VERSION 5.1

JANUARY 8, 2020

AC ELECTRIC MOTOR REFURBISHMENT SPECIFICATION

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AC Electric Motor Repair Specification

Fletcher Moorland promotes best practice and reliability throughout the business. We ensure each and every repair or refurbishment is to the highest industry specification superseding the technical requirements of ISO60034:23. By following this repair specification, we ensure motors repaired by us are as good as, if not better than new by enhancing material and process specifications found on standard industry offering AC motors. We back this up by covering all rewinds with a 3-year guarantee.

Controlled Document - Fletcher Moorland Ltd
V5.1 January 2020 (supersedes all previous documents)

1. Incoming Inspection

1.1. The motor is to be booked into FML BOS job tracking system. Record all customer data and information supplied and all motor details into the relevant tables.

1.2. Photographs of the motor and motor nameplate must be uploaded to BOS.

1.3. The motor must be visually inspected by a competent person for parts that maybe missing and/or damaged. Make notes and take photographs in the relevant area of BOS.

2. Initial Tests (pre-stripdown)

2.1. Remove the motor terminal box lid and carry out an IR (megger) test @ 500v and a winding resistance test with a DVM.

2.2. If the IR test is < 20MΩ & the winding resistance appear balanced and the motor shaft rotates freely by hand, lift the motor to the test bed for a pre-stripdown test run. If the motor cannot be test run in its incoming condition, strip the motor and go to section 3.1.

2.3. Test run the motor at nameplate voltage, frequency and speed, check the current drawn per phase.

2.4. Using the vibration conformance checker, carry out a vibration test in the vertical, horizontal, and axial planes on the DE, Vertical and horizontal planes (at least) on the NDE.

2.5. Analyse the results on the reporting software. Record the conformance check results for the final repair report comparison. If these results show as acceptable, check with the customer for the reasons the motor has been sent for service.

2.6. Record a SERVICEview video showing the motor running and the results of the vibration test on the screen.

3. Motor Inspection (Electrical Checks)

3.1. A full test of the winding condition shall be carried out with the motor stripped down. The SKF/Megger AWA-IV test unit is to be used to carry out the following tests –

Baker surge comparison testing to ensure winding integrity

3.1.1. Winding resistance comparison tests (There shall be no more than 3% difference between the winding resistance readings)

3.1.2. Insulation resistance (IR) test @ 500v (The IR test should be 20MΩ minimum to earth)

3.1.3. Baker Surge comparison @ 2 x Line voltage + 1000v

3.1.4. DC High Potential (Hi-Pot) test @ 2 x Line voltage + 1000v

3.1.5. Dielectric Absorption (DA) test to be carried out on motors below 150Kw (DA reading to be recorded for comparison)

3.1.6. Polarisation Index (PI) test to be carried out on motors above 150kw (PI reading to be above 2 (certain modern insulating material may not polarise; it the reading is below 2 see your supervisor))

3.1.7. Visual check of the winding condition including insulation condition, slot wedge & liner condition, lead condition, lacing and varnish condition.

3.1.8. All these tests need to be carried out in order to accurately judge the condition of the stator windings. Any failed windings should be compared against EASA Document 'failures in three phase windings' for root cause failure identification.

3.1.9. NB – Used or in-service windings are usually tested at x 0.7 the above ratings.

4. Motor Inspection (Mechanical Checks)

4.1. Bearings shall be removed from the rotor and examined for condition and/or failure mode. All failure modes shall be classified in accordance with ISO 15243: 2004.

4.2. The bearing housings and journals shall be measured to ensure correct size and fit to ISO 15243:2004 tolerance. Measurements are to be taken by personnel trained in the use of the Mitutoyo CMM. Most motor failures are bearing related, the majority of motor repair companies do not go to this level in ensuring correct bearing fits.

Measurement to 0.001mm achieved using a Mitutoyo CMM.

4.2.1. Journal measurements to be carried out using the Mitutoyo CMM,
4.2.2. Housing measurements to be carried out using the Mitutoyo CMM.
4.2.3. Measured dimensions are to be checked against nominal size and ISO fit. A print off for each measured part is to be added to the repair report.

4.3. Shaft extension run-out is to be checked and should not exceed 0.02mm for 1500 & 3000 rpm machines & 0.05mm for machines below 1500 rpm. Measure and check the condition of the keyway.

4.4. The rotor is to be checked for broken bars, cracked end rings and general condition.

4.5. All mechanical parts are to be thoroughly cleaned and inspected for defects, cracks or damage. Acceptable cleaning methods include steam pressure cleaning, shot blasting, solvent cleaning and immersion washing. Ensure all motor cooling fins are clean and free of debris.

4.6. All rotors are to be dual plane dynamically balanced to achieve grade G1.0 (ISO 1940-1) or at least Grade G2.5. All balancing is to be half-key where there is a keyway present. This is an enhancement, most motors when new are G6.3 balance grade. G1.0 is a better specification.

Rotor balancing to G1.0 for reduced machine vibration, quieter operation, increased efficiency and longer life

4.7. Acceptable repair methods for bearing mounts include sleeving and new shafts.

4.8. Unacceptable repair methods for bearing mounts include, knurling, peening, metal-spray, welding and Loctite. (Only metal-spray and Loctite may be used with customer concessions and in very exceptional circumstances)

4.9. Check for broken rotor bars and high resistance joints on the end-rings using the Lesesco tester, magnetic paper and thermal image camera.

4.10. Foot flatness will be checked on each foot on a Grade 1 surface table. Measure each corner of each foot with a feeler gauge and record the clearances found. Anything over 0.05mm will require the feet to be milled flat.

4.11. Check the condition of any eyebolts and lifting lugs.

4.12. Safety. For larger motors with gearboxes or other attachments DO NOT use motor eye bolt ONLY for lifting, ensure the weight is fully supported.

4.13. Once the motor has been fully assessed a SERVCEview video is to be created detailing the faults found with the motor and a description of the work we will carry out to refurbish it. The SERVICEview link is to accompany the quote on email to our customer.

5. Stator Rewinding

5.1. Rewinding an electric motor does not mean there is a decrease in efficiency. Critical steps need to be followed to ensure this though and these steps must be followed with every motor we rewind.

5.2. A core loss test is to be carried out on stators that are to be rewound. The test is to be carried out using the Lexseco core loss tester. The core loss tester gives a value of the core losses in watts loss per kg of stator iron. This test is to be carried out before the windings are stripped and the core loss value recorded.

Core loss reading < 13	Good
Core loss reading 13 – 22	Marginal
Core loss reading > 22	Unacceptable

Core loss testing to prove stator core condition and verify motor efficiency pre and & post rewind

5.3. Remove the stator connection end windings (Crown), determine the winding configuration and wire size. Document this in the repair worksheet and check against OEM data if available.

5.4. Strip the windings in a controlled pyrolysis (Burn off) oven with the temperature of the oven set to 370°C to prevent damage to the inter-laminar insulation layer.

Controlled burn-off at 370°C to ensure motor efficiency is not reduced

5.5. Remove the windings using mechanical pullers and clean out the stator slots ready for inspection.

5.6. Carry out a post-burnoff core loss test and compare this with the readings gained from the pre burn off test. Ensure no further losses have been introduced. Any stator with increased losses should be re-stacked or scrapped.

5.7. Carry out a hot-spot test on the winding core using a thermography camera. General rule is no spot should be greater than 15°C above ambient after 20 minutes under test. Any hot spot found should be repaired before rewind.

5.8. Rewind the stator to a full class 'H' insulation specification. Ensure full slot wedges and full phase separation is included and reduce the size of coil to reduce the LMT (length of mean turn) Class 'H' is a better specification than is standard for new motors and the majority of repair companies who offer Class 'F'.

5.9. Winding wire to be used is a minimum of grade 2 enamelled copper wire, suitable for inverter duty.

5.10. In most cases the stator will be copy wound (Any redesign must be cleared with your supervisor)

5.11. Acceptable varnish methods are Vacuum Pressure Impregnation (VPI), trickle impregnation or encapsulation. Cure the varnish in a temperature-controlled oven for VPI varnish.

5.12. Check the integrity of the rewound stator by performing tests 3.1.1 to 3.1.4. Document the results.

6. Motor Assembly

6.1. All motor internal surfaces are to be coated with an anti-tracking paint. The terminal box internals are to be painted with anti-tracking paint.

6.2. Only FAG and SKF bearings are to be fitted to a motor and the OEM fitting procedures should be followed at all times. Only use an approved bearing induction heater, temperature controlled and with a degaussing function. (Temperature cut-off set to 110°C)

Correct bearing fitting methods and procedures to ensure long motor life

6.3. Lubricate the bearings in accordance with the manufacture's guidelines. Use standard Fuchs Renolit MP3 grease or customers specified grease and record the grease weight used.

6.4. Replace all grease pipes (seamless pipes only) and ports, ensure a new grease cap is placed on each grease port. Where it is not practical to replace grease pipes they should be cleaned as required. Grease ports should be labelled with the type of grease used and the date they were filled.

7. **Motor Testing**

7.1. Motor testing is to be carried out on an isolated test bed. SKF/Megger test to be carried out before test run.

7.2. The motor is to be run at nameplate voltage, frequency and speed. Record the current drawn per phase and document.

Final motor test run following repair

7.3. The motor shall be vibration acceptance tested. Using the SKF Mx Microlog conformance checker, carry out a vibration test in the vertical, horizontal, and axial planes on the DE, Vertical and horizontal planes (at least) on the NDE. Record the vibration spectrum for each position measured. Our vibration acceptance specification is higher than is expected for a new motor.

SKF Mx Microlog used for motor vibration acceptance testing

7.3.1. Results are to be below limits for each of the following tests

Test	Range	Limits
Vibration band 1	0.3 – 0.8 x freq	0.72 mm/s (RMS)
Vibration band 2	0.8 – 1.2 x freq	1.35 mm/s (RMS)
Vibration band 3	1.2 – 3.5 x freq	0.72 mm/s (RMS)
Vibration band 4	3.5 – 8.5 x freq	0.54 mm/s (RMS)
Vibration band 5	8.5 – 40 x freq	0.54 mm/s (RMS)
Vibration band 6	40 – 80 x freq	0.54 mm/s (RMS)
Acceleration	5 – 2000 Hz	0.5 g (0-Pk)
ISO 10816-3	10 – 1000 Hz	2.4 mm/s (RMS)

7.4. Bearing temperatures to be measured and recorded once stabilised.

7.5. All motors with roller bearings at the DE are to be preloaded using a pre-load rig to ensure no damage is caused to the rolling elements by skidding.

8. Paint & Protection

8.1. The motor shall be painted, unless otherwise requested by the customer, with two coats of FML grey paint.

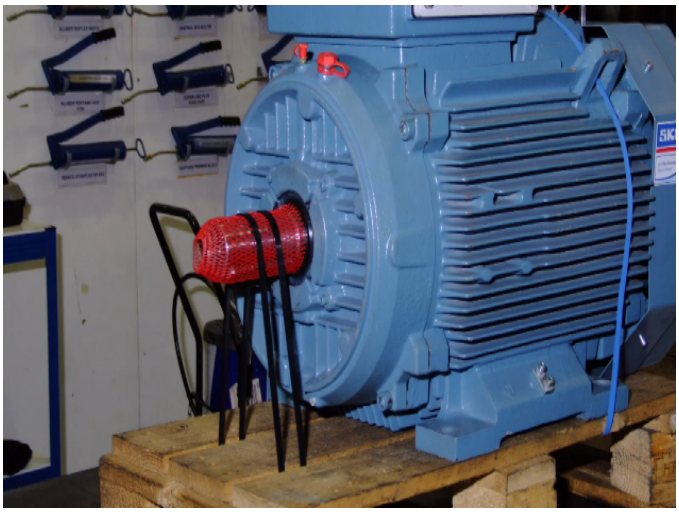
8.2. The shaft shall be protected by either a rust preventing coating or mechanical impact cover.

8.3. The rotor shall be secured for transportation to prevent against any false brinelling during transport.

8.4. Moisture control (silica gel) sachets are to be added to all terminal boxes to prevent moisture corrosion to connection surfaces.

8.5. Add FML stickers to the motor where process improvement or material improvements have been made. E.g. Class 'H' insulation, VPI, G1.0 balancing and 3-year warranty.

8.6. The motor will be shrink/stretch wrapped to protect against damp or dirt ingress.



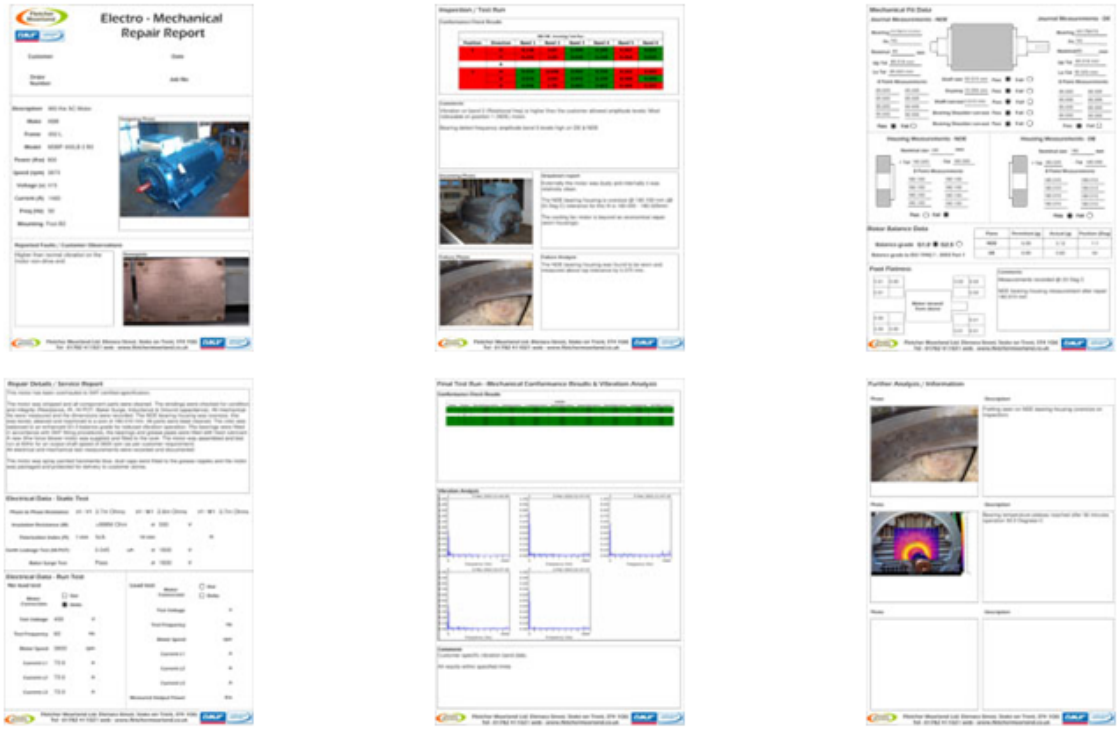
Shaft protected and secured for transport; Grease caps fitted to ensure lubrication protection

9. Repair Documentation

9.1. To complete the repair, a full-service document must be compiled detailing the following –
Incoming inspection and test results, Root cause failure analysis, Bearing condition analysis,
Mechanical fit measurements and tolerances, Winding test data, Final tests results & Vibration acceptance results.

9.2. A SERVICEview video is to be recorded showing the motor being tested. Give a summary of the repair carried out along with the data of the test run.

Repair report example



See the full example at www.fletchermoorland.co.uk