL-I-24178 (glass tape, semi-cured)	
Magnet wire (Note 8)	J-W-1177 type M2 (polyamide film coated)	
Slot insulation (slot cell)	MIL-I-24204 (polyamide paper)	
Phase insulation	MIL-I-24204 (polyamide paper)	
Lacing, tying cord	CID A-A-52084, Type V (aromatic polyamide)	
Sealed insulation system	See Paragraph 5.1 (Certification for sealed insulation system).	

NOTES FROM TABLE I

1. Random windings consist of ac motor stator and dc armatures.
2. See applicable appendices for available sizes, types and grades.
3. For Class A, B and F insulation systems, use materials indicated for Class F materials.
4. Commercial grades, no applicable Government specification available.
5. Insulation material used under metallic bands.
6. Untreated glass must be given a VOLAN treatment to remove the starches and oils used in weaving.
7. Materials specified in a NAVSEA certified rewind procedure shall be used in lieu of the materials in this table, when there is a difference between the two.
8. When the OEM drawings specify a different wire type, and it is known that the insulation system has not been upgraded, or when the wire removed can be typed, that wire can be used in lieu of type M.

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TABLE V. VARNISH DIP AND BAKE TREATMENT PROCEDURES

STEP	PROCESS	CLASS	
		A,B,F	H,N
1 **PREBAKING**	Put into 150°C (300°F) oven; raise to and hold at temperature for 2 to 4 hours. Cool to 40°C (104° F).	A,B,F	H,N
2 **DIPPING**	Immerse hot coils or wound apparatus (40°C) (104°F) in organic varnish until bubbling stops.	A,B,F	
	Immerse hot coils or wound apparatus (40°C) (104°F) in silicone varnish for a maximum of five minutes.		H,N
3 **DRAINING**	Drain and air-dry for one hour. Rotate wound apparatus to prevent pocketing varnish.	A,B,F	H,N
4 **CLEANING**	With a solvent moistened cloth, wipe the metal surfaces of the armature, stator's bore, and field structure's pole face.	A,B,F	H,N
5 **BAKING**	Put into circulating type, forced exhaust oven at 150°C (302°F) for six to eight hours.	A,B,F	
	Put into circulating type, forced exhaust oven at 150°C (302°F) for two hours.		H,N
6 **COOLING**	Remove from oven and cool to approximately 140°F (60°C).	A,B,F	H,N

3.3.9 Final electrical tests. The Contractor shall repeat all tests in subsection 3.7. Provide a written report of all findings and any recommended repairs to the COR within 24 hours after performing all tests.

3.3.10 Repairs. Perform the following routine repairs as part of the overhaul.

3.3.10.1 Rotor restoration. Mount the rotor in the lathe and check for trueness. Resurface commutator and slip ring surfaces as necessary.

3.3.10.2 Brush rigging assembly. If applicable, disassemble and clean the brush rigging. Renew brushes with the same size, type, and hardness. Reassemble the brush rigging using new springs and brush tension arms.

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3.3.11 Bearings. Renew and lubricate all bearings on machines of less than 25 HP rating. Inspect and lubricate the bearings on larger machines in accordance with the manufacturer's recommendations.

3.3.12 Reassembly. Reassemble the machine using new seals and gaskets. Make adjustments to the brushes and brush rigging, as necessary.

4. QUALITY ASSURANCE

4.1 Operational bench test. The Contractor shall perform an operational bench test of the machine to rated load, making note of all operating parameters.

5. NOTES

5.1 Certification for sealed insulation system.

5.1.1 Background. Using vacuum pressure impregnation with solventless epoxy varnish, coil taping, and the materials and procedures to seal winding connections, the sealed insulation system has demonstrated excellent moisture resistance when compared to either the conventional varnish dip-and-bake method or the obsolete encapsulation method.

5.1.2 Requirements. Only activities certified by NAVSEA in accordance with MIL-STD-2037 may rewind motors with a sealed insulation system. The cost of becoming certified is borne by the activity becoming certified. Repair facilities afloat are not included in this program due to space constraints for vacuum-pressure impregnating (VPI) equipment and materials.

5.1.3 Procedures. Activities desiring to become certified to do sealed insulation work must contact NAVSEA prior to beginning the certification procedure identified in MIL-STD-2037.

5.2 Resistance ratings calculations. The figures given are for machines rated at 250 volts or less. For machines having greater rated voltages, multiply the figures by E/250, where E is the machine's rated voltage.

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5.3 Armature measurements. Small machines usually have one of the shunt field leads connected internally to the armature circuit. To avoid disassembly in such cases, measure the complete armature circuit and complete shunt field circuit without breaking this connection. If necessary, isolate the armature by lifting all brushes. With brushes left in place, the complete armature circuit will include armature, armature circuit, and the permanently connected shunt field circuit. With brushes lifted, the armature circuit, less the armature and the complete shunt field circuit, will be measured and considered to be "armature circuit less armature."

5.4 Surge tester. A mid-potential is displayed on a cathode ray oscilloscope. If a short circuit occurs in one half of the winding that does not exist in the other, the difference is the impedance of the windings causing two traces to be observed on the oscilloscope, indicating fault. If the windings are good, only one trace appears.

5.5 Tracing. A double trace indicates a faulty winding. Typical examples of waveshapes are shown in Figure 2. Double lines at the top of the trace and at the horizontal centerlines for form wound stators are typical and do not indicate failures.

5.6 Three-phase machine fault detection. Detection of one-turn shorts or grounded coils is possible in all windings of few parallel circuits. Often only a small trace separation may be detectable with a one-turn short in very large motors of several parallel paths per phase; however, the winding connections can be broken to reduce the number of parallel paths or exploring coils can be used. See Figure 3 (E).

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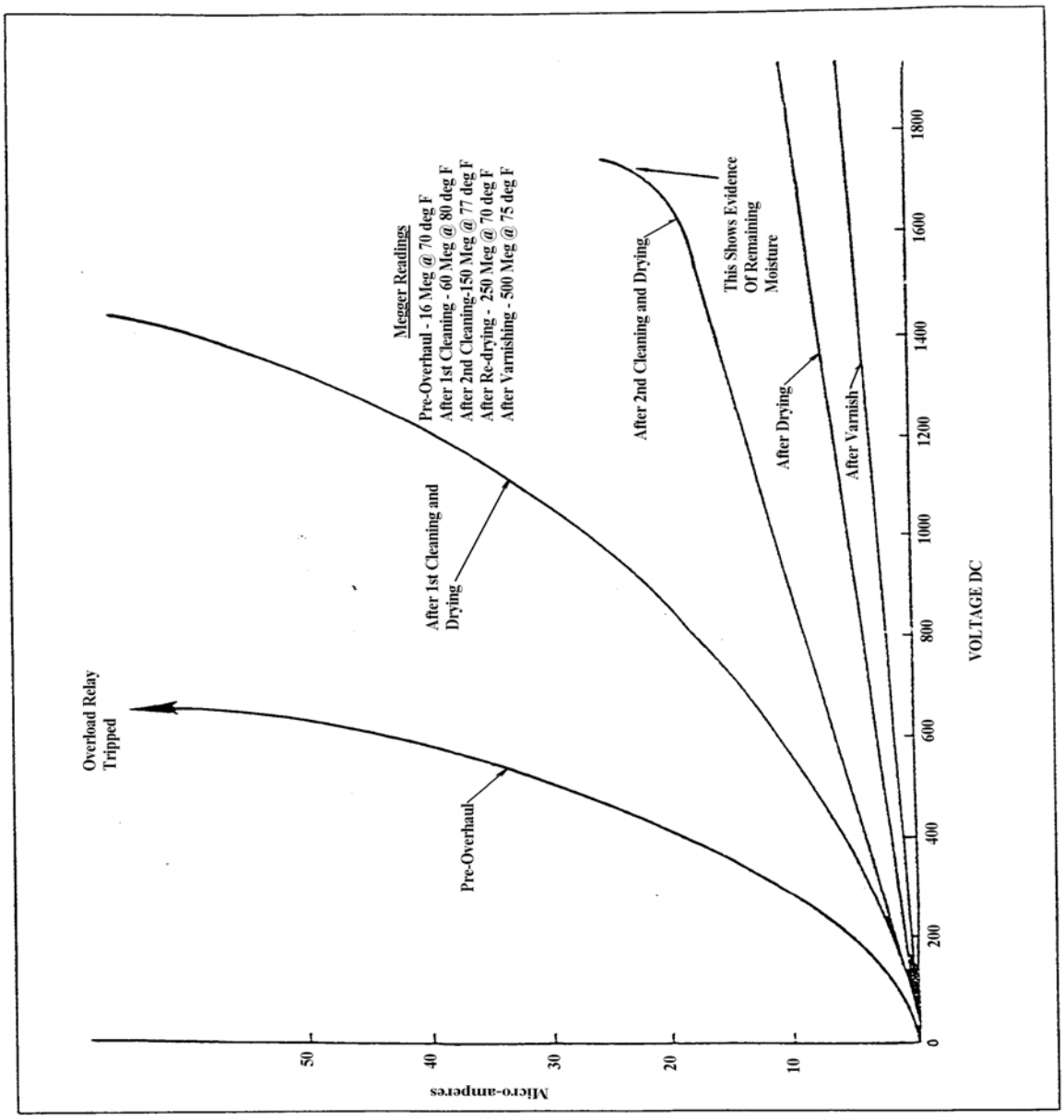

FIGURE 1. Typical DC high potential test curves.

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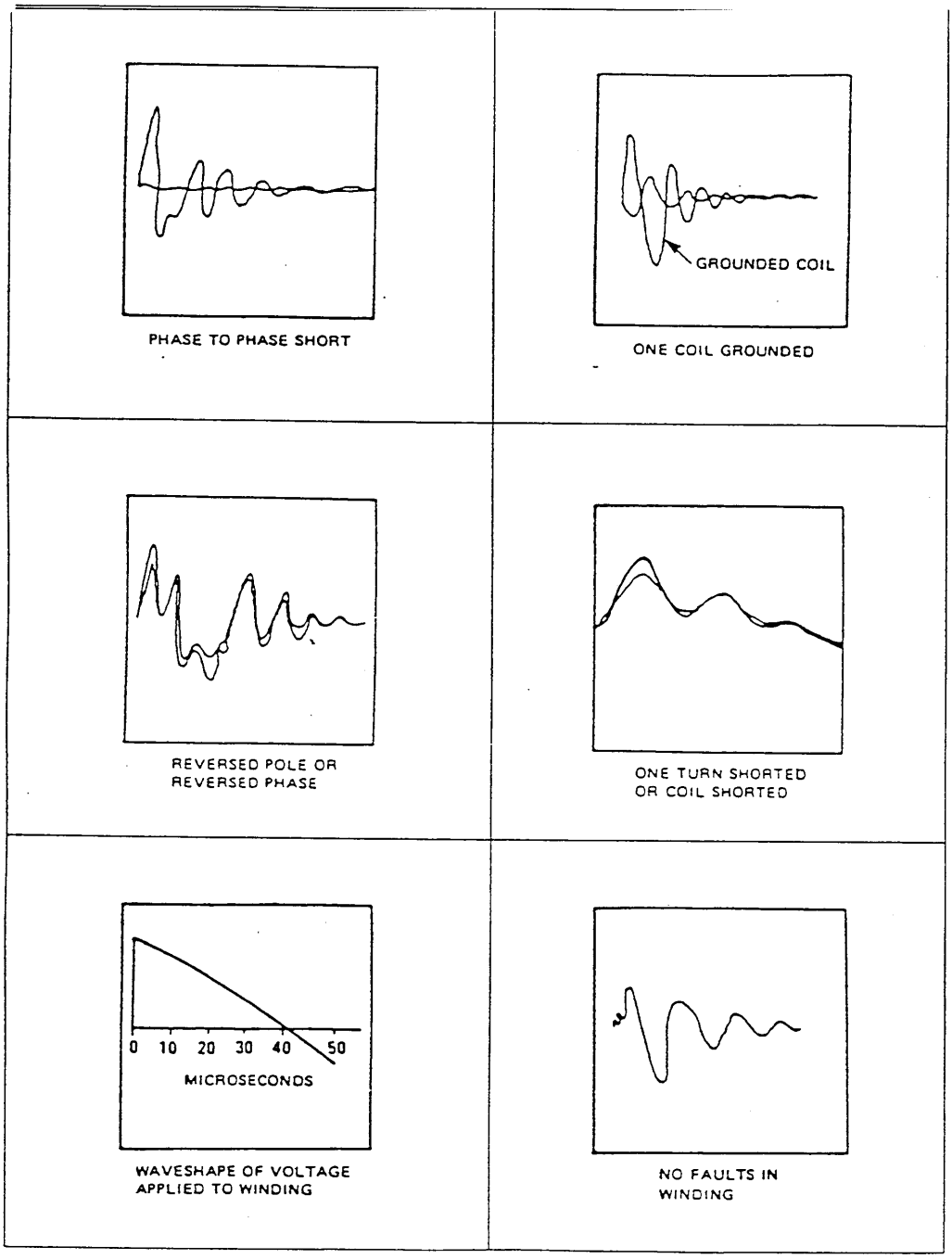

FIGURE 2. Typical surge comparison test waveshapes.

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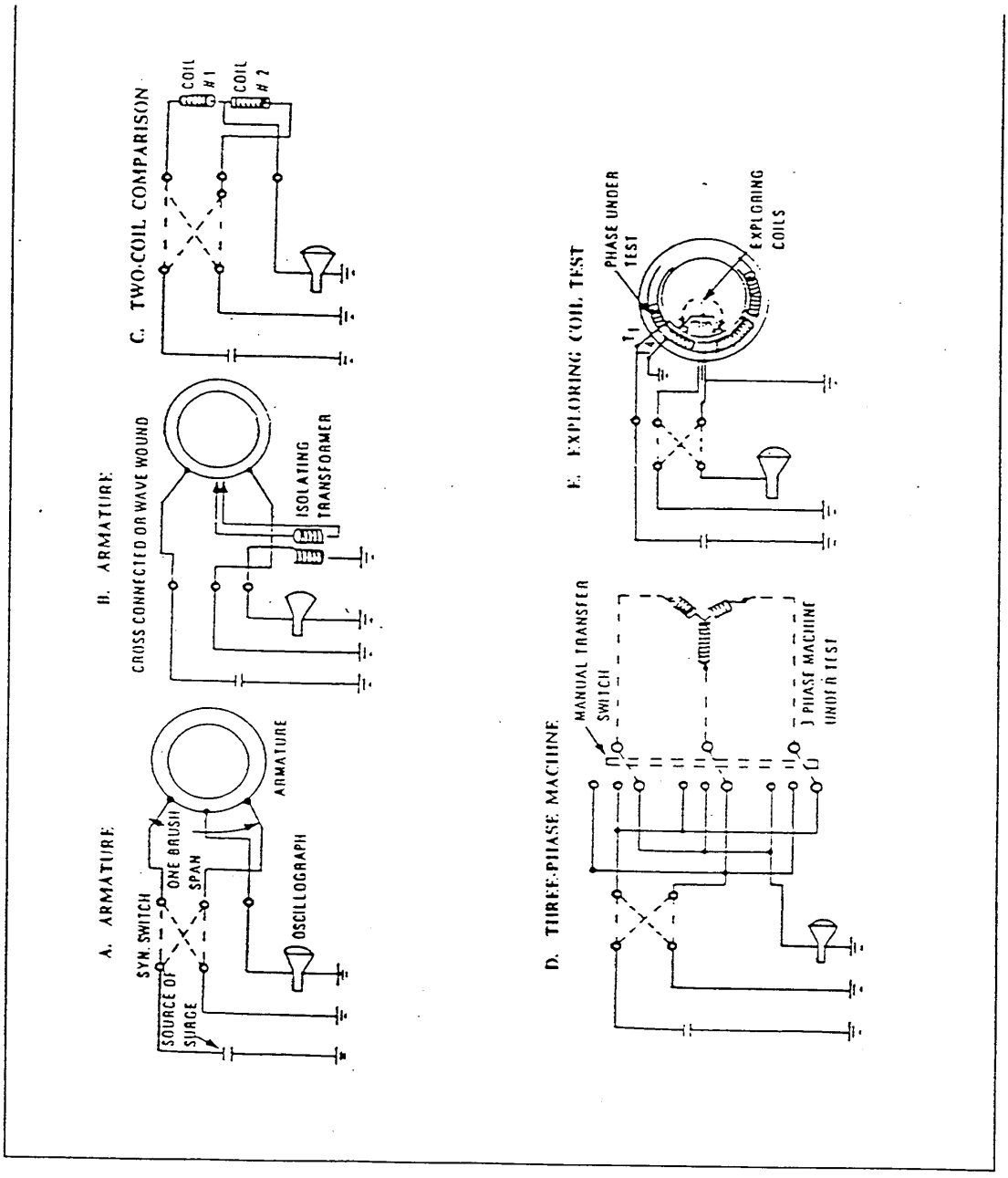

FIGURE 3. Typical surge comparison test connections.

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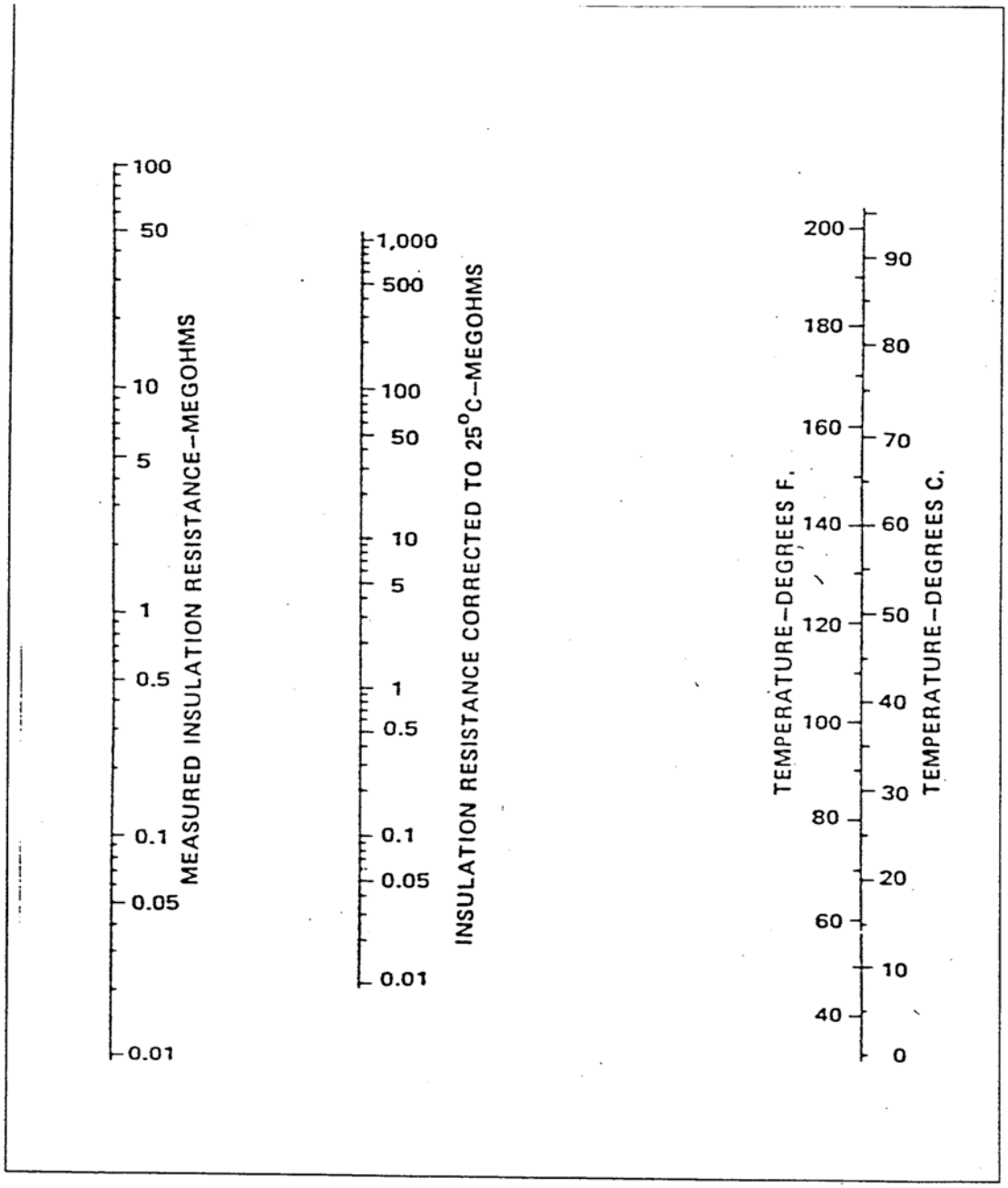

FIGURE 4. Resistance temperature nomograph.

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Appendix A

Table A-1. ROUND FILM INSULATED MAGNET WIRE (J-W-1177)[5]

Round magnet wire. Film coated type round magnet wire shown on shipboard electrical equipment drawings may be listed as T2, B2, L2, H2, K2, M2, or with other numeric suffixes. The number indicates the insulation film thickness. No number indicates single, 2 indicates heavy, 3 means triple, and 4 is quadruple. The letter symbols indicate the temperature class: T= 105°C, B=130°C, L=155°C, H=180°C, K=200°C, M=220°C. Fibrous coverings may be shown as G2V, Dg, or Dg2. The G means a single glass serving; G2 means double glass; V means varnished. Dg means single Dacron-glass and Dg2 means a double Dacron-glass serving. Round magnet wire shall be utilized as follows:

Present Magnet Wire Types	Recommended Rewind Magnet Wire Types[8]
T,B, L, H,K,M T2,B2, L2, H2, K2, M2 T3, B3, L3, H3, K3, M3 T4, B4, L4, H4, K4, M4 BV,G2V,Dg, Dg2, TGV, T2GV, T2G2V, BGV, B2GV, BDg, B2Dg2, B2Dg2V, LDg, L2Dg2, L2Dg2V, HDg, H2Dg, HDgG, H2DgG, MDgGM, M2DgGM	M M2 M2 M2 DGg, BDg2, BDgV, BDg2V, B2Dg, B2Dg2 For 155°C Ins. Sys H2GX, H2G2X For 200°C Ins. Sys LDgH, LDg2H, L2DgH, L2Dg2H For 180°C Ins. Sys M2DgGM For 220°C Ins. Sys

AWG	Type	NSN 6145-00	Weight (lb)	AWG	Type	NSN 6145-00	Weight (lb)	AWG	Type	NSN 6145-00	Weight (lb)
#7	M2	937-8587	250	#20	M	937-8386	75		M	937-7852	8
					M2*	937-8368	75	#31	M2*	937-7852	8
#8	M2	937-8585	200								
				#21	M	937-8366	75	#32	M	937-8231	8
#9	M2	937-8583	250		M2*	937-7864	75		M2*	937-8575	8
#10	M2	937-8410	250	#22	M	937-8243	75	#33	M	937-8561	8
					M2*	937-8579	75		M2*	937-8573	8
#11	M2	937-8408	75								
				#23	M	937-8563	75	#34	M	937-8229	8
#12	M2	937-8406	75		M2*	937-8211	75		M2*	937-7866	8
#13	M2	937-8404	75	#24	M	937-8241	75	#35	M	937-8644	2
					M2	937-8392	75		M2*	937-8197	2
#14	M	937-8376	75								
	M2*	937-8581	75	#25	M	937-7848	75	#36	M	937-8642	2
					M2*	937-8213	75		M2*	937-8201	2
#15	M	937-8374	75								
	M2*	937-7862	75	#26	M	937-8239	75	#37	M	937-8640	2
					M2*	937-8390	75		M2*	937-8209	2
#16	M	937-7858	75								
	M2*	937-8402	75	#27	M	937-8237	75	#38	M	937-7854	2
#17	M2	937-8400	75		M2*	937-8215	75		M2*	937-8203	2
#18	M	937-8372	75	#28	M	937-7850	75	#39	M	937-8227	2
	M2*	937-8398	75		M2*	937-8577	75		M2*	937-8386	2
	M2	937-8887	75								
				#29	M	937-8235	75	#40	M	937-8638	2

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Table A-1. ROUND FILM INSULATED MAGNET WIRE (J-W-1177)[5] (Continued)

Round magnet wire. Film coated type round magnet wire shown on shipboard electrical equipment drawings may be listed as T2, B2, L2, H2, K2, M2, or with other numeric suffixes. The number indicates the insulation film thickness. No number indicates single, 2 indicates heavy, 3 means triple, and 4 is quadruple. The letter symbols indicate the temperature class: T= 105°C, B=130°C, L=155°C, H=180°C, K=200°C, M=220°C. Fibrous coverings may be shown as G2V, Dg, or Dg2. The G means a single glass serving; G2 means double glass; V means varnished. Dg means single Dacron-glass and Dg2 means a double Dacron-glass serving. Round magnet wire shall be utilized as follows:

Present Magnet Wire Types	Recommended Rewind Magnet Wire Types[8]
T,B, L, H,K,M	M
T2,B2, L2, H2, K2, M2	M2
T3, B3, L3, H3, K3, M3	M2
T4, B4, L4, H4, K4, M4	M2
BV,G2V,Dg, Dg2, TGV, T2GV, T2G2V, BGV, B2GV, BDg, B2Dg2, B2Dg2V, LDg, L2Dg2, L2Dg2V, HDg, H2Dg, HDgG, H2DgG, MDgGM, M2DgGM	DGg, BDg2, BDgV, BDg2V, B2Dg, B2Dg2 For 155°C Ins. Sys H2GX, H2G2X For 200°C Ins. Sys LDgH, LDg2H, L2DgH, L2Dg2H For 180°C Ins. Sys M2DgGM For 220°C Ins. Sys

AWG	Type	NSN 6145-00	Weight (lb)	AWG	Type	NSN 6145-00	Weight (lb)	AWG	Type	NSN 6145-00	Weight (lb)
#19	M	937-8370	75		M2 *	937-8199	75		M2*	937-8384	2
	M2*	937-8396	75								
				#30	M	937-8233	8	#41	M	937-8636	2
					M2*	937-8207	8		M2*	937-8571	2
								#42	M	937-8634	3/4
									M2*	937-8205	3/4
								#43	M2*	937-8569	3/4
								#44	M2*	937-8382	3/4

NOTES:
1. Unit of Issue (U/I) is reel for AWG #7 through #29 and spool for AWG #30 through #44.
2. Preferred magnet wire types are designated *.
3. AWG Sizes 42, 43, and 44 were formerly supplied in 2-lb spools.
4. In instance where these types of wires are not available per Federal Spec J-W-1177, the NEMA Standard Publication No. MW 1000 for magnet wire as listed on applicable J-W-1177 slash sheet can be substituted.
5. J-W-1177, Wire, Magnet, Electrical, General Specification.
6. Sequence of preference for substituting magnet wire type: M → K → H. Film thickness should be equal or less than that of original wire.
7. Use of re-spooled magnet wire should be avoidable if possible.
8. Materials specified in a NAVSEA certified rewind procedure shall be used in lieu of the materials in this table, when there is a difference between the two. When the OEM drawing specify a different wire type, and it is known that the insulation system has not been upgraded, or when the wire removed can be type, that wire type can be used in lieu of type M.

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Appendix B

Table A-2. SQUARE AND RECTANGULAR FILM INSULATED MAGNET WIRE (J-W-1177)[1]

Square and Rectangular magnet wire. Equipment drawings should list the rewind size to use. Square and rectangular magnet wire should be utilized as follows:	
Present Magnet Wire Types	Recommended Rewind Magnet Wire Types[3]
T2,B2, L2, H2, K2, M2	M2
T3, B3, L3, H3, K3, M3	M4
T4, B4, L4, H4, K4, M4	M4
GV, G2V, Dg, Dg2	BDg, BDg2, BDgV, BDg2V, B2Dg, B2Dg2 For 155°C Ins. Sys
TGV, T2GV, T2G2V,	H2GX, H2G2X For 200°C Ins. Sys
BDg, B2Dg, B2Dg2,	LDgH, LDg2H, L2DgH, L2Dg2H For 180°C Ins. Sys
LDg, L2Dg, L2Dg2,	M2DgGM[2] For 220°C Ins. Sys
MDgGM, M2Dggm	

NOTES:

1. J-W-1177, Wire, Magnet, Electrical, General Specification.

2. In instance where these types of wire are not available per Federal Spec J-W-1177, the NEMA Stand Publication No. MW1000 for magnet wire as listed on the applicable J-W-1177 slash sheet can be substituted.

3. Materials specified in a NAVSEA certified rewind procedure shall be used in lieu of the materials in this table, when there is a difference between the two. When the OEM drawings specify a different wire type, and it is known that the insulation system has not been upgraded, or when the wire removed can be typed, that wire can be used in lieu of type M.

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Appendix C

Table A-3. FLEXIBLE INSULATION SHEET

Slot and phase insulation. Slot and phase insulation may also be designated as ground insulation, slot linear, basic insulation, core insulation, or just insulation. Drawings may show any of the following materials as slot and phase insulation: mica glass, fish paper, varnish cambric, mylar, DMD, silicone mica glass, varnished glass, mica paper. Slot and phase insulation shall be utilized as follows:	
Present Slot and Phase Insulation	**Recommended Rewind Slot and Phase Insulation**
Mica-glass types Mica paper types (MIL-I-21070)	For equipment rated over 600 volts use Mica-glass composites (MIL-I-3505).
Fish paper and composites (MIL-I-695) Polyethylene-terephthalate composites DMD (MIL-I-22834) Mylar (MIL-I-631)	For equipment rated 600 volts and below use POLYAMIDE paper (MIL-I-24204)

MIL-I-24204 POLYAMIDE PAPER FEDERAL SUPPLY CLASS 5970* (FOR EQUIPMENT RATED 600 VOLTS AND BELOW)			
Thickness	**Width (in.)**	**Length (in.)**	**NSN 5970-00-**
0.005	36	36	016-3053
0.007	36	36	016-3342
0.010	36	36	016-3367
0.015	36	36	016-3375
0.020	36	36	016-3377
0.030	36	36	016-3492

MICA GLASS COMPOSITS FEDERAL SUPPLY CLASS 5870* (FOR EQUIPMENT RATED OVER 600 VOLTS)					
Thickness	**Width(in.)**	**Length (in.)**	**NSN 5970-00-**	**Type**	**Class**
0.007	36	36	198-8415	Mg	H
0.010	36	36	198-8417	Gmg	H
0.010	36	36	198-8420	Mg	B
0.012	36	36	198-8421	Gmg	B
0.012	36	36	198-8416	Gmg	H
0.007	36	36	198-8419	Pmg	B
0.015	36	36	244-2659	Pmg	B

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Appendix D

Table 300-A-4. INSULATING SLEEVING

Sleeving. Older types of sleeving crack when bent thus causing a likely spot for eventual failure at a joint or connection. Present types of sleeving must meet a 90 degree bend test. Sleeving shall be utilized as follows:	
Present Type of Sleeving	**Recommended Types of Rewind**
Cotton braid CID A-A-1, CID A-A-2 (MIL-I-3190F)	For class A, B, or F, insulation systems, use acrylic-glass (class 155) For class H or N insulation systems rewound with Class F systems thermally upgraded materials, use silicone rubber glass (class 200) on AC equipment and polyamide glass (class 220) on AC or DC equipment
Glass braid B-A-1, B-B-1 (MIL-I-3190F)	Insulation system
Glass braid H-A-1, H-B-1, H-C-1 (MIL-I-3190F)	Use silicone rubber glass (class 200) on ac systems and
Glass braid, vinyl (MIL-I-3190F)	polyamide-glass (class 220) on dc systems

MIL-I-3190C Acrylic Glass (Temperature Index 155) Federal Supply Class 5970, U/I ft.				**MIL-I-3190C Silicone Rubber Glass (Temperature Index 200) Federal Supply Class 5970 U/I ft/**			
Size No	**Nominal ID (in)**	**Wall Thickness (in)**	**NSN 9G 5970-00**	**Size No**	**Nominal ID (in)**	**Wall Thickness (in)**	**NSN 9G 5970-00**
24	0.022	0.030	488-7811	18	0.042	0.030	838-7278
22	0.027	0.030	488-7794	17	0.047	0.030	025-1789
20	0.034	0.030	488-7792	16	0.053	0.030	825-3680
18	0.042	0.030	488-7789	15	0.059	0.030	025-1788
17	0.047	0.030	488-7784	14	0.066	0.045	825-3678
16	0.053	0.030	488-7477	12	0.085	0.045	953-8478
15	0.059	0.030	488-7448	11	0.095	0.045	025-1782
14	0.066	0.045	488-7447	10	0.106	0.045	025-1781
13	0.076	0.045	488-7431	9	0.118	0.045	578-9037
12	0.085	0.045	488-7429	8	0.113	0.045	852-2654
11	0.095	0.045	488-7261	7	0.148	0.045	825-3677
10	0.106	0.045	488-7208	5	0.186	0.045	025-1780
9	0.118	0.045	488-7046	4	0.208	0.045	025-1779
8	0.133	0.045	488-7043	3	0.234	0.045	285-0489
7	0.148	0.045	488-7016	2	0.263	0.055	025-1778
6	0.166	0.045	488-7014	1	0.294	0.055	285-0490
5	0.186	0.045	488-6997	0	0.330	0.055	025-1777
4	0.208	0.045	488-6918	3/8	0.387	0.055	852-4758
3	0.234	0.045	488-6917	7/16	0.450	0.065	
2	0.263	0.055	488-6648	1/2	0.512	0.065	285-0492
0	0.330	0.055	488-6623	5/8	0.640	0.065	
3/8	0.387	0.055	488-6621	3/4	0.768	0.075	285-0493
5/8	0.640	0.065	488-6592	7/8	0.893	0.075	
3/4	0.768	0.075	488-6464	1	1.018	0.075	
7/8	0.893	0.075	488-6244				
1	1.018	0.075	488-5710				

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Table A-4. INSULATING SLEEVING (CONTINUED)

MIL-I-3190F Polyamide Glass (Temperature Index 220) Federal Supply Class 5970, U/I ft.			
Size No.	**Nominal ID (in)**	**Wall Thickness (in)**	**NSN 5970-00-**
16	0.053	0.030	488-5091
14	0.066	0.030	488-5087
12	0.085	0.045	488-5082
10	0.102	0.022	488-4991
8	0.133	0.045	488-4942
6	0.166	0.045	488-4883
2	0.263	0.055	488-4660
0	0.330	0.055	

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Appendix E

Table A-5. LAMINATED UNSULATION SHEET (U/I LB)

MIL-I-24768/1 Glass Melamine, Type GME (Temp., Index 130)[1]	
Thickness (in)	**NSN 5970-00-**
0.031	912-1907
0.062	905-8336
0.125	912-1908
0.250	912-1909
Glass Polyester, Type SG 200 (Temp., Index 200)[2]	
0.031 0.064 0.094 0.125 0.250	N/A

NOTES:

1. Suitable for class 155°C applications for slot wedges and coil separators
2. Available from the Glastic Company, 4321 Glenridge Road, Cleveland Ohio 44121

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Appendix F

Table A-6. LACING AND TYING TAPE

Lacing and tying cords and tapes have been made from twisted cords, braided cords and braided flat tapes using cotton, flax or glass yarns. Finishes applied to these materials to improve knot strength and application have been waxes, synthetic rubbers and resin coatings. Lacing and tying tape shall be utilized as follows:	
Present Types	**Recommended Type**
Glass cord (MIL-Y-1140) Cotton Cord (MIL-T-713 (Also flax, hemp or resin	Polyamide, Type V Finish A (natural) per CID A-A-52083

MIL-T-43435A. POLYAMIDE TAPE - HEAT RESISTANT, FLAT BRAIDS, FEDERAL SUPPLY CLASS 5970 (Cont'd)					
NSN 5970-00-001	**Size**	**Width (in)**	**Thickness (in)**	**Breaking Strength (lb)**	**U/I Yds per Spool**
9356	1	0.200	0.016	85	250
9357	2	0.110	0.014	50	250
9358	3	0.090	0.012	35	500
9359	4	0.055	0.01	25	500

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Appendix G

Table A-7. INSULATION TAPE (U/I ROLL)

MIL-Y-1140 TAPE, TEXTILE, GLASS, UNTREATED, ECC-B FEDERAL SUPPLY CLASS 8315			
NSN 8315-00	**Width (in)**	**Thickness (in)**	**Break Strength (lb)**
290-8265	3/8	0.003	45
290-8256	3/8	0.007	115
290-8266	1/2	0.003	60
290-8260	1/2	0.005	135
290-8264	3/4	0.003	95
290-8259	3/4	0.005	225
290-8254	3/4	0.007	225
290-8258	1	0.005	310
290-8278	1	0.007	240
MIL-I-15126 TAPE, ADHESIVE, GLASS BACKING FEDERAL SUPPLY CLASS 5970 (TEMP. INDEX 155)			
NSN 5970-00	**Width (in)**	**Thickness (in)**	**Dielectric Strength (volts)**
543-1154	1/2	0.007	1000
686-9151	1	Any	Any
MIL-I-19166 TAPE, ADHESIVE, GLASS BACKING FEDERAL SUPPLY CLASS 5970 (TEMP. INDEX 200)			
NSN 5970-00	**Width (in)**	**Thickness (in)**	**Dielectric Strength (volts)**
709-0045	0.625	0.007	2000
933-1406	0.250	0.007	2000
650-5345	0.500	0.012	4000

MIL-I-24391 TAPE, ADHESIVE, PLASTIC BACKING, BLACK FEDERAL SUPPLY CLASS 5970 (TEMP. INDEX 105)		
NSN-5970-00-	**Width (in)**	**Thickness (in)**
419-3164	1.000	0.0085
419-4291	0.750	0.0085
419-4290	0.500	0.0080

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Appendix H

Table A-8. LEAD WIRE (MIL-DTL-16878)

AWG	DIAMETER (IN)	NSN 6145
Type EPDM (Ethylen-Propylene Diene Elastomer) Class 150°C, 600V		
18	0.142	01-212-4772
16	0.155	01-212-4773
14	0.170	01-212-4774
12	0.197	01-212-8028
10	0.252	01-212-1603
8	0.327	01-212-1604
6	0.383	01-270-8558
4	0.440	01-212-1341
2	0.494	01-212-4775
Type FF Sil. Rubber Gl. Braid (Class 200)[1]		
22	0.100	00-284-1480
20	0.108	00-284-1481
18	0.118	00-284-1482
16	0.127	00-284-1483
14	0.176	00-284-1484
12	0.195	00-284-1485
10	0.215	00-284-1486
8	0.327	00-284-1487
6	0.356	00-284-1488
4	0.412	00-284-1489
2	0.495	00-284-1490
1	0.552	00-284-1491
0	0.598	00-284-1492
00	0.651	00-284-1493
0000	0.775	00-284-1494
Type EE Tetrafluoroethylene (Class 200)		
24	0.054	01-995-1603
22	0.060	00-643-2494
20	0.068	00-811-2232
18	0.079	01-062-4011
16	0.089	00-089-6563
14	0.100	00-089-6289
12	0.124	01-089-6562
10	0.145	01-957-1985
8	0.207	00-542-6677

Note 1: Silicone lead wire shall not be used in non-ventilated brush type machines.

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Appendix I

Table A-9. VARNISH INSULATION

MIL-I-24092 CLEAR, BAKING, SOLVENT TYPES			
Class	**NSN-5970-01-**	**U/I**	**Thinner**
155	931-2413	1 gal can	Xylene
155	931-1170	5 gal can	Xylene
200	931-2414	5 gal can	Xylene
200	548-7211	1 gal can	Xylene

MIL-I-24092 CLEAR, AIR-DRYING, SOLVENT TYPES				
Grade	**NSN-5970-01-**	**U/I**	**Thinner**	**Mfr. Brand No.**
CA	190-5473	1 gal can	Mineral spirits	AC 41 Dolph
CA	252-7481	1 gal can	Mineral spirits	AC 43 Dolph

MIL-I-24092 VARNISH, CLEAR, AIR-DRYING TYPE				
Type	**NSN 5970-01-**	**U/I**	**Mfr.**	**Part No.**
CA	078-5636	1 gal	Sterling	U-122

RED INSULATING VARNISH – AIR DRY[1]			
Type	**U/I**	**NSN**	**Mfr. Brand No.**
Air dry – moisture, oil, and salt water resistant	16 oz spray can	5900-00-076-8988	ER-41 RED
Note:			
1. For SWBD buswork, frame coating, etc			

SOLVENTLESS BAKING VAR		
Composition	**Mfr. Brand No.**	**Mfr.**
POLYESTER	Esterlite 605	Epoxylite
POLYESTER	Isolite 826M	Schenectady Chemical

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Appendix J

Table A-10. SLOT WEDGE INSULATION

FORMES POLYAMIDE PAPER (U SHAPE) FEDERAL SUPPLY CLASS 5970; U/I-FEET; FSCM (Mfgr code) – 87952				
Shape	**Width (in)**	**Thickness (in)**	**NSN 5970-00-**	**Mfgr Type**
Curve	5/32	11/64	004-4491	NHT 70-30
Curve	7/32	3/16	004-4490	NHT 86-30
Curve	1/4	7/32	004-4489	NHT 99-30
Curve	5/16	1/4	004-4488	NHT 117-30
Curve	3/8	5/16	004-4487	NHT 144-30
Square	5/32	7/32	004-4486	NHT 30-10-14
Square	1/4	11/64	004-4492	NHT 30-16-11
Square	23/64	1/4	004-4493	NHT 30-23-16