GREEN MOTORS PRACTICES GROUP™

Electric Motor Repairing Specification April, 2008

1.0 INTRODUCTION

This Specification covers Green Motors Practices Group (GMPG) repair and rewind efficiency retention protocol of low-voltage random-wound three-phase AC squirrel cage induction motors and lists and describes the minimum requirements for repair and overhaul of such machines.

2.0 INITIAL INSPECTION

If tests and inspection indicate defects of a catastrophic nature, the machine's owner or designated person shall be contacted and given a description of the defects, plus an estimate of their effect on energy consumption, delivery, and associated costs.

2.1 WINDING REMOVAL

2.1.1 Winding Data shall be recorded so as to permit replicating precisely the original configuration. Replacing concentric with a lap winding configuration is preferred when appropriate and based on the following: Changes that do not affect the magnetic densities or current densities by more than 2% are permissible, as well as changes that reduce the current density (increase cross sectional area per turn). Otherwise, the total cross sectional area of a turn, the turns per coil, the end turn extension, the span and connection of the coils shall not be changed.

2.1.2 Core Loss. A core loss test shall be done on all stators both before and after stripping and iron repair, to check for damaged interlaminar insulation. The tests shall be done at a flux density of 85,000 lines per square inch rms. Exciting current and watts loss shall be recorded each time, as well as a physical check carried out for hot spots. If data from previous tests are available, the results shall be compared. Testing at other flux densities may be done if previous data is available. If hot spots exceed 15°C above the average temperature after 15 minutes, or losses are excessive overall either before or after stripping, the situation shall be discussed with the purchaser before proceeding further. For a core without any hot spots, the losses after stripping shall not be more than 10% higher than the pre-strip losses. To avoid misleading results, the second core loss test should not be done until the core has been cleaned and dried.

2.1.3 Burn Out. The winding shall be burned out in a controlled temperature burnout oven where the part is monitored by attaching a sensing probe to the stator core and temperature is limited by means of fuel control and supplementary (water spray) cooling to 360°C (680°F) for organic (C3) or 400°C (750°F) for inorganic (C5) interlaminar insulation. If a higher temperature is deemed necessary, repairer shall reference communication or documentation from the motor manufacturer indicating that the core iron can safely withstand the temperature and confirmed by the core loss test. It is acceptable to cold or chemically strip windings provided the lamination is not exposed to an open flame and the laminations are not flared (splayed).

2.1.4 Winding Extraction. Lamination damage due to coil cutoff or splaying of teeth shall not be permitted.

2.2 CORE PREPARATION

2.2.1 Iron Damage. All obvious iron damage and significant frame damage, plus any defects indicated by a core loss test, shall be corrected and/or reported to the purchaser (consumer) before proceeding further.

2.2.2 Method of Repair; shall be chosen from the following:

Grinding; Grinding of the lamination is not permitted, however limited de-burring is acceptable.

Removal of lamination; Removal of individual lamination(s) is not permitted. However, restacking part or all of the assembly with the same number of de-burred laminations that have the same material composition, dimensions, and interlaminar insulation characteristics as the original lamination assembly is permitted.
Mica between lamination; Inserting split mica between the laminations is permitted provided lamination assembly dimensions remain unchanged.

2.3 WINDING

2.3.1 Insulation system shall be equal to or better than the original materials supplied by the manufacturer. Individual insulation system components shall be compatible as a group and suitable to the environment intended.
2.3.2 Conductors and conductor cross sectional area shall be equal to or greater than the original materials supplied by the manufacturer.
2.3.3 Stator coil(s) extension shall not be greater than original. Care must be taken to minimize crossed slot conductors.
2.3.4 Coil connections or splices shall be equal to or greater than the conductivity of the winding conductors. Compounds or chemicals used in the connection process shall be neutralized.
2.3.5 Impregnation method shall include preheating, treatment, and curing of stator with materials suitable for operating temperature and environment.

2. 4 ROTOR TEST AND REPAIR

2.4.1 Testing. All rotors shall be given a test for damaged bars and end rings, whether the motor is suspect in these areas or not. This test shall apply a stable single-phase voltage to the stator of the assembled motor while the shaft is slowly turned through at least one revolution. Variation of stator current in excess of three percent is an indication of a rotor defect. When electrical or mechanical defects with the rotor are suspected, or if the stator winding is defective, other tests shall be used, including one or more of the following:

- Growler tests.
- Current analysis or vibration analysis of a loaded motor.
- Physical examination.
- Ultrasonic or magnetic impression examination of the bars and end rings.
- Core loss tests (axial current thorough shaft).

2.4.2 Repair. Since repair of squirrel cages can be expensive and difficult, no further work shall be permitted. In the event a rotor is determined to be defective, if the motor is repaired it shall *NOT* be identified as a GMPG product.

2.5 SHAFT AND BEARING FITS

2.5.1 Shaft extension shall be checked to be straight and to size. If dimensional tolerances are unavailable reference ANSI/EASA AR100-2006, Tables 2-1 and 2-2. If defective it shall be corrected and the consumer notified of the fault.
2.5.2 Bearing fits both at shaft and end bracket contact points shall be measured and verified to be within bearing manufacturer tolerance. If dimensional tolerances are unavailable reference ***ANSI/EASA AR100-2006***, Tables 2-13 and 2-14.

2.6 END BRACKETS

2.6.1 Repairs to end bracket bearing housings shall be by building up the metal and machining to size concentric and parallel to rabbet. Welding, plating and sleeving are the accepted methods. Wear resistant high strength epoxy products designed for use on bearing journals shall be acceptable. General epoxies or other compounds, knurl, and/or peen shall not be used to lock or seat bearings.

2.7 FANS

2.7.1 Fans shall be checked for cracks and fit to the shaft or rotor. Fans shall be firmly fixed to the shaft or rotor by the original factory method, unless there has been corrosion between dissimilar metals, in which case a new method shall be proposed to the purchaser. Welding to the shaft is not permitted. Repairs to fans shall only be made after discussion with the consumer. Replacement fans shall have the same number of blades, be dimensionally, and structurally equivalent to the original manufacturer supplied fan. It is preferred to replace fans with an original equipment component supplied by the manufacturer specifically designed for the applicable motor. If a fan is replaced and air velocity or quantity is varied from original characteristics the repaired motor shall *NOT* be identified as a GMPG product.

2.8 BALANCING

The motor rotor shall be checked for balance. In the event rotor unbalance exceeds manufacturer's original specifications it shall be dynamically balanced and meet the following criteria:
Half key. It shall be balanced with a half key in the keyway.
Tolerance G2.5 (ISO 1940-1; generally, the permitted total imbalance is 7.5W/N = oz in/plane where W is weight of rotor in pounds and N is operating speed in RPM. (213 W/N gm. in/plane)
Tolerance G1.0 (ISO 1940-1); two Pole rotors should be balanced to 3W/N = oz. in./plane. (85 W/N gm. in/plane)
Material removal; if material is removed, electrical and structural integrity and fan capacity shall be maintained.
Added material; added material shall be able to withstand the centrifugal forces and be positioned either in the manufacturer's designated positions and locked in place, or positioned in a location where centrifugal force will tend to keep the material in place. Weights may be attached to metallic parts only.

2.9 REASSEMBLY

The assembly of the motor is the reverse of the disassembly process and the following points shall be observed:

- Match marks shall line up.
- On reinsertion of the rotor, take care not to damage the journals or the stator windings and laminations.
- Dowels and fitted bolts shall go back into the same holes that they came from.
- On motors with insulated bearings, the insulation shall be checked and noted.
- Bearing type (open, shielded or sealed), internal fit, and lubricant shall be equivalent to the original.
- On vertical motors, the endplay shall be the same as the original manufacturer's setting, unless the consumer and repairer agree that a modified setting would give better performance.
- Motors for use in hazardous environments shall have all explosion-proof features maintained and be recertified in accordance with UL674.

2.10 FINAL TESTS

2.10.1 Insulation. Prior to running, the motor shall be given an insulation resistance test to ground at 500 volts DC. The minimum value shall be 5 megohm corrected to 40° C. If acceptable, the winding shall be hipot tested in the following manner:

- Rewound motors shall be tested for one minute at 1700VDC plus 3.4 times the machine's voltage rating, e.g. 3264VDC for a 460VAC machine.
- Repaired motors not rewound shall be hipot tested to 65% of the new winding value.

2.10.2 Running Test. After the insulation tests, the motor shall be run at no load at rated terminal voltage. The test shall determine that:
No Load Amps; no load current unbalance should not exceed- six to ten times voltage unbalance.

Vibration; Horizontal, vertical and axial readings shall be taken at each bearing and results recorded. Tolerance shall not exceed ANSI/*EASA AR100-2006, Table 4-5*, or other standard provided by the consumer.

3.0 QUALITY CONTROL

3.1 MEASURING INSTRUMENTS

3.1.1 Calibration. All measuring instruments shall be calibrated regularly, including burn off oven temperature control. The calibration records shall be available for consumers and GMPG inspection. Minimum frequency of calibration shall be annually, except:

Dimension Meters. Micrometers, vernier calipers and other dimension measuring devices—every six months against a minimum grade B (or better) certified gauge block set.

Bore Gauges. Bore gauges shall be calibrated to a certified standard before and after each use.

Core Loss Test Equipment; shall be calibrated per manufacturer's instruction and documentation shall be on file and available for review.

3.3 TESTS AND INSPECTION DURING WORK

3.3.1 Records. Records shall be kept of all tests and inspections carried out during the work. Supervisor signed copies of these records shall be shipped in original form, at the same time as the motor, to the designated client or consumer contact person.

3.4 FINAL INSPECTION. Consumers shall have the right to be present for tests on any motors. In emergency cases, tests will not be held up waiting for consumer representatives, but every effort shall be made to keep a consumer informed so that they can be present if possible.

3.5 TEST RESULTS AND DOCUMENTATION. All final inspection and test results shall be sent, in their original form, to the designated consumer contact person. GMPG completed compliant motors shall be tagged as such and documented. The tag shall include power cost to operate based on estimated kilowatt hours per year consumed. GMPG documentation shall be completed for each motor processed and digitally reported monthly to GMPG headquarters. Motors not meeting GMPG standards but still repaired shall NOT be tagged as compliant and the consumer shall be notified.

SPECIFICATION REFERENCES

EASA	ANSI/EASA AR100 Recommended Practice For The Repair of Rotating Electrical Apparatus
EASA	Guidelines for Maintaining Motor Efficiency During Rebuilding (Tech Note 16)
IEEE	Std. 43, Recommended Practice for Testing Insulation Resistance of Rotating Machinery
	Std. 112, IEEE Standard Test Procedure for Polyphase Induction Motors and Generators
NEMA	Std. MG-1, Motors and Generators
USDO	Office of Industrial Technology, Model Repair Specifications for Low Voltage Induction Motors