CONSIDERATIONS WHEN SERVICING OR REWINDING A MOTOR

Core Loss Testing

Core loss testing provides a good indication of the condition of the motor's stator and / or rotor laminations. Most good service shops will perform a core loss test on the stator prior to burning out the windings. If the core losses are excessive, this typically means that the stator lamination steel is substandard or the interlaminar insulation is damaged. If the core losses are high, a decision should be made whether or not to proceed. Once the burnout is completed, the core loss test should be repeated to make sure the interlaminar insulation is still sound. If not, the stator has to be un-stacked, re-insulated then re-stacked or a decision needs to be made to stop work. If core losses are high, the motor will run hot, have lower efficiency and may not be able to run at its rated HP.

Stator Burnout

Once it is decided to rewind the motor, the old windings need to be stripped from the stator. The most common method is to put the stator assembly into a controlled burnout oven. These ovens include a water mist system to quench any fires that start due to the varnish burning. It is important to keep the stator at a safe temperature which does not damage the insulation between the stator laminations. Typically the oven is controlled to a maximum temperature of 600^{O}F. Other methods include cold stripping which uses a hand held torch to apply heat to one slot at a time. As the varnish softens, the specific winding is pulled out. This is a more labour intensive method which, if done properly, does not put the stator at risk.

Magnet Wire Type and Size

Reputable motor manufacturers will provide service shops with proper rewind information which includes the number and size of wire in the coils. If the same performance is expected after a rewind as the original motor, manufacturers' specifications should be followed.

Phase and Slot Liner Insulation

Many EASA (Electrical Apparatus and Service Association) member shops use the latest and best materials available. It is prudent to ask a service shop what types of material are used for phase and slot liner insulation. Products such as Nomex and Nomex/Mylar/Nomex for phase and slot liner insulation have excellent thermal aging properties and therefore afford long life. Check with the service shop and ask what they use.

End Winding Bracing

In order prevent movement in the end turns during starting, it is important to make the end turns as close to a solid mass as possible. High speed photography of end turns during a start reveals that flexing can occur during every start. If this happens, the individual windings can rub and damage the turn to turn insulation resulting in a premature failure. Reputable manufacturers use shrink type lashing material which tightens when it is heated by the warm varnish and/or in the varnish curing oven. Rewind shops should use techniques that mimic the manufacturer.

Shaft Journal and Bearing Bracket Tolerances

Once a motor is torn down, rotor journal and bearing bracket tolerances should be checked against specs. The EASA Technical manual details minimum and maximum shaft diameters and minimum and maximum bearing housing bores for each bearing size. If the motor isn't to specs, it needs to be fixed.

Rotor Balance and Runout

After the motor is disassembled, the rotor should be checked for balance and shaft runout. It is suggested that balance values be established with the service shop. NEMA specifies minimum balance levels, however, reputable motor manufacturers will balance to a much tighter tolerances than the NEMA minimums. It would be prudent to specify the IEEE 841 specs for balancing if the highest level of balance is desired. The NEMA and IEEE 841 specifications are as follows:

Motor Speed (RPM)	**Unfiltered Vibration NEMA MG 1-7.08.1 (in/sec peak velocity)**	**Unfiltered Vibration IEEE Std 841-1994 (in/sec peak velocity)**
3600	0.15	0.08
1800	0.15	0.08
1200	0.15	0.08
900	0.12	0.06
720	0.09	Not spec'd
600	0.08	Not spec'd

All testing is with a half key located in the shaft extension.

The IEEE spec. is based on a fully assembled motor when tested at no load on an elastic mounting per section 12.08 of NEMA MG1-1993. In addition to the above, IEEE specifies that Motor filtered vibration at rated voltage and frequency shall not exceed 0.05 in/sec at frequencies of 2n (twice speed) or 2f (twice frequency). Also, motor unfiltered axial vibration shall not exceed 0.06 in/sec. peak on bearing housings. This limit shall not apply to roller bearings.

The IEEE 841 standard indicates that the maximum permissible shaft runout on NEMA T and TS shaft extensions, when measured at the end of the shaft extension on the assembled motor shall be:

a) for 0.1875” to 1.625” diameter shafts (inclusive), 0.001” indicator reading
b) for over 1.625” to 6.5” diameter shafts (inclusive), 0.0015” indicator reading

Rotor Integrity Testing

Once the rotor is pulled out, it should be inspected carefully for cracked end rings and end rings that have been separated from the laminations. The rotor should be checked for signs of overheating which, in the case of cast aluminum rotors can include particles of melted metal that have run or been slung from the rotor slots. The rotor should be inspected for signs of hot spots which appear as blackened spots on the painted rotor finish. These burn marks can indicate that arcing has occurred or there is a high resistance joint or break in the rotor cage. Sometimes localized heating occurs because of eddy currents flowing near the surface of the rotor due to shorting between laminations on the rotor surface.

If it is suspected that rotor bars may be damaged, they can be checked for integrity. There are several methods of doing this including a growler test, iron filing method, hacksaw blade method, magnetic imaging, hand held growler method, single phase ammeter test, vibration analysis equipment, stray flux pickup coil, motor current monitoring, etc. Some tests, such as using a growler with too much current applied, can partially damage the rotor (much like an extended locked rotor condition).

Core loss testers to test rotors are in common use by many service shops. This is a high current tester which applies current through the rotor shaft causing a strong magnetic field in the rotor. This test shows up hot spots in the rotor. Care must be taken with this test because if too much current is applied, the magnetic field can cause overheating in the aluminum rotor bars and damage them.

Testing After Rewind to NEMA Standards

NEMA defines routine tests that should be done on new motors after manufacture. These tests include:

- Measurement of winding resistance.
- No load current and speed at normal voltage and frequency.
- Current input at rated frequency with rotor at standstill for squirrel cage induction motors. This may be taken single phase or polyphase at rated or reduced voltage.
- High-potential test

In addition to the above, it is prudent to run the motor and check bearing vibration to make sure that the bearings aren't defective or weren't damaged during installation (which can happen quite easily with roller bearings).

Surge Test

Most quality service shops are now using surge testers. This tester applies brief surges or pulses to the coil to create a voltage gradient (or potential) across the length of the wire in the winding. This produces a momentary voltage stress between turns. The inductance of the coil sets up a ringing or tank circuit between itself and the internal capacitance of the surge tester. The inductance of the coil is proportional to the number of turns, (the more turns, the more inductance). The frequency of the tank circuit set up is based on the inductance of the winding and the known capacitance of the tester per the following formula:

$$\text{Frequency} = \frac{1}{2\pi\sqrt{LC}}$$

where:
L = Inductance of the winding
C = Capacitance of surge tester

If a turn is shorted to another turn or to ground, the inductance will change and a defective winding can be identified.

Electrical Integrity Testing

When a motor is sent in for a preventative maintenance overhaul, it is important that proper test voltage levels are used so as not to damage the insulation. High-potential tests for example, can be destructive and therefore should be used at reduced values on used motors as per NEMA MG1-12.03.

Dipping and Baking a Motor at a Service Shop

As a matter of course, many rewind shops give motors a “dip and bake” when they do any work on the motor. This is considered a good thing to do. A word of caution however, too much varnish buildup will cause reduced heat transfer from the end turns and result in hotter running insulation. This provides no improvement in electrical insulation value and unless the windings mechanically need bolstering, provides no benefit, but rather reduces the motor’s thermal margin. On high HP motors, which often have cooling slots in the stator core, dipping and baking can plug or partially block cooling slots which can severely hamper the motor’s ability to cool itself. Unless there is good reason to dip and bake a motor (over and above the original factory treatment), it is probably wise not to.

If the motor is to be dipped and baked, it is advisable to make sure that the service shop’s varnish is compatible with the factory’s varnish. Varnish serves a few purposes. The initial coat of varnish put on at the factory fills in any voids in the insulation and bonds the random wound magnet wire together plus helps lock the windings into the slots. Filling in the voids helps prevent corona inception from occurring (this typically can only happen when powered by fast rise time IGBT PWM drives). Subsequent varnish dips add mechanical strength to the end turns and improve the bonding between the windings and the slots. This bonding between the windings and the stator slots helps the transfer of heat away from the windings. If the varnish is not compatible with the factory varnish, it may weaken the winding assemblies mechanical strength.

Type of Grease Rewind Shops Use

Often, not much thought is put into the type of grease that a rewind shop uses. We have, for example, seen a rewind shop that uses one type of grease for roller bearings, and another type of grease for ball bearings. Neither of these greases were the same as the one the plant used. The original factory grease was different again. This meant that the plant had at least 4 types of grease in installed motors. Many mills use more than one rewind shop which means that there could be even more combinations of grease at a facility. As discussed elsewhere, it is important that there are no incompatibilities between greases used in a motor otherwise the effectiveness of the grease can be dramatically reduced. Ideally, only one type of grease is used everywhere in the plant. It is highly recommended that the type of grease to be used in refurbished motors be specified to the service shop.