PROMET High-Precision Ohm Meters

Quality of electrical connections – Guide to low resistance measurements

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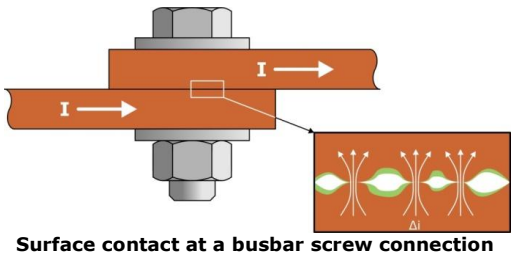
Right through from generators to consumers, electrical energy transmission and distribution systems feature a multitude of electrical connections, especially in substations and switching stations. The reliability and the state of these electrical connections have a decisive influence on the availability, safety and economic efficiency of electrical supply networks.

When high currents are transmitted, the aim is for transfer resistance at connection points to be kept as low as possible. The transfer resistance is affected by a number of quantities und increases with age during operation. A high transfer resistance results in an increase in heat losses, affects longevity and can also lead to a connection being interrupted.
By carrying out on-site tests, a faulty connection can be identified and eliminated.

Substation

Even if the connection between two contact surfaces appears to be ideal, the surfaces of contact of two contact pieces are never identical with the size and the surface area for the passage of current. When examined under a microscope, the contact surfaces are uneven and are covered by an isolating impurity layer. During connection, the micro-surfaces which constitute the true contact surfaces are pressed together by the contact force, the current passes through these surfaces. The reduction in the cross-sectional area results in a higher resistance. Because of the higher resistance, more power is dissipated at the contact point and this leads to a rise in temperature. The higher temperature leads to an increase in the specific resistance at the contact point.

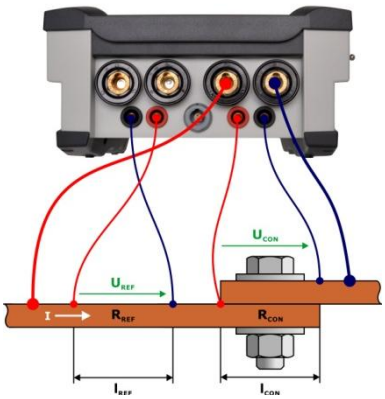
The power dissipation at the contact point is dependent on the current and the resistance: $\mathbf{P = I^2 \cdot R}$



Surface contact at a busbar screw connection
showing the true surfaces of contact (green: oxide layer/impurity layer)

As electrical connections age, the resistance of the contact point increases with time. The reasons for this include the reduction in the contact force of the connection, the formation of impurity layers, fretting corrosion and the resulting further temperature rise.
The contact force of the contact point drops as a result of a slackening in the tightness of the screw connection and this leads to the surface area for the passage of current becoming smaller.
The rise in temperature and external influences accelerate the formation of impurity layers, leading to the growth of oxide layers.
With fretting corrosion, which is caused by mechanical displacement or expansion, contacts become misaligned and existing micro-contacts are destroyed.
These factors impact on the ageing process and, if the worst comes to the worst, can lead to an interruption of the connection.

The quantity used to assess an electrical connection is the resistance. The resistance of an electrical connection is in the order of micro-ohms. These low resistance values require specialist measurement technology, such as four-wire resistance measurement (Kelvin method).
PROMET SE ohm meters can determine the quality of a connection so that it can be assessed.
Because there are two voltage measurement inputs, the quality of connections such as screw connections on busbars can be determined quickly and easily using the quality factor. The quality factor is defined by the ratio of the resistance of the connection over the overlap length to the resistance of the busbar over the same length.



PROMET SE: Setup for quality factor measurement

The quality factor **K** results from the ratio of the resistance of the connection $\mathbf{R_{CON}}$ over the overlap length $\mathbf{l_{CON}}$ to the resistance of the busbar $\mathbf{R_{REF}}$ over the same length $\mathbf{l_{REF}}$.

$$K = \frac{R_{CON}}{R_{REF}}$$

$\mathbf{R_{CON}}$: Resistance of the connection
$\mathbf{R_{REF}}$: Resistance of the busbar

When considering electricity distribution, it is important to bear in mind that losses occur as a result of poor connections and that generators of electricity have to provide additional power in order to compensate for these losses.
When making an electrical connection, care should therefore be taken to minimise the consequences of ageing and to create a low-maintenance and reliable connection.
By determining the resistance or the quality of a connection during installation and maintenance, it is possible to verify that a connection has been made correctly and thus achieve a reduction in electrical losses, an increase in longevity and an improvement in system safety.

Set up and measurement with PROMET SE