MEASUREMENT OF CONTACT RESISTANCE IN ELECTRIC EQUIPMENT

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The measurement of resistance of electric circuits is important as resistance causes a power loss. This loss in not useful and the energy typically causes hot spots and is spent harming the conductor or harming the insulation. As this loss is proportional to the square of the current, it increases quickly as the load increases and typically limits the amount of current a circuit can safely carry. The limitations may be due to an excessive temperature rise of the conductor or excessive temperature of the insulation. In either case, once certain limits are exceeded an irreversible degradation of conductor or insulation characteristics may be taking place. The degradation of conductor characteristic is typically not as severe as the degradation of contacts or joints of said conductor. While the characteristics of a conductor will not typically degenerate rapidly unless excessive temperatures are reached repeatedly, insulation, contacts or joints may deteriorate under normal conditions once these are damaged by a single excessive temperature exertion.

The measurement of resistance, be it solid conductor, joint or contact, is conducted by passing a current through the specimen and measuring the voltage drop across the specimen. The amount of current used is determined by the resistance to be measured and the current carrying capacity of the test specimen. As accurate measurements of resistance can be made using a voltage drop of 1 -10 millivolts, a current in the orders of 1 ampere is required to measure resistances in the range of 1-10 milliohms. Thus instruments typically called >milliohm meters< will offer a maximum test current in the order of 1 -2 amperes and provide ranges down to 1-10 milliohms full scale, with microhm resolution. Measurements of samples having lower resistance will typically dictate higher test currents so that the voltage drop can be increased to a value that can be measured accurately.

The accuracy of low resistance measurements depends on several factors.

These are :

- The resistance to be measured,
- The current that can be used,
- The composition of the test sample,
- The composition of the measuring circuit.

The lower the resistance value, the more difficult it is to measure.

This is because the measurement of a lower resistance requires a higher current to generate a measurable voltage drop, but the power in the circuit increases as the square of the current. This causes the size, capacity and price of the measuring equipment to rise rapidly with increase in current. If one imposes a current limitation on the sample, one that would dictate a lower current and therefore lower voltage drop, the voltage drop and therefore the resistance would not be measured as accurately as possible.

As the measurement of resistance involves the measurement of small DC voltages, one can introduce errors in measurement by introducing DC voltages other than those proportional to the current in the test circuit. Such voltages can be introduced by differences in temperature of contacts of dissimilar metals (thermal emf's)

As the test specimen may use copper, brass, bronze steel and other metals, and temperature differences can be easily present, one must assure oneself that such temperature differences are small, or that the metals used in the test samples are similar in nature and do not generate such thermal voltages.

The importance of thermal emf's is equally as important in the measuring circuit as they are in the test sample. The connections within the measuring instrument should use only copper. The circuitry connecting the instrument to the specimen should use only copper terminals, copper connectors, copper leads and pure copper clips. No copper plates clips. Only in this manner can the thermal emf's be maintained at a very low value and the measurement at high accuracy.

There are several techniques that can be used to cancel the effects of thermal emf's on a measurement. These typically employ the reversal of test current or similar. This technology is typically difficult and expensive to employ in high current test equipment suitable for micro-ohm test samples.

As the errors in resistance measurement primarily involve the thermal emf's, such errors will therefore occur more frequently on equipment that is hot, such as equipment recently removed from service, or equipment that has been allowed to sit exposed to the sun.

Given below is an error table listing test specimen values and test currents. The table assumes a thermal emf of 40 microvolts which is the emf for a copper –steel connection with one degree Celsius temperature difference.

Error in % of reading				
TEST CURRENT (A)		1	10	100
Rx	1m	0.4	0.04	0.004
	100u	4.0	0.4	0.04
	10u	40.0	4.0	0.4
	1.0u	400.0	40.0	4.0

The above table indicate that a current in the order of 100 amperes is needed if a resistance in the order of 10 micro ohms is to be measured accurately.