GUIDELINES FOR MAINTAINING MOTOR EFFICIENCY DURING REBUILDING

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The challenge for every motor repair firm is twofold: to repair the equipment properly; and to demonstrate to their customers by means of adequate testing and documentation that rewound motors retain their operating efficiency. Following the guidelines in the "DOs" and "DON'Ts" below will help you accomplish both.

Numerous studies have been done to determine the effect rewinding has on motor efficiency. These studies identified several variables that can impact the efficiency of a rewound motor, including core burnout temperature, winding design, bearing type, air gap and winding resistance. The following guidelines were developed as a result of those studies, which found that the efficiency of both standard and energy efficient electric motors can be maintained during rebuilding and rewinding.

To ensure that motors retain their efficiencies when rewound, EASA also strongly recommends that electric motor repair centers comply with *EASA Recommended Practice For The Repair Of Rotating Electrical Apparatus* and strictly adhere to the "DOs" and "DON'Ts" that follow. These guidelines, which contain safe values (based on available data) and correct procedures, apply to both energy efficient and standard motors. Further study of the matter continues, and these guidelines will be revised if additional information warrants.

DO:

1. **Have a quality assurance program.**
2. **Implement a calibration program that will assure the accuracy of all measuring and test equipment.**
3. **Conduct a stator core test *before and after* stripping.**
4. **Repair or replace all defective laminations.**
5. **Evaluate the impact on efficiency before changing the winding design.**
6. **Measure and record winding resistance and room temperature.**
7. **Measure and record amperes and voltage during the final test.**

DON'T:

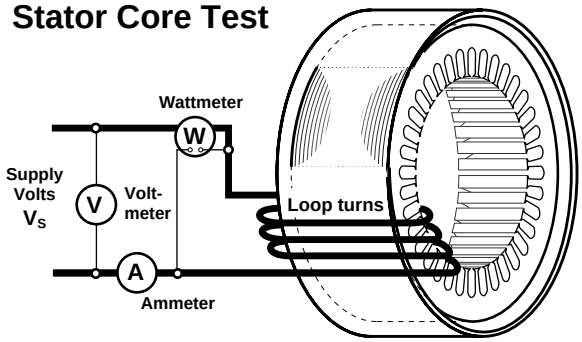
1. **Don't overheat the stator core.**
2. **Don't use an open flame for stripping.**
3. **Don't sandblast the core iron.**
4. **Don't short the laminations when grinding or filing.**
5. **Don't increase the air gap.**
6. **Don't increase the resistance of the stator windings.**
7. **Don't knurl, peen or paint bearing fits.**
8. **Don't make mechanical modifications without the customer's prior approval.**

What follows is a discussion of the individual points.

DO:

1. **Have a quality assurance program.** Be sure that your suppliers are shipping you what you ordered**.** Measure your wire to be sure the spools are properly marked. Check your lead wire and insulating materials for proper size**.** Maintain written documentation of your tests, and especially of your stripping and bake oven temperature cycles and times**.** Test your varnish at the intervals recommended by the varnish manufacturer.
2. **Implement a calibration program that will assure the accuracy of all measuring and test equipment.** Have your instruments calibrated at least annually by an instrument testing service whose calibration is traceable to National Institute of Standards & Technology (NIST), National Research Council of Canada (NRC) or an equivalent standards laboratory. For core testing, use test instruments that read "true rms" values because core test voltage and currents may contain harmonics.
3. **Conduct a stator core test *before and after* stripping.** Record the "before" and "after" core test readings and retain them as proof to your customer that you have not damaged the core.

   If you do not have a core tester, follow the procedure outlined in EASA *Tech Note 17* (also contained in Section 8 of the *EASA Technical Manual*.) To test for core loss using this method, you must connect a single-phase wattmeter in the circuit. You must also adjust the induced voltage to the value used in your calculations. It is also important to make sure that the coil used for the "after" test duplicates as closely as possible the one used for the "before" test.
4. **Repair or replace all defective laminations.** Separate all shorted laminations. When restacking a core, use a coreplate varnish on one side of the laminations,



Test stator cores *before* and *after* you remove the windings, using a commercial tester or the method outlined in your *EASA Technical Manual*. Give the customer a copy of the computer printout or test records to assure them that you have not damaged the core.

cure the varnish at the recommended temperature, and stack an unpainted side against a dry painted side. If new laminations must be cut, send a sample to your supplier. Be sure to specify that losses in the new laminations must be equal to or less than those of the original laminations. Deburr all new or restacked laminations.

5. **Evaluate the impact on efficiency before changing the winding design.** Before changing the winding from concentric to lap or vice versa, determine the effect the change will have on efficiency. This type of change can affect stray load losses and increase winding resistance. Avoid changes that will reduce the cross-sectional area of the total conductors, increase mean turn length, or otherwise affect total winding resistance. Incorrect conversions may change other motor characteristics, not just efficiency.

   It is sometimes possible to improve efficiency when changing a 2-layer concentric winding to lap. Evaluate the effects of winding changes before proceeding with them.

6. **Measure and record winding resistance and room temperature.** Since resistance is affected by temperature, measure and record both the resistance and the temperature of the winding.

7. **Measure and record amperes and voltage during the final test.** Measure and record the amperes and voltage on all phases. Voltages on utility power lines change with load, so do not assume you have a particular voltage. A high voltage will cause the no-load current to increase. Unbalanced voltages cause currents to be unbalanced in a much greater percentage than the voltage unbalance. If currents are unbalanced, interchange all three leads in such a way that the motor's direction of rotation does not change. Now retest the motor, noting whether the high current leg stays with the power lead or the motor lead. If it stays with the power lead, the motor is okay. If not, there may be a problem with the motor. Be sure to record and retain all readings.

DON'T:

1. **Don't overheat the stator core**. EASA's *Core Iron Study* (1984) and the Association of Electrical and Mechanical Trades' (AEMT) *The Repair Of Induction Motors: Best Practices To Maintain Energy Efficiency* (1998) demonstrate that the effects of burnout temperature depend on the type of lamination insulation. Organic material (C3) tends to break down at lower temperatures than inorganic materials (C5). The obvious conclusion is that stripping stators at too high a temperature damages the core plating on the laminations. This causes shorts between laminations, increasing core losses. For this reason, EASA recommends that maximum core (part) temperature not exceed 680° F (360° C) for organic and 750° F (400° C) for inorganic coreplate. Most newer cores may be safely processed at the higher temperature. If in doubt about the type of coreplate used in a particular motor, contact the motor manufacturer. Refer to the *EASA Technical Manual*, Section 1, for contact information, or look them up on EASA's Web site (www.easa.com).

   To prevent overheating, follow the recommendations of the oven manufacturer when loading the oven. Different oven designs call for different procedures. *Do not pile* stators on top of one another or place small stators inside the bores of larger ones. Burn-off ovens should also be equipped with a water spray device that activates automatically if something inside the oven ignites, or if the part temperature exceeds the setpoint. Part temperature, which can vary depending on location within the oven, should be monitored with a chart recorder.

2. **Don't use an open flame for stripping.** Using uncontrolled heat degrades coreplate and warps cores.

3. **Don't sandblast the core iron.** Blasting with sand or other hard materials can cause shorts between laminations if the laminations are struck at certain angles. Shorted laminations increase core losses. Use glass beads, walnut shells, corncobs or similar materials.

4. **Don't short the laminations when grinding or filing.** This procedure, if done improperly, can cause shorts between laminations, thereby increasing core losses. When removing varnish from the stator bore after baking, take care to avoid enlarging the diameter of the bore or causing shorts in the laminations.

5. **Don't increase the air gap.** Enlarging the diameter of the stator bore or taking a cut off the rotor increases the air gap. This produces a higher magnetizing (no-load) current and may adversely affect losses.

6. **Don't increase the resistance of the stator windings.** Measure the wire size carefully with a micrometer after first removing the varnish coating. Since many motor manufacturers today use half size or metric wire,

do not use a wire gauge to determine wire size. The total circular mil area of the conductors-in-hand should not be reduced. No change should be made that changes the *effective turns* of the windings.

Before disturbing the winding, carefully measure and record the coil dimensions: inside nose-to-nose; span; core length and coil extensions. Count the turns carefully, being sure to count the turns in a full group. If you find different turns in coils of the same group, check another group for same pattern.

When making replacement coils, measure the wire after the first group of coils has been wound. Too much tension can stretch the wire, thereby decreasing its diameter and increasing resistance and stator copper losses.

7. **Don't knurl, peen or paint bearing fits.** Bearing fits should not be knurled, peened or painted because they could become loose in service. Loose fits increase friction losses and cause early bearing failure.

8. **Don't make mechanical modifications without the customer's prior approval.** Changes to the fan can adversely affect the cooling system of the motor and possibly increase the temperature rise. Making mechanical modifications to bearings and seals can affect friction losses. Altering shaft material can also affect rotor core losses. The result in each case could be lower efficiency.

CONCLUSION

Following the above guidelines and complying with *EASA Recommended Practice For The Repair Of Rotating Apparatus* will help assure that the motors you rewind and repair retain the same efficiency. By adhering to these guidelines, you will also have the appropriate documentation to demonstrate the quality of your work to your customers.

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