The Feasibility of Electrical Safety Grounding Tool for Medium Voltage Distribution with A3CS Cables

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Abstract: In this globalization Electrical energy has become like a primary need. Electrical energy consumption growth has coherency with economic growth. The electricity supply system is designed to improve the reliability without blackout. Reliability improvement can be done by construction, maintenance, repair and improvement of the system. Construction, maintenance, repair and improvement of the distribution system must be guaranteed work safety and health. In Australia, electrical safety and health are very tightly regulated, because it very dangerous if the equipment is not grounded properly. The preparation of electrical safety grounding for medium voltage distribution with A3CS cables is very important, because now only available for A3C cables. This research is quantitative research through statistical and mathematical data processing. This study examines the feasibility of electrical ground safety assembled for medium voltage distribution with A3CS cables. The results found that electrical safety grounding tools is feasible to use in construction, maintenance, repair and improvement of over head medium voltage distribution system with A3CS and A3C cable. This grounding tools has an insulation resistance more than 100 mega ohms, a leakage current smaller than 1 milli amperes, and the distance of workers to the active part is more than 0.9 meters.

1 INTRODUCTION

1.1 Problems Background

The electricity is very important in this globalization era, the electricity has become like a primary need. So many economic activity need electrical power. Electrical energy consumption had a positive impact and there was bidirectional causality with economic growth (Yılmaz Bayar and Hasan Alp Özel, 2014). The growth of energy consumption will be followed by increase electricity consumption as a result of economic growth (Zhenya Liu, 2016). An electrical energy consumption increased during the economic growth.

So many economic activities need electrical energy. In Aceh Province of Indonesian the empirical evidences indicate that the long-run bidirectional relationship exists between, commercial electricity consumption and economic growth and, in the short-run bidirectional relationship between economic growth and all of the sectoral electricity consumption (Fahrul Rizal, 2014). That so very vital the electrical energy, the engineer did some experimental to build, maintenance and repair the system for a safe and reliable electrical energy distribution(Math H Bollen, 2000).

This reliability system is designed to guarantee the electricity supply quality that meets to the standards. The quality of electricity supply aims to protect consumer rights and so the State Electricity Company's (PLN's) advantages. So that all parts of the electrical energy supply system must meet the standards of reliability and security. The hope to electricity distribution by PT.PLN must not be interrupted for 24 hours. Routine maintenance such as a vegetation management program can reduce unnecessary tripping especially during excess channel situations (Chan F.C., 2008). These steps can minimize the external interference. Thus, the maintenance, repair and improvement of the distribution system is an important action.

Maintenance, repair and improvement of the distribution system must be safety and healthy work processed. The work process must follow to standard operational procedures with available standards tools. In Australia, occupational safety and health in working electricity is very tightly regulated, because accidents to burns or falling from a height site, thus the equipment must be earthed properly (Alex Ward,

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1982). My assembled that grounding tool for electrical work safety at A3CS cable on medium voltage distribution, will protect the workers from electric shock and lightning strikes. There are many people are not aware of the threat electricity danger, so this awareness is very important, and safety and healthy tools are prepared (Saba et. al., 2014).

A good grounding system if the equipment is well connected to the earth. Electrical Working safety if the whole system equipment bended and connected to the ground. The quality of earthing is the basic protection against AC interference (Mohamed, 2018). The source of interference is lightning, switching, or an error in the distribution system. To do this bending and grounding must be done with adequate tools to a good connection between the equipment and the earth. The problem now is that are the overhead medium voltage distribution in Indonesia, has been replaced by an insulated cable like all alloy aluminum conductor sheated (A3CS). This will be an obstacle for bending and grounding conductor to earth, because the current grounding equipment is properly to A3C conductors.

This research is very important to get a model of earthing tool for electrical work safety in over head medium voltage system, that can grounded whole equipment with properly to the earth, due construction work, maintenance, repair and improvement of over head medium voltage electrical distribution system. This paper to explore how to assembly dan tested the grounding tool for electrical work safety at A3CS cable on medium voltage distribution..

1.2 Problem

How the feasibility Of Electrical Safety Grounding Tool For Medium Voltage Distribution With A3CS Cables?.

2 RESEARCH METHOD

2.1 Research Approaches and Concepts

To analyses that problems, this study was designed as a qualitative approach study. The problems will be discussed by the data from measurement dan tested, ware calculation to obtain the good insulation for medium voltage work safety handle, and all of component connected. This research tested is done in the Politeknik Negeri Bali Workshop and PLN UP2D laboratory, and the test results statistically and mathematically analyse to obtain the feasibility of electrical safety grounding tool assembly, comparing to the electrical work safety roles, and than taken conclusions and recommendations. This grounding tool is assembled by plastic pipe, rubber rings, life line connector, and flexible copper cable. This grounding tool is an innovation assembly for electrical work safety tool. This grounding tools is properly applied at medium voltage distribution with all alloy aluminium conductors (A3C) and all alloy aluminium conductors Sheeted (A3CS), but the other only for A3C.

2.2 Total Sample

This research was conducted by tested three samples “Electrical Safety Grounding Tool For Medium Voltage Distribution With A3CS Cables” that was taken from a product assembly.

2.3 Variable Operational Definition

In this study, we observed magnitude of the connection, leakage current an insulation test, dielectric strength and clearance distance. The connection test is applied between connection head of grounding tool and the medium voltage distribution circuit. The test voltage is the amount of voltage applied to the sample through the high voltage tester. Leakage current is the amount of current flowing in to the test sample, due to given test voltage. Dielectric and clearance distance measured by ruler meter.

2.4 Tested

The connection test is tested by ohm meter, where the good connection is indicated by resistance value at about zero ohm. Electrical test voltage against minimal insulation resistance is tested with a voltage equal to the operating voltage. For testing a minimum 20 kV system equipment is tested with a voltage tester at 20 kV. Tests are carried out using electronic high voltage tank, volt meters and ampere meters. All equipment connected with grounding system. Tested are made between phase and ground.

For the connection tested, each sample (connection head) is connected and screwed until the pin piercing to the A3CS insulation. The connection head is connected with red probe and the A3CS conductor connected with black probe of ohm meter. Selector switch of AVO meter was turned around to 1x of ohm meter. That connection tested process have been done in three time reply.

For Current leakage tested, each test sample (grounding shaft) is placed between the connection head and winding electrode at the handle. The connection head is given a 0.2 Hz AC voltage and the winding electrode is grounded trough ampere meter. The voltage given to the samples is increased step by step, with each step is 5 kV, starting from 5 kV to 30 KV. In every voltage step, the current leakage flow was measured with ampere meter. This current leakage tested was processed three time at dry and wet conditions of grounding shaft. Voltage detector is applied to ensure the level of voltage leakage trough current leakage from the head connection to the grounding shaft.

2.5 Data Analysis

Data obtained from the test results are processed quantitatively. Data is processed mathematically by the process of multiplication and divide. The data is also processed statistically by finding the smallest value from all of data if the limit is minimum such as insulation resistance, dielectric strength, space clearance, and finding for the biggest value from all of data if the limit is maximum such as at leakage current condition.

3 RESULT AND DISCUSSION

The result of this research described by figure and table. The analyses of the feasibility of a grounding shaft was carried out is to guarantee the work safety. Grounding tools must have good ground resistance and the insulated shaft to ensure work safety in the construction, maintenance, repair and improvement of the medium voltage distribution. However, there is no perfect shaft material, therefore the research on this assembled shaft so important. This earthing shaft constructed by polypropylene pipe, which has good electrical characteristics because the coefficient of resistivity volume is 8.5×10^{14} Ohm-cm. Safety grounding shaft was designed like as shown in Figure 1 below.

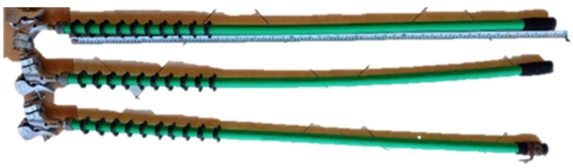

Figure 1: Safety grounding shaft.

In accordance to the safety grounding shaft function is insulation. A perfect shaft insulating material has an unlimited resistance, that currently cannot obtained. There is a small leakage current that flows in insulation material. The problem is the resistance of insulating material is not unlimited. The insulation resistance is according to Ohm's Law is voltage divided by leakage current (Salman and Muhammad, 2011) and can be shown as an equation below.

$$V = I \times R \tag{1}$$

$$R = V / I \tag{2}$$

where :

R = Insulating Resistance (Giga Ohm)
V = Voltage charge due the sample (Kilo Volt)
I = Leakage Current (micro Amperes)

The normal air dielectric strength coefficient is 30 kV/cm, the total dielectric strength is total distance multiple with dielectric strength coefficient, as shown in the formula below (Kumail et. al., 2018).

$$\mathscr{E} = \mathscr{E}_0 \times d \tag{3}$$

where :

$\mathscr{E}$ = Dielectric strength (KV)
$\mathscr{E}_0$ = Dielectric strength coefficient (KV/cm)
d = distance (cm)

3.1 Result

Conducting to the tested, insulation resistance after the leakage current tested with the High Voltage VLF Hi-pot Instruments Type: VLF4022, dielectric strength, and safe distance between active voltage equipment with workers. These four benchmark must be considered to determining the feasibility of the electrical work safety grounding shaft. The minimum insulation for medium voltage is 100 Mega Ohms (Sanjay et. al., 2018). The maximum leakage current flow does not affect a shock to the human body is 1 milli amperes (Saba et. al., 2014). Total the dielectric strength must exceed than the active voltage to avoid the electric discharge (Saba et. al., 2014). The minimum safe distance between workers and 15 Kilo Volt active equipment is 90 cm (Manik et. al., 2015).

Conducting to the trial this safety grounding tools connecting to the medium voltage distribution network, occurred a good connection. Measurement results of connections on A3CS and A3C cables is limit to zero. Thus the head of the grounding shaft can properly pierce the A3CS cable insulation and well grip well on to A3C conductor.

Isolation resistance pretest was conducted at the Electrical Engineering Workshop Bali State Polytechnic, Before insulation resistance tested in the UP2D Bali PLN laboratory. A pretest is carried out to conduct an early detection of the insulation resistance

Figure 2: Electrical safety grounding on the trial.

quality this electrical work safety grounding shaft. The pretest is carried out by applying a voltage of 5,000 volts and 10,000 volts to the terminal head and handle connected by grounding trough coil electrode as shown in the following figure 3. Insulation resistance pretest is done in dry and wet condition three times for each sample, the wet condition testing as shown at figure 4.

Figure 3: Dry insulation resistance pretest with megger 10,000 volt.

The pretest is very important because it is not easy to get permission to do it again at PLN UP2D Bali. Pretest is done using 10,000 Volt meggers. the results of the insulation resistance pretest using megger are analyzed to obtain leakage currents, such as the calculation below.

Leakage current analysis, sample 1 at 1st step

Voltage tested: 5,000 Volt DC

Insulation resistance : 250,000 Mega Ohm

The leakage current calculation:

Figure 4: Wet insulation resistance pretest with megger 10,000 volt.

I = V/R
= 5,000/250,000,000,000
= 0.02x10-6 amperes
= 0.02 micro amperes

Through the same calculation, the leakage current as displayed in table 1 at below.

Table 1: Leakage current analysis grounding shaft with Megger 10 kV.

Sample	Step of testing and condition	R Iso. at 5 KV (Giga Ohm)	R Iso. at 10 KV (Giga Ohm)	Leakage current at 5 KV (micro amperes)	Leakage current at 10 KV (micro amperes)
	1 dry	250	500	0.0200	0.0200
	2 dry	200	400	0.0250	0.0250
	3 dry	225	450	0.0222	0.0222
1	1 wet	78	156	0.0641	0.0641
	2 wet	80	160	0.0625	0.0625
	3 wet	80	160	0.0625	0.0625
	1 dry	220	440	0.0227	0.0227
	2 dry	300	600	0.0167	0.0167
	3 dry	250	500	0.0200	0.0200
2	1 wet	40	80	0.1250	0.1250
	2 wet	45	90	0.1111	0.1111
	3 wet	45	90	0.1111	0.1111
	1 dry	300	600	0.0167	0.0167
	2 dry	250	500	0.0200	0.0200
	3 dry	275	550	0.0182	0.0182
3	1 wet	38	76	0.1316	0.1316
	2 wet	40	80	0.1250	0.1250
	3 wet	40	80	0.1250	0.1250
I leakage max.				0.1316	0.1316
R Iso min.		38	76		

The insulation resistance tested with High Voltage VLF Hi-pot Instruments like shown in figure 3 below is done at PN UP2D Bali Laboratory. High voltage VLF hi-pot instruments are high voltage test equipment with low frequency. This measuring instrument changes the voltage 220 Volt 50 Hz, into a DC voltage, then converted back into low frequency AC high voltage. The output of High Voltage VLF Hi-pot Instruments test equipment Type: VLF 4022 is 40 KV AC with a frequency of 0.2 Hz.

Figure 5: High voltage VLF hi-pot instruments.

The leakage current testing circuit is carried out by connecting the sample in series with a measuring instrument. The test equipment is solidly grounded for safety in the testing process. the return switch is positioned on the guard as shown in figure 6.

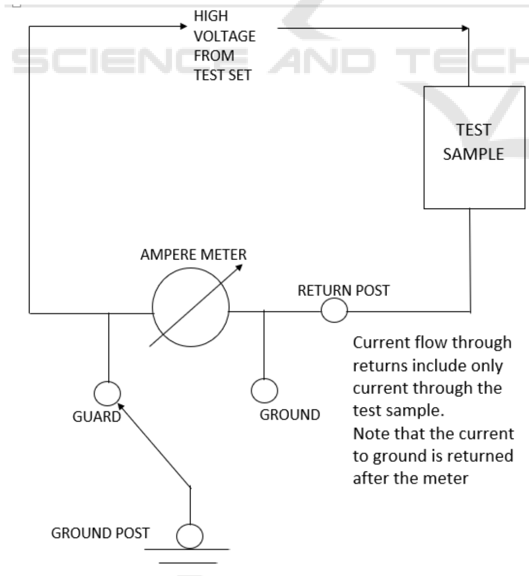

Figure 6: Test diagram.

This leakage current tested start at a voltage test of 5 kV, then increased by 5 kV per step up to 30 kV. When testing a leakage current, also detecting a leakage voltage using a voltage detector, which starts working with a voltage of 2.7kV and above like shown on figure 7. Tests were carried out on three ground stick samples that had been assembled, with dry and wet conditions.

Figure 7: Voltage detector.

Leakage current tested for dry test samples first. After six voltage step dry test is finished the test equipment is turned off, followed by making artificial rain from the spryer, placed on top of test sample with an angle of 30 degrees. After being wet, the test sample was given a voltage from 5 kV to 30 kV, noted the leakage current and the dielectric discharge voltage was detected by voltage detector.

The analyses the insulation resistance tested with High Voltage VLF Hi-pot Instruments, using the ohm formula. Insulation resistance is equal to the tested voltage given divided by the leakage current. The calculation of insulation resistance to sample 1 tested step 1 as described below.

Tested result:

Voltage tested : 5,000 Volt AC

Leakage current : 1 micro ampere

The calculation of insulation resistant:

$R = V/I = 5{,}000/(1 \times 10\text{-}6)$

$= 5 \times 10^9$ Ohm = 5 Giga Ohm

In the same calculation process, the insulation resistance for other step is as displayed in the table 2.

To determine the safe electrical work distancing there are two conditions must be discussed for the grounding shaft, that are the total distancing dielectric strength and the distancing between the potential life voltage equipment with the worker when to connecting the "electrical safety grounding tool for medium voltage distribution with A3CS cables" to the medium voltage equipment.

The angle of rain is expected to be a maximum of 30 degrees. The wet condition decrease the dielectric strength. There are 10 pieces rubber ring like an umbrella will protect the shaft from solidly wet. Part of the shaft dry protected by the rubber ring to maintain dielectric strength. Thus, the dielectric strength distance of “the electrical safety grounding tool for medium voltage distribution with A3CS cables” can be calculated as described below.

Table 2: Leakage current analysis grounding shaft with Megger 10 kV.

Sample	Voltage Tested (KV)	Dry		Wet	
		Leakage current (micro ampere)	Insulation Resistance (Giga Ohm)	Leakage current (micro ampere)	Insulation Resistance (Giga Ohm)
1	5	1.00	5.00	1.00	5.00
	10	1.00	10.00	2.00	5.00
	15	2.00	7.50	4.00	3.75
	20	2.00	10.00	4.00	5.00
	25	2.00	12.50	5.00	5.00
	30	3.00	10.00	4.00	7.50
2	5	1.00	5.00	3.00	1.67
	10	2.00	5.00	4.00	2.50
	15	2.00	7.50	4.00	3.75
	20	3.00	6.67	5.00	4.00
	25	4.00	6.25	6.00	4.17
	30	4.00	7.50	5.00	6.00
3	5	1.00	5.00	1.00	5.00
	10	1.00	10.00	2.00	5.00
	15	2.00	7.50	3.00	5.00
	20	2.00	10.00	4.00	5.00
	25	3.00	8.33	5.00	5.00
	30	3.00	10.00	4.00	7.50
Lowest insulation resistance			5.00		1.67
Biggest leakage current		4.00		6.00	

Figure 8: Rubber Ring on The Safety Grounding Shaft.

If the black-shaded triangle in figure 8 to copy and pasted it will be obtained as shown in Figure 9 below.

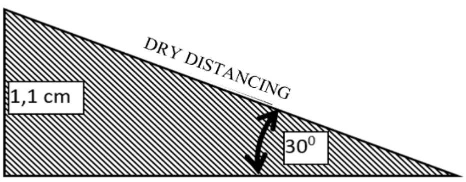

Figure 9: Distancing angle.

Dry distancing calculation

Sin Q = Y/Z

Dry Distancing = 11/sin 300

= 1.1/0.5 = 2.2 cm

Total Dry Distancing = 10 x 2.2 cm = 22 cm

The normal air dielectric strength is 30 kV/cm (Saba et. al., 2014). The total dielectric strength of grounding shaft with 10 pieces rubber ring is:

$\mathcal{E}=\mathcal{E}0 \text{ x } d$

$= 30 \text{ x } 22 = 660 \text{ KV}$

The total dielectric strength the shaft of “electrical safety grounding for medium voltage distribution with A3CS cables” with mathematic calculation is 660 kV. The result of voltage indicator tested at 30 kV AC given, 3 pieces rubber ring is lost dielectric in wet condition.

Like as shown di Figure 1, the length of the shaft is variability, that out of the three shaft, one stalk has the smallest length of 123.5 cm. Thus the grounding shaft is qualified to keep the distance between the worker and the active part of the 15 kV phase to the ground with a distance of 90 cm (Manik et. al., 2015). Medium voltage distribution system in Indonesia more lower only 11.6 KV from phase to ground.

3.2 Discussion

Based on the trial results it can be observed that work safety grounding for medium voltage distribution systems with A3CS cable, has been able to pierce A3CS cable insulation to make a contact between the clamp head and A3CS cable. Clamp heads also have been trial to installed on A3C conductors. when installed on the A3C conductor and A3CS cable AVO Meter pointing to limit zero number.

Based on table 1 can be seen the maximum value of leakage current is not more than 1 ampere and minimum insulation resistance of grounding shaft is not less than 100 Mega Ohm. The discussion can proceed to the data shown in table 2. Based on table 2 can be seen the maximum value of leakage current and minimum insulation resistance of grounding shaft. Table 2 shows the minimum insulation resistance occurs when the wet condition of shaft is 1.67 Giga Ohms and that the maximum value of leakage current is 6 micro amperes. The benchmark of minimum insulation for medium voltage is 100 Mega Ohms (Sanjay et. al., 2018). The benchmark of maximum leakage current flow does not affect a shock to the human body is 1 milli amperes (Kumail et. al., 2018).

Based on the results of the analysis of safe distance obtained two values to assessment the feasibility of the safety grounding shaft, namely: the value of the dielectric strength and the distance of the worker with an active part with potential voltage discharge. The analysis founded that the safety grounding shaft has dielectric strength of 660 kV, and provides safe distance between the worker and the active part of 123.5 cm. The benchmark of total the dielectric strength must exceed than the active voltage to avoid the electric discharge (Kumail et. al., 2018). The benchmark of the minimum safe distance between workers and 15 kV active equipment is 90 cm (Manik et. al., 2015)

4 CONCLUSIONS AND SUGGESTIONS

4.1 Conclusions

Based on the results of the research and discussion, conclusions can be drawn as described. Safety grounding tools for medium voltage distribution systems with A3CS cables is appropriate. This eligibility are determined based on good connection capability, leakage current, insulation resistance, dielectric strength and safety distance. The results show that it exceeds the requirements specified in the benchmark. Its connection capability is limit to zero, the insulation value is more than 100 Ohms, the leakage current is a lower than 1 milliampere, with dielectric strength more than 11.6 kV, and more than 90 cm of the distance of the workers to the active parts, to make the system in safe condition.

4.2 Suggestions

Based on the results of this study, there are many suggestions as describe: PLN must requires the vendors to prepare this "electrical safety grounding for medium voltage distribution with A3CS cables. This is a very important thing to electric work safety of the workers, which has an impact on providing benefits to both PLN and the vendors. This research is not finish yet. because this research was carried out in an covid19 pandemic situation, so the research was carried out not by measuring instruments that met laboratory standards. The next researcher could continue this research in the laboratory.

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