IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
IJARSCT
Impact Factor: 7.301
Volume 3, Issue 1, September 2023

Study of Earthing System for AC Substation: A Case Study

Chinmayi Satish Thakare
B.E. Electrical Engineering Final Year
Jawaharlal Darda Institute of Engineering and Technology, Yavatmal, Maharashtra, India
cthakare002019@gmail.com

Abstract: *This paper presents the design of Earthing system for 400 kV substation and calculation of its parameters. Successful operation of entire power system depends to a considerable extent on efficient and satisfactory performance of substations. Hence substations in general can be considered as heart of overall power system. In any substation, a well designed earthing plays an important role. Since absence of safe and effective earthing system can result in maloperation or non-operation of control and protective devices, earthing system design deserves considerable attention for all the substations. Earthing system has to be safe as it is directly concerned with safety of persons working within the substation. Main purpose of this work is designing safe and cost effective earthing systems for 400 kV substations situated at such locations where soil of the substation site is not uniform. Initially significance of earthing is explained & methodology for design of substation earthing system is discussed for 400 kV substations. Standard equations are used in the design of earthing system to get desired parameters such as touch and step voltage criteria for safety, earth resistance, grid resistance, maximum grid current, minimum conductor size and electrode size, maximum fault current level and resistivity of soil. By selecting the proper horizontal conductor size, vertical electrode size and soil resistivity, the best choice of the project for safety can be performed. This paper mentions the calculation of the desired parameters for 400 kV substations & which are simulated by MATLAB program. Some simulated results are evaluated. A case study is done at 400 kV substations at Aurangabad in Maharashtra state of India.*

Keywords: Earthing, earth grid, 400 kV substations, Power systems, Safety, Touch and Step voltages.

I. INTRODUCTION

Earthing practices adopted at Generating Stations, Substations, Distribution structures and lines are of great importance. It is however observed that these items are most often neglected. The codes of practice, Technical Reference books, Handbooks contain a chapter on this subject but they are often skipped considering them as too elementary or even as unimportant. Many reference books on this subject are referred to and such of those points which are most important are compiled in the following paragraphs. These are of importance for every practicing Engineer & In-charge of Substations. earthing systems thus design must be easily maintained and future expansion must be taken into account while designing the dimensions of earth mat Substation earthing system is essential not only to provide the protection of people working in the vicinity of earthed facilities and equipment against danger of electric shock but to maintain proper functioning of electrical systems. Reliability, security and statutory obligations are to be taken in considerations for proper design. (IEEE,Indian standards on electrical safety and environmental aspects). This paper is concerned with earthing practices and design for outdoor 400 kV AC substation for power frequency of 50 Hz [1, 2]

IMPORTANCE

The earthing system in a plant / facility is very important for a few reasons, all of which are related to either the protection of people and equipment and/or the optimal operation of the electrical systems. These include: Equipotential bonding of conductive objects (e. g. metallic equipment, buildings, piping etc) to the earthing system prevent the presence of dangerous voltages between objects and objects& earth.

- The earthing system provides a low resistance return path for earth faults within the plant, which protects both personnel and equipment
- For earth faults with return paths to offsite generation sources, a low resistance earthing grid relative to remote earth prevents dangerous earth potential rises (touch and step potentials)

II. EARTHING DESIGN METHODOLOGY

Earthing System in a Sub Station comprises of Earth Mat or Grid, Earth Electrode, Earthing Conductor and Earth Connectors.

2.1 Earth Mat or Grid Primary requirement of Earthing is to have a low earth resistance.

Substations involves many Earthlings through individual Electrodes, which will have fairly high resistance. But if these individual electrodes are inter linked inside the soil, it increases the area in contact with soil and creates number of parallel paths. Hence the value of the earth resistance in the inter linked state which is called combined earth value will be much lower than the individual value. The inter-link is made through flat or rod conductor which is called as Earth Mat or Grid. It keeps the surface of substation equipments as nearly as absolute earth potential as possible. To achieve the primary requirement of Earthing system, the Earth Mat should be design properly by considering the safe limit of Step Potential, Touch Potential and Transfer Potential. [4]

III. MOST AFFECTED PARAMETERS FOR THE EARTH MAT DESIGN

- Magnitude of Fault Current
- Duration of Fault.
- Soil Resistivity
- Resistivity of Surface Material (soil structure and soil model)
- Shock Duration.
- Material of Earth Mat Conductor
- Earthing Mat Geometry (Area covered by Earth mat).
- Permissible touch and step potentials

IV. THE DESIGN PARAMETERS

- Size of Earth Grid Conductor
- Safe Step and Touch Potential
- Mesh Potential (Emesh)
- Grid configuration for Safe Operation
- Number of Electrodes required

The different methodologies are adopted for earthing grid designs. Here we adopted universal method as per IEEE-80. An earthing design starts with a site analysis, collection of geological data, and soil resistivity of the area. Typically, the site engineer or equipment manufacturers specify a resistance-to-earth number. The National Electric Code (NEC) states that the resistance-to-earth shall not exceed 25 Ω for a single electrode. However, some reputed manufacturers will often specify 3 or 5 Ω, depending upon the requirements of their equipment and safety. For sensitive equipment and under extreme circumstances, a 1 Ω specification may sometimes be required. When designing a earthing system, the difficulty and costs increase extremely as the target resistance-toearth approaches the unobtainable goal of zero Ω. [5, 6]

The most favorable earth surface potential distribution concepts have horizontal earth electrodes, especially meshed ones, whose surface potential can be controlled easily. The potential distribution of vertical electrodes is the most unfavorable, with high values of touch potential. On the other hand, vertical electrodes can easily reach low earthing resistance with stable values, largely independent from seasons. Vertical electrodes are also used in combination with horizontal ones in order to reach lower values of earthing resistance. The results obtained here can be referred for safe

IJARSCT

ISSN (Online) 2581-9429

International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)

International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal

Impact Factor: 7.301

Volume 3, Issue 1, September 2023

earth grid design of 400 kV substations. Graphs represents the Reference & Actual calculated values of step potential, touch potential & ground resistance (Rg) with different values of soil resistivity between 100 - 350 Ω meter.

V. CONCLUSION

This paper has a focus on design of 400 kV AC substation earthing system. The results for earthing system are obtained by computational method & MATLAB programming. For earthing conductor and vertical earth electrode, mild steel isreferred and step by step approach for design of substation earthing system is presented. When high voltage substations are to be designed, step and touch voltages should be calculated and values must be maintained as per specified standards. Importance to be given to the transfer of Ground Potential Rise (GPR) under fault conditions to avoid dangerous situations to the public, customers and utility staff. The calculated values of step, mesh voltages and ground resistance (Rg) obtained for 400 kV substations are respectively 389.6783 Volts and 374.1747 Volts and 0.3017 Ω which are within the permissible limits. R.M.S. value of fault current is 31.5 kA for 132 kV substations and for 400 kV substations it is to be taken 50 kA to enhance safety In general we spread 150 mm crushed rock as a surface layer of resistivity 3000 Ω m for limiting the touch & step potentials but for 400 kV voltage levels use of granite or other gravels of higher resistivity as a surface layer can reduce the risk of possible high touch & step potentials .

REFERENCES

[1] N.M. Tabatabaei, S.R. Mortezaeei,"Design of Grounding System in Substation by ETAP Intelligent Software", IJTPE Journal, March 2010, pp.45-49

[2] Chae-Kyun Jung; Jong-kee choi; Ji-won Kang, "A study on effect of grounding system on transient voltage in 154 kV Substation" , IEEE Conference Publications, 2009, pp. 1-6

[3] "IEEE guide for safety in AC Substation Grounding," IEEE 80-2000, pp.1192

[4] Marlar Thein oo, Ei Ei Cho, "Design of earthing system for new substation project", Myanmar. World Academy of Science, Engineering and Technology – 2008, pp.430-434

[5] Dawalibi and D. Mukhedkar, "Optimum Design of Substation in a Two Layer Earth Structure, Part I Analytical Study", IEEE Transactions on Power Apparatus and Systems, March/April 1975, vol. PAS-94 (2), pp. 252--261 [6] H.B. Dwight, "Calculations of Resistances to Ground", AIEE Transactions, December 1936, pp.1319-1328

[7] IEEE STD 81-1983, " IEEE Guide for Measuring Earth Resistivity, Ground Impedance and Earth Surface Potentials for a Ground System"

[8] "Indian standard specifications", IS 3043 Earthing, pp.1- 85

[9] Massimo Mitolo and Michele Tartaglia, Senior Member, IEEE "An Analytical Evaluation of the Factor k2 for Protective Conductors", IEEE transactions on industry applications, vol. 48, no. 1, January/February 2012, pp.211-217
.