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Analysis Of Testing On Circuit Breaker Bay 7AB3 Gistet Adipala In The Framework Of Biennial Maintenance

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ABSTRACT

Power Breaker (PMT) is a switch that is used to connect or disconnect electrical power in normal conditions or in abnormal conditions or disturbances. To always maintain the reliability of the PMT, regular maintenance needs to be carried out. This writing aims to identify the working principles of the PMT bay 7AB3, what tests are carried out on the PMT and identify the reliability and suitability of the Power Breaker (PMT). In this writing analysis, data from Power Breaker Maintenance (PMT) results during the 2 (two) yearly maintenance period for 2022 are used and compared with the minimum standards set. The results of the analysis state that in testing the grounding resistance for the R, S, T phases is 0.5Ω; 0.4Ω; 0.7Ω and the difference in simultaneous resistance time for open time condition 1 is 0.9 ms, open time condition 2 is 0.65 ms and closing time condition is 2.15 ms. In the contact resistance test, the value for phase R was 39.1 μΩ; S phase of 36.7 μΩ; phase T is 20.7 μΩ where this value is in accordance with the permitted standard, namely.

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1. INTRODUCTION

Electricity is one of the essential basic needs in contemporary human life; almost all human activities are related to electrical energy. With the economic growth and population increase in Indonesia, the demand for electricity is rising[1]. Therefore, various efforts are made by the government to ensure the ability to meet the public's electricity needs. One of them is by enhancing reliability in the infrastructure and equipment of the electricity system, from generation to distribution, through regular operations and maintenance[2].

The network system consists of generating units and distribution units in the form of electrical equipment installed in substations, both in main substations and distribution substations, operated both automatically and manually. Its activities include the regulation, division, transfer, and distribution of electrical energy from the power generation center to consumers effectively, ensuring the continuity of distribution and service[3].

High voltage electrical equipment that plays a crucial role in the power system is Gas Insulated Switchgear (GIS). GIS serves as a connection between the generation system and the PLN transmission system. Additionally, GIS functions as a high voltage switch. It contains SF6

gas as its insulation, which is the most effective insulation gas compared to others. SF6 gas has a breakdown strength three times that of air, approximately 89 kV/cm[4]. Nowadays, GIS is commonly used in substations, and using GIS allows for a reduced spacing between phase conductors in a substation compared to air insulation. This is particularly advantageous, especially in urban areas where land area is a critical consideration. One of the GIS units under the jurisdiction of the Transmisi Unit (Transmission Unit) in Purwokerto is located in Cilacap Regency, namely the GISTET 500 KV Adipala. The power supply is transmitted by PLTU Jawa Tengah 2 Adipala with a capacity of 1 X 660 MW and PLTU S2P to be transmitted to GITET Kesugihan[5].

Power Breaker (PMT) is a switch component or mechanical switch that can close or open, as well as interrupt the flow of current under normal conditions according to its rating. It can also open and disconnect the load current in abnormal conditions or constraints according to its rating (IEEE C37.100:1992)[6]. If the Circuit Breaker does not function when needed due to a disturbance, it can result in damage to other equipment[7,8]. Maintenance of the Circuit Breaker is carried out by conducting tests on grounding resistance, contact resistance, and the alignment of Circuit Breaker contacts. The purpose of these tests is to assess the condition of the Circuit Breaker, thereby preventing damage to equipment and avoiding unplanned power outages[9]. Grounding resistance testing is necessary to assess the terminal resistance point to the ground; a lower value is considered favorable. Evaluating the load resistance of the Circuit Breaker helps determine the amount of leakage current between the voltage capacitors and the ground. Capacity insulation testing is essential to check if the insulation capacity is within the normal threshold, preventing current flow to other phase terminals due to low insulation capacity. Connection capacity experiments are conducted to identify technical faults caused by advanced points. The goal is to minimize connection capacity to reduce wasted energy. Alignment testing of the Circuit Breaker aims to observe the independent operation time and alignment during blocking or stripping. This testing is done to conclude the suitability of the 7AB3 GISTET Adipala Circuit Breaker after a two-year maintenance analysis. It serves as a reference for continuous maintenance control on the ability of the Circuit Breaker, considering the minimum standard values set by PLN.

2. METHOD

2.1. Single Line Diagram Adipala 500KV

Using a double busbar system serves as a backup and enhances the reliability of the power system. This way, maintenance at the main substation does not disrupt the overall system. The GISTET Adipala 500 kV comprises 8 (eight) bays, with each bay consisting of various substation equipment components such as Wave trap, Disconnecting Earthing Switch, DS Line, Current Transformer, Circuit Breaker, and DS BUS. The single-line diagram of GISTET Adipala 500 kV is illustrated in Figure 2.1.

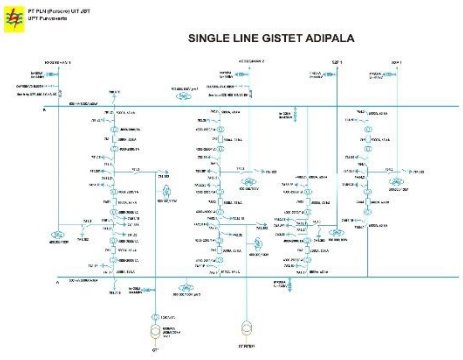

Figure 2.1. Single Line Diagram Gistet Adipala

2.2. Power Breaker (PMT)

According to the International Electrotechnical Vocabulary, a Circuit Breaker,is a mechanical switch component that can close or open and block the flow of current under normal conditions according to its rating. It can also close, open, and disconnect the load current in abnormal conditions or constraints according to its rating.

On the other hand, the definition of PMT from IEEE C37.100:1992 describes it as a mechanical switch component that can close, distribute, and interrupt the flow of current in good conditions according to its rating. It is capable of blocking, distributing (at a specific time), and closing the flow of current under certain obstacle conditions, similar to its rating.

Due to its importance, it serves as a vital component in either renewing or ending an electrical circuit in loaded conditions. It can release or block the flow of current when there is a disturbance in the line or other equipment.

2.3. Gas Insulated Switchgear

GIS (Gas Insulated Switchgear) in construction is built with a metal enclosure system and consists of conductive parts grounded and supported by epoxy-resin insulator components. These conductors and insulators are placed inside the metal enclosure filled with SF6 gas. GIS utilizes SF6 gas as both an insulation medium and an arc quenching agent at pressures of 2 (two) or 3 (three) atmospheres.

GIS is a substation division using gas insulation. Depending on its placement, GIS is positioned in densely populated areas such as cities due to its smaller footprint, compared to conventional substations. GIS can be installed both indoors and outdoors.

GIS is increasingly chosen and utilized due to challenges related to limited land availability and high land prices, especially in large cities. Currently, GIS is favored as it can address several issues that cannot be resolved by AIS (Air Insulated Substation). The dominant factors influencing the growth of GIS include:

a) Increasing land prices and very limited land availability, coupled with a continuous demand for electrical power, especially in densely populated urban areas.
b) The environmental impact caused by conventional substations, leading to growing complaints from residents.
c) The tendency for high pollution levels in densely populated areas, resulting in potential contamination issues with installed insulators and equipment.

These factors highlight GIS as a viable solution for urban areas where land is scarce and expensive, and environmental concerns play a significant role in decision-making.

2.4. SF6 Gas Maintenance

In the maintenance of GIS, preventive maintenance is carried out with the aim of preventing damage and improving the equipment's condition to meet standards. In performing Switchgear equipment maintenance, coordination between maintenance personnel and officers at GISTET Adipala is crucial to avoid procedural errors. After coordination, the next step is to check and record the types and models of equipment to be maintained. If there are replacements or repairs, proper documentation facilitates easy identification.

Subsequently, the condition of the equipment is checked. If the equipment is in a ready condition, maintenance proceeds, including sterilization from contaminants such as dust and oil that may hinder smooth operation. Next, testing is conducted, covering resistance contact testing, insulation resistance testing, grounding resistance testing, and alignment testing. After all the tested equipment is ready, maintenance undergoes operational testing. In this operational testing, the functionality of the equipment is assessed. If it does not function properly, the testing is promptly stopped, and a recheck is performed.

If the testing results meet the established standards, a final check is conducted to ensure that the obtained values align with the predefined standards before the equipment can be put into operation.

2.5. Testing Step

Contact resistance refers to the connections on the main contacts of Circuit Breakers (PMT), Disconnecting Earthing Switches (PMS), or busbars in GIS installations, which have a specific resistance value. The presence of fault points can generate voltage, and under certain conditions, equipment can be damaged. Contact resistance needs to adhere to factory standards, and its value should be monitored regularly to estimate potential damage. The following is a circuit of contact resistance.

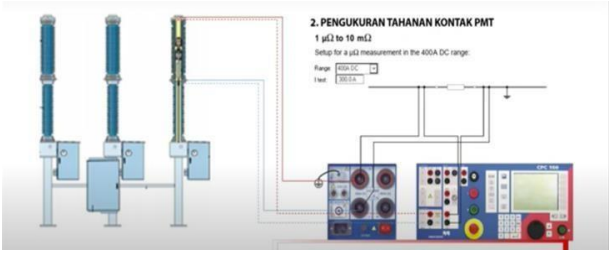

Figure 2.2. Measurement of Contact Resistance

Testing Steps for Contact Resistance.

A. Ensure that the circuit breaker tube is properly connected and verify that the contacts inside the Circuit Breaker (PMT) are stationary and movable.

B. The standard used in IEC60694 is a value of <100μΩ. The contact resistance measurement tool consists of a current source and a voltage measuring device, providing precise and accurate electronic system readings.

C. To facilitate and determine the contact resistance value more quickly, a current of 100 amperes should be used.

D. Ensure the PMT is in the closed position, connect the current selector to the upper and lower sides of the pole, then apply the measuring probe to measure the generated potential.

E. Apply a current of 100 A during the test, so that the resulting current and voltage values provide the tested contact resistance.

F. Record the obtained results.

To assess the condition of the grounding system, a grounding test is conducted. If anomalies are present in the grounding system, large grounding values may occur. This grounding measurement is performed in a de-energized state, and the following is the circuit for grounding resistance.

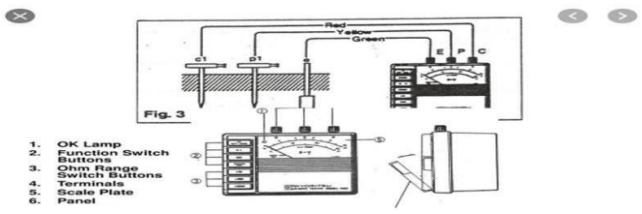

Figure 2.3. Measurement of Grounding Resistence

Things to be considered during the grounding measurement process are as follows:

A. Ensure that the testing equipment has a good power supply.

B. Disconnect the grounding wire from the circuit. Before conducting the measurement, calibrate the equipment to prevent any residual current inside it.

C. To ensure proper connection, clean the grounding wire beforehand.

D. After the measurement, make sure the grounding system is reconnected correctly.

2.6. PMT Testing

Titik Ukur	Trip 1			Delta Time
	R	S	T	
Waktu Buka 1	15.9 ms	15 ms	15.75 ms	0.9
Waktu Buka 2	15.25 ms	15.1 ms	15.75 ms	0.65
Waktu tutup	62.75 ms	61.2 ms	60.6 ms	2.15

Table 2.1. Synchronization Measurement

Based on the SPLN No. 52-1 1984 standard, the maximum fault clearing time for PMT contact in a 500 KV system is set at 90 milliseconds. Next, to compare the difference between the highest and lowest values in contact synchronization, it can be calculated. According to the officially endorsed standard, the allowable time difference is 10 milliseconds.

$\Delta t = tmax - tmin$

Where:

Δt = Time difference

tmax = Highest time

tmin = Lowest time

Here are the results of the synchronization calculation for PMT bay 7AB3.

Year 2022:

Δt Open 1 : 15.9 ms - 15 ms = 0.9 ms

Δt Open 2 : 15.75 ms - 15.1 ms = 0.65 ms

Δt Closing time: 62.75 ms - 60.6 ms = 2.15 ms

Based on the calculations carried out, the average uniformity of the power breaker contacts in bay 7AB3 still meets the standards. The value of contact uniformity at the time of open and close in 2022 is very much in accordance with the standards that have been set. In order for kesermpakan to be well maintained, continuous maintenance must be carried out. Revisions can also be made if there are values that do not meet the standards, where the checks carried out include checking the working voltage, checking the coil, checking the auxillary contact / contactor, replacing damaged mechanics, checking the drive wheels and repairing the mechanical drive. If there is a surge in current, it can be seen in the comparison of a very long time difference which will lead to damage to other equipment connected to the PMT. In order for the PMT to work properly and simultaneously in a short or fast time, periodic maintenance is carried out by testing the uniformity of PMT contacts so that damage caused by the non-uniformity of the PMT at the time of open or close can be minimized.

Titik Ukur Atas – Bawah (PMT Posisi ON)	Phasa	Kondisi Akhir
	R	39.1 μΩ
	S	36.7 μΩ
	T	20.7 μΩ

Table 2.2. Contact Resistance Testing Results

Based on the results of the contact resistance measurements in table 2.2, the test results meet the SPLN reference standard where the contact resistance value is <100 μΩ. If the contact resistance measurement results exceed the existing standard of R < 100 Micro Ohm, then

retesting and checking the PMT is carried out to analyze the cause of the error and find out whether repairs need to be made. Where to clean and make sure there is no moisture on the PMT flanking rod ES, and conduct SF6 gas testing using an SF6 gas test tool, namely the Multi-Analyzer. If it is forced to operate, it is feared that damage to the PMT will occur due to the heat generated by the contact device. This incident will certainly disrupt the system and material losses.

Titik Takar	Standar	Perolehan		
		Phase R	*Phase* S	*Phase* T
Terminal Pentanahan	≤ 1 Ω	0,5 Ω	0,4 Ω	0,7 Ω

Table 2.3. Grounding resistance measurement

Based on the results of the resistance measurements carried out as listed in table 2.3, the value of the measurement results obtained on the resistance of the ADIPALA GISTET PMT is in accordance with the standards set by PLN, which is less than 1 Ω so that the PMT tested is still feasible to operate.

Pengujian	Phase		
	R	S	T
Presentase (%)	99.5	99.7	99.5
Dew point	-35.2	-36.5	-36.2
SO_2	0	0	0
Presure	6.52	6.3	6.32

Table 2.4. SF6 Gas Purity Testing

Based on the results of the SF6 Gas purity measurements carried out as determined by PT PLN where the standard of SF6 Gas presentation is 97%, then Dew Point -40, then the pressure is 6 Bar, and for SO2 is 0. So it can be concluded that it still meets the threshold of reasonableness so that the equipment is in good condition

3. RESULTS AND DISCUSSION

Based on the analysis and calculation results of the data obtained from the 2 (two) annual testing results of bay 7AB3 at GISTET Adipala, the following conclusions can be drawn:

a) Tests carried out on PMT Bay 7AB3 at GISTET Adipala are visual inspection, simultaneous testing, contact resistance testing, grounding resistance testing and SF6 purity testing.
b) In visual testing or observation, PMT Bay 7AB3 found no anomalies or was in normal condition.
c) In the simultaneous test, the resulting value has not reached 40 ms, so the PMT Bay 7AB3 still meets the standard, where the calculations obtained, the difference between the work of the Power Breaker connection when closing is slower than when the Power Breaker works when opening.
d) In the contact resistance test, the test result value obtained is in accordance with the SPLN reference standard where the value is <100 μΩ so that it does not have to be retested and can operate under normal conditions.
e) In the grounding resistance test, the test value obtained is still below the maximum limit (<1 Ω) so it can be said to be normal.
f) The purity level of SF6 Gas in all three phases is around 99.5%, indicating that the SF6 Gas content in PMT Bay 7AB3 is still normal.
g) Based on the tests carried out, PMT Bay 7AB3 GISTET Adipala is declared to be operating under normal conditions.

4. CONCLUSION

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