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GROUNDING ANALYSIS USING THE POTENTIAL DROP METHOD FOR TECHNICAL REPORTS

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Abstract: The analysis of electrical grounding and the preparation of technical reports are fundamental procedures in Electrical Engineering, aimed at guaranteeing the safety and efficiency of electrical installations. This article presents a literature review on this subject, focusing on the Fall of Potential method, addressing theoretical and practical aspects, and the use of the Megabras MTD-20KWe earth meter. The research was carried out by consulting a variety of sources, including scientific articles, professional videos, books, national and international technical standards, with emphasis on ABNT NBR 15749/2009 - Measurement of Grounding Resistance and Potentials on the Ground Surface in Grounding Systems. It was therefore concluded that this is an effective method, but that it must be based on careful visual analysis and has limitations to be observed, such as in the case of densely populated areas and extensive grounding systems, requiring other methods for these analyses that are able to overcome the adversities found in these environments.
Keywords: Earthing measurement, earthing reports, measurement methods.

INTRODUCTION

The aim of this work is to understand how to carry out an assessment of an existing earth, the standards, methods and equipment involved in the analysis and a detailed description of how to apply the potential drop method.

Electrical grounding is a vitally important system for electrical and electronic power systems to function properly. It is responsible for providing a path for the dissipation of unwanted currents, guaranteeing the protection of equipment and people. In order to guarantee the correct operation and optimum performance of the protection system and, perhaps even more importantly, to guarantee the limits of personal safety levels, it is necessary to pay special attention to this topic.

This subject has several standards to back up its importance, including ABNT NBR 5410 - Low Voltage Electrical Installations, ABNT NBR 7117-1 - Soil Parameters for Electrical Grounding Projects Part 1: Resistivity Measurement and Geoelectric Modeling and ABNT NBR 15749 - Measurement of Grounding Resistance and Potentials on the Soil Surface in Grounding Systems.

Therefore, the objectives of grounding can be listed as: to obtain the lowest possible grounding resistance for earth fault currents; to keep the potentials produced by fault currents within safety limits, so as not to cause permanent damage to the health of those in the protected area; to make protective equipment more easily sensitized and quickly isolate earth faults; to provide a path for lightning discharges to flow; to use the earth as a current return in the Single-wire Earth Return (MRT) system; to drain static charges generated in equipment housings.

MATERIAL AND METHODS

The research carried out in this article consisted of a literature review, which allowed for a qualitative and descriptive approach on the subject of Grounding Analysis using the Potential Drop Method and the preparation of reports.

To carry out this review, various sources of information were consulted, including books, scientific articles, dissertations and theses, selected by searching relevant electronic databases. The databases used were IEEE Xplore, Scopus, Web of Science, terrometer manufacturers' manuals and ABNT standards. The search period covered the last 8 years. The key words used in the search were: grounding measurement, grounding reports, measurement methods.

RESULTS AND DISCUSSION

In order to carry out earthing reports, it is necessary to use suitable equipment such as terrometers and resistivity meters in accordance with NBR 15749 (Brazilian Association of Technical Standards, 2009).

In practical terms, resistivity meters are still considered expensive instruments and are neglected by the professional market as a whole, being used more by companies specializing in reports and consultancies, which deal on a daily basis with situations involving more complex analyses.

Measuring the grounding mesh as earth meters basically consists of injecting a current and a potential into the ground and measuring the dispersion in the installed mesh, thus verifying its resistance and making it possible to analyze how effective the ground drainage is, in accordance with NBR 15749 (Associação Brasileira de Normas Técnicas, 2009).

For the measurement with a terrometer, the Megabras MDT - 20KWe Terrometer is used as a reference, which is widely used both for measuring earth resistance and for carrying out vertical electrical surveys, formerly known as soil stratification, in accordance with NBR 7117-1 (Brazilian Association of Technical Standards, 2020) and complies with the requirements of IEC 61557-5:2019 - *Electrical safety in low voltage distribution systems up to 1000 V AC and 1500 V DC - Equipment for testing, measuring or monitoring of protective measures - Part 5: Resistance to Earth.*

To start measuring the resistance of the ground loop, use terminals H (EC) - red, current injection electrode, S (ET) - blue, voltage electrode, or probe, and E (EXC) - green, current return electrode, as shown in Figure 1.

The nomenclatures E - ES - S - H are those recommended by IEC 61557-5:2019 and Exc - Ext - Et - Ec are those standardized by the manufacturer.

To begin the procedure, we will use earth socket resistance measurements (MODENA, 2024). Therefore, 3 rods will be used and the equipment will be in the R (3 pole) configuration. In this function, terminals E and ES are internally short-circuited, and terminal ES is not used for this type of measurement.

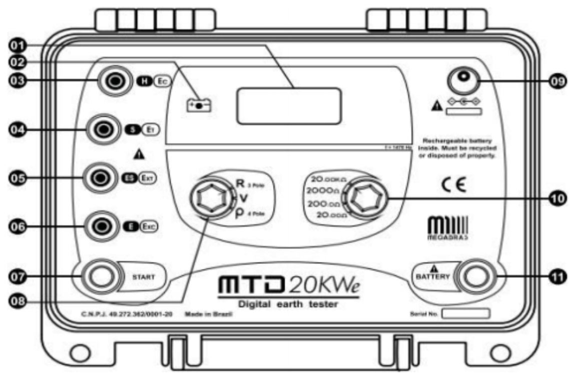

Figure 1 - Megabras MTD 20KWe terrometer.

Source: Megabras (2008).

First of all, the E - (ESC) terminal of the earth meter must be connected to the ground to be measured (E1), in most cases to the existing ground rod, using a 5m cable. At this stage, care must be taken to disconnect any earth connected to the grounding grid. Figure 2 shows the connection at point E1.

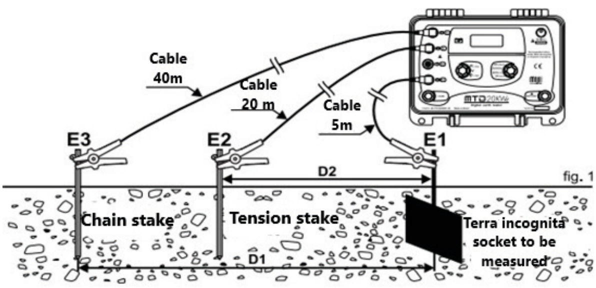

Figure 2 - Grounding resistance measurement.

Source: Megabras (2008).

Subsequently, two auxiliary stakes, E3 and E2, should be driven into the ground, one being the auxiliary current electrode, E3, and the other the auxiliary voltage electrode, E2. The stake corresponding to the current auxiliary electrode must be connected to the H -

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(EC) terminal of the terrometer and at a distance D1 of at least three times the length of the rod. The stake corresponding to the auxiliary voltage electrode, E2, must be connected to the S - (ET) terminal of the terrometer and at a distance D2 of 62% of the distance D1, according to NBR 15749 (Associação Brasileira de Normas Técnicas, 2009).

After this configuration, press the Start key, number 07 in Figure 1, and identify the measured value on the display, number 01 in Figure 1. It should be noted that the equipment's measurement limit is 20 kΩ, which reinforces the need for careful pre-analysis before going into the field to measure the system, in order to avoid rework or unnecessary expense.

In this application, the current generated by the terrometer circulates through the earth socket E1 and the current electrode E3. As a result, the device measures the voltage between the grounding point and the voltage electrode, E2. The value of the grounding resistance, called R, is then obtained indirectly, through the quotient of voltage and current.

There are two zones of influence that affect the results (Duque, 2015). If the voltage stake is very close to the grounding point, this point has a destructive influence on the signal obtained, as shown in Figure 3. If the voltage stake is very close to the current stake, there is a constructive influence on the signal. Both scenarios result in masked grounding resistance data. This is why it is recommended to move E2 62% away from E1 (Mendes, 2024).

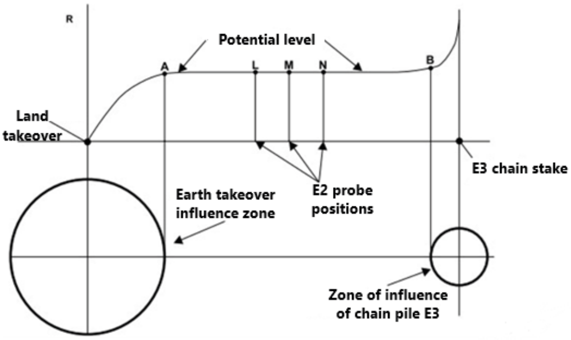

Figure 3: Signal in relation to zones of influence.

Source: Megabras (2008).

In order to guarantee an exact reference for the grounding resistance, at least two other measurements are required for the electrode or voltage stake. To do this, a linear direction is drawn between the earth socket and the current stake, in which the tension stake was previously driven at 62% of E1. For the next two measurements, the E2 stake should be varied by 5% of the distance D1, E1 to E3, to the right and then to the left of this initial point, which will be called $S_{(initial)}$, in accordance with ABNT NBR 15749 (Associação Brasileira de Normas Técnicas, 2009, p.12).

This is necessary to ensure that the measurement is taking place in the Potential Level Zone, which is the zone that will guarantee the grounding resistance, i.e. that it is not being influenced by the current electrodes and the connection point.

With the first measurement being $S_{(initial)}$, the second being S_1 and the third being S_3 , the measurement will be coherent if, and only if, the values found comply with eq. (1), according to NBR 15749 (Brazilian Association of Technical Standards, 2009).

$$\frac{R_{S1} - R_{S2}}{R_{S(inicial)}} \leq 10\% \tag{1}$$

If this equation is not respected, i.e. the values found differ from the expected result in eq. (1), the measuring stakes should be repositioned, as the values do not coincide with reality. If the values found meet the requirements of eq. (1), the grounding resistance value will be given by the arithmetic mean of the three values, according to eq. (2), in accordance with NBR 15749 (Associação Brasileira de Normas Técnicas, 2009).

$$R_{aterramento} = \frac{R_{S(inicial)} + R_{S1} + R_{S2}}{3} \qquad (2)$$

The method of measuring soil resistivity is quite satisfactory for carrying out the necessary day-to-day analyses to ensure the safety and efficiency of electrical installations.

This method, in order to be even more efficient in the complete preparation of a report, should be supported by a visual inspection of the system, in order to check the connection points to the grounding grid, if there are no oxidation/corrosion points and the physical integrity of the same, including continuity tests, to ensure that the points under analysis are properly connected to the ground and fulfilling their role of protection and equipotentialization, as guided by NBR 15749 (Associação Brasileira de Normas Técnicas, 2009).

Although it is a simple and effective method, there are some difficulties in carrying it out, which should be carefully observed by professionals and, when it is impossible to apply, another method for measuring the ground should be studied.

Because of the distance recommended by NBR 15749 (Associação Brasileira de Normas Técnicas, 2009) for driving the pile or current electrode, 3 to 5 times the longest distance of the mesh, this measurement can be complicated or even impossible to obtain.

In densely populated areas, there are many underground systems that can interfere with the measurement.

In installations where the grounding loops are extensive, in the order of a few hundred meters or even kilometers, it would be necessary to extend the current and potential circuits over great distances. Another characteristic of this type of installation is the significance of impedance in relation to resistance, making it necessary to analyze circuit couplings and reactance (Mendes, 2024).

CONCLUSION

Grounding analysis using the Potential Drop Method and the subsequent preparation of technical reports are fundamental processes for guaranteeing the safety, efficiency and compliance of electrical systems.

It was evident that the proper application of the Fall of Potential Method, observing the region where the measurement takes place, allows potential problems in grounding systems to be identified and diagnosed, providing accurate and reliable data to guide corrective and preventive interventions.

Finally, this article aims not only to provide a comprehensive overview of earth leakage analysis using the Potential Drop Method and the preparation of reports, but also to raise awareness of the importance of these processes in modern electrical engineering. Through knowledge and the application of best practices, we can ensure a safer and more reliable electrical environment for everyone.

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