TECH TIPS

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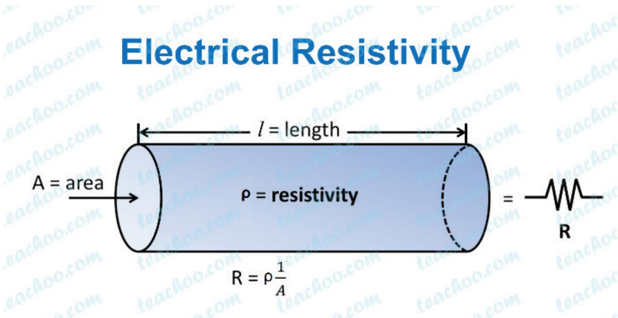
Winding Resistance

Resistance is a fundamental property of a materials ability to resist the flow of electricity through it. The units of resistance are ohms and uses the Greek symbol omega (Ω) and the mathematical symbol is (R). All materials have some amount of resistance, most metals have low resistance and are known as conductors. The Specific Resistance of a material is resistivity and is represented by (ρ). The resistance of a material is dependent on the type of material, the length and shape of the material. The resistance of an object or material determines how much work or heat is created as current flows through the material. For example, a material with a high resistance will consume a large amount of energy as current flows through the material. The current that produces work and creates heat is known as resistive current (Ir).

The resistance measurement is named after Georg Simon Ohm a 19th century, German physicist who studied the relationship between voltage, current, and resistance. He is credited for formulating Ohms' Law which is the resistance of a circuit (R) is equal to voltage (E) applied to the circuit divided by the current flow (I) through a circuit. R = E/I



Materials in electrical circuits are classified as either conductors or insulators.

Conductors are materials that have loosely bonded electrons in the outer most shell of the atoms making up the conductive material and offer very little resistance to current flow. Electrons flow easily through conductive material. Examples of conductors are copper, steel, iron, bronze, and many other metals.

Insulators are materials that have very tightly bonded electrons in the outer most shell of the atoms that make up the insulating material and resist the free flow of current through the material. Insulators present a high resistance and restricts the flow of electrons. Examples include rubber, glass, wood, and many plastics.

The fundamental of electricity is that current takes the path of least resistance, therefore insulators are used to direct the of current flow through the intended path and prevent the flow of current through unwanted paths.

In motors conductors are formed into coils or windings to create the magnetic field required to convert electrical energy into mechanical torque. To maximize the strength of the magnetic field current needs to flow through each turn of the winding. Therefore, the conductors that are used build the windings are coated with multiple layers of insulation to direct the current through the winding. This insulation is referred to as winding or turn insulation.

When the insulation between conductors begins to break down, current will still not flow between conductors until the resistance of the insulation falls below the resistance of the conducting material around the conductor. Therefore, the resistance measurement of the individual windings will remain unchanged until the insulation is has completely failed.

Resistance is directly proportional to the overall length of the conductor, the size of the conductor (in circular mills), and the temperature of the conductor. For example, it is much easier for water to flow through a wide, short pipe then it is for water to flow through a more narrow, longer pipe. Current through an electrical conductor reacts the same way. Current will flow much easier through a large, short piece of wire then it will through a more narrow and longer piece of wire, because there is less resistance of flowing electrons in the larger conductor than the smaller conductor.

Therefore, when measuring the winding resistance in a deenergized three phase motor electric motor, any resistance unbalance is usually the result of connection issues. The resistance of all three phases should be balanced in relationship to each other. Any unbalance of 5% is a warning and indicates there are issues in the motor circuit.

When testing from the MCC a resistance unbalance could be anywhere from the connection in the MCC (Motor Control Cabinet), the cabling or the motor itself. Additional testing needs to be performed progressively closer to the motor to locate connections that are causing the unbalanced resistance. If resistance measurements at the motor are balanced this verifies the issue is somewhere between the MCC and the motor cables. If resistance values directly at the motor are unbalanced this confirms there is an issue inside the motor. Examples of things that can cause unbalanced resistances are loose connections, cold solder joints either in the motor or at the MCC, frayed or broken wire, dirty terminals or oxidation of the connections anywhere in the motor circuit.