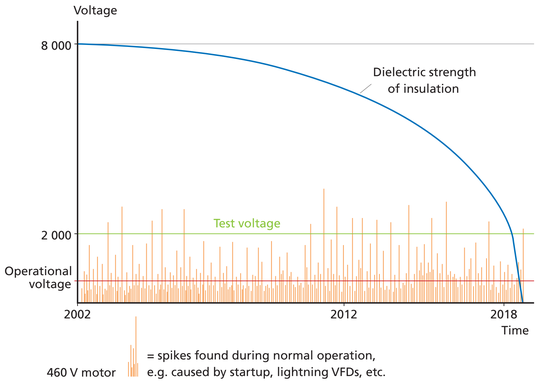
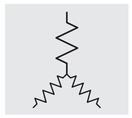
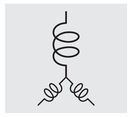
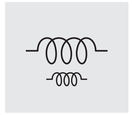
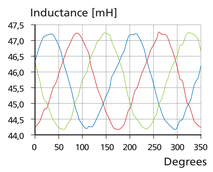
Static Electric Motor Testing Diagnostic Chart

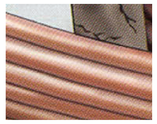


Megger
Baker Instruments

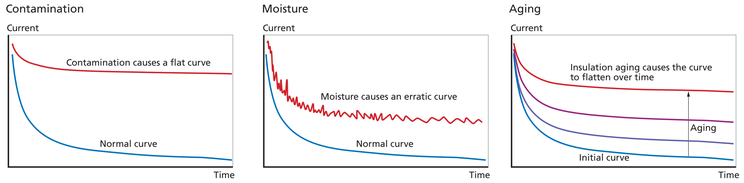
Low Voltage Testing

Indications	Probable Cause	Recommended Actions	Additional Information
Resistive Imbalance 	High resistance connections, ground insulation failure	Find the specific location of high resistance connection, repair and re-test. Ensure motor is not spinning.	Imbalance values should be <5% for lap wound motors. Low voltage concentric windings are likely to have a higher imbalance (<20%). Induced voltage and spinning rotors can also cause variation in measurement leading to high indicated imbalance. Line to line surge comparison variation will increase if an imbalance exists.
Inductive Imbalance 	Shorted turns or coils, ground insulation failure	Verify motor leads are properly connected. Verify ground repair insulation integrity. Repair, re-test.	Inductive imbalance is often caused by shorted turns or missed turns on a parallel connected circuit. If the short is to ground, a groundwall insulation test will fail at very low voltages. Inductive imbalance can occur even when the resistive unbalance is low.
High and Low Resistance 	Moisture or contamination at connections High resistance contacts Improper temperature correction Improper winding connection Improper reference value	Check all connection points for corrosion, contamination and proper torque. Verify temperature correction Verify comparison reference value Verify the same motor is being tested Perform groundwall insulation testing for low ground resistance	Typically faults associated with resistance will present as an imbalance in the circuit. Refer to the "Resistive Imbalance" section above for these indications. A reference value and winding correction temperature must be employed to validate high or low resistance values. If the motor was recently rebuilt, verify proper wire used. When comparing values to references/baselines, ensure that the reference applies to the motor under test. If the motor has been changed out variations in resistance will likely be present.
High and Low Inductance 	Improper winding, connection Improper reference value	Verify comparison reference value Verify the same motor is being tested Perform groundwall insulation testing for low ground resistance	Changes in inductance are caused by a change in the number of turns/loops/coils in the circuit under test. Hard shorts or internal connection issues can indicate both high and low value changes. Typically faults associated with inductance will present as an imbalance in the circuit. Refer to the "Inductive Imbalance" section above for these indications. When comparing values to references/baselines ensure that the reference applies to the motor under test. If the motor has been changed out variations will likely be present. Verify comparisons are made at the same test frequency.
Ground capacitance change 	Contamination / delamination, insulation failure, capacitor degradation if present	Perform groundwall insulation resistance test and PI/DA to aid in evaluting motors. All power factor correction capacitors should be removed from the circuit in order to properly evaluate the motor winding.	As motor contamination builds up the effective capacitance of the circuit will increase. Insulation degradation in the of the circuit will increase. Insulation degradation in the capacitance readings with no corresponding reduction in insulation resistance. Delamination of older asphaltic insulation systems (1970 or older) can exhibit an increase in insulation capacitance resulting in increased PI/DA ratios > 6.0.
Rotor influence testing Resistance, inductance, impedance, phase angle vs. rotor position 	Broken rotar bar, eccentricity, rotor porosity, low magnetic signature	If motor is in service perform dynamic testing to validate the static rotor test findings. Trend data for evidence of further degradation.	Rotor influence testing should be treated with caution. The data can vary based on motor design. The effect of rotor position on the circuit characteristics is evaluated for balance and symmetry. Resistance values are commonly temperature corrected to 25° or 40°C. Temperature correction is used to compare the measured value to a standard and should have no effect on the balance of the circuit.

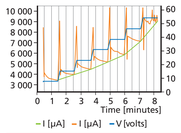
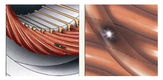
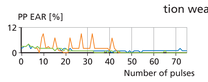
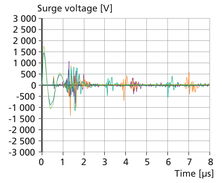
High Voltage Testing

Indications	Probable Cause	Recommended Actions	Additional Information
Low MegOhm reading 	Contamination, deterioration of groundwall insulation	Evaluate PI/DA for evidence of moisture and contamination. Clean and inspect motor or send out for overhaul if efforts prove ineffective.	Low insulation resistance readings are most commonly caused by contamination and/or moisture. PI evaluation will aid in determining the environmental factors present. Driving off moisture through heating may be effective in increasing low readings. In some cases heating the junction box may be sufficient to reduce leakage current paths. Minimum thresholds could be set to reflect the nature of the operating environment. It is common to set a minimum threshold of 100 MegOhm @40°C for most industrial motors. Motors with IR values < (1 MegOhm per 1000V of nameplate + 1Megohm) @40°C should not be started until the IR value has been improved. Test voltage for MegOhm insulation resistance testing is typically at or below the motor's nameplate rating.
MegOhm Failure (over current) 	Failed groundwall insulation	Isolate the location of the ground wall failure. Repair/Replace motor as required.	Insulation failure resulting in an overcurrent during a low voltage (at or below line voltage) insulation resistance test means the motor should not be started and will likely require rewind and repair.
Low PI 	Contamination, insulation deterioration	Clean / dry insulation system / overhaul	A clean dry insulation system should have a PI > 2.0. This means that the measured current has been reduced by half from the 1 minute to the 10 minute measurement. Contamination and moisture can significantly reduce this ratio due to parallel leakage paths. It is not uncommon for example to have PI readings of 1.5 in high humidity environments. For small motors (< 100 Hp), and motors with very little detectable polarization, like VFD insulation systems, a Dielectric Absorption test (DA) may be more representative of the insulation's ability to polarize. A DA is performed for only 3 minutes. The final reading is compared to the 30 second reading.
High PI 	Delamination of asphaltic insulation	If motor winding is older than 1970, rewing; otherwise, no action is required.	Motors with modern insulation system can have very high PI values. This is not an indication of a problem with the system. Older asphaltic insulation systems from before 1970 could delaminate causing increased air spaces in the insulation build. This increased the capacitance of the circuit and therefore increased the PI values > 6.0.

PI Graph Shapes



High Voltage Testing

Indications	Probable Cause	Recommended Actions	Additional Information
Low MegOhm on Hipot 	Groundwall contamination, insulation deterioration	Evaluate PI/DA for evidence of moisture and contamination. Clean and inspect motor or send out for overhaul if efforts prove ineffective.	When performing insulation testing at higher voltages it is possible that surface leakage paths will increase causing lower insulation resistance values during high potential testing. Contamination effects of this kind typically show up as a single linear step change in current and not a continual exponential increase.
Non linear Hipot indication 	Groundwall insulation breakdown voltage reduced	Test motor more frequently	As voltage is increased during a DC test the current will increase proportionally until the insulation resistance begins to decrease. As the voltage approaches the insulation breakdown voltage the resistance will begin to decrease and the current will begin to increase in a greater than linear fashion. This departure from linearity or "knee in the curve" indicates that the breakdown voltage is being approached. If this "knee" is present at or below test voltage the insulation is in the later stages of its life and has reduced reliability. Step voltage testing should include at least five (5) voltage steps to ensure a linear change can be definitively observed.
High Potential Test Overcurrent Trip 	Insulation breakdown at indicated voltage	Isolate source of ground. Repair/replace motor as required.	Motors with breakdown voltages at or near bus voltage should be replaced immediately. If the insulation breakdown voltage is well above nominal bus voltage the motor may start. It should be noted that attempting to start a motor with a weak insulation system could result in additional damage to the stator if the motor were to fail on start.
High Line to Line Surge Comparison Ratio 	Rotor influence; copper to copper insulation failure	Verify motor leads are connected properly. If not rotor influence repair/replace motor.	Line to line comparison: L - L EAR% (Error Area Ratio) is used to evaluate each phase circuit's response to the surge impulse while the motor is disassembled and the rotor is removed from the stator. This is due to the secondary rotor impedance influencing the stator circuit. A balanced winding will have identical surge ringing patterns that should overlay on top of each other. Because the rotor has to be removed for this test, line to line comparison is rarely used as a field test.
Unstable Pulse to Pulse 	Weak insulation between coil turns, ground insulation weakness	Test motor more frequently	Pulse to pulse comparison (PP EAR%) is used to evaluate the winding insulation when the motor is fully assembled. Variation in PP EAR indicates an instability which is usually caused by weak turn-to-turn insulation. Up to 80% of winding failures begin as turn to turn weakness, progressing to phase to phase or groundwall failure. PP EAR values should be <5% and the curves should have no spikes.
High Partial Discharge 	Voids in the insulation	Continue to monitor PD activity. Test the motor more frequently. Repair or replace as necessary.	Partial discharge inception voltage (PDIV) is the voltage at which partial discharge events begin to occur within the insulation due to voids or surface effects. While performing surge testing, the gases in the voids are energized and will discharge internally within the insulation adding high frequency signals on the surge waveform. As the insulation degrades and internal defects such as cracks form, PDIV will begin to decrease. As PDIV and RPDIV begin to approach bus voltage, the number of discharges increases significantly, degradation accelerates, and then the PDIV and RPDIV will increase, signalling imminent breakdown; action should be taken to repair or replace the motor.

Electric motor testing chart - static - Megger.pdf
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