MECOMARE, 13 (4x) (2024) pp. 119-126

Published by: TRIGIN Publisher

International Journal of Mechanical Computational and Manufacturing Research

Journal homepage: www.trigin.pelnus.ac.id

Lightning arrester aging rate due to contamination by soluble pollutants

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ARTICLEINFO

Article history:

Received,23 January 2024
Revised,02 February 2024
Accepted, 29 January 2024

Keywords:

Lightning Arrester;
Degradation;
Pollutant;
Contamination;
Leakage Current.

ABSTRACT

The leakage current in the lightning arrester can be used as an indicator to determine the aging level of the arrester. Leakage current is influenced by contaminants in the arrester insulation. This research analyzes the effect of soluble contamination on the internal and external leakage current of lightning arresters as an indicator of arrester degradation. The contaminant used is NaCl (Sodium Chloride) which is dissolved in water, and a ZnO type lighting arrester to determine the level of NaCl contamination, the ESDD (Equivalent Salt Deposit Density) method is used. Lightning arresters that have been contaminated are measured for internal and external leakage currents flowing through the arrester insulation. Based on the experiments that have been carried out, the increase in leakage current in the internal lightning arrester for light, medium and heavy levels of contamination increases by an average of 30% for all test voltages. When compared with the international standard IEC 61643-1 which is determined at 1 mA, the internal leakage current value for light, medium and heavy pollution of the ZnO type Lightning arrester still meets the standard. However, if you use the PLN testing standard, namely 150 µA, the internal leakage current value for light, medium and heavy pollution of the ZnO type Lightning arrester does not meet the standard. Meanwhile, with low and medium contamination, there is no leakage current that occurs on the external part of the Lightning arrester. significant change.

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1. INTRODUCTION

A lightning arrester is a component of electrical equipment that plays an important role in the distribution of electrical energy, namely as a protective device against voltage surges, which functions to protect electrical equipment by limiting incoming overvoltage surges and channeling them to the ground.(Tobing, 2003)The resistance of this arrester will become very small when there is overvoltage due to a lightning strike or electrical connection. At that time the arrester acts as a conductor that carries excess current to the ground. And when the overvoltage disturbance ends, the arrester function will return to normal(Aprianto, 2012)If the voltage that an arrester must withstand exceeds the arrester's capacity, a current flow will occur which is called a leakage current. The generation of leakage current is initiated by the conductive layer on the surface of the arrester body(Purba, 2016)The dielectric ability of an insulating material is influenced by the level of contaminants and the surface condition of the insulator(Jumari, 2020).The heavier the level of contaminants will greatly affect the electric field value on the insulator itself. The electric field value will also change if there is damage or there is an air cavity on the surface of the insulator(UYDUR et al., 2018). Several studies have analyzed the electric field distribution and leakage current of Lightning Arresters(Anwar et al., 2019; Novizon et al., 2020; Okto Hendri Gunawan, 2021; Wahyu Ramadhani et al., 2022). The leakage current in the insulator is influenced by the presence of conductive parts on the insulator surface(Dhofir et al., 2017) Leakage current caused by a layer of pollutants on the surface of the insulator causes heating of the insulator(Hussain et al., 2015)sThe greater the ESDD value, the greater the leakage current(State et al., 2021)

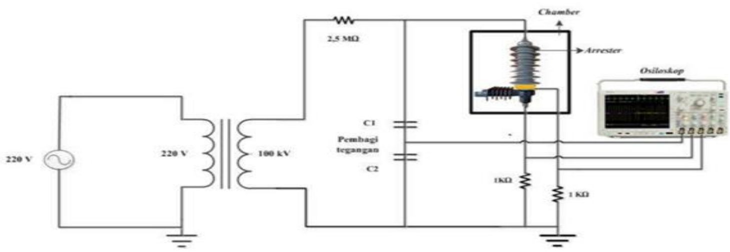
2. RESEARCH METHOD

The research was conducted at the High Voltage Engineering Laboratory in August and November 2021. This research will be analyzed descriptively. using direct measurement methods. In this research, the ESDD method was used to determine the level of pollution. Determination of the level of insulator pollution using the ESDD method based on the IEC 60815-1 standard is presented in Table 1(International Standard IEC 60851-1, 2008)and the tools used are HV Transformer (Test Transformer), Capacitor, Voltmeter, Multimeter, Spray Equipment, Digital Scales. The materials used are Lightning Arrester type ZnO and NaCL. The type of insulator for the Lightning arrester used is polymer and the pollutant used is NaCl which is a soluble pollutant. Polymer insulators have hydrophobic characteristics which make the insulator's performance superior in polluted environmental conditions compared to insulators made from different materials.(Gutman & Dernfalk, 2010; Han-Goo Cho et al., nd)The level of contamination or fouling is determined manually by mixing NaCl into the water solution. Spraying method is carried out according to IEC 507 standard(International Standard IEC 507, 1991)

Table1. Pollution Level based on ESDD value

No	ESDD (mg/cm2)	Pollution Levels
1	0 – 0.03	Very Light
2	0.03 – 0.06	Light
3	0.06 – 0.1	Currently
4	> 0.1	Heavy

The experimental series to determine the arrester leakage current can be seen in Figure 1. The arrester is connected to an alternating high voltage generator circuit. The voltage input to the arrester is measured using a capacitor divider



Figures1.Test Suite

Table 2.Internal Leakage Current and External Leakage Current of Lightning Arrester

Test Voltage (kV)	Leakage current in blocks (µA)			Leakage current on insulation (µA)		
	Light	Currently	Heavy	Light	Currently	Heavy
14	217.3	282.7	339.4	6.3	6.4	7.9
18	280.1	356.5	424.8	7	7.7	10.4
20	315.6	387.8	455.1	7.5	7.8	11.3
22	373.1	424.7	494.6	7.7	8.8	11.9
24	404.9	449.1	525.3	7.8	9	13.8

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3. RESULTS AND DISCUSSIONS

The levels of light, medium and heavy contamination can be seen in Figure 2 below:

(a) (b) (c)

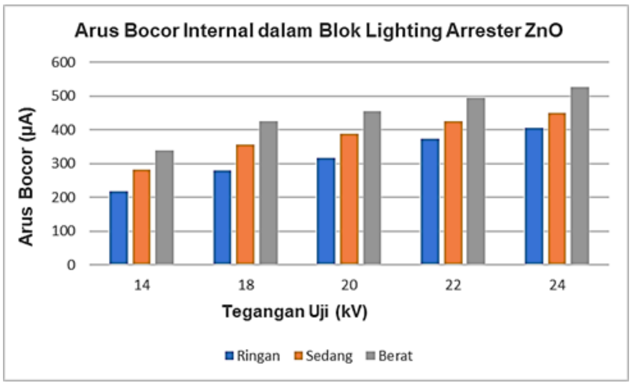
Figures 2. Level of arrester contamination, (a) light (b) moderate and (c) heavy

For light types of contamination, it is made by mixing 30 grams of NaCl with 150 ml of aqua distillation. So that contaminants can stick to the Lightning arrester body, the pollutant solution is sprayed on the Lightning arrester body and then left for 10 minutes. After that, the arrester is dried for ± 24 hours in a room for drying

For moderate levels of contamination/fouling, 150 ml of aqua distillation is mixed with 59 gr of NaCl. So that contaminants/pollutants can stick to the arrester body, the pollutant solution is sprayed onto the Lightning body and left for 10 minutes. After that, the Lightning arrester is dried for ± 24 hours in a room for drying.

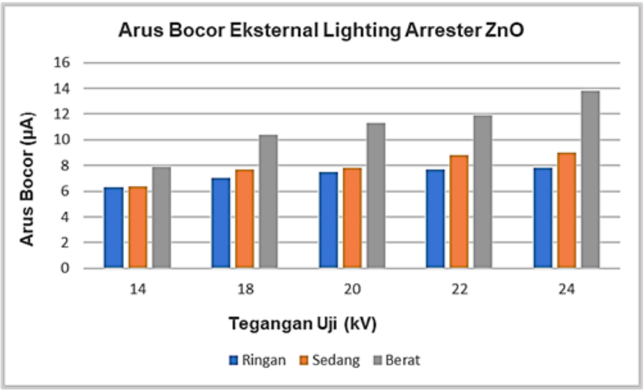
Next, heavier types of contaminants/foulings are made by adding 196 grams of NaCl to 150 ml of aqua distillation. To attach contaminants/pollutants to the arrester body, it is the same as the previous process, namely using the same process, the pollutant solution is sprayed onto the Lightning arrester body and left for 10 minutes, then dried for ± 24 hours in a room.

Based on the test results in Table 1, internal and external leakage current test results. As a result of the research, a bar diagram of the leakage current occurring inside the Lightning arrester block (internal leakage current) and a bar diagram of the leakage current on the Lightning arrester insulation surface (external leakage current) were created as follows:



Figures 3. Internal leakage current bar diagram

The internal leakage current value of the Lightning arrester based on the concentration of light pollutants is at a value of 217.3 µA – 404.9 µA, then the concentration of medium pollutants is at a value of 282.7 µA – 449.1 µA and the concentration of heavy pollutants is at a value of 339.4 µA – 525.3 µA. Next, the leakage current bar diagram on the Lightning arrester insulation surface (external leakage current) is shown in Figure 4. External leakage current bar diagram.



Figures 4. External leakage current bar diagram

The internal leakage current value of the Lightning arrester based on the concentration of light pollutants is at a value of 6.3 µA – 7.8 µA, then the concentration of medium pollutants is at a value of 6.4 µA – 9 µA and the concentration of heavy pollutants is at a value of 7.9 µA – 13 .8 µA. Leakage currents inside the block and on the surface of the lightning rod insulation were evaluated at voltages of 14 kV, 18 kV, 20 kV, 22 kV, and 24 kV in situations of light, medium, and high pollutant contamination (Figure 3 and Figure 4).

The two figures shown above (Figure 3 and Figure 4) show that the internal leakage current inside the Lightning arrester block and the external leakage current on the insulator surface increase as the applied voltage increases. At low, medium and high concentrations of pollutant solutions, this applies across the board. Table 1 shows the comparison results of internal leakage current with external leakage current in three test conditions for low, medium and heavy pollutant concentrations. Leakage current increased by an average of 30% for all test voltages for low, medium, and high contamination levels. When compared with the international standard IEC 61643-1 which is determined at 1 mA, the internal leakage current value for light, medium and heavy pollution of the ZnO type Lightning arrester still meets the standard. However, if you use the PLN testing standard, namely 150 µA, the internal leakage current value for light, medium and heavy pollution of the ZnO type Lightning arrester does not meet the standard.

This is caused by the heat generated due to sinusoidal voltage stress on the Lightning arrester which cannot be released completely through the Lightning arrester's polymer insulation because it is covered by kaolin pollutant contamination. Heat that cannot be vented out will result in an increase in temperature in the Lightning arrester block so that the leakage current from within the Lightning arrester block becomes high

4. CONCLUSION

Based on the test results, the amount of internal leakage current in the Lightning Arrester block element is influenced by the amount of NaCl pollutant. The highest leakage current occurs in conditions of heavy pollutant contamination at a voltage of 24 kV where the internal leakage current value is 525.3 µA and the external leakage current value is 13.8 µA and this can affect the life of the Lightning arrester.

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