

Performance Investigation of Polymer Isolator on Non-Soluble Pollutant of Distribution Sub Station

Sonong¹, A. M. Shiddiq Yunus², Herman Nawir³, Muhammad Ruswandi Djalal⁴
{sonong@poliupg.ac.id¹, shiddiq@poliupg.ac.id², herman.nawir@poliupg.ac.id³, wandi@poliupg.ac.id⁴}

^{1,2}Energy Conversion Study Program, Department of Mechanical Engineering, Politeknik Negeri Ujung Pandang, Indonesia. 90245

^{3,4}Power Generation Engineering Study Program, Department of Mechanical Engineering, Politeknik Negeri Ujung Pandang, Indonesia. 90245

Abstract. Isolator has an important role as a separator of lived voltage system with unlived voltage system in distribution and transmission line. It is also used as wire support in distribution and transmission line. The main usual problem in an isolator is the pollutant layer on the isolator surface. The pollutant layer on the isolator surface could lead to breakdown voltage that might harm the electrical systems and human being. The polluted isolator can be conducted by Equivalent Salt Deposit Density (ESDD) and Non-Soluble Deposit Density (NSDD). The NSDD is material that capable of absorbing water and binding the salt pollutant on the isolator surface, this could prevent the maximum natural cleaning process during rainy session.

Keywords: Breakdown Voltage, ESDD, NSDD, Pollutant.

1 Introduction

Transmission and distribution lines are two important parts in delivery electric power from power plants to the consumers. Therefore, it is important to maintain their reliability to guarantee the continuity of power supply [1]-[3]. It is inevitable that a healthy transmission line should be maintained properly based on the surrounding condition such as the influence of nearby cement industry, close to a beach, forest, etc. Moreover, to support the reliability of smart grid system, where renewable based power plants are involved such as wind and PV [4]-[6], a connected transmission line must be always in robust condition [7].

One important part of the transmission and distribution line is isolator. An isolator is used to separate the lived voltage system with the non-lived one. For the last decades, polymer isolator type has been popular to be used in transmission and distribution line due to its some advantages including hydrophobic characteristic, better thermal and dielectric characteristic, lighter, mechanically stronger than ceramic and glass types [8]-[10]. However, it is vulnerable to environmental impacts such as UV radiation, temperature, humidity, rain, and high pollution, etc [11], [12].

The main problem that usually occurs on isolator is the pollutant layer that might cover the isolator surface. This pollutant might cause current leakage and breakdown voltage. Compared to soluble pollutant, non-soluble pollutant could absorb water and bind the salt on the isolator surface. This condition cause the natural clean of rain does not use to clean the pollutant on the isolator surface [13]-[15].

The level of pollution can be categorized as shown in Table 1.

Table 1. Level of Pollution

Pollution Level	Example and Environment Characteristic
Light	<ul style="list-style-type: none"> • Non-Industrial Place with a low density of residential houses • Agriculture Varsity • Mountain Varsity
Medium	<ul style="list-style-type: none"> • Medium industrial activity with low pollution • The high industrial and residential density with high wind and rain
Heavy	<ul style="list-style-type: none"> • The very high density of industrial activities • Large place but very close to a beach • Desert place with very low rainy session

2 Research Methodology

In this paper, there is three analysis are employed; chemical analysis, physics analysis, and electrical analysis. The polymer isolator 2.0 kV is taken from two places; 1) cement industry close to a mountain, 2) polymer isolator at the sub-station close to a beach which is very vulnerable with the non-soluble pollutant. The research steps are as follows:

- a. Checking Chemical Composition on The Pollutant
To obtain the chemical compound of the pollutant, An Atomic Absorption Spectroscopy (AAS) is used.
- b. Conductivity Measurement of The Pollutant
To measure the conductivity, TDScan IV is employed. This device has a resolution of 0.1 mS with an error margin of 2%. This device is equipped with Automatic Temperature Compensation (ATC), therefore obtained data does not require to be re-converted.

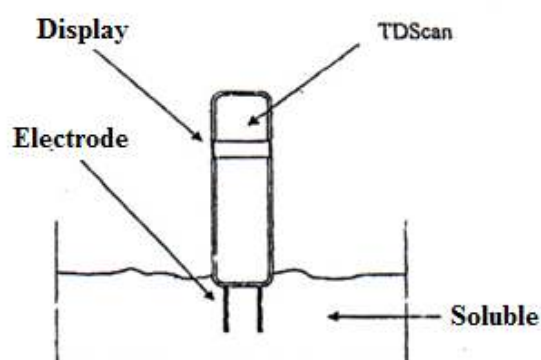


Fig. 1. A typical system of TDScan IV

To obtain an accurate conductivity result, mineral water is used where its conductivity is 0.2 $\mu\text{S}/\text{cm}$.

c. Physical Measurement (Contact Angle) and Analysis.

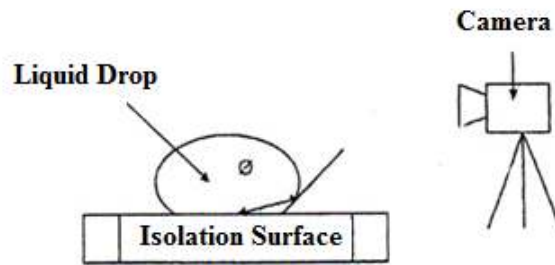


Fig. 2. Contact Angle Measurement Scheme

d. Electrical Characteristic Measurement and Analysis

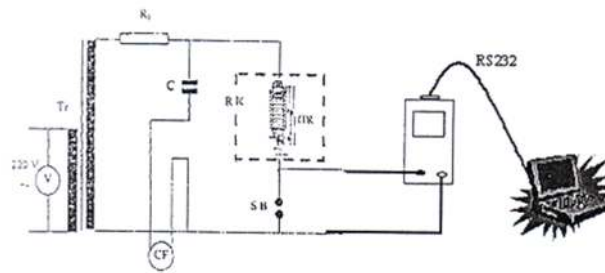


Fig. 3. Test Configuration of Conductivity Measurement

Legend of Fig. 3 as follows:

- Tr : High voltage transformer, 220 V/100 kV
- C : High voltage capacitor, 100 pF
- CF : Peak voltage measurement of Chubb & Fortescue
- SB : Ball gaps, distance: 1 cm
- R₁ : short circuit transformer protection, 10 M ohm
- μA : micro amperemeter connected to a computer
- RK : fog room equipped with steam injection
- ITR : Tested isolator, polymer, and PIN Post 20 kV.

e. Voltage Characteristic Measurement and Analysis

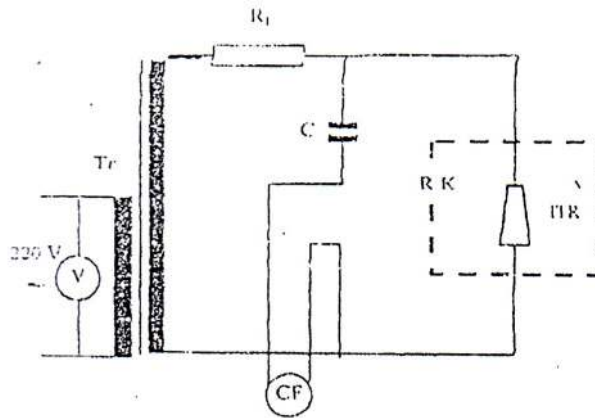


Fig. 4. Test Configuration of Breakdown Voltage

Legend of Fig. 4 as follows:

- Tr : High voltage transformer, 220 V/100 kV
- C : High voltage capacitor, 100 pF
- CF : Peak voltage measurement of Chubb & Fortescue
- R₁ : short circuit transformer protection, 10 M ohm
- ITR : Tested isolator, polymer, and PIN Post 27 kV

3 Results and Discussion

3.1 Chemical Compound

Table 2 shows the composition of the pollutant of sub-station isolator. The sub-station isolator sample is taken from sub-station PT. Semen Tonasa, located at South Sulawesi, Indonesia.

Table 2. Chemical Compound Contents of Pollutant

Compound	Example and Environment Characteristic	
	Sub-Station Isolator	Kaolin
Sulfur (S)	0.007	0.002
Seng (Zn)	0.01	0.01
Natrium (Na)	0.15	0.43
Fosfor (P)	0.309	0.309
Aluminum (Al)	3.62	4.56
Besi (Fe)	0.41	0.001
Kalsium (Ca)	0.26	9.41
Silicon (Si)	0.102	0.002

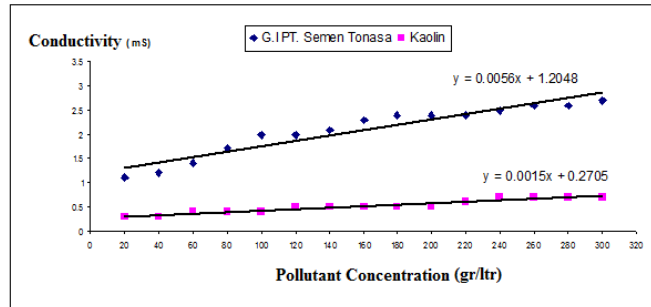


Fig. 5. Comparison results of conductivity level of both tested isolators

As can be seen in Fig. 5, conductivity value of pollutant from Sub Station Semen Tonasa is larger than Kaolin pollutant comparator. It shows that the level of pollutant surrounding sub-station Semen Tonasa is in the alert level for workers.

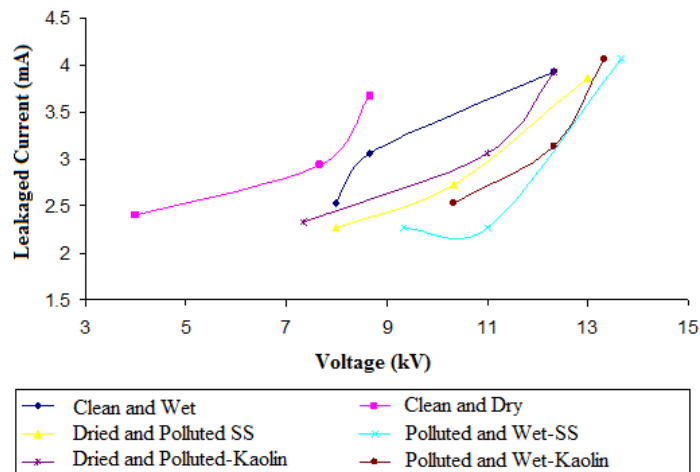


Fig. 6. Comparison of polymer isolator in several conditions
(Note: SS stands for Sub-Station of Semen Tonasa)

Figure 6 exhibits the comparison graph of various condition applied to Polymer Isolator for both isolator SS-Semen Tonasa and Kaolin. Clean and Dry condition giving information that with a small increase of applied voltage (kV), it will cause a significant leakage current. Meanwhile, the condition of all dried and polluted of SS and Kaolin are similar where larger leakage current is achieved in between 7-13 kV. Condition of polluted and wet of SS gives more leakage current after tested with almost 14 kV.

4 Conclusion

From obtained results of all physical and chemical tests, it can be draw conclusion that:

1. The conductivity of polymer isolator from sub-station (SS) PT. Semen Tonasa is larger than the Kaolin due to the conductivity contents of pollutant surrounding substation of PT. Semen Tonasa is larger than Kaolin.

2. Leakage current is larger in wet condition compared to the dried one, as a soluble pollutant in wet condition is much more conductive than the dried condition
3. It is important to regularly check and re-clean the potentially polluted polymer around substation PT. Semen Tonasa to avoid any large leakage current that might damage the substation facilities and harm human life.

Acknowledgments

Authors would like to thanks Politeknik Negeri Ujung Pandang to support this research.

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