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by Wayan Jondra

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Insulation resistance and breakdown voltage analysis for insulator cover type YSL-70AP

I W Jondra¹, I G S Widharma¹, I N Sunaya¹

¹ Department of Electrical Engineering, Politeknik Negeri Bali, Kampus Bukit Jimbaran, Bali, Indonesia

E-mail: wjondra@pnb.ac.id

Abstract. Electrical energy has become a primary necessity, for every human around the world in globalization era. Electrical energy very important in every human activity to supporting the economy. Currently requires reliable of electrical distribution energy. Reliability of electrical energy supply is measured by the low value of SAIDI and SAIFI. Most of the PLN APJ has not able to fulfil SAIDI and SAIFI targeted by SPLN. There are 54 percent medium voltage disorder due to temporary interference. These disorders are caused by trees, animals and birds. insulator cover applied to reduce temporary interference. The problem is no research explaining the isolation quality and voltage breakdown capacity. This research conducted by quantitative testing and analysis. It was finding that the insulator cover type YSL-70-AP is reliable to reduce temporary disorder and environmentally with consideration: (a) The insulation value is 278.80 Mega Ohm, so that the electrical current of phase-ground fault is only 41.61 micro Ampere, just 0.36 percent of maximum limitation of PLN standard; (b) The voltage breakdown capacity is 49.63 Volt, more than 207 percent of minimum limitation of PLN standard. The voltage breakdown capacity can be increase by wings extension.

1. Introduction

1.1. Problems background

In this globalisation era, electrical energy has become a primary need in the world. Electricity is very important component of human activity [1]. Global electricity consumption has continued to go up faster than energy consumption [2]. Electricity consumption occupied by residential to reach its highest point in China [3]. The world economy movement is strongly influenced by the availability of electrical energy. There will be several problems in human life without electrical energy.

The electrical energy supply system consists of several parts, such as, power plants, substations, transmission, distribution and distribution substations. These part should be reliable in handling problems in electrical system. This reliable system is designed to guarantee the continuously of standard electrical energy availability. The system should meet the standard of reliability and security operation, consumer rights protection and the National Electricity Company (PLN) benefit. Electricity System reliability measured by the lower of SAIDI and SAIFI value [4].

Security is very important in the electrical energy distribution. The green electrical energy distribution system securely to the humans, environment, animals and plants. There were many electrical black out caused by animal and tree disorders [5]. This will disrupt the green electrical energy distribution, because animals die after electrical discharge.



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The reliability electrical energy index occurs which has a SAIFI is not more than 2.415 numbers of failure/customer/year and the SAIDI is not more than 12.842 hours of failure/customer /year standard issued by PT. PLN (Persero) in SPLN 59:1985 [6]. Blackout of medium voltage open air circuit distribution system, 61.36% due to the relay execution without exactly interference so the circuit breaker connected again. The disturbance like this is a temporary disturbance. To reduce this disturbance, the electrical distribution system must insulate from the ground.

The good electrical insulation for medium voltage performance is more than 100 mega Ohm [7]. Based on this, insulator cover must have insulation resistance more than 100 mega Ohm. Material formulation is most importance for insulator production. The problem is, material with a good electrical specification.

Thermoplastic elastomeric (TPE) materials is a good performance insulation to use in outdoor electrical insulation [8]. Insulator cover also produced by thermoplastic material. Insulator cover is produced by polyvinyl chloride (PVC). But the output insulator process influences by the production process. The performance of an insulating material is strongly influenced by high oxidation, voids, and a mixture of non-homogeneous materials [9]. To find out the performance of the insulator cap, this research is very important.

1.2. Problem

In this paper, some problems such as the insulator cover type YSL-70AP insulation resistance, breakdown voltage of the insulator cover type YSL-70AP, and the preferable of the insulator cover type YSL-70AP to applied in the 20 KV system, were investigated.

2. Research method

2.1. Research approaches and concepts

This research is quantitative research. The formulation of these problems will be discussed by samples testing of Insulator Cover type: YSL-70 AP at the high voltage laboratory of Malang Brawijaya University. The test results will be analysed statistically and mathematically to obtain resistance and breakdown voltage, comparing to the standard, and then taken conclusions and recommendations.

2.2. Total sample

This research was conducted by testing three samples that was taken randomly from PT. Adi Putra warehouse.

2.3. Variable operational definition

In this study, the observed magnitude of the test voltage, leakage current and the amount of breakdown voltage. The test voltage is the amount of voltage applied to the sample through the test transformer. Leakage current is the amount of current flowing in to the test sample, due to given test voltage. The breakdown voltage is the amount of voltage which results in failure of the insulating function of the insulator cover.

2.4. Tested

Electrical test voltage against minimal insulation is tested with a voltage equal to the operating voltage. For testing a minimum 20 KV system equipment is tested with a test voltage of 20 KV. Tests are carried out using step-up transformers, volt meters and ampere meters. To secure the ampere meter, the ampere meter is connected in parallel with the spark gap. All equipment connected with grounding system. Tested are made between phase and neutral.

For current leakage tested, each test sample (insulator cover) is placed between the electrodes of the AAAC conductor, the first electrode is given a 50 Hz AC voltage and the second electrode is grounded through ampere meter. The voltage at the first electrode is increased step by step from 5 KV until 25 KV.

Every voltage step, current leakage flow was measured with ampere meter. That current leakage tested process are three times reply.

For breakdown voltage tested, each test sample (insulator cover) is placed between the electrodes of the AAAC conductor, the first electrode is given a 50 Hz AC voltage and the second electrode is grounded directly. The voltage at the first electrode is increased step by step until the beginning of the corona, until a breakdown and this voltage is recorded as a breakdown voltage. The flashover model is based on evaluating surface resistance under wet conditions [10], but this sample tested under clean conditions.

2.5. Data analysis

Data obtained from the test results are processed quantitatively. To obtain the value of the resistance result by the value of the test voltage divided by the leakage current. The average value is all resistance results are summed, then divided by the amount of data.

To obtain the value of the breakdown voltage, it is done by summing the value of the breakdown voltage measurement divided by the amount of data. In this way, the insulator breakdown voltage rate obtained.

3. Results and discussion

In accordance to the function, a perfect insulating material is a material with unlimited resistance. In accordance to the function, a perfect insulating material is a material with unlimited resistance. But in reality no once material be obtained. Although small current, all electrical insulating materials flowed by electricity current. That is leakage current trough insulation material. This problem justify that the resistance of insulating material is not unlimited. The value of insulation material resistance according to Ohm's Law is voltage divided by leakage current [11] as Equation (1).

$$R = \frac{V}{I} \quad (1)$$

remark:

R = Insulating Resistance (MΩ)

V = Voltage charge due the sample (K V)

I = Leakage Current (μA)

3.1. Results

The result of this research described by figure and table. The data collected by measured voltage between conductor and electrode test, and current leakage trough conductor-sample-electrode test-ampere meter, like describe at Figure 1. Voltage breakdown test just measured voltage between conductor and electrode test, and without ampere meter to measure the current.

Voltage breakdown test leaved a mark, like marks in the red rounded rectangle in Figure 2. This mark is the flash over from conductor to electrode test. The voltage value to charge at flash over discharge is noted voltage breakdown.

Data noted from value displayed at measuring equipment like voltmeter and ampere meter. The data analysed by formula:

$$R=V/I = 5.28/16.82 =316.18M\Omega$$



Figure 1. These electrode connected.



Figure 2. Breakdown voltage gate.

The other data analysed with the same role. The data and output analysis is described at the Table 1.

Table 1. Data and analysis insulation resistance of insulator cover type : YSL-70 AP.

Voltage (kV)	Leakage Current (μ A)	Resistance (M Ω)
5.28	16.82	316.18
10.46	34.26	307.59
15.02	52.42	291.53
19.77	78.39	261.95
25.24	118.51	216.77
Temperature ($^{\circ}$ C)		25.03
Humidity		76%
Pressure (mBAR)		955.00
Voltage corona (kV)		24.00
Voltage Breakdown (kV)		49.63
Average resistance (Ω)		278.80

3.2. Discussions

Based on Table 1, the value of insulation resistance of the insulator cover is obtained as follows: 316.18; 307.59; 291.53; 261.95; 216.77 M Ω . The average results are 278.80 M Ω . If installed on 20 KV system, the voltage phase to ground is equal to 11.6 KV. When there is a ground fault disturbance by temporary interference, the ground fault current is 41.61 μ A. The interference current is 41.61 μ A, only 0.36% from the allowable maximum leakage current its mean $1,000 \mu\text{A}/\text{KV} \times 11.6 \text{KV} = 11,600 \mu\text{A}$.

Based on Table 1, the breakdown voltage of 49.63 KV is obtained. Resistance to breakdown of 49.63 KV is equal to 207% higher than that specified in SPLN 1: 1995. If seen from Figure 1 (a), the breakdown voltage appears on the surface of the insulation. So if a higher breakdown voltage is needed, the insulator cover type: YSL-70AP need modification. modification can be done by adding wings, so that the creepage distance more longer. This long line will increase the breakdown voltage of insulator cove type: YSL-70AP.

4. Conclusions and suggestions

4.1. Conclusions

Based on the results of the research and discussion, conclusions can be drawn as described. The insulation resistance of insulator cover type: YSL-70AP is 278.80 M Ω . Insulator cover type: YSL-70AP based on Polyvinyl chloride (PVC) material. The breakdown voltage of insulator cover type: YSL-70AP is 49.63 KV. Insulator cover type: YSL-70AP is reliable to cover the pin post insulator on 20KV in electrical distribution system, because: (a) The fault current is only 0.36% under the maximum allowable leakage current (11,600 μ A) which is 41.61 μ A; and (b) Breakdown voltage is 207% higher than minimum that specified, which is 49.63 KV. Polyvinyl chloride (PVC) is conventional medium voltage insulation category [12].

4.2. Suggestions

Based on the results of this study, there are many suggestions as describe: PLN must utilize Insulator cover type: YSL-70 AP optimally, because the results of this study indicate the performance is over than standardization [13]. This insulator cover can protect again tree and animal disturbance. Tree disturbance is the problem of equipment outage [14]. If it is deemed to increase the isolation resistance of this insulator cover, it is need some modification, so that improve the safety to install insulator cover. For further researchers, further research needs to be done, the performance of insulator cover after the breakdown voltage.

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