VOLTIMUM AVANZA
Earth Resistance Measurement
Medicação de Resistência de Terras
30th June 2020
Founded in Paris, France in 1893, CHAUVIN ARNOUX has spent the centuries since then developing its expertise in the design, manufacture and marketing of measuring instruments for professionals. From handheld instrumentation to fixed electrical equipment and energy performance systems, and from control of the entire thermal process chain to industrial metrology, the CHAUVIN ARNOUX Group’s offering meets every customer requirement across all the sectors (self-employed electricians, industry, government bodies, etc.).

Earth/ground* resistance measurement

One of the basic prerequisites for guaranteeing safety on any residential or industrial electrical is to provide an earth electrode.

If there is no earth/ground electrode, people’s lives may be endangered and electrical installations and other property may be damaged. An earth/ground electrode alone, however, is not enough to guarantee total safety. Only regular inspections can prove that the electrical installation is operating correctly. There are many earth resistance measurement methods available, depending on the type of neutral system, the type of installation (residential, industrial, urban environment, rural environment, etc), the possibility of cutting off the power supply, etc.
What should the value of the earth resistance be?

Before starting any earth resistance measurements, the first thing you need to find out is the acceptable maximum value for correct earthing.

The earth resistance requirements vary according to the country, the neutral systems used and the type of installation. For example, a power distributor such as EDF will require an extremely low earth resistance, often of only a few ohms. So it is important to check beforehand on the standards applicable to the installation to be tested.

### Maximum resistance of earth electrode according to RCD rated current

<table>
<thead>
<tr>
<th>Maximum rated current of RCD (IΔn)</th>
<th>Maximum resistance of earth electrode for chassis earths (Ohms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low sensitivity</td>
<td></td>
</tr>
<tr>
<td>20 A</td>
<td>2.5</td>
</tr>
<tr>
<td>10 A</td>
<td>5</td>
</tr>
<tr>
<td>5 A</td>
<td>10</td>
</tr>
<tr>
<td>3 A</td>
<td>17</td>
</tr>
<tr>
<td>Medium sensitivity</td>
<td></td>
</tr>
<tr>
<td>1 A</td>
<td>50</td>
</tr>
<tr>
<td>500 mA</td>
<td>100</td>
</tr>
<tr>
<td>300 mA</td>
<td>167</td>
</tr>
<tr>
<td>100 mA</td>
<td>500</td>
</tr>
<tr>
<td>High sensitivity</td>
<td></td>
</tr>
<tr>
<td>&lt; 30 mA</td>
<td>&gt; 500</td>
</tr>
</tbody>
</table>
It is important to point out that the earth resistance measurement of reference is the 2-stake method. This method is referenced in all the electrical installation testing standards and can be used to measure the earth resistance both accurately and safely.

\[
R_E = \frac{U_{ES}}{I_{EH}}
\]
3-pole measurement method (62% method)

Example: Measurements at different distances R1 to R9 from 10 to 90% of the distance SH

Test Results

<table>
<thead>
<tr>
<th>Percentage</th>
<th>R1</th>
<th>R2</th>
<th>R3</th>
<th>R4</th>
<th>R5</th>
<th>R6</th>
<th>R7</th>
<th>R8</th>
<th>R9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance</td>
<td>0</td>
<td>10</td>
<td>20</td>
<td>30</td>
<td>40</td>
<td>50</td>
<td>60</td>
<td>70</td>
<td>80</td>
</tr>
<tr>
<td>Ohm value</td>
<td>0</td>
<td>11.4</td>
<td>28.2</td>
<td>33.1</td>
<td>35.3</td>
<td>35.6</td>
<td>37.8</td>
<td>57.4</td>
<td>101.7</td>
</tr>
</tbody>
</table>

Potential in relation to S

 Disconnect the earth bar before measuring
4-pole earth resistance measurement method

The 4-pole earth resistance measurement method is based on the same principle as 3-pole measurement, but with an additional connection between the earth to be measured E and the measurement instrument. This method offers better resolution (10 times better than the 3-pole method) and means that the resistance of the measurement leads no longer needs to be taken into account.

This function is ideal for measuring very low earth resistance values, so it is particularly prized by power transmission and distribution companies who need to measure earth resistance values of just a few Ohms.

The variant 62 % method (one stake)

(only on TT or imp:edant IT systems)

This method does not require disconnection of the earth bar and only one auxiliary stake (S) is necessary. With this method, the earthing system of the distribution transformer acts as the H stake and the PE conductor accessible on the protective conductor (or earth bar) acts as the E stake.
Phase-PE loop measurement

(only on TT systems)

In urban environments, it is often difficult to measure earth resistances with methods using stakes because it is impossible to set up the stakes for reasons of space, concreted areas, etc. For this reason, the standards for electrical installation testing allow measurements by the loop impedance method if it proves impossible to use stakes.

Cf IEC 60364-6: “NOTE: if it is not possible to measure RA, this measurement can be replaced by a fault loop measurement.”

The real earth resistance value is therefore lower:

\[ R_{\text{measured}} > R_{\text{earth}} \]

Note: On TN or IT (impedant) systems, loop impedance measurement can be used to calculate the short-circuit current for correct sizing of the protective devices.
Some electrical installations have multiple earthing systems in parallel, particularly in countries where the earth is "distributed" to each user by the power supplier. In addition, on sites equipped with sensitive electronic equipment, a grid of earth conductors connected to multiple earth electrodes is used to obtain a totally equipotential floorplan. For this type of network, selective earth resistance measurements help to optimize safety and speed up testing.

- Selective 4-pole earth resistance measurement

- Earth loop measurement with 2 clamps and measurement with an earth clamp

Measuring without disconnecting the earth bar and without earth stakes

These measurement methods have revolutionized "traditional" earth resistance measurements: like selective 4-pole measurement, these 2 methods do not require disconnection of the parallel earthing systems and they also save time because it is no longer necessary to search for the most suitable places to position the auxiliary stakes, a task which may take a long time on resistive soils.
Earth resistance measurement at high frequencies

Earth resistance measurement on pylons linked by an overhead earth cable

Equivalent diagram of a high-voltage line:

- Overhead earth cable
- Current injection stake
- Current injection point
- Pylon measured
- Z_equivalent
- R_pylon
- Z_equivalent

Diagram showing:
- Overhead earth cable
- Current injection stake
- High-voltage lines
- Reference potential connection
- 4 Ampflex channels connected
- R_S
Gama Controladores de tierra
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- 1 hoja de seguridad
- 1 informe de prueba
- 1 documentación sobre la batería

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