OVERHAUL DC GENERATORS & MOTORS

1. SCOPE

1.1 Intent. This standard specification describes the requirements for the Contractor to overhaul (ashore in a suitable repair facility) a direct current (DC) generator or motor of 75 to 6000 horsepower. This specification applies to the following Coast Guard vessels:

1.1.1 Main propulsion generators and motors:

- BAY class ice breaking tugs (WTGB)
- POLAR STAR (WAGB-10) & POLAR SEA (WAGB-11) – main propulsion motor only

1.1.2 Auxiliary motors:

- 175' Keeper class coastal buoy tenders (WLM) – bow thruster
- 225' JUNIPER class seagoing buoy tenders (WLB) – bow and stern thrusters
- POLAR STAR & POLAR SEA – oceanographic and trawl/core winches

1.2 Appendices. The following appendices are part of this standard specification:

PROCESS STANDARD	APPENDIX
Remove and Reinstall DC Generator or Motor Aboard Vessel	A
Recondition DC Generator or Motor	B
Rebuild DC Generator or Motor Commutator	C
Rewind DC Generator or Motor Armature	D
Rewind DC Generator or Motor Field	E
Miscellaneous DC Generator or Motor Repairs	F

1.3 Alternate terminology. The term machine, when used in this specification, shall imply a generator or motor.

2. REFERENCES

COAST GUARD DRAWINGS

None

COAST GUARD PUBLICATIONS

Surface Forces Logistics Center Standard Specification 3042 (SFLC Std Spec 3042), Latest Edition, Shipboard Electrical Cable Removal, Relocation, Splice, Repair, and Installation

OTHER REFERENCES

American National Standards Institute (ANSI/EASA) AR100, 2010, Recommended Practice for the Repair of Rotating Electrical Apparatus

International Organization for Standardization (ISO) 1940-1, 2003, Mechanical Vibration – Balance Quality Requirements of Rigid Rotors

DOD-STD-2188, Apr 1987, Babbitting of Bearing Shells

MIL-I-24092/2, Sep 1993, Insulating Varnish, Solvent Containing, Baking, Flexible, for Dip Processing, Grade CB, Class 130 to 180 Thermal Class

MIL-I-24092/5, Sep 1993, Insulating Resin, Solventless, Baking, Flexible, for Dip Processing, Grade SF, Class 130 to 180 Thermal Class

MIL-I-24718/3, Apr 1990, Insulating Resins, Solventless, Vacuum-Pressure-Impregnating Polyester Diallyl Phthalate, Slightly Thixotropic

MIL-D-16791, Jan 1993, Detergents, General Purpose (Liquid Nonionic)

American Society for Testing and Materials (ASTM) B177, 2011, Standard Guide for Chromium Electroplating on Steel for Engineering Use

National Electrical Manufacturers Association (NEMA) MG1, 2011, Motors and Generators

U.S. Department of Energy (DOE/GO) 10099-935, Nov 1999, Model Repair Specifications for Low Voltage Induction Motors

3. REQUIREMENTS

3.1 General. Perform the particular overhaul task(s) specified in the work item, in accordance with this standard specification and the applicable appendix(ces) herein.

3.1.1 Notification and documentation. Abide by the following rules for all inspections, tests, and cleaning operations specified herein.

3.1.1.1 Advance notice. Notify the Coast Guard Inspector at least 24 hours before performing each test, inspection, and cleaning operation. The Coast Guard Inspector shall be present shipboard and in the shop to witness the performance of all tests, inspections, and cleaning operations performed under this specification.

3.1.1.2 Documentation. Submit a CFR upon completion of each inspection and test, along with a completed copy of each applicable test data sheet.

3.1.2 Original equipment manufacturer’s guidance. Adhere to the requirements, cautions, and warnings stated in the machine manufacturer’s instruction book during the performance of this work.

3.1.3 Machine overhaul technician. Machine inspection and shop work shall be performed by a firm that is a member of the Electrical Apparatus Service Association (EASA) and that shop shall adhere to the association’s standards, including ANSI/EASA AR100.

3.1.4 Materials. New material used or installed during work on the machine shall be equal or superior to the material used by the original manufacturer.

3.1.5 Machine Protection.

3.1.5.1 Particular care should be taken so that no foreign materials or dust are allowed to lodge on the machine, particularly the commutator. Ensure that supply air to the compartment is filtered to preclude entry of paint over spray, dust, and industrial grit.

3.1.5.2 Absolutely no silicone or silicone based insulations, cables, paints, varnishes, laminates, tapes, compounds, rubber, greases, or other products shall be used within the interior of the machine. Mechanics using protective hand creams containing conductive or silicone materials shall not handle internal machine parts, as even small amounts of silicone materials will cause greatly increased brush wear.

3.1.5.3 Take adequate security measures to ensure that foreign objects do not enter a machine at any time, as a small bolt, nut, or other object in the air gap may cause damage that could require weeks to repair. Small, loose objects shall not be permitted in the pockets of workers within the compartment while a machine is uncovered. Account for all tools and fasteners entering and leaving a machine. Protect each open machine with stock or temporary covers during periods when no shipboard work is actively in progress on the internals.

3.2 Removal from vessel. When stated in the work item, or if a Change Request has been released and authorized by the KO, remove the designated machine or assembly from the vessel per Section A2.1 of Appendix A and ship to a suitable repair facility.

3.3 Initial inspection. Prior to performing the shop work specified by the work item, the machine repair facility shall accomplish the following:

3.3.1 Access cover removal. Remove, clean, and retain all machine access covers and fasteners.

3.3.2 Disassembly and inspections. Unpack the machine assembly removed from the vessel. Disassemble the generator and remove the rotor. Accomplish the following machine inspections:

3.3.2.1 Visual inspections. Perform a visual inspection of the machine components for the presence of contamination by dust, dirt, moisture, oil, and other foreign matter. Attempt to determine the origin, such as leaking seals, or any unusual conditions prior to the start of cleaning. Inspect the commutator for signs of surface roughness, loose bars, uneven bar height, mica degradation, and cracked or broken risers. Note all abnormal conditions on the magnet frame, armature, windings, risers, commutator, brush holders, brushes, and brush holder springs. Carefully examine the interior of the machine for loose objects such as, nuts and bolts; remove all such items. Inspect all electrical connections for tightness. Check all wedges, bands, and soldered connections and correct any minor deficiencies. Check for evidence of overheating, both general and localized. Identify any mechanical deficiencies, including non-conformance with Section 2 of ANSI/EASA AR100. Inspect insulation condition in accordance with Section 1.5.1 of ANSI/EASA AR100. Record all findings, including the types of contaminants (oil, water, carbon, dirt, etc.) found.

3.3.2.2 Brush removal. If installed, remove and inspect all brushes, brush rigging insulators, brush holders, and brush holder springs. Dispose of the removed brushes. Clean and retain the remaining components.

3.3.2.3 Commutator wear and concentricity. Measure and record the commutator wear and concentricity. Include manufacturer's specifications and diametrical limit. Note any corrosion, deep scratches, misaligned bars, abnormal wear patterns, or mica degradation. Identify locations (relative to a reference point) on the commutator where runout is excessive or damage is significant.

3.3.2.4 Accessories. Inspect any machine accessories, such as temperature sensor, electromagnetic brake, inspection lights, or space heater, and the associated internal wiring. Test accessory operation and submit a CFR with recommendations for repair or renewal.

3.3.3 Initial winding tests. Assess winding conditions per Section 4.3 of ANSI/EASA AR100:

3.3.3.1 Insulation resistance test. Measure and record the insulation resistance of each circuit listed in Table 1A through 1C below, as applicable. Apply a test voltage of 500 VDC for all circuits and temperature correct all insulation resistance readings to 25°C using the nomograph of Figure 1. Record uncorrected insulation resistance reading, winding temperature, and corrected insulation resistance for each measurement taken. The following formula can be used as a cross check on the nomograph temperature correction:

$$R_{25} = R_T \, 10^{0.0305(T-25)}$$

where	R_{25}	is the corrected insulation resistance
	R_T	is the uncorrected insulation resistance
	T	is the winding temperature (°C)

3.3.3.2 Insulation resistance polarization index (PI) test. Measure and record the PI tests as follows:

3.3.3.2.1 Measure and record the insulation resistances of the windings after applying the test voltage specified in paragraph 3.3.3.1 above for one minute. Separately test the complete armature circuit, the armature alone, the armature circuit less armature, and the complete field circuit. Apply armature voltage between the copper conductors and the rotor structure to eliminate the insulating effect of the bearing lubrication film.

3.3.3.2.2 If the value of the one minute insulation resistance is between the values shown in Table 1A through 1C below, as applicable, continue applying test voltage until a steady state value is reached. Measure and record the insulation resistance each minute during the test and more frequently when results are changing quickly. Plot the insulation resistance as a function of time on log-log paper for each winding tested. A PI value of less than 2.0 indicates that the windings are moist or dirty.

3.3.3.3 Bearing insulation resistance test. Measure and record bearing insulation resistance per Section 4.2.8 of ANSI/EASA AR100.

3.3.3.4 Additional tests. Perform remaining tests as needed to fully assess winding condition.

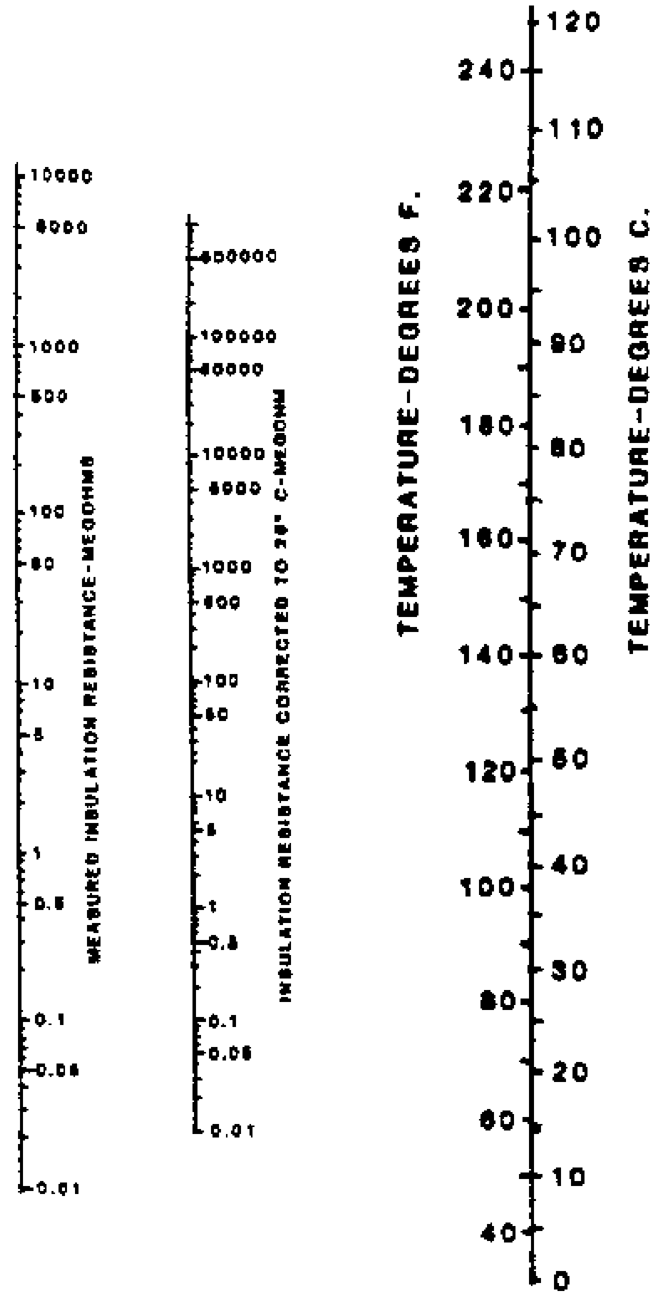

FIGURE 1 – INSULATION RESISTANCE TEMPERATURE CORRECTION NOMOGRAPH

TABLE 1A – POLARIZATION INDEX APPLICABILITY FOR 500 VDC MAIN PROPULSION GENERATORS & MOTORS

Windings	Minimum Resistance	Maximum Resistance
Complete armature circuit	0.2 MΩ	62 MΩ
Armature alone	0.2 MΩ	99 MΩ
Armature circuit less armature	0.2 MΩ	99 MΩ
Complete field circuit	1.0 MΩ	224 MΩ

TABLE 1B – POLARIZATION INDEX APPLICABILITY FOR 900 VDC MAIN PROPULSION GENERATORS & MOTORS (BAY & POLAR)

Windings	Minimum Resistance	Maximum Resistance
Complete armature circuit	0.4 MΩ	110 MΩ
Armature alone	0.4 MΩ	177 MΩ
Armature circuit less armature	0.4 MΩ	177 MΩ
Complete field circuit	1.8 MΩ	398 MΩ

TABLE 1C – POLARIZATION INDEX APPLICABILITY FOR 500 VDC AUXILIARY MOTORS

Windings	Minimum Resistance	Maximum Resistance
Complete armature circuit	0.2 MΩ	10 MΩ
Armature alone	0.4 MΩ	20 MΩ
Armature circuit less armature	0.4 MΩ	20 MΩ
Complete field circuit	1.0 MΩ	25 MΩ

3.4 Shop work. Perform the following work at the machine repair facility:

3.4.1 Reconditioning. When stated in the work item, or if a Change Request has been released and authorized by the KO, recondition the designated machine or assembly per Appendix B.

3.4.2 Commutator rebuilding. When stated in a work item, or if a Change Request has been released and authorized by the KO, rebuild the commutator of the designated machine or assembly per Appendix C.

3.4.3 Armature rewinding. When stated in the work item, or if a Change Request has been released and authorized by the KO, rewind the armature of the designated machine or assembly per Appendix D.

3.4.4 Field rewinding. When stated in a work item, or if a Change Request has been released and authorized by the KO, rewind the specified field(s) of the designated machine or assembly in accordance with Appendix E.

3.4.5 Miscellaneous repairs. When stated in a work item, or if a Change Request has been released and authorized by the KO, repair the designated machine or assembly per the applicable paragraph of Appendix F shown in Table 2 below.

TABLE 2 – MISCELLANEOUS REPAIRS MATRIX

Repair	Appendix F
Shafting	F2.1
Commutator	F2.2
Frame and bearing housings	F2.3
Bearings	F2.4
Journals	F2.5
Temperature sensors	F2.6
Leads	F2.7
Space heater	F2.8
Windings	F2.9
Brushes	F2.10

3.4.6 Balancing. Dynamically balance the armature assembly per the manufacturer's specifications. In the absence of manufacturer's specifications, balance per ISO 1940/1 to quality grade tolerance G2.5.

3.4.7 Reassembly. Reassemble the machine after all shop work, tests, and inspections have been accepted by the Coast Guard Inspector. Reinstall all machine access covers and fasteners, except those at the terminal box.

3.4.7.1 Renew all disturbed seals and gaskets.

3.4.7.2 Clean bearing grease passages and lubricate in accordance with Section 2.3 of ANSI/EASA AR100.

3.4.7.3 Reinstall the brush rigging and renew the brushes with the same size, type, and hardness as originally installed. Adjust the brush rigging and seat each brush to fit the commutator curvature per Sections 2.9 and 2.10 of ANSI/EASA AR100.

3.5 Shop acceptance testing. Perform the following shop acceptance tests:

3.5.1 Final shop insulation resistance tests. Assess insulation system conditions in accordance with Section 4.2 of ANSI/EASA AR100. At a minimum, the following shall be performed:

3.5.1.1 Insulation resistance test. Measure and record the insulation resistance of the complete armature circuit, the armature alone, the armature circuit less armature, and the complete field circuit (see paragraph 3.3.3.1 above). If the insulation resistance on any circuit, adjusted to 25°C, is below the value shown in Tables 3A through 3D below, as applicable, submit a CFR along with proposed corrective action.

3.5.1.2 Insulation resistance polarization index (PI) test. Repeat the insulation resistance PI tests of Section 3.3.3.2 above. If the PI is less than 2.0 (3.0 after reconditioning or rewinding), submit a CFR along with proposed corrective action.

TABLE 3A – MINIMUM INSULATION RESISTANCE FOR OPERATION

WINDINGS	MINIMUM INSULATION RESISTANCE (M□) FOR MACHINE OF RATED VOLTAGE (VDC)		
	MAIN PROPULSION		AUXILIARY
	500	900	500
Complete armature circuit	0.2	0.4	0.2
Armature alone	0.2	0.4	0.4
Armature circuit less armature	0.2	0.4	0.4
Complete field circuit	1.0	1.8	1.0

TABLE 3B – MINIMUM INSULATION RESISTANCE AFTER CLEANING & DRYING

WINDINGS	MINIMUM INSULATION RESISTANCE (M□) FOR MACHINE OF RATED VOLTAGE (VDC)		
	MAIN PROPULSION		AUXILIARY
	500	900	500
Complete armature circuit	0.7	1.3	1.0
Armature alone	1.2	2.2	2.0
Armature circuit less armature	1.2	2.2	2.0
Complete field circuit	2.5	4.4	3.0

TABLE 3C – MINIMUM INSULATION RESISTANCE AFTER RECONDITIONING

WINDINGS	MINIMUM INSULATION RESISTANCE (M□) FOR MACHINE OF RATED VOLTAGE (VDC)		
	MAIN PROPULSION		AUXILIARY
	500	900	500
Complete armature circuit	14.9	26.5	2.0
Armature alone	24.9	44.2	4.0
Armature circuit less armature	24.9	44.2	4.0
Complete field circuit	49.7	88.4	5.0

TABLE 3D – MINIMUM INSULATION RESISTANCE AFTER REWINDING

WINDINGS	MINIMUM INSULATION RESISTANCE (M□) FOR MACHINE OF RATED VOLTAGE (VDC)		
	MAIN PROPULSION		AUXILIARY
	500	900	500
Complete armature circuit	49.7	88.4	200
Armature alone	497	884	400
Armature circuit less armature	497	884	400
Complete field circuit	994	1770	400

3.5.1.3 Bearing insulation resistance test. Measure and record bearing insulation resistance per Section 4.2.8 of ANSI/EASA AR100. If the bearing insulation resistance is less than 1 megohm, submit a CFR along with proposed corrective action.

3.5.2 High potential tests. For windings that have been reconditioned or rewound, perform high potential tests in accordance with Section 4.4 of ANSI/EASA AR100.

3.5.3 Accessory tests. Test accessories in accordance with Section 4.4.2 of ANSI/EASA AR100.

3.6 Final assembly. Complete the remaining tasks in Section 1 of ANSI/EASA AR100. Reinstall the terminal box cover plate with new gasket.

3.7 Packaging. Package the machine assembly for transport back to the vessel. To prevent damage, ensure that brushes are removed and separately wrapped for shipment. If the machine will not be promptly reinstalled, store the packing crate in a climate-controlled environment or pack the container with desiccant and shrink-wrap it with heavy plastic film.

3.8 Reinstallation aboard vessel. When stated in the work item, or if a Change Request has been released and authorized by the KO, transport the designated machine to the vessel, reinstall per Section A2.2 of Appendix A, and test per Section A2.3 of Appendix A.

4. NOTES

4.1 Section 4.3 of ANSI/EASA AR100 lists additional shop acceptance tests that could be performed. If such testing is justified by the particular condition or operating history of the machine, the performance of such additional tests and the associated acceptance values shall be specified in the work item.

APPENDIX A

REMOVE AND REINSTALL DC GENERATOR OR MOTOR ABOARD VESSEL

A1. SCOPE

A1.1 Intent. This appendix describes the requirements for removing and reinstalling a direct current (DC) generator or motor aboard a vessel. As directed by the work item, the removed machine or assembly may be sent to a suitable repair facility for overhaul or replaced by a new machine or assembly.

A2. REQUIREMENTS

A2.1 Removal from vessel. Perform the following to remove the machine or assembly from the vessel, retaining all shims, fasteners, and other hardware for reinstallation:

A2.1.1 Secondary power sources. Ensure that secondary power sources, such as space heaters, resistance temperature detectors, and internal inspection lights, are secured prior to commencing work.

A2.1.2 Preliminary measurements. Accomplish the following, prior to removal of the armature or machine:

A2.1.2.1 Measure and record the coupling and alignment clearances; match mark each coupling prior to disassembly for later reconnection.

A2.1.2.2 Measure all main pole and interpole air gap clearances as follows, ensuring that the amount of removed varnish is kept to a minimum, and varnish residuals from the iron on the pole and the iron on the armature are removed, wherever measurements will be taken:

- Choose and non-destructively mark the centerline of each main pole on both ends (fore and aft), as well as a single point on each end of the armature.
- Align the mark on the armature with the mark on the number one main pole (arbitrarily chosen). Carefully measure the air gaps with a tapered feeler gauge to the nearest thousandth of an inch; record the readings in the "Main Pole" section, "A" columns (Fore and Aft) of the DATA SHEET A-1 (Air Gap Readings) provided herein.
- Repeat the above procedures, until the mark on the armature has been aligned with the marks on each of the remaining main poles.
- Measure the interpole air gaps, as specified above for the main poles; record the readings in the "Interpole" section, "A" columns (Fore and Aft) of the DATA SHEET A-1 (Air Gap Readings) provided herein.

A2.1.3 Cable. As needed to perform the work, disconnect the machine stator power cable, field power cable, and any accessory (e.g., inspection lighting, electromagnetic brake, temperature sensor, or space heater) or auxiliary (e.g., blower motor) wiring in accordance with SFLC Std Spec 3042.

A2.1.4 Ventilation. As needed to perform the work, remove blower(s) and duct sections to separate the machine from its ventilation system. Clean air stream surfaces of the removed components and the first 3 feet of ductwork in each direction from each break.

A2.1.5 Sea water. For a machine with a salt water to air heat exchanger:

A2.1.5.1 Establish two barriers (e.g., two shut valves, preferably with a telltale drain between them to warn if the upstream pressure barrier is leaking) between the sea water joints to be broken and the surrounding waters. If two barrier protection is not possible due to system design, then permission of the cutter’s Commanding Officer is required to use single barrier protection and that barrier shall be locked in the secured position (e.g., lockwire the valve handwheel). Single barrier isolation is also acceptable if the vessel will not be waterborne, the barrier is a blank flange capable of withstanding normal system operating pressure, or the piping to be disconnected is supplied by a depressurized header and is located at an elevation above the highest expected waterline for the duration of the work.

A2.1.5.2 As needed to perform the work, drain, disconnect, and blank sea water piping to separate the air cooler from ship’s piping.

A2.1.5.3 Inspect electrolytic zincs and report wastage condition. If Government furnished replacements are provided, renew zincs; otherwise, scrub existing zincs with a wire brush and reinstall.

A2.1.6 Lubricating oil. For a machine with oil lubricated bearings, drain, disconnect, and blank lube oil piping as needed to separate the bearings from ship’s piping.

A2.1.7 Brushes. Remove and inspect all brushes. Also remove brush rigging insulators, brush holders, and brush holder springs as needed for armature removal.

A2.1.8 Coupling disassembly. Disassemble machine coupling(s) and retain for reuse, accomplishing the following as applicable:

A2.1.8.1 When design, rigging, access, or space constraints preclude removing the fully assembled machine from the vessel, remove the armature in accordance with the machine manufacturer’s recommended rigging procedure.

A2.1.8.2 If the machine is of single bearing design and is to remain fully assembled during off load, install appropriate blocking to support the driven end.

A2.1.9 Removal. Remove the machine to be overhauled from the vessel, retaining all shims, fasteners, and other hardware for reinstallation:

A2.1.10 Disposition. Perform the following on each designated component or assembly as directed by the work item:

A2.1.10.1 Package the removed machine or assemblies for transport to a suitable machine repair facility. If the armature and magnet frame were off loaded separately, they may be reassembled before crating or individually packaged; however, package brushes separately to prevent damage. Support the armature so that its windings cannot make physical contact with unprotected adjacent surfaces during the transit.

A2.1.10.2 Scrap items that will not be reinstalled.

A2.1.10.3 Retain the remaining items for future reinstallation and store in a protected location.

A2.1.11 Clean, inspect, and paint the vacated foundation while the machine is not installed.

A2.2 Reinstallation aboard vessel. Unpack the machine assembly and visually inspect for shipping damage. Reinstall the removed components using shims, fasteners, and other hardware retained in paragraph A2.1 above.

A2.2.1 Shaft coupling. Remake the coupling(s), remove blocking, and realign the machine. Measure angular and parallel misalignment, adjusting, as necessary, to within manufacturer’s tolerances. If no manufacturer’s data is available, angular misalignment shall not exceed 0.005 inch and parallel misalignment shall be no greater than 0.002 inch.

A2.2.2 Alignment. Measure and record air gaps in accordance with section A2.1.2.2 above.

A2.2.3 Brush holders. If removed, reinstall and align the brush rigging insulators, brush holders, and brush holder springs to the factory brush position setting. If such setting is unknown, locate the electrical neutral and adjust brush positions to minimize sparking using the DC kick or AC Reeder method (see section A3.2 below). Set all brush holders the same distance from the commutator, not more than ⅛-inch, nor less than $^{1}/_{16}$ inch, unless otherwise specified by the manufacturer. Align all brush holders per manufacturer’s recommendations, usually such that the toes of all brushes on each brush stud line up with each other and with the edge of one commutator segment. Space brush holders evenly around the commutator circumference using a paper tape to ensure uniformity within $\pm^{1}/_{32}$ inch. Stagger brush holders axially per the manufacturer’s recommendations.

A2.2.4 Brushes. Install retained or replacement brushes into the brush holders. After the brushes have been installed, check and ensure the following:

- Brushes are free to move in the brush holder without sticking.
- Brush tension is adjusted in accordance with manufacturer’s recommendations. If no data is available, adjust brush tension to achieve a pressure of 2½ pounds per square inch of brush cross sectional area.
- The shunt terminals are firmly attached to the brush holders.

A2.2.5 Ventilation. Reinstall blower(s) and duct sections removed in paragraph A2.1.4 above.

A2.2.6 Cables. Perform insulation resistance tests and reconnect cables lifted in paragraph A2.1.3 above in accordance with SFLC Std Spec 3042 using retained hook-up data.

A2.2.7 Sea water. Using new gaskets, reinstall and reconnect salt water to air heat exchangers that were removed in paragraph A2.1.5 above.

A2.2.8 Lubrication. Ensure that machine bearings are properly lubricated. Using new gaskets, reconnect any lube oil piping that was removed in paragraph A2.1.6 above; refill drained piping with fresh oil and purge any trapped air. Slowly rotate the assembled machine using the barring gear or turning motor if installed. Verify that air gap is adequate to prevent mechanical contact of the armature windings with the field coils through at least one complete revolution.

A2.2.9 Covers. Reinstall the cleaned machine access covers and any other removed equipment. Reuse retained fasteners.

A2.2.10 Space heater. Energize the machine space heating system to exclude moisture whenever the unit is not in operation.

A2.3 Final acceptance testing. Perform the following final acceptance tests:

A2.3.1 Insulation resistance test. Measure and record the insulation resistance of the complete field and armature circuits to ground. If the insulation resistance on any circuit, adjusted to 25°C, is below the value shown in Tables 3A through 3D above, as applicable, submit a CFR along with proposed corrective action.

A2.3.2 Operational test. Ship's force will operate all machinery during operational tests.

NOTICE

In order to run the machine during the next tests, the associated mechanical systems may need to be refilled and vented prior to operation. Prime mover air intakes and exhaust systems must be clear and ready for operation. Ensure that fire suppression, fuel oil, compressed air, sea water cooling, and lube oil system valve lineups support machine operation before commencing electrical tests.

A2.3.2.1 Perform a direction of rotation test of the overhauled machine. Also test the direction of rotation of any motorized accessory, such as a blower or brush rig lifting mechanism, which was removed and reinstalled as a work interference. Correct any reverse phase rotation problems.

NOTICE

Coordinate machine operational testing with mechanical system retests. Inspect disturbed mechanical joints in fluid systems for leakage as the system is pressurized for the first time.

A2.3.2.2 For main propulsion machinery, season the commutator by operating sequentially at the power levels shown in Table A-1 below during dock and/or sea trials. For a main propulsion generator or motor, log all machine parameters (e.g., voltage, current, rotational speed, winding temperature) shown on the cutter's full power trial maintenance procedure card every 15 minutes.

A2.3.2.2.1 A dock trial shall be performed to verify that the main or auxiliary propulsion machinery affected by this item is operating satisfactorily and to reestablish the commutator carbon film. Limit propeller rotational speed to prevent the ship from pulling away from its mooring. Take appropriate precautions on the cutter and nearby ships to prevent fouling of seawater piping systems when bottom sediment may be stirred up by the propeller.

A2.3.2.2.2 A sea trial shall be performed to complete the restoration of the commutator film and verify that the propulsion or scientific machinery is operating correctly at all speeds and directions. When main propulsion generator or motor work has been accomplished, perform a full power trial in accordance with the cutter's maintenance procedure card after commutator seasoning is complete. Other tests may proceed concurrently as conditions allow.

A2.3.2.2.3 Verify that all machine accessories (e.g., inspection lights, electromagnetic brake, temperature sensors, and space heater) are operating properly.

TABLE A-1 – DC PROPULSION GENERATOR AND MOTOR OPERATING PARAMETERS

POWER	DURATION
25%	2 HOURS
35%	1 HOUR
45%	1 HOUR
55%	1 HOUR
65%	1 HOUR
75%	1 HOUR
85%	1 HOUR
95%	1 HOUR
100%	4 HOURS

A2.4 Final insulation resistance. Immediately after docking, measure and record the insulation resistance of the complete field and armature circuits (see paragraph 3.3.2.2 above).

A2.5 Post sea trial inspection. After the sea trial, visually inspect the machine internals for evidence of overheating, loose fasteners, commutator problems, broken brushes, and other conditions recommended by the technical representative.

A3. NOTES

A3.1 Non-contracted work. For instances where the Contractor is not tasked with removal or reinstallation of the machine, Ship's Force should perform the related steps of this Appendix instead.

A3.2 Neutral plane determination. Where it is necessary to locate the electrical neutral position on a direct-current machine in the machine in the field, it may be correctly and simply located by the electrical DC kick or AC Reeder method if due care is exercised.

A3.2.1 General.

A3.2.1.1 Ensure that all auxiliary circuits, including space heaters and temperature alarms, are deenergized. With the machine at standstill, raise all brushes. Check for no continuity between both polarities of the brushholders and the armature to verify that no brushes are touching the armature.

A3.2.1.2 Lock the armature in position by putting wedges in the air gap.

A3.2.1.3 To avoid scratching or gouging the commutator bar surface in contact with the brushes, voltmeter probe tips should only contact the vertical ends of the bars during the tests below.

A3.2.1.4 The following example will be used to explain how to locate the electrical neutral. Determine the number of commutator bars per main pole by simple division:

A3.2.1.4.1 If, for example, there are 8 poles and 432 commutator bars, then there are exactly 54 bars per pole and the throw will be from bar 1 to 55. Number (in the direction of rotation) an arbitrary portion of the commutator (approximately 60 consecutive bars for this example) so that the neutral zone of two adjacent main poles is included. During the testing below, voltmeter probes will initially be placed on bars 1 and 55. After each reading, they are then moved one position (e.g., 2 and 56, 3 and 57, etc.) for the next reading, maintaining the same span.

A3.2.1.4.2 Some machines, such as a 20 pole motor with 1170 bars, will have a fractional pole pitch, 58½ bars per pole in this example. Since the measurement span must be an integral number, two sets of readings (one at the nearest integral position on each side of the fractional value) will have to be taken to determine the electrical neutral. The first set would use a bar pitch of 58 (even), taking readings from bars 1 to 59, 2 to 60, 3 to 61, etc.. For the second set, increase the bar pitch to 59 (odd), and take readings from bars 1 to 60, 2 to 61, 3 to 62, etc.

A3.2.2 DC kick method. Use an analog DC voltmeter, preferably one having 0.5, 1.5 and 15 volt scales. Temporarily disconnect external shunt field wiring and separately excite the shunt field from a DC source through a quick-break switch. Insert enough external resistance in the excitation circuit to keep the field current small at the beginning. If the shunt field windings begin to smoke, insert additional resistance or reduce the applied voltage.

A3.2.2.1 Use the smallest field current that gives a good deflection on the low scale of the voltmeter. When "kick" voltage is read as the switch is opened for the first time, begin with the 15 volt scale and change to lower scales only when it is certain that the voltage is within their respective ranges. Before the switch is opened for each reading, wait long enough for the induced voltage caused by closing the circuit to decay.

A3.2.2.2 When a satisfactory value of field current is found, note this value, then move the voltmeter test lead points to the next bar pair and read the deflection as the field is opened. If possible, rotate the armature slightly in either direction and repeat these operations until the two readings are equal and opposite. The correct neutral is exactly midway between the two bars. Shift the rocker ring so that the centerline of the brush arc is over the correct neutral point.

A3.2.2.3 If the armature cannot be rotated, the neutral can also be located by plotting a curve of induced voltage versus bar position. Proceed as described in paragraph A3.2.2.1 above to adjust the field current. When a satisfactory field current is found, read induced voltages between bar pairs until a point is reached at which the polarity of the induced voltages reverses. Then record four readings, two on either side of the reversing point, and plot these induced voltages as ordinates and the commutator bars as abscissas, using first number of each bar pair as the position. Keep in mind that an integral number represents the center of the bar and the ½ position is the center of the mica between bars. Draw straight lines through the data points on each side of the neutral. The point at which the two lines intersect (should be at zero volts) is the point of reversal. Locate this position on the commutator as the electrical neutral.

A3.2.2.3.1 For an integral pole pitch machine, shift the rocker ring so that the center of the brush arc is set over this point.

A3.2.2.3.2 For a fractional pole pitch machine, plot curves for odd and even numbers of bars per pole on the same graph, determining the point midway between these two curves where they cross the abscissas (or the point of reversal). Locate this position on the commutator as the electrical neutral.

A3.2.3 AC Reeder method. This method is similar to the DC kick method of paragraph A3.2.2 above except that a digital AC volt meter is used and the shunt field is excited by an external AC power source. For most medium and large machines, single phase 120 VAC power from a nearby receptacle can be used satisfactorily with no resistor. For smaller motors, a variable transformer (variac) can be used to limit shunt field current during the test. No quick break switch is necessary as the alternating current passing through the shunt field induces voltage into the armature. For AC measurements, there is no polarity change. The measured voltage will decrease as the neutral is approached and then increase again once it has been passed

A3.2.3.1 Record AC voltage readings for each bar pair to three significant digits to the right of the decimal point. If .straight line plots are not obtained when using the technique of paragraph A3.2.2.3 above, try a different instrument or omit the two lowest values. See Figure A-1 for a typical integral pole pitch machine plot.

A3.2.4 Final adjustment. A machine manufacturer may recommend a slight shift off neutral for better brush performance. For a generator the neutral plane is advanced slightly in the direction of rotation; for a motor, the position is retarded.

A3.2.5 Restoration. Remove all armature blocking. Reconnect the lifted shunt field external wiring, observing proper polarity.

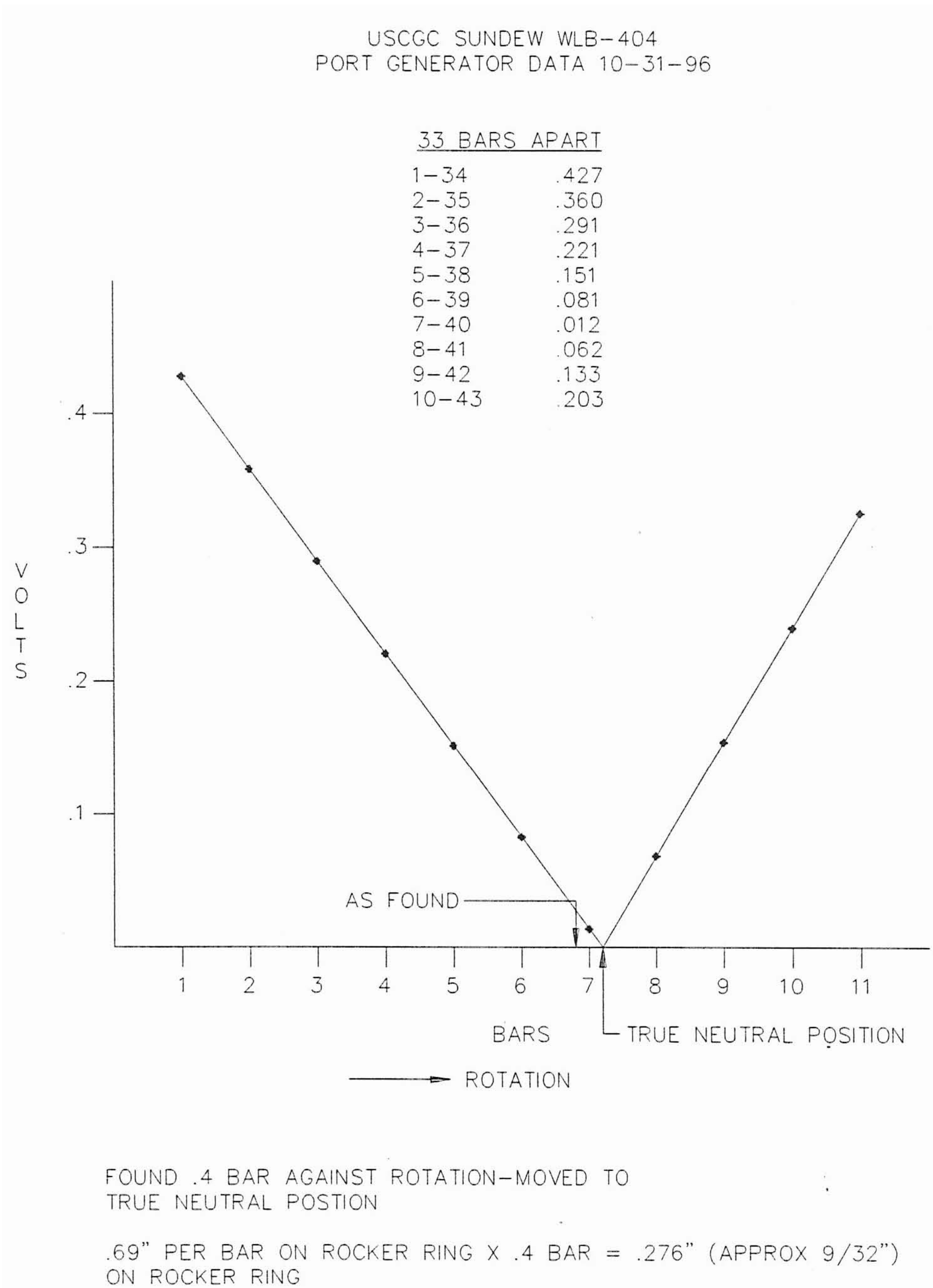

FIGURE A-1 – AC REEDER METHOD PLOT FOR DETERMINING NEUTRAL PLANE

DATA SHEET A-1 – AIR GAP READINGS

VESSEL NAME: ________________________ HULL#:________________	MPG/MPM/OW No. ___; BT/ST/TCW Serial No. _________________________

POLE NO.	MAIN POLE				INTERPOLE			
	FORE		AFT		FORE		AFT	
	*A	**B	*A	**B	*A	**B	*A	**B
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								

***Column A is for recording of preliminary air gap clearances.**
****Column B is for recording of post-installation air gap clearances.**

	NAME (Type/Print)	SIGNATURE	DATE
Contractor			
Test conductor			
USCG Inspector			
Ambient conditions:			

APPENDIX B

RECONDITION DC GENERATOR OR MOTOR

B1. SCOPE

B1.1 Intent. This appendix describes the requirements for reconditioning the windings of a direct current (DC) generator or motor at a suitable repair facility.

B2. REQUIREMENTS

B2.1 Cleaning. Clean the armature and magnet frame windings as follows:

B2.1.1 Suction. Use suction to remove abrasive particles such as loose grit, iron dust, carbon and copper particles. Clean the commutator using a canvas cloth while rotating the armature. Clean the commutator slots, using a combination of suction and a small bristle brush; wipe commutator and adjacent parts with a clean, lint-free canvas or cheese cloth.

B2.1.2 Compressed air. Use compressed air with suction such that material dislodged by the air stream will be captured and exhausted. Remove dry loose dust and foreign particles, particularly from inaccessible locations such as air vents in the armature punchings. Ensure the following:

- The compressed air is clean (oil free with the use of an oil filter) and dry.
- The air pressure does not exceed 30 pounds per square inch.
- The machine is opened from both ends, to allow a path of escape for air and dust.
- Extreme caution is used when using compressed air, particularly if abrasive particles are present.

B2.1.3 Cleaning solution. All cleaning solutions shall be water based. Dry ice, citrus terpenes, or other waterless organic solvents shall not be used. Prepare one of the following solutions for cleaning:

- Liquid non-ionic water-soluble general-purpose detergent, meeting the requirements of MIL-D-16791, mixed in a proportion of 1 ounce of concentrate to 1 gallon of fresh water. If the cleaning solution is batch prepared, heated the mixing water to 130°F to 150°F prior to dissolving the detergent.
- Steam cleaner, typically in the proportions of 15 to 20 pounds of steam cleaning compound and 1 quart of butyl alcohol to 1,000-gallons of water.

B2.1.4 Cleaning method. After removal of loose materials above, clean the coils, windings, and structural members until all carbon dust, oil, grease, and foreign deposits are removed. Cleaning and rinse solution temperature shall be no less than 140°F and shall not exceed 194°F. Use clean lint-free cloths to check for cleaning effectiveness.

B2.1.4.1 For tank cleaning, place the armature in the solution with its axis vertical and the commutator end up. Hold the solution at a constant temperature of 88°C (190°F) and circulate it through the windings with an air agitator or other means.

B2.1.4.2 For steam cleaning or pressure washer applications, ensure that all surfaces are thoroughly wetted. Set the sprayer controls to avoid damaging the insulation by limiting winding impingement pressure to 30 psig. Avoid striking varnished surfaces with the cleaning nozzle or wand.

B2.1.5 Rinse. At the conclusion of a wash cycle, rinse the windings using hot fresh water. Do not let cleaning solution dry on machine surfaces. Continue wash and rinse cycles until the machine is clean. The final rinse of the work day shall include all machine internals to ensure that any overspray is completely removed from all surfaces. Wipe off accessible wetted surfaces and blow dry or wet vacuum any remaining surface water.

B2.1.6 Drying. Immediately after cleaning, rinsing and hand drying, bake the windings in an oven until completely dry. Do not allow winding temperature to exceed 230ºF and maintain oven temperature below 300ºF. Do not exceed manufacturer's temperature limits. Take insulation resistance readings per Section 4.2.1 of ANSI/EASA AR100 when the drying is started and at regular intervals thereafter. Plot the data on semi-logarithmic paper with the logarithm of temperature corrected insulation resistance as ordinate and time as abscissa. Continue drying until either:

- The temperature corrected insulation resistance readings show no abrupt changes and do not increase more than 5% over a 12-hour period.
- The polarization index is greater than 3.0.

B2.2 Evaluation. A shop cleaned and dried machine should have an insulation resistance of no less than the applicable value shown in Table 3C above in order to proceed with insulation treatment. If insulation resistance is less than this value after two clean and dry cycles, submit a CFR. If a Change Request is released and authorized by the KO as a result of this CFR, discontinue further work on the affected circuit(s) under this appendix and rewind per Appendix D.

B2.3 Insulation treatment. Upon satisfactory completion of cleaning, drying, and any other authorized repairs, accomplish insulation treatment of the armature and magnet frame windings per Section 3.4 of ANSI/EASA AR100 using one of the methods below, except that a machine constructed with sealed insulation systems shall only be vacuum pressure impregnated (VPI). The work item may further restrict the choice of materials or methods. The temperature class of the applied treatment shall be no less than that of the existing insulation system.

B2.3.1 Solvent-varnish dip and bake. Varnish shall be of Grade CB per MIL-I-24092/2 when required by the work item; an industrial electrical grade polyester solvent-varnish compatible with the original varnish may be used otherwise.

B2.3.2 Solventless resin dip and bake. Resin shall be of Grade SF per MIL-I-24092/5 when required by the work item; an industrial electrical grade solventless resin compatible with the original varnish may be used otherwise.

B2.3.3 Vacuum-pressure impregnation. Resin shall meet MIL-I-24718/3 when required by the work item; an industrial electrical grade resin compatible with the original insulation may be used otherwise.

B2.4 Curing. Cure the treated windings in accordance with the varnish manufacturer's recommendations.

B3. NOTES

B3.1 Solventless varnish. In recent years epoxy-type 100% solid (solventless) varnishes have been used in geographical areas that regulate industrial facility volatile organic air emissions. Such treatment may be applied by the traditional dipping and baking approach or by the VPI method.

B3.2 Vacuum-pressure impregnation. A VPI resin may be successfully applied over windings that were previously varnish dipped and baked. Many electric machinery repair shops now have automated VPI equipment, reducing the cost of such treatment to near that of the traditional dip and bake method. Unless the cost is significantly greater, the windings of a machine constantly exposed to moist salt air should be reconditioned using the VPI method.

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APPENDIX C

REBUILD DC GENERATOR OR MOTOR COMMUTATOR

C1. SCOPE

C1.1 Intent. This appendix describes the requirements for rebuilding the commutator of a direct current (DC) generator or motor at a suitable repair or fabrication facility.

C2. REQUIREMENTS

C2.1 Disassembly. Break the commutator riser connections and press the commutator off the armature shaft. Unbolt the V-ring and disassemble the segments. Clean and inspect the steel structure, clamping fasteners, and any other components that will be reused. Correct minor deficiencies and submit a CFR if major discrepancies are identified.

C2.2 Fabrication. Fabricate the following components:

C2.2.1 Segments. When stated in the work item, or if a Change Request has been released and authorized by the KO, renew the commutator segments with bars manufactured from hard-drawn, cold-rolled, or drop-forged copper with silver alloying content in accordance with the manufacturer’s specifications. Cast copper is too porous and its use is prohibited. The new bars shall be sufficiently thick so that after machining the rebuilt commutator will be restored to the manufacturer's original diameter.

C2.2.2 Risers. When stated in the work item, or if a Change Request has been released and authorized by the KO, manufacture new commutator risers from hard-drawn copper. Ensure that all risers are the same height and make electrical connections to the commutator segments using the same method, either silver brazing or tungsten inert gas (TIG) welding, as the original manufacturer.

C2.2.3 Insulation. Renew all commutator insulation (segment, ground wall, and V-ring).

C2.3 Reassembly. Install commutator segments and insulation. Ensure that the axial skew of the commutator segments does not exceed 0.010 inch from the front end to the back end of the bars. Carefully install the clamping ring bolts.

C2.3.1 Inspection. Inspect the assembled commutator before torquing the clamping bolts. Correct misaligned bars, mica deficiencies, and cracked or broken risers.

C2.3.2 Torque. Torque the commutator clamping bolts with a calibrated torque wrench in accordance with the machine manufacturer's recommendations to ensure that the bars will not move, heating and cooling bars as necessary. As the machine is reassembled, periodically recheck the torque of clamping bolts and tighten loose fasteners as necessary.

C2.3.3 String bands. Renew the string bands and adjust tension per manufacturer’s recommendations, not to exceed 600 pounds per inch of tape width. Apply varnish treatment and cure the banding as specified by the machine manufacturer.

C2.3.4 Reinstallation. Press the commutator onto the armature shaft in accordance with manufacturer's instructions.

C2.3.5 Truing. Machine the commutator outside diameter to concentricity with the armature shaft bearing seats. Capture all removed material with a vacuum as it is being produced. Total indicated run out shall be no greater than 0.002 inch.

C2.3.6 Stoning. Grind the commutator outside diameter with a finishing stone, capturing all removed material with a vacuum as it is being produced.

C2.3.7 Undercutting. Undercut the mica in accordance with manufacturer's instructions. In the absence of manufacturer's specifications, use a "U" or "V" shaped cutter to form slots with width and depth equal to the thickness of the mica. Vacuum all removed mica and copper, ensuring that no sheet mica remnants are adhering to the copper slot walls such that they could abrade the brush surface.

C2.3.8 Chamfering. After undercutting, bevel the commutator bars in accordance with manufacturer's instructions. In the absence of manufacturer's specifications, chamfer $^{1}/_{64}$ to $^{1}/_{32}$ inch. Vacuum all removed copper.

C2.3.9 Burnishing. Polish the commutator outside diameter with a very fine burnishing stone to remove scratches, surface roughness, and copper slivers. Vacuum all loose copper as it is being machined off and clean each slot.

C2.4 Pre-installation testing. Perform the following testing prior to reconnecting the commutator risers to the armature windings:

C2.4.1 Bar-to-shaft insulation resistance. Wrap several turns of bare copper wire securely around the commutator bars and perform the following series of tests:

C2.4.1.1 Connect one terminal of a megohmmeter to the bare copper wire and the other terminal to the armature shaft. Measure and record bar-to-shaft insulation resistance per Section 4.2.1 of ANSI/EASA AR100. Acceptance criteria are the same as those for the armature alone circuit in Table 3C above.

C2.4.1.2 Replace the megohmmeter with a high potential tester and perform a high potential test in accordance with Section 4.4 of ANSI/EASA AR100, except that test voltage shall be as specified by the machine manufacturer. In the absence of a manufacturer's isolated commutator specifications, apply a potential of 3500 VAC.

C2.4.1.3 Disconnect the high potential tester and remove the bare copper wire wrapped around the commutator.

C2.4.2 Bar-to-bar low potential. Perform a low potential test between each pair of adjacent commutator segments in accordance with Section 4.4 of ANSI/EASA AR100, except that test voltage shall be 120 to 250 VAC. Correct any short circuits between adjacent bars.

C2.5 Risers. After satisfactory completion of pre-installation testing, electrically connect the commutator risers to the armature windings.

C2.6 Final shop acceptance testing. If Appendix D is not being performed, accomplish the following final shop acceptance tests:

C2.6.1 Bar-to-bar. Reperform the low potential test of paragraph C2.4.2 above.

C2.6.2 Surge comparison. Perform surge comparison testing of the armature windings to identify open, grounded, and high resistance coils in accordance with Section 4.2.6 of ANSI/EASA AR100.

C3. NOTES

C3.1 The most common commutator repairs are performed by Appendix F and this appendix should rarely be invoked. The most likely reasons for invoking this appendix would be:

- Ground wall insulation failure.
- Commutator bars that have been scratched or pitted more deeply than the remaining segment wear thickness.
- Widespread oil or salt water contamination of the sheet mica between segments.

APPENDIX D

REWIND DC GENERATOR OR MOTOR ARMATURE

D1. SCOPE

D1.1 Intent. This appendix describes the requirements for rewinding the armature of a direct current (DC) generator or motor at a suitable repair facility.

D2. REQUIREMENTS

D2.1 Core loss test. If not previously accomplished in Section 3.3.3.4 above, perform an interlaminar insulation resistance test of the armature in accordance with Section 4.2.7 of ANSI/EASA AR100 and Section 2.5.3 of DOE/GO 10099-935.

D2.2 Rewinding. Strip, clean, test, and rewind the armature per Section 3 of ANSI/EASA AR100, observing the following:

D2.2.1 Commutator removal. Carefully document all winding connections to the commutator segment risers. Break all riser connections and remove the commutator from the armature shaft.

D2.2.2 Burn out. Strip the old windings in accordance with Section 3.3 of ANSI/EASA AR100 and Section 2.5.4 of DOE/GO 10099-935. Armatures that have not been rewound since 1980 may still contain asbestos. Keep accurate records of coil data, size and type of conductors, number of turns, slot spacing, coil shape, equalizer connections, and riser connections.

D2.2.3 Cleaning. Clean and dry each core in accordance with Section 2.6.1 of DOE/GO 10099-935. Very light abrasive blasting with organic materials or glass beads may be used to clean laminated surfaces. Remove all varnish and insulating materials from the slots and all varnish accumulation on the shaft, coil support rings, and spider. Ensure all air passages, vents, and holes are clean and free of old varnish and other material.

D2.2.4 Core inspection. Reperform the test of paragraph D2.1 above on the bare core. If results are unsatisfactory or there is visual evidence of damage, submit a CFR with the recommended repair course of action. Reperform the core loss test after any iron restacking or interlaminar insulation repairs.

D2.2.5 Core preparation. Prepare the bare core for winding, touching up the interlaminar insulation, varnishing the iron, and installing ground wall insulation, as necessary, to restore machine to a like new condition.

D2.2.6 Commutator reinstallation. Reinstall the removed commutator onto the armature shaft.

D2.2.7 Windings. Wind coils in accordance with Sections 3.6 through 3.12 of ANSI/EASA AR100 and Sections 2.7.1 through 2.7.7 of DOE/GO 10099-935.

D2.2.8 Banding. Apply banding in accordance with Section 3.13 of ANSI/EASA AR100. Use the same type of wire or glass banding that was installed by the original manufacturer. Do not substitute one for the other, nor replace magnetic banding wire with non-magnetic or vice versa.

D2.3 Pre-connection testing. Visually inspect and test the windings per Section 2.7.8 of DOE/GO 10099-935 to ensure that there are no improper connections or shorted turns. At a minimum, perform the following prior to connecting the commutator risers to the armature windings:

D2.3.1 Coil-to-shaft insulation resistance. Temporarily connect all armature coils together and perform the following series of tests:

D2.3.1.1 Connect one terminal of a megohmmeter to the coils and the other terminal to the armature shaft. Measure and record coil-to-shaft insulation resistance per Section 4.2.1 of ANSI/EASA AR100. Acceptance criteria are the same as those for the armature alone circuit in Table 3D. above.

D2.3.1.2 Disconnect the megohmmeter and separate the armature coils from each other.

D2.3.2 Coil-to-coil low potential. Perform a low potential test between each pair of adjacent armature coils in accordance with Section 4.4 of ANSI/EASA AR100, except that test voltage shall be 120 to 250 VAC. Correct any short circuits between adjacent coils.

D2.3.3 Winding resistance. Measure and record the resistance of each coil with a precision resistance bridge or micro-ohmmeter. Measured resistances shall be within 2.5% of the original manufacturer's specification, temperature corrected as necessary. In the absence of manufacturer’s specifications, the measured resistance of each coil shall be within 2.5% of the average.

D2.4 Risers. After satisfactory completion of pre-connection testing, electrically connect the commutator risers and equalizers to the armature windings.

D2.5 Pre-impregnation testing. Perform the following tests prior to impregnating the armature:

D2.5.1 Bar-to-bar. Perform a low potential test between each pair of adjacent commutator segments in accordance with Section 4.4 of ANSI/EASA AR100, except that test voltage shall be 120 to 250 VAC. Correct any short circuits between adjacent bars.

D2.5.2 Surge comparison. Perform surge comparison testing of the armature windings to identify open, grounded, and high resistance coils in accordance with Section 4.2.6 of ANSI/EASA AR100.

D2.6 Vacuum-pressure impregnation. Upon satisfactory completion of rewinding and any other authorized repairs, accomplish insulation treatment of the armature windings per Section 3.4 of ANSI/EASA AR100 using the vacuum pressure impregnation (VPI) method. The temperature class of the applied treatment shall be Class F or better and no less than that originally applied by the machine manufacturer. Resin shall meet MIL-I-24718/3 when required by the work item; an industrial electrical grade resin may be used otherwise. Cure the treated windings in accordance with the varnish manufacturer’s recommendations.

D3. NOTES

D3.1 Vacuum-pressure impregnation. Many machine repair shops now have automated VPI equipment, reducing the cost of such treatment to near that of the traditional dip and bake method. Unless the cost is significantly greater, the windings of a machine afloat should be rewound with a sealed insulation system using the VPI method.

APPENDIX E

REWIND DC GENERATOR OR MOTOR FIELD

E1. SCOPE

E1.1 Intent. This appendix describes the requirements for rewinding the main field (shunt and/or series) poles, commutating (inter) poles, and compensating (pole face) windings of a direct current (DC) generator or motor at a suitable repair facility.

E2. REQUIREMENTS

E2.1 General. Rewind only the pole piece(s) specified by the work item or Change Request.

E2.2 Disassembly. Carefully document all winding connections and shim stack up. Break electrical connections as necessary and remove the designated pole piece(s) from the magnet frame.

E2.3 Core loss test. If not previously accomplished in Section 3.3.3.4 above, perform an interlaminar insulation resistance test of the specified pole piece(s) in accordance with Section 4.2.7 of ANSI/EASA AR100 and Section 2.5.3 of DOE/GO 10099-935.

E2.4 Rewinding. Strip, clean, test, and rewind the specified pole piece(s) per Section 3 of ANSI/EASA AR100, observing the following:

E2.4.1 Burn out. Strip the old windings in accordance with Section 3.3 of ANSI/EASA AR100 and Section 2.5.4 of DOE/GO 10099-935. Coils that have not been rewound since 1980 may still contain asbestos. Keep accurate records of coil data, size and type of conductors, and number of turns.

E2.4.2 Cleaning. Clean and dry each core in accordance with Section 2.6.1 of DOE/GO 10099-935. Very light abrasive blasting with organic materials or glass beads may be used to clean laminated surfaces. Remove all varnish and insulating materials from each pole piece.

E2.4.3 Core inspection. Reperform the test of paragraph D2.1 above on the bare pole piece(s). If results are unsatisfactory or there is visual evidence of damage, submit a CFR with the recommended repair course of action. Reperform the core loss test after any iron restacking or interlaminar insulation repairs.

E2.4.4 Core preparation. Prepare each bare core for winding, touching up the interlaminar insulation, varnishing the iron, and installing ground wall insulation, as necessary, to restore machine to a like new condition.

E2.4.5 Windings. Wind coils in accordance with Sections 3.6 through 3.12 of ANSI/EASA AR100 and Sections 2.7.1 through 2.7.7 of DOE/GO 10099-935.

E2.5 Pre-impregnation testing. Perform the following tests prior to impregnating each pole piece:

E2.5.1 Surge comparison. Perform surge comparison testing of like windings to identify open, grounded, and high resistance coils in accordance with Section 4.2.6 of ANSI/EASA AR100.

E2.5.2 Winding resistance. Measure and record the resistance of each winding with a precision resistance bridge or micro-ohmmeter. Measured resistances shall be within 2.5% of the original manufacturer's specification, temperature corrected as necessary. In the absence of manufacturer’s specifications, the measured resistance of each similar winding shall be within 2.5% of the average.

E2.6 Vacuum-pressure impregnation. Upon satisfactory completion of rewinding, accomplish insulation treatment of the field windings per Section 3.4 of ANSI/EASA AR100 using the vacuum pressure impregnation (VPI) method. The temperature class of the applied treatment shall be Class F or better and no less than that originally applied by the machine manufacturer. Resin shall meet MIL-I-24718/3 when required by the work item; an industrial electrical grade resin may be used otherwise. Cure the treated windings in accordance with the varnish manufacturer’s recommendations.

E2.7 Post-impregnation testing. Perform the following tests after impregnating and baking each pole piece:

E2.7.1 Insulation resistance. Take insulation resistance readings per Section 4.2.1 of ANSI/EASA AR100. Insulation resistance shall be no less than the applicable value shown in Table 3D. above. To expedite testing, all rewound fields in the same circuit may be connected together for testing. If the test is unsatisfactory, perform individual coil testing to isolate the unsatisfactory winding.

E2.7.2 High potential tests. Perform high potential tests in accordance with Section 4.4 of ANSI/EASA AR100. For situations where all field windings in a circuit have been rewound, defer this test until after completion of this appendix (see paragraph 3.5.2 above).

E2.8 Reassembly. Reinstall all windings and shims. Remake and insulate electrical connections.

E3. NOTES

E3.1 Vacuum-pressure impregnation. Many machine repair shops now have automated VPI equipment, reducing the cost of such treatment to near that of the traditional dip and bake method. Unless the cost is significantly greater, the windings of a machine afloat should be rewound with a sealed insulation system using the VPI method.

APPENDIX F

MISCELLANEOUS DC GENERATOR OR MOTOR REPAIRS

F1. SCOPE

F1.1 Intent. This appendix describes the requirements for miscellaneous repairs to a direct current (DC) generator or motor.

F2. REQUIREMENTS

F2.1 Shafting. Correct generator shafting deficiencies in accordance with Section 2.1 of ANSI/EASA AR100 and Section 2.10 of DOE/GO 10099-935. Renew cracked or bent shafts; do not attempt weld repair or straightening unless specifically authorized by the work item or Change Request.

F2.2 Commutator. True, resurface, undercut, and bevel the commutator bars in accordance with Section 2.8 of ANSI/EASA AR100.

F2.2.1 If insufficient material remains to accomplish such work without reducing the commutator diameter below the manufacturer's minimum allowable, submit a CFR and do not proceed without COTR concurrence.

F2.2.2 If the mica in the slots between bars is missing or has become carbonized, scrape out the defective mica and fill the space with sodium silicate (water glass) or other suitable insulating cement.

F2.3 Frame and bearing housings. Repair the frame and bearing housings in accordance with Section 2.4 of ANSI/EASA AR100 and Section 2.12 of DOE/GO 10099-935.

F2.4 Bearings. Inspect and measure all bearings in accordance with Section 2.2 of ANSI/EASA AR100 and Section 2.11 of DOE/GO 10099-935. Renew bearing insulation if resistance measured in paragraph 3.3.3.3 above is less than 10 megohms. As directed by the work item, renew worn bearings or rebabbit bearing shells in accordance with the manufacturer's instruction book or DOD-STD-2188 if no guidance is given; measure and record new bearing clearances.

F2.5 Journals. Restore the bearing journal(s) to their original diameter as follows:

F2.5.1 Chrome-plate the bearing journals in accordance with ASTM B177.

F2.5.2 Record the depth of metal machined from the journal diameter before buildup. Advise the Coast Guard Inspector before proceeding if machining deeper than 0.025 inches.

F2.5.3 Apply the buildup metal so that it will not flake or crack under normal operating conditions.

F2.5.4 Polish all journal areas after completing buildup metal process.

F2.6 Temperature sensors. Renew temperature sensors in accordance with Section 3.9 of ANSI/EASA AR100 and Section 2.13.2 of DOE/GO 10099-935.

F2.7 Leads. Renew the machine leads in accordance with Section 2.13.3 of DOE/GO 10099-935.

F2.8 Space heater. Renew the machine space heater and its internal wiring in accordance with Section 2.13.5 of DOE/GO 10099-935.

F2.9 Windings. Repair damaged windings by stripping back damaged insulation and applying new. If conductors are also damaged, submit a CFR with the recommended repair.

F2.10 Brushes. Renew brushes and sand their faces to fit the curvature of the commutator. Ensure that new brushes have a surface contact of 100% and that they are not chipped or broken on either the heel or toe. Accurately align all brushes with the commutator bars. Before new brushes are seated, inspect the holders and file smooth any roughness. Ensure that the brushes do not overhang the edge of the commutator. Vacuum up loose sand paper grit and carbon dust as the brushes are being cut. Upon completion, vacuum and blow out the entire machine with clean, dry air to remove all traces of carbon dust.

F2.11 Blowers. Remove each externally powered blower from the machine and ship to a suitable shore facility for overhaul. Renew all bearings, belts, and filter media. Test, clean, and inspect each blower motor in accordance with ANSI/EASA AR100. Clean and dynamically balance each fan assembly. Upon completion, reinstall each blower and perform a direction of rotation test.

F3. NOTES

F3.1 Common repairs. The above are the most common miscellaneous generator repairs. Requirements for correcting other deficiencies shall be placed in the work item.

F3.2 Brush renewal. Brushes are typically renewed during shop work when less than 75% of the original length remains. To minimize potential delays for long lead time material and obtain higher quantity discounts, it may be advisable to furnish replacement brushes from on board spares rather than task the Contractor with ordering them.

F3.3 Brush seating methods. New brushes are normally seated in accordance with one of the following methods. Never use emery cloth, crocus cloth, emery paper, or carborundum for seating brushes or polishing the commutator. In addition to being conductors, the particles are very abrasive, and any particles that become imbedded in the brush face will score the commutator.

F3.3.1 Preferred seating method.

F3.3.1.1 Ensure that the bearings of the machine and any components or shafting connected to it are free to turn and properly lubricated before attempting to rotate the armature.

F3.3.1.2 Sandpaper is available in rolls that fit the entire circumference and width of the commutator area desired. Seating all brushes simultaneously on smaller machines and by the row on larger machines rather than singularly may be accomplished. Use medium (80 grit) sandpaper.

F3.3.1.3 Wrap the sandpaper around the commutator in the direction opposite forward rotation and overlap. It can be held in position with cellophane or masking tape, but ensure the tape does not pass under a brush box.

F3.3.1.4 Install the brushes to be seated. When the desired number of brushes has been installed, manually rotate the armature slowly in the forward direction of rotation. Approximately 5-6 revolutions of the armature are required to achieve the correct contour.

F3.3.1.5 Lift and inspect several brushes to ensure no further seating is required. Never pull the sandpaper from under the brushes because this will round brush edges, scratch the brush surfaces and unnecessarily contaminate components with carbon dust. When seating has been completed, turn the armature in the forward direction of rotation until the overlap of sandpaper is visible.

F3.3.1.6 Remove the tape and lift the top layer of sandpaper at the overlap. Remove the sandpaper by rotating the armature slowly in the forward direction of rotation and rolling the bottom layer of sandpaper (grit side in) until all of the paper is free of the commutator. This method maintains a smooth surface on the brush and reduces carbon fouling of the machine's internals. Vacuum and blow out the machine with clean, dry air to remove all free carbon dust. Ensure that no adhesive residue is left on the commutator surface.

F3.3.2 <u>Alternate seating method</u>.

F3.3.2.1 When it is preferable not to rotate the armature or adequate access cannot be gained to the brush boxes, the following alternate method may be used to seat brushes. With this method, brushes are inserted only into brush boxes readily accessible through access openings.

F3.3.2.2 When seating brushes, pull the sandpaper in the forward direction of rotation with the grit side facing the brush. Pull the ends of the sandpaper along the curvature of the commutator to prevent rounding the edges of the brushes. Lift the brush when returning the sandpaper for another pull. Frequently vacuum up loose sand paper grit and carbon dust.

F3.3.2.3 To facilitate this operation, coarse sandpaper (40 grit) may be used for the initial cutting, followed by a medium grade (80 grit) for the final cut. The brushes must be lifted when changing grades of sandpaper. After the brushes have been seated, they may be transferred to the brush boxes not readily accessible to the access opening.

F3.3.2.4 Repeat this technique until all brushes are seated.