Grounding Measurement Applied to a 13.8 kV Substation in Manaus - Amazonas

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Abstract

The aim of this study is to show a practical grounding measurement method for 13.8 kV step-down sheltered substation to serve as support material for use in the area.If required, an analytical comparative method for groundmeasurementthroughtheterrometer measurement equipment in the ground measurement process of a step down 13.8 kV substation with its equipment,comparing the data obtained referring to the commonly used methods, thus identifying among the most efficient grounding processes.The development of this study was based on the measurement of electrical grounding with a terrometer in a factory located in the city of Manaus. The procedure used was to perform resistance measurements, to record through measurements and images all the system measurements, to compare the values through Conventional measurement method, with electrical ground ohmic resistance meter, displaying tables and graphs to demonstrate whether the electrical grounding of the entire system would be at adequate levels.

Palavras chaves: electricity; electrical grounding; sheltered substation.

Introduction

Electricity was one of the phenomena that, when studied, most revolutionized the development of technology in history.Today, electricity is indispensable and essential for the accomplishment of industrial tasks or simpler activities that would require more time.For the correct handling of electrical energy, it is

necessary to take protective measures of the electrical installations and the people who frequent the installation, in this case, the grounding system is used.
Electrical grounding is basically one of the safest ways to use electricity resources to protect and ensure the proper functioning of the electrical installation as long as it is designed to the specific parameters under which the system is subjected to all adverse conditions, and meet regulatory requirements[1]-[2].The grounding still raises many questions and is still ignored by many professionals working in this area, either for lack of knowledge or lack of interest in seeking technical information for the correct implementation of the grounding system, because it is perceived that in many places the simple grounding is not performed. in the right way[3].
The scarcity of technical content about grounding in electrical substations does not encourage the development of new methods for the area, its wrong dimensioning brings risks to people who pass near the substations, as well as can cause equipment damage, which generate strict fines from the agencies responsible for inspecting these sites, it is necessary to maintain an electrical system in a regulated situation to provide safety for people and equipment.
The work in question seeks to demonstrate the most common type of grounding used in a 13.8 kV sheltered substation lowering, in practice, from theoretical analysis, avoiding the most common faults through measurements so that in case of inappropriate values to be The project makes the necessary adjustments for security and stimulates the search for new technologies in development from other regions and countries with a view to upgrading to future new local techniques,making it clearer if what is used today in other locations can be used more efficiently in the city of Manaus.
An analytical comparative method for ground measurement by the terrometer measurement equipment is required in the ground measurement process of a step down 13.8 kV substation, and the data obtained are compared by reference to the commonly employed methods, thus identifying between the grounding, themosteffective.

Grounding System

Grounding systems are designed to protect people, animals, and materials against possible system failure.This failure can range from a slight leakage of current to a visible electrical arc that could damage equipment and cause a fire in a serious situation. The main concern, in fact, is to protect the life of living beings by avoiding their exposure to dangerous electrical potentials which, when exposed, may be adequately protected[4].
Grounding is the connection of structures or installations with the earth, in order to establish a reference for the electric network and allow to flow to the earth electric current of various natures, such as lightning currents, electrostatic discharges, filter currents, surge suppressors and line arresters, earth fault current (faults)[5].
Grounding systems are important with regard primarily to personal safety from electric shock. Therefore, it is crucial that everyone knows how to protect themselves from dangerous electrical currents that can even lead to death.

Grounding is a system that is intended to provide a safe, controlled, low-impedance path to earth to protect people and animals from exposure to hazardous potentials.Grounding is implemented by the grounding electrodes, which are conductive parts, are purposely buried or are already buried, and ensure good electrical contact with the earth.[4].
The grounding criteria for low voltage installations are well established in the current technical standard[1], they may be supplemented with the recommendations in the Technical Standard for Protection of Structures against Lightning[2].

Classification of Low Voltage Systems in relation to Food and Masses in Relation to Earth

Distribution networks are classified according to various grounding schemes, which differ according to the power supply and grounding situation, following the letter code in the form XYZ[5].
The type of grounding system to be adopted depends on the importance of the power system involved, the location and the cost; the most efficient system is, of course, the earth grid. Grounding schemes are mentioned in the Low Voltage Electrical Installations standard[1].
The material of the earthing rods should have characteristics of being good conductors of electricity, suffer the smallest possible action of galvanic corrosion, and mechanical resistance compatible with crimping and ground movement [4].

Grounding Systems Resistance

Grounding resistance is the resistance offered to the passage of electric current when a voltage is applied to the grounding system, which consists of: conductors, cables, rods, busbars, connectors, plates, etc. The measurement consists of the ratio measured between the remote ground electrode and the current injected into the electrode. The device used for the measurement is the terrometer and the applied method is thepotentialdrop [6]-[7].

Factors that influence the value of a Ground Resistance

Soil resistivity in the vicinity of the electrodes, in this case if resistivity is a factor that influences, then all the factors that compose it also determine its value.
Electrode geometry (Dimension and shape), for electrodes, one can consider their dimensions, shapes, number employed, relative positioning and spacingbetweenthem[8].

Frequency of Grounding Measurements

It is known that the soil usually presents unsatisfactory conditions, such as homogeneity, constant humidity, etc. In such cases there is a need to carry out periodic checks, according to item 7.2 of the technical standard regarding the protection of structures against atmospheric discharges[2].

Soil resistivity

Soils with similar characteristics may have different resistivities, there are several factors that may influence the value of soil resistivity, such as soil type; mixing of different types of soil; soils consisting of stratified layers with different depths and materials, moisture content, temperature, compaction and pressure, chemical composition of salts dissolved in retained water; concentration of dissolved salts in retained water[4].

Measurement Methods

Grounding resistance measurement, when prescribed, shall be performed with alternating current, and one of the two methods described in Annex J of the Low Voltage Installation Technical Standard may be used [1].

Methodology

The research methods of this study are field research, since it is performed from data obtained at the place where the phenomenon occurs in a natural situation spontaneously [11]; since it requires the consultation of articles, norms, books and manuals and is descriptive, since it aims to describe the characteristics of certain populations or phenomena [12].

The object of this study was an asphalt emulsion factory X located in the city of Manaus, where the electrical grounding system of a sheltered substation of 13.8 kV was measured. To perform this procedure, it began with soil measurement. To measure the variables voltage, current and resistance of the ground, 02 ground electrodes were used, interconnected to the conductors of the terrometer. During the measurement, records were made through images and annotations of all measurements of the grounding system.

The equipment used to collect the measurement data was the Minipa model MTR 1520D digital terrometer with calibration n° AM06523 / 14. Resistance Scales v: 0-20 Ω, 0-200 Ω; 0-2000 Ω and 0-20KΩ, tension scale: 0-200 Vac, resistance measurement: ± (2% reading + 1% full scale), voltage measurement: ± (2% reading + 1% full scale), reading resolution: 0.01Ω for resistance measurement and 0.1V for resistance measurement. Output voltage, power and current: Operates with output power less than 0.5 W and current less than 15 mA (peak to peak) and operating temperature: 23ºC ± 2ºC.

Components Evaluated by Measurement

The components evaluated by the measurement were 14 (fourteen) tanks, 02 (two) mixers, 01 (one) diesel tank, 01 (one) water tank, 01 (one) Franklin lightning rod and 01 (one) scale. .

After collecting all the material researched in the field, the samples were verified to compare with the theoretical methods provided in the current norms, besides updated bibliographic material, the expected analysis time will be 4 months.

The analysis is performed through intensive direct observation, observation to a data collection technique to obtain information and use the senses in obtaining certain aspects of reality. It consists not only in seeing and hearing, but also in examining facts or phenomena that one wishes to study [13].

For the measurements two galvanized iron piles were inserted in the ground, the current pile E3 and the voltage pile E2, and connected through the cables supplied to the terminals (P) and (C) respectively. Terminal E1 was connected to the ground conductor to measure resistance, with cable of 05 m, as shown in Figure 1.

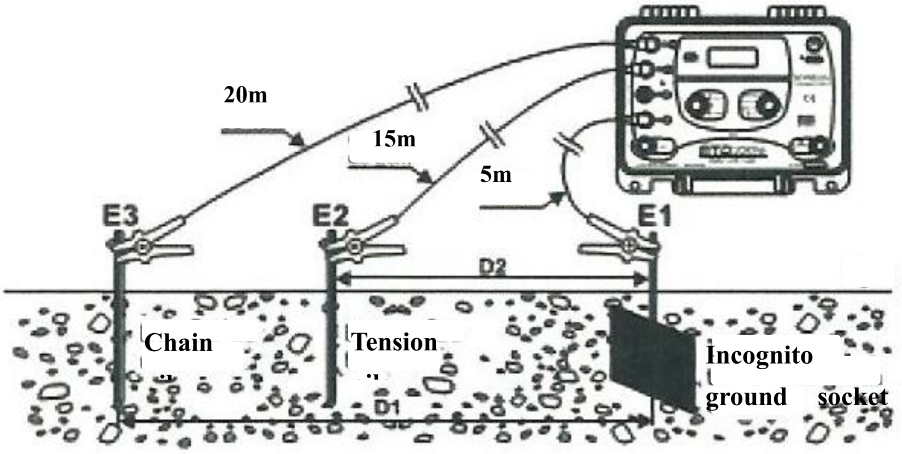

Figure1– Groundingresistancemeasurement: potentialdrop.
Fonte: https//www.eletricidade.net.

Analysis and Discussion of Results

During the grounding resistance analysis of the plant's electrical components, the day was sunny, with relative air humidity around 70% and ambient temperature ranging between 24° C and 36° C. However, the soil was generally moist. Position 01 on the function key on the terrometer was 20 Ω on the scale switch and holding down the Start key to find the resistance value.

The displacement from point E3 to point E2 is 20 meters, from point E2 to point E1, which is the electrode to be measured, 15 meters, from point E1 to the device, 5 meters. The electrode was implanted at a depth of 1.5 meters. 48 5/8 inch x 2.4 meter electrodes were implanted at a distance of 2.4 meters, interconnected by 70 mm bare copper cable to dissipate lightning to the ground. The grounding system was interconnected with a special GTDU connector, in a manhole, according to NBR 5419: 2019 and the fireman's technical standard 40/2017.

To determine the ground conditions for the grounding, the information that the soil is alkaline was used, which favors the grounding conditions. In this first measurement, the soil resistivity of 20.55 Ω near the distribution board was obtained, 12.63 Ω near the substation grounding; 22.85 Ω at the end of the containment concrete tank with an area of approximately 830 m^2 near the scale; 24.12 Ω, near the water tank; 9.46 Ω near the entrance cabin as shown in Figure 2.

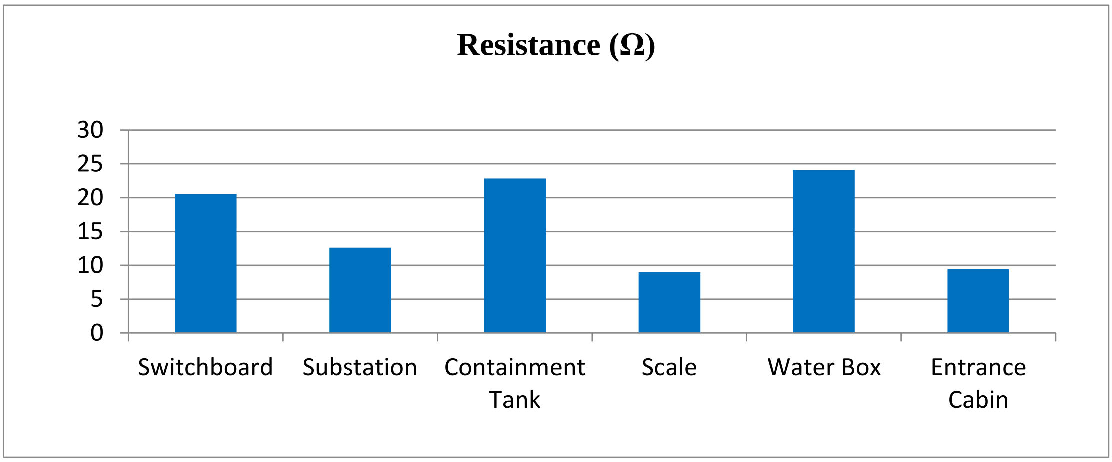

Figure2 -Soilresistancemeasurement

It can be observed in Figure 2 lower soil resistivity value near the scale installation region, allowing to conclude that this area would be the most suitable location for the installation of a simplified grounding, however there is no minimum soil resistivity value. conditioning the installation of the grounding to a certain location, which allows the installation of the grounding even near the water tank, where the highest ground resistivity value was found, since for the installation of a more complex grounding, with Use of more grounding electrodes Other variables, such as location, should be considered when choosing the installation location.

For the analyzed equipment, measurements were obtained at the respective points of resistance and voltages of the electric earthing, mixers, diesel tanks, water tank and scales, which are shown in Table 1.

Table 1 - Measurementofequipmentresistanceandvoltage

Place	Resistancemeasurement(Ω)	Voltagemeasurement(V)
Tank 01	0,39	0,1
Tank 02	0,31	0,1
Tank 03	0,35	0,1
Tank 04	0,79	0,0
Tank 05 - CAP	0,21	0,0
Tank 06	0,72	0,1
Tank 07 - RR2C	1,77	0,1
Tank 08	1,73	0,1
Tank 09	1,23	0,1
Tank 10	0,98	0,0
Tank 11	1,26	0,0
Tank 12	1,29	0,0
Tank 13	1,61	0,1
Tank 14	0,72	0,1
Misturador 01	0,01	0,0
Misturador 02	0,39	0,0

DieselTank	0,10	0,1
Water Box	0,80	0,0
Scale	1,67	0,1

All measurements made in this study are in accordance with the Standards: ABNT NBR 5419 - Protection of structures against lightning strikes and technical standard of fire brigade 40/2017, where the descriptive grounding memorial is evaluated for project approval.

The ohmic resistance values measured in the tanks, mixers, diesel tanks, water tank, scale, are in accordance with ABNT NBR 5419-3: 2015 recommendation in item 5.4.1, it is recommended that obtain the lowest possible grounding resistance, compatible with the electrode arrangement, topology and ground resistivity on site.

Figure 3 shows the values of the grounding resistance measurements for the points connected to the tanks, mixers, diesel tank, water tank and scales. It is observed that the measured values for resistance are low. As described above, it is of utmost importance to obtain low resistance for a substation, since the lower the resistance, the greater the absorption capacity of electric current by the ground, providing greater protection for theequipment..

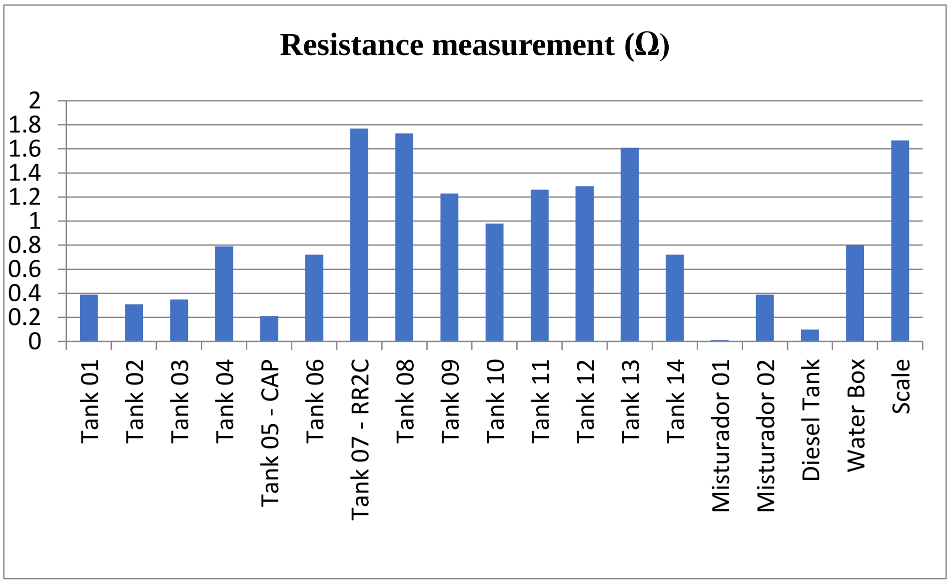

Figure 3 - Resistancemeasurement

Figure 4 shows the ground voltage measurement values of the points interconnected to the tanks, mixers, diesel tank, water tank and scales. The purpose of measuring voltage is to check for floating points, if they are found to be present, electrical grounding is the correction alternative to stabilize them.

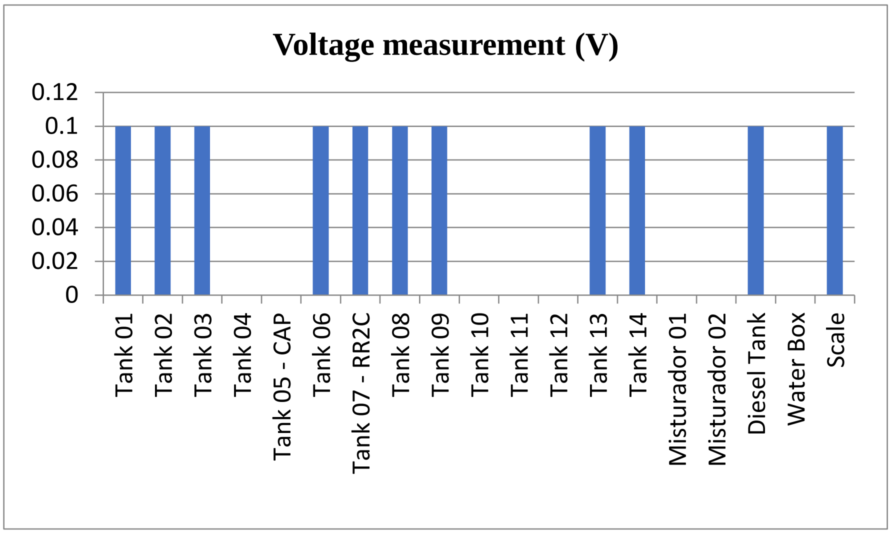

Figure4 - Voltagemeasurement

It is observed that the measured voltage values were equal to 0 and 0.1 V. Obtaining this value refers to the understanding of the Terrometer injecting a current of 1.2 A between the extreme points under test, being able to at the same time. time you inject this current, measure the voltage drop (V) between these points. The substation grounding serves to stabilize the transformer voltage level when connected in single phase and to ensure the equipment protection. Upon completion of the grounding system, it was subjected to analysis for inspection and approval by the Fire Department.

Conclusion

It was possible to conclude that the conventional measuring method, with ohmic resistance of the electric grounding, in sheltered substation of 13.8 kV lowering, in a factory in the city of Manaus, proved to be effective for the grounding system. The measurements shown by the ohmic resistance meter are conditioning factors for the safety of living beings at electrical grounding sites.

In this study, it was observed that the reference values of the measurements are very close, remaining within the acceptable tolerable values, because the soil resistance may be different for each measured area, since the measured points were not close, being in this case 20 meters away, showing slight differences.

Another important contribution refers to the proper use of this measurement methodology, considering that the grounding still generates some doubts about its norms and procedures, among the people who do not work in the area and also among the electricians professionals. The method used minimizes the difficulties of understanding the theory and its practical applications, this material shows through the results presented greater simplicity in obtaining the data.

Therefore, after the revision of the manuals and norms that cover the theme about the lowered 13.8 kV sheltered substation grounding system, as well as a practical analysis in a grounding system, it was possible, through a process commonly employed, be expanded through ancillary learning materials related to electrical ground area.

References

[1]NBR 5410, ABNT - Associação Brasileira de Normas Técnicas. Instalações Elétricas de Baixa Tensão. Rio de Janeiro. 2008.

[2]NBR 5419, 2015 - Proteção de estruturas contra descargas atmosféricas.Rio de Janeiro.2005

[3]CAVALIN, Geraldo. Instalações Elétricas Prediais. São Paulo : Érica, 2006. 16ª.

[4]KINDERMANN & CAMPAGNOLO, Geraldo, Jorge Mário. Aterramento elétrico. Porto Alegre : SAGRA - D. C. LUZZA1T0, 2011. pp. 3.

[5]CREDER, Hélio.Instalações Elétricas. 15ª. Rio de Janeiro : LTC, 2007.

[6]Institute of Electrical and Electronics Engineers. IEEE81 (Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System). 2012.

[7]ABNT NBR 15749. "Medição de Resistencia de Aterramento e Potenciais na Superfície do Solo em Sistemas de Aterramento". Rio de Janeiro. 2009.

[8]Visacro Filho, Silvério. Aterramentos elétricos: conceitos básicos, técnicas de medição e instrumentação, filosofias de aterramento. São Paulo : Artliber, 2002.

[9]NR 10:2016, ABNT. Associação Brasileira de Normas Técnicas. Norma Regulamentadora - Segurança em Instalações e Serviços em Eletricidade. 2016. p. 2.

[10]Comunidade de Eletricidade.Disponível <https//www.eletricidade.net> Acesso em 19 ago. 2019; 03:30:00.

[11]RODRIGUES, Auro de Jesus. Metodologia científica. São Paulo : Avercamp, 2006.

[12]GIL, Antonio Carlos."Como elaborar projetos de pesquisa". São Paulo : Atlas, 2008. pp. 4.

[13]LAKATOS, Eva Maria."Fundamentos de metodologia científica". São Paulo : Atlas, 2010. 7.