STABILIZATION OF SOIL RESISTANCE IN NEW INSTALLATION IN THE COASTAL SOIL IN NIGER DELTA

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Abstract

Earthing is an intrinsic part of the electricity system and one of the requirements is to provide a sufficient low impedance to facilitate satisfactory protection and operation under fault conditions.

In the coastal area of Niger Delta where the soil resistance is low due to the salt content of the subsoil water and the nature of soil the wanted advantage results to nuisance tripping of the protective device. This situation is common with the residual current device (RCD). This experience last for a period of 3 months to 6 months after that becomes normal. A study was carried out to identify the reasons of the local problem.

The soil resistivity test was carried out in 10 different locations on the different soil at a depth of 1.0 to 1.5 meters, which is an approximate electrode planting depth for domestic installations. From the tests and analysis it was concluded that the low soil resistivity contributes to the nuisance tripping of residual current devices. If other protective devices (fuses) are used the nuisance tripping effect is not felt.

Keywords: Nuisance tripping, residual current device, Physico-chemical property of soil, Adiabatic Equation, Prospective short circuit current

Introduction

Earth (earth system) is a conducting connection, whether intentional or accidental by which an electric circuit or equipment is connected to the mass of earth or some conducting body of relatively large extent that serves in place of the mass of earth [1].

The reasons for earthing a system are

- To provide sufficient low impedance to facilitate satisfactory protection operation under fault conditions
- To ensure that living beings in the vicinity of substations are not exposed to unsafe potentials under steady state or fault conditions.
- To retain system voltages within reasonable limits under fault conditions and ensure that insulation voltages are not exceeded
- Provide an equipotential platform on which electronic equipment can operate.

In order to be able to carry out these functions and more, the earthing system must generally have low impedance so that in dispersing or collecting current from the ground, an excessive voltage rise does not occur [2, 3].

Earthing system is to ensure that in the event of an earth fault, any fault current which does result can return to source in controlled manner. By controlled manner, we mean that the return path is predetermined such that damage to equipment or injury to individuals does not occur. However, the impedance of the earthing system should be low enough that sufficient earth fault current can flow to operate protective device correctly, which will in turn initiate the operation of circuit breaker or fuses to interrupt the flow of current [3, 4, 5].

Another area of earthing is bonding. Any exposed conductive metal work which can be touched is connected together via bonding conductors. Bonding is to ensure that should a live conductor come in contact with exposed conductive metal work, then the potential on all exposed conductive part becomes virtually the same.

Low impedance is possible when the soil resistivity is low. The resistivity is the resistance of the soil to the passage of current and it varies from soil to soil.

The soil in which the over flow of current from the earthing arrangement takes place is very complicated and heterogeneous in composition as well as structure. The main component parts of soil are hard particles of inorganic or organic origin and water. The electrical conductivity of hard components of soil in dry condition is negligible. It shows that chemically pure water similarly posses very high specific resistance [6, 7].

The different salts and alkali contained in the soil in presence of moisture, forms electrolyte which determines the electrical conductivity of the soil. In this way the specific resistance of soil depends very much on its chemical composition and moisture content. The moisture retaining capacity of soil does not only depend upon the quantity of suspended moisture and nearness to subsoil water but also on the structure of soil. Smaller the dimension of soil particles, greater the quantity of water retained by the soil; that is the greater is its moisture retaining capacity.

The resistivity of a soil can be determined by the quantity of water held by the soil and the resistivity of the water itself. It may be noted that resistance drops quickly to a more or less steady minimum value at about 15 percent moisture contents. A further increase of moisture level in soil will have little effect on soil resistivity. From the value given in table 1, in normal soil condition, the resistance remains fairly different for increase in moisture condition (15%-20%).

Table 1: Resistivity Values for different moisture and salt percentages.

Moisture content weight (%)	Resistivity ohm-m	Added salt by weight (%)	Resistivity ohm-m
0	$1,000 \times 10^4$	0.0	107
2.5	2,500	0.1	18
5	1,650	1.0	4.6
10	530	5.0	1.9
15	310	10	1.3
20	120	20	1.0
30	64		

The percentage of salt needed for the most effective earthing is about 5 percent weight of salt.

Protective Devices

The protection requirement in an electric circuit depends on the anticipated hazards, relative degree of protection required and the capacity of the undertaking to bear the cost of the protective devices.

In domestic installations protection is undertaken by fuses (rewirable and HRC), circuit breakers (MCB, RCCB ELCB) etc. A fuse acts both as protective and disconnecting device. The fuse protection is based on the concept of thermal heating given by I^2t (Amp^2s). A fuse breaks a short circuit in two stages-pre-arcing and then arcing.

The pre-arcing thermal stress corresponds to the minimum energy necessary for the fuse element to start melting. The arcing thermal stress corresponds to the energy limited between the end of the pre-arcing and total breaking. The sum of the arcing and pre-arcing stress gives the total thermal stress [8, 9].

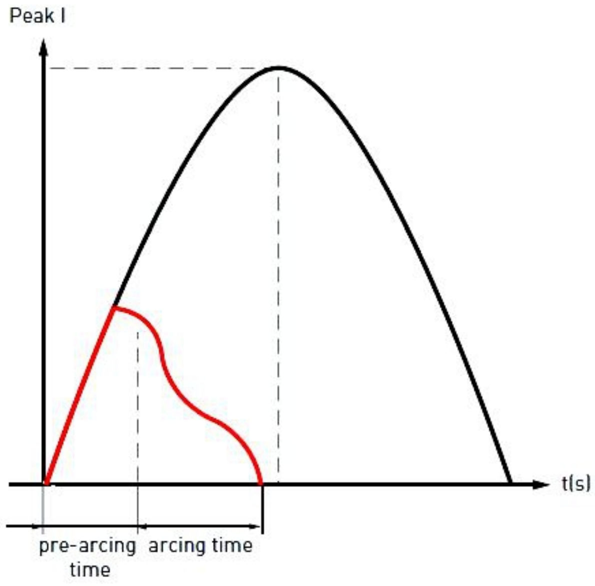

Figure 1: Pre-arcing and Arcing Curve (Thermal Stress)

The time versus current characteristics of a fuse are approximately I^2t constant (k) for large current (psc). The amount of heat energy that cable can withstand is given by K^2S^2. Hence the let-through energy should not exceed K^2S^2, that is

$$I^2t=K^2S^2 \tag{1}$$

Therefore, $t = K^2S^2/I^2$, which is the maximum disconnection time in sec.
Where k = a factor depending on insulation material of conductor
S= conductor cross-sectional area
I=fault current in amps
t=duration of short circuit time in sec.
The value of current which assumes the correct operation of a fuse can be ascertained from the current/time performance graph for the fuse concerned.

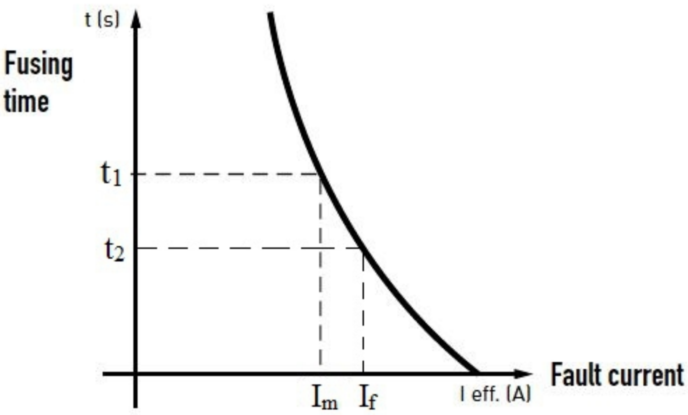

Figure 2: Current–time performance curve for a fuse

If the maximum disconnection time t_1 corresponds to a value of current I_m.

$$R_m = \frac{V}{I_m} \tag{2}$$

If the fault current for instantaneous operation must be greater than I_m ($I_f > I_m$)
The impedance value Z_r for the fault current is I_f, then

$$I_f = \frac{V}{Z_r} \tag{3}$$

Circuit Breaker Operation

Overcurrents are detected by the different devices, thermal for overload current, magnetic for short circuits and electronic for both. Thermal consist of a bi-metal strip which if heated beyond the normal operating value becomes deformed, releasing the lock holding the contact. The reaction time of a bi-metal strip is inversely proportional to the intensity of the current [8, 10].

The magnetic release consist of a magnetic loop whose effect releases the lock holding the contact, thus triggering the breaking if there is a high over current. Thus, the responds time is very short.

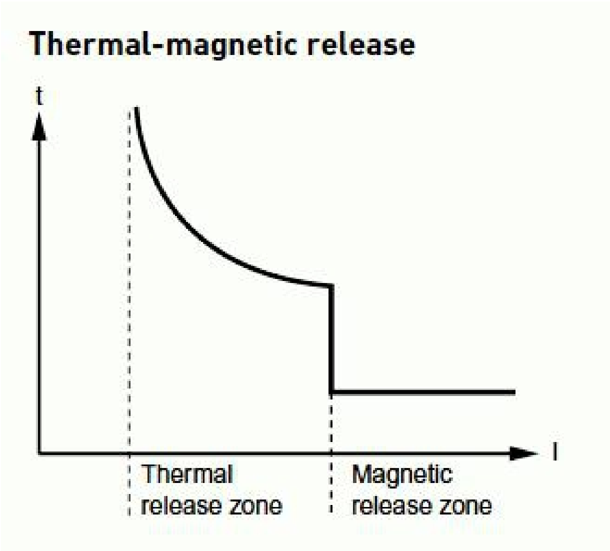

Figure 3: Thermal-magnetic release

Electronic Release

A coil placed on each conductor continuously measures the current in each of them. This information is processed by electronic module which controls the tripping of the circuit breaker when the values of the settings are exceeded [9, 11].

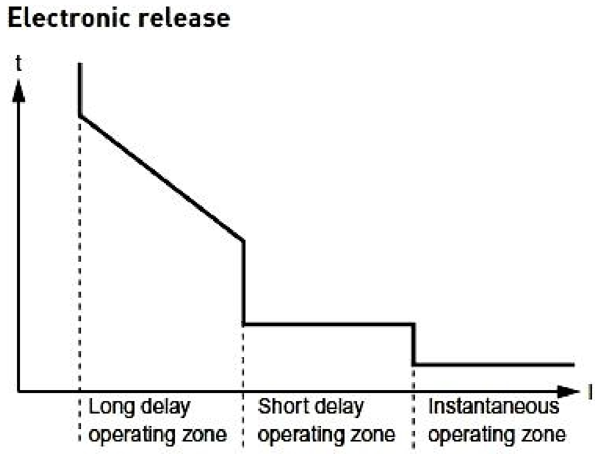

Figure 4: Electronic release curve

If there is a short circuit without any protection the current that flows through the installation is the prospective short circuit current (PSCC). When a short circuit crosses a circuit breaker, the circuit breaker has the capacity to a greater or lesser extent to allow only a part of this current to flow.

The short circuit is then limited in amplitude and duration. The purpose of limitation is to reduce

- thermal stress
- electrodynamics forces
- effects on electromagnetic forces

It also makes discrimination and combination easier. The limitation capacity of device is represented in the form of limiting curves. This is shown in figure

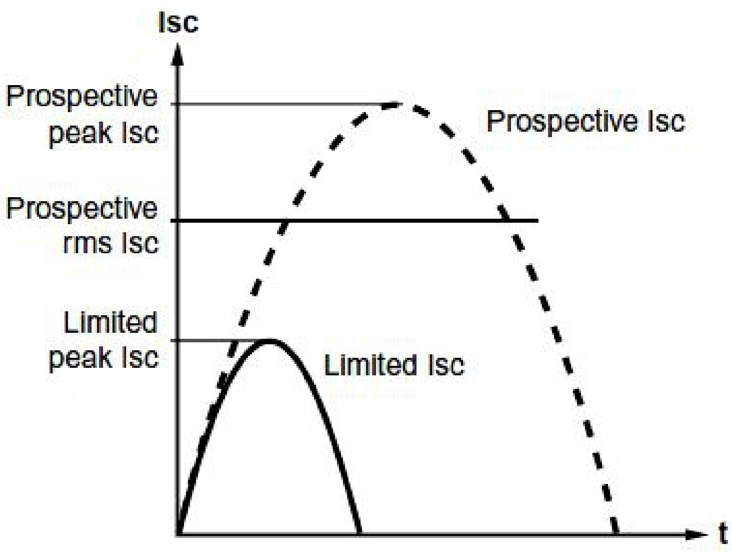

Figure 5: Limiting curve for prospective peak current

Current Limitation Curves: This gives the maximum peak current values (peak) limited by the devices according to the values of the prospective short circuit current. The limited current values are used to determine the size of the busbar and to check the withstand conductor and devices.

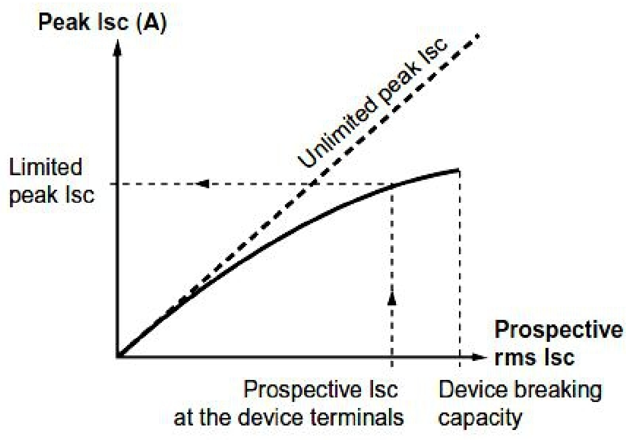

Figure 6: Current limiting that determines the different operations of RCD

Nuisance Tripping: Due to the nature of trip device of (RCD) circuit breaker, nuisance tripping occurs as a result of several factors. Included among these are

- Choice of wrong rating
- Harmonic current and voltage generated by an increasing number of loads.
- Constant load, leakage current both at power and higher frequency
- Florescent lighting or electronic ballastand house hold appliance
- Switching surges – opening and closing of capacitive and inductive circuits (RLC circuit).

With the recognition of such effect it was still realized that the unwanted tripping was within 90 to 180 days of the installation.

It was discovered that the cause of this effect was the stabilization of electrode resistance that takes place within the quoted period.

Methodology

The soil test was carried out in ten (10) different locations of different soil type. The instrument used was the four point electrode method (the Wenner method). The Wenner technique uses four equally spaced electrodes connected in a line. Current was passed between the outer two electrodes (c_1, c_2) and the voltage between the inner electrodes P1 and P2. The resistivity of the soil is proportional to V/I

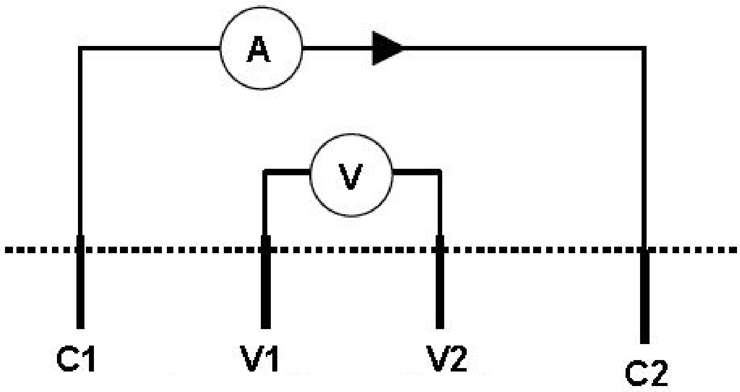

Figure 7: Wenner Configuration method

When the planting depth of electrode is much less than the distance between electrodes D, the formular takes the form

$\rho = 2\pi DR$

Where ρ = soil resistivity in ohm-

R = the value V/I in ohms

Results

The results of the measurements for the 10 sites are presented in table 2.

Table 2: Soil type, Resistivity, pH, Temperature and rainfall in some locations in Niger Delta

Site	Type of soil	Marshy ground water	Mean temp °C	Annual rainfall mm	Moisture %	pH	Resistivity Ω
Brass	Sandy subsoil mixture of sand and clay with marshy	1.2	32.6	2284	82	3.1	40
Bonny		1.2	33.1	2312	78	3.6	50
Degema	Sandy clay	1.8m	34	1878	77	4.1	180

Onne	Clay loam	3m	33.4	1.901	78	4.2	580
GRA CPH	Clay laom with sandy clay (surface)	34.5	1711	77	5.9	415	
Borikiri PH	Clay loam	2.2	34	2065	79	4.0	165
Sagbama	Sandy clay	1.8	34.3	2341	81	3.9	102
Ekowe	Sandy clay muck	1.2-1.8	33.7	2290	82	6.1	80
Swali Yenagoa	Sandy clay	1.8-2.0	34.1	2209	80	5.6	240
Obogene Yenagoa	Clay loam	2.4m	33.9	2075	80.2	6.4	405

For decay vegetation areas (low drainage) and other humus areas were aggressive. This was seen in some area of Ekowe. These sites were more alkaline, especially some areas that pond.

Discussion

The effect of ohmic resistance can be predicted on the basis of the resistivity of soil and the distance between the anode and the cathode. The short circuit current of a cell is usually maximum at the beginning, decreases gradually with time and after a certain period then stabilizes. This behaviour is represented by asymptotic nature of cell current-time curves (4-6).

The reduction in initial current value is attributed to reduction in initial potential difference due to the displacement of initial anode potential in positive direction (anodic polarization). Anode polarization increases with retardation in chemical reaction between metal ions and electrolyte, concentration of metal ions in the anode region and passivation of metal. Certain cells deviate from this general pattern of the chronological behaviour of cell current. Some require a small period for stabilization after which the cell current becomes maximum [1, 12]. The cells constituted by a soil having some depolarizing agents register increment in the cell current at stage but after attaining the maximum, the behaviour becomes as usual. But in all such cases the current usually stabilizes within a period much earlier than 180 days and then the change in the cell current with time becomes mush less significant. Therefore the electrode potentials measured at the end of 180 days are the indices of the potential of the electrodes after the initial covering of the rapidly forming corrosion product, whose protective action becomes fairly constant and does not significantly increase with further increment in the film thickness.

This tripping of soil resistivity was common in the coastal area of brass, bonny and also on marshy areas with low resistivity. The ground water of Bonny and Brass contain various salts (electrolyte) so the resistivity is small, that is the resistivity was like the resistivity of water contained within the electrolyte.

From the foregoing reasons, the soil resistance is small and the earth resistance can be calculated as $\frac{2\rho\ell}{A}$

Conclusion

It has been established that the initial internal resistance of a cell is primarily due to the resistance offered by the soil intervening the two electrodes. As the corrosion proceeds the internal resistance increases due to the polarizing influence of the film of the products of the corrosion reactions. It is also realized that the internal resistance due to the soil at the initial period was fairly of the order of 10 percent of internal resistance at the end of the 180 days, that is the initial resistance is one-tenth of the normal value of the system value after 180days. In a fairly old installation the value may increase due to other factors. Therefore for areas with small earth resistance, nuisance tripping is likely in new installations. This also occur in area with small or no drainage and humus deposit areas.

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