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Study and Design of Earthing and Fault Analysis at 33/11 KV Substation

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ABSTRACT

Earthing is an essential aspect of substation design, primarily aimed at providing a low-resistance path for fault currents to flow in case of a fault occurrence. A well-designed earthing system helps to limit the voltage potential between different metallic objects in the substation, thereby minimizing the risk of electric shock hazards and equipment damage. The design of the earthing system takes into account various factors, including soil resistivity, fault current magnitude, and acceptable touch and step voltages.Fault analysis is another critical aspect of substation design, which involves studying and analysing the behaviour of the power system under various fault conditions.

Keywords: - Earthing,Earth electrodes,Safety, Touch and Step voltages, Earthing Grid, Mesh voltage, Step voltage, Slipt factor,33/11 kv substation,Analysis of two substation.

I. INTRODUCTION

The term earthing means connecting the non- current carrying parts of the electrical equipment of the neutral point of the supply system to the general of the earth in such a manner that at all times an immediate discharge of electrical energy takes place without danger. Earthing means making a connection to the general mass of earth. The use of earthing is so widespread in an electric system that at practically every point in the system, from the generators to the consumers equipment's, each connectionis made. Earthing is achieved by electrically connection the respective parts in the installations to some system of electrical conductors or electrodes placed in the Safety and Prevention of Accidentscylinders, may re-fill intimate contact with the soil some distance below the ground level. The contacting assembly is called the Earthing.

All electrical equipment with high- and low-level voltages have to be grounded solidly not only to protect from severe shock hazards but also to maintain integrity in the system. An overall earthing system should be maintained to obtain a healthy operation in the system, otherwise it could be a serious cause for malfunctioning of equipment, loss of life, loss of money, service failure, sometimes could be an explosion of all equipment's if not taken care. There were different grounding procedures and standards involved for different considerations like, grounding for Static discharge, Lightning, Equipment/body and Neutral of a transformer. This paper gives the information of designing an effective earth grid to neutralize the faults at all levels in the substation i.e., lightning faults, equipment/body earth fault and unsymmetrical for designing of earthing for AC outdoor/ indoor substation. An overall earthing system should be maintained to obtain a healthy operation in the system, otherwise it could be a serious cause for malfunctioning of equipment, loss of life, loss of money, service failure, sometimes could be an explosion of all equipment's if not taken care. There were different grounding procedures and standards involved for different considerations like, grounding for Static discharge, Lightning, Equipment/body and Neutral of a transformer. This paper gives the information of designing an effective earth grid to neutralize the faults at all levels in the substation.

II. OBJECTIVE

The objective of earthing in a 33/11kV substation, or any electrical system, is to provide a safe path for the dissipation of fault currents and to ensure the protectionof personnel, equipment, and the surrounding environment. Here are the main objectives of earthing in a substation. Personnel Safetyof Earthing helps to prevent electric shock hazards to personnel working in and around the substation. It provides a low-resistance path for fault currents, diverting them away from people and reducing the risk of electric shock. Equipment Protectionof Earthing is crucial for protecting electrical equipment, such as transformers, circuit breakers, and switchgear, from damage caused by fault currents. By providing a low-impedance path, it allows fault currents to flow and enables protective devices like fuses or circuit breakers to operate, isolating the faulty section and preventing extensive damage.Lightning Protection of Substations are susceptible to lightning strikes due to their large structures and the presence of overhead power lines. Proper earthing systems help to divert lightning currents safely into the ground, protecting the substation equipment and reducing the risk of damage.

III. LITERATURE SURVEY

C.V. Chandra Chaitanya, Designing Earthing Grid/Mat for 33/11 KV substation using GI earth flats and pipes maintaining tolerable Step and Touch Potential. The step-by-step procedure for designing earth mat has been presented for which design parameter.

Yinka Oyeleye, Design of Effective 33/11 kV Injection Substations Using Appropriate Standard This research focuses on the design of an effective 33/11 kV modelled injection substation that conforms to an appropriate standard for equipment protection, the safety of personnel and power quality compliance. This is to provide a solution to one of the major problems industries in Nigeria faces due to sudden voltage fluctuations in the power system which results in damages to equipment and thus outage of power supply and damages to substation equipment Hamsa Fawaz Thanoon,Improving the Grounding System in 33/11 kV Distribution Substation, The grounding is the connection of the metal structures of machines with electrical equipment in order to remove the electrical charge from the earth by the grounding through locked connection and to prevent possible damaging of the equipment and the loss of the operator's life.

Daud Ahmad, Dr. Javed sAshraf,Design of Earthing in Underground Substation using ETAP with

Constraint,this paper describes the earthing design of a distribution substation 33kV/415V, 50Hz system. in this type of substation equipment's are 33kV HV panel, transformer, battery, battery charger and Low voltage panels.

Daniel S. Gazzana, Arturo S. Bretas,Contribution to the Study of Human Safety Against Lightning Considering the Grounding System Influence and the Variations of the Associated Parameters.This paper presents a study about the influence of the different types of soils and surge wave characteristics in terms of human safety. The study is focused on the step, contact and transferred potentials generated by a lightning reaching a grounding system and the produced potential gradients that a person could be exposed to. A Transmission Line Modeling Method and a circuit-based model are used to represent the grounding system and the human body. Several simulations were performed in order to evaluate the behavior of the current passing through the heart.

Main parameters of earthing

To save human life from shock due to current leakage of installation on the Electrical Earth wire. To protect large buildings from lightening fall. To isolate the faulty section. This is achieved by providing path of leakage current through earthing system at this instant protective gearing operates. To protect installed machines fed from O.H. line is to earth electrodeing an from lightening arresters. To maintain the line voltage constant every alternator, transformer is earthed).To maintain the potential of any part of a system at a definite value with respect to earth.

Soil resistivity

Determining soil resistivity ohm *meter* is an important factor for designing earth grid/mat since the effective resistance could be able to calculate the necessary size for earthing/grounding electrodes .The resistivity of soil is determined by using various methods, Wenner method, Megger test.Using three point method or fall of potential method which is an inbuilt operation of earth resistivity tester determine the resistivity of the soil.To decrease the soil resistivity use backfill component like zerolyte, bentonite powder to increase the conductivity and keep the soil moisture all the time.

Earth Type	Aproximate Resistivity
Wet organic soil	10
Moist soil	10^2
Dry soil	10^3
Bedrock	10^4

Table 1

Touch voltage

Touch voltage is defined to be the potential that is present when the person touches the equipment in the substation. It is the voltage present between hand and foot. The fault current flows through 3 paths if the person is in contact with the substation equipment.

Step voltage

Step voltage is the voltage or potential that is present with in the foot of a person standing on the earthing grid. This difference in potential occurs because of the Ground Raise Potential caused by the fault current being conducted to earth grid. This increase in the potential causes an electric shock which flow through the legs and could lead to fatality.

Grounding systems or earth mat in include:

Ensure safety to personnel in substations against electrical shocks. Provide the ground connection for connecting the neutrals of stat connected transformer winding to earth (neutralearthing). Discharge the overvoltage from overhead ground wires or the lightning masts to earth. To provide ground path for surge arresters. Provide a path for discharging the charge between phase and ground by means of earthing switches. To provide earth connections to structures and other non-current carrying metallic objects in the sub-station (equipment earthing). In addition to such a grid below ground level, earthing spikes (electrodes) are driven into the ground. They are connected electrically to the earth grid, equipment bodies, structures, neutrals, etc. All these are connected to the station earthingsystem by earthing strips. If the switchyards have a soil of low resistivity, earth resistance of the earthingsystem would be low. If the soil resistivity is high, the mesh rods are laid at closer spacing. More electrodes are inserted in the ground

Equipment's Of Substation:

1. Power Transformer - The base of the earthing transformer must be connected to the main earthing grid through two risers. The neutral point of the Earthing transformer must be connected to the pipe earth electrode with a test link. The neutral to ground connection should go through a neutral Current transformer for earth fault protection purpose.
2. Lighting Arrester - The base of the lightning arrestors must be connected to the main earthing grid. one riser and structure of the lightning arrestors must be connected to the main earthing grid through another riser.
3. Circut Breaker – Supporting structure of each pole of a circuit breaker along with the metallic base of the poles are connected to the main earthing grid through two risers one preferably from x and other from y direction. The structure of the poles is connected together with 50 mm × 8 mm ms flat. The mechanism box of each pole is also connected to the main earthing grid.
4. Isolator - The base of each pole of the isolator should be connected together with the help of one 50 mm × 10 mm ms flat. This ms flat will be connected to the main earthing grid through two risers one preferably from x and other from y direction earth mat conductors.
5. Current Transformer - One 50 mm × 10 mm ms flat comes down along a leg of current transformer support structure from metallic base of the CT. This is connected to the main earthing grid through riser. Diagonally opposite vertical leg members of the structure are connected to the main earthing grid via another riser.

IV. METHODOLOGY

Design codes (Standards)

Substation element	Code
Low tension fuse	1.25
High tension fuse	1.25-3
Isolator	1.25
Circuit breaker /panel/bus bar	1.25
Load future expansion	1.25 of the actual loads
Lightning arrester	1.1
Earthing value	10-ohm max
Maximum voltage	33 ± 5%

Table 2

Calculation table

Substation 1

Name	Formula	Unit
Size of grid conductor	$A_{mm^2}=\frac{I}{\sqrt{\frac{TCAP.10^{-4}}{t_c.\alpha_r.\rho_r}\ln\left(\frac{k_0+T_m}{k_0+T_a}\right)}}$	631.91 mm^2
Grid conductor	$I_g=S_f * I_f * D_f$	22312.5 KA
Current division factor	$S_f=\frac{Z_{eq}}{Z_{eq}+R_g}$	0.85%
Decremental factor	$D_f = \sqrt{1+\frac{t_a}{t_f}\left(1-e^{-2\left(\frac{t_f}{t_a}\right)}\right)}$	1.05
Grounding Resistance	$R = \rho\left[\frac{1}{L}+\frac{1}{\sqrt{20A}}\left(1+\right.\right.$	1.90 ohm

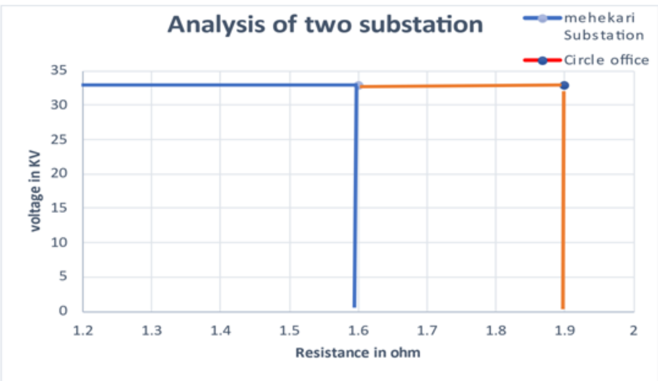
	$\frac{1}{h\sqrt{\frac{20}{A}}}\Big)\Big]$	

Table 3

SUBSTAION NO 2

Name	Formula	Unit
Size of grid conductor	$A_{mm^2}=\frac{I}{\sqrt{\frac{TCAP.10^{-4}}{t_c.\alpha_r.\rho_r}\ln\left(\frac{k_0+T_m}{k_0+T_a}\right)}}$	519.52 mm^2
Grid conductor	$I_g=S_f * I_f * D_f$	22185.75 KA
Current division factor	$S_f=\frac{Z_{eq}}{Z_{eq}+R_g}$	0.85%
Decremental factor	$D_f = \sqrt{1+\frac{t_a}{t_f}\left(1-e^{-2\left(\frac{t_f}{t_a}\right)}\right)}$	1.04
Grounding Resistance	$R = \rho\left[\frac{1}{L}+\frac{1}{\sqrt{20A}}\left(1+\frac{1}{h\sqrt{\frac{20}{A}}}\right)\right]$	1.6 ohm

Table 4



V. RESULT

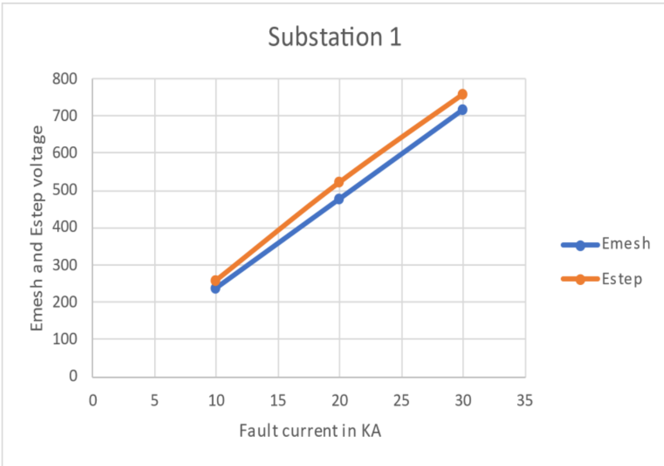
The input values considered for designing the earthing grid has been estimated and calculated according to it. Table 5 and 6 are below

Substation 1

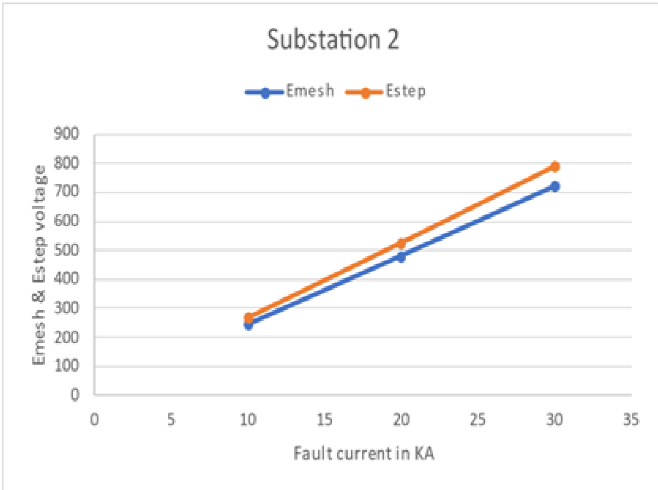
Fault Current in KA	E_{mesh}	E_{step}
10	238	261
20	477	523
30	716	758

Substation 2

Fault current in KA	E_{mesh}	E_{step}
10	244	267
20	480	526
30	720	790



Substation 1[circle office]



Substation 2[Bingar office]

VI. CONCLUSION

The touch and step voltages at any part of the substation are within the permissible safe limits.In the above result we have seen that the E_{mesh} and E_{step} voltage increase with increase in fault current. The substation reliability and effective carry expected load demand. this research recommended by high quality power supply injection substation should be designed for area with high energy consumers for reliable power quality. The first substation [Circle office substation Ahmednagar] (33/11 KV) is more reliable than secondsubstation [Bingar substation Ahmednagar],(33/11 KV) because we have to maintain 2-ohmresistanceinthe substation grounding is the main part of substation design the design as to be both safe and reliable the need and importance of improving earthing system proposed.

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