

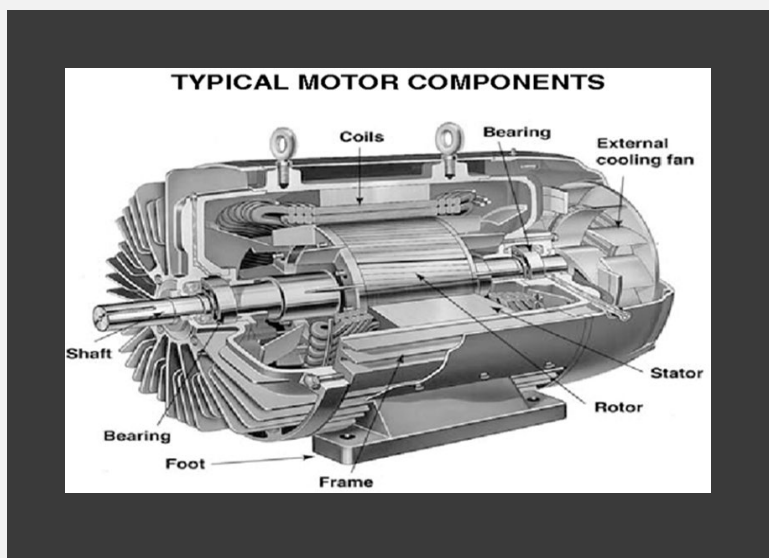
## Medium Voltage Motor Inspection and On-line Assessment

Compiled by John Sherriff | May 2020 | Rev 1

### The scope

To create a real competitive advantage, an organisation has to achieve optimum performance from its asset base, with simultaneous cost and risk reduction. Martec understands this uncompromising need and has developed a functionally rich portfolio of solutions for the organisation wanting to take up this challenge.

This TechTalk serves as an inspection and routine testing guide for AC motors in support of a predictive maintenance strategy. The objective is to identify the system components for inspection and testing purposes to complement good maintenance practices and enhance reliability. The benefits include fewer unplanned outages, more efficient equipment in support of production and an extension of the useful life of asset components.



### Visual inspections

The schedule should include at least the following items during visual inspection of a motor, wiring and its components before re-applying power:

- Check that the holding-down bolts are tight.
- Check all visible fixings and bolts, including those holding the cover to the baseplate, the cooler to the cover (if any).
- Inspect the terminal cubicle, bus bar for any insulation failure due to overheating.
- Check for any corrosion of metal parts inside the panels.
- Check for any dust accumulation or any foreign matter.
- Look for leakage of oil from the bearings along the shaft. Clean around the bearing area.
- Ensure all covers fitted.
- Check coupling for any defects.
- Check condition of brushes and brush compartment (if any).

### Background

An electrical motor is one of the most used components in any plant, and it is mostly the end-user that allocates resources for the maintenance of the motor. The contrary is, however, valid for condition assessments and reliability. Although condition monitoring has been studied at length and that complex monitoring systems are available, the resource availability still seems insignificant.

The main objective is to perform visual inspections and assessments to indicate the risk of failure for critical motors and its components. The statistics are indicative of the number of motor failures and related financial losses and also provide enough information to motivate finding solutions for motor condition indicators to prevent outages.

### References

- 1) IEC 60034: Rotating electrical machines – All parts
- 2) GE Energy – Maintenance schedule checklist
- 3) Eskom System Engineers Manual – Electrical Machines

### Insulation Resistance - Motor

Perform IR check between motor leads and ground. This determines condition of the ground insulation. Record, temperature correct and trend.

Motor Voltage	Test Voltage (VDC)	Acceptable reading (MΩ)
<1000	500	>5
1000 – 2500	1000	>100
2501 – 5000	2500	>100
>5000	5000	>100

### Insulation Resistance - Rotor

A 500V tester to be used, and the tester earth lead fixed to the rotor body. Make sure that all diodes are temporarily short circuited to avoid damaging them, and make sure that the short circuits are removed when testing is complete.

### Polarization Index (PI)

Ratio of the 10-minute IR to the 1-minute IR. (10 min IR / 1 min IR) Determines condition of ground insulation Test voltages similar to the IR test voltages Acceptance criteria ratio > 2. This indicates a wet or dry winding insulation system.

### High Voltage (HV) Test

Megger readings must be taken before High Potential Tests. The test voltage must be of approximately sine wave form and during the application of the test the peak value as prescribed in IEC 60034.

### Winding Resistance Test

A comparison of the line to line resistances of the motor's winding. This test should be done at the motor terminals using a meter capable of measuring low resistance (milliohms). A typical ohm meter does not have adequate accuracy. Record, temperature correct and trend. Each phase should be +/- 5% of the average of all three phases.

### Winding Resistance Test

The correct rotation of the machine must first be checked in accordance with the manual.

### Shaft Voltage Test

The volts are to be measured by shaft-voltage spectrum analyser and recorded.

### Bearing run

Motor vibration with respect to bearing housing should be checked. Temperatures must be recorded and stabilised, before the last vibration measurement is taken.

### Bearing Lubrication

Ensure that all excess oil is cleaned off pedestals, shafts and baseplate; this is to enable any leaks to be detected later, as well as to promote greater safety. Oil analysis may also be required.

### Bearing Insulation Test

Check for Cracks, Distortion, evidence of excessive heating, Oxidized or corrected conductor/stands, Loose connections. To Complete similar to other IR (megger) test. Used to verify condition of insulation on a bearing. Test voltage: 500 Vdc Acceptance criteria: 1 megohm

### Voltage Balance Test

A clamp-on ammeter to be used to take readings in each phase of a motor in actual operation under normal load. A Tachometer to be used to check the speed of a motor.

### Temperature Measurement

Winding and bearing temperatures must be recorded. Additionally, cooling systems temperatures must be recorded if applicable. Use of Infrared Thermography must be applied to identify cooling system deficiencies, and motor thermal profile.

### Winding Insulation Test

The minimum insulation resistance to ground is 1 megohm per kV of rating plus 1 megohm at 40 degrees Celsius ambient.

### Partial Discharge Test

The winding insulation is checked using partial discharge phase resolved data and discharge repetition rate as a minimum. This should be done off-line and on-line (no-load & load).







### Ultrasound Measurement

Ultrasound analysis must be used to identify electrical defects (sparking, arcing, tracking, etc) as well as mechanical defects on bearings.

### Vibration Measurement

Motor frame and housing vibration measurement are taken to identify many defects such as unbalance, misalignment, bearing defects, etc.

## Breakdown process caused by partial discharges within motor

Motor	Section	Failure mode	Failure cause	Failure effect	Failure end-result
	Bearing	High vibration High temperature Bearing Failure	Improper lubrication Incorrect type of lubrication Improper mounting Damaged parts/seals Shaft voltage Shaft misalignment	Overload Overheating Shaft Damage	Equipment Shutdown Equipment Damage
	Stator	Stator Defect	Eccentricity Short Laminations Loose Core Corrosion Contamination	High Temperature High Vibration Accelerated Wear Premature Ageing	Inefficiency Overheating
	Rotor	Rotor Defect	Eccentric Rotor Broken Rotor Bars Bowed Rotor Rotor winding shortened	Abnormal Heat Pattern Thermal Stress High Vibration Imbalance	Bearing Damage Rebuild
	Insulation and winding	Wind failure/short	Moisture Contamination Insulation Breakdown Voltage Surges High Vibration	Partial Discharge Accelerated Ageing	Motor Failure Rewind/Rebuild
	Coupling and shaft	Misalignment	Physical Damage Manufacturing Defect Improper Installation Wear/Bad Material	High Vibration Abnormal Heat Distribution	Coupling Failure Equipment Shutdown
	Fan	Fan Failure	Corrosion Physical Damage Foreign Material Build-up	Overheating High Noise Level	Motor Failure Winding and Insulation Damage

## Routine inspections and maintenance

Description	Description of action	Reason for action	Frequency
Bearings	Measure and record bearing vibration	Bearing failure/wear	Monthly
	Measure and record bearing temperature	Bearing failure/wear	Monthly
	Drain, clean and refill bearing housing	Normal wear	CBM
Motor Fixing	Check fixing bolts, couplings, guards for tightness	Normal wear, looseness	CBM
Stator Insulation	PD, PI and IR test on stator and record	Insulation deterioration	Yearly
Motor	Clean motor	Dust accumulation	Monthly
Heat Exchanger	Check heat exchanger pipework for obstruction	Maintain cooling	CBM/Yearly
Terminations	Inspect and clean terminal box and cable terminations	Dust and dirt accumulation, loose/hot connections	Yearly
Stator	Record stator currents	Loading verification	Monthly