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Performance Testing of Power Breaker 20 kV at the Senayan PLTMG Substation Netto Cubicles

Sri Hartanto [1], Tri Ongko Priyono [2], Reza Pahlavi [3], Dubois Benoît [4]

[1] *Universitas Krisnadwipayana, Indonesia*
[2] *Universitas Krisnadwipayana, Indonesia*
[3] *PT PLN (Persero), Indonesia*
[4] *Atlantic Technological University, Ireland*

Corresponding Author: Sri Hartanto, E-mail; sri.hartanto@unkris.ac.id

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ABSTRACT

A Power Breaker is a mechanical switch that is able to open to allow current to flow under normal conditions and close when there is a disturbance under abnormal conditions, such as a short circuit current disturbance. Damage to the Power Breaker has a considerable influence on the operation of the electric power system, resulting in losses and the operating system of the electric power being disrupted. For this reason, it is necessary to periodically test Power Breaker performance in order to meet operating standards, improve reliability, guarantee quality, and maintain the continuity of electric power distribution. This research was limited to testing before and after the Power Breaker 20 kV Net Cubicles Maintenance located at the Senayan PLTMG Substation during February 2023 in the form of contact resistance testing, Insulation resistance testing, simultaneity testing, and trip relay testing. By testing the performance of the Power Breaker, it is hoped that it can prevent malfunctions that result in damage to the Power Breaker and other components at the Senayan PLTMG Substation.

Keywords: *Circuit Breaker, Performance, Testing*

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INTRODUCTION

The quality and continuity of electricity distribution are important factors in ensuring that electricity can be delivered reliably and uninterruptedly to PLN customers (Abid, 2019; Fitriono dkk., 2022). However, it is often found that there is a lack of maintenance on the electrical installation equipment at the substation, in the form of a connecting device that functions to divide the load and measure the cubicle.

The substation is part of the electric power distribution system, which plays an important role in the distribution of electric power (Adis Galih Firdaus, 2021; Nurjannah dkk., 2021). Inside the 20 kV substation, there are several components of electrical equipment, one of which is the Power Breaker (Hakim dkk., 2019; Prabowo Darminto, 2022). A Power Breaker is a mechanical switch that is able to open to allow current to flow under normal conditions and close when there is a disturbance under abnormal conditions, such as a short circuit current disturbance (Sasana dkk., 2023). A power breaker can be used to connect and disconnect electricity in an electric power distribution system (Fikri dkk., 2021; Winantara & Husodo, 2019). In principle, when the Power Breaker switch opens and closes, an electric arc will occur (Afifah & Latifa, 2021; Muarif Ridwan Setyo Pambudi & Ulinnuha Latifa, 2023). Therefore, the Power Breaker has an arc suppressor to avoid equipment damage when connecting and disconnecting the electric current.

Damage to the Power Breaker has a considerable influence on the operation of the electric power system, resulting in losses (Azizah dkk., 2022; Nicholas dkk., 2023). In addition, the electric power operating system becomes disrupted. For this reason, it is necessary to periodically test Power Breaker performance in order to meet operating standards, improve reliability (Fathia dkk., 2022; Saputra dkk., 2022), guarantee quality, and maintain the continuity of electric power distribution.

Power Breaker performance testing needs to be done in particular to determine the feasibility of the Power Breaker during operation (Putri dkk., 2023; Vicky dkk., 2023). This Power Breaker performance test is in the form of contact resistance testing, insulation resistance testing, Simultaneous testing, and trip testing. By testing the performance of the Power Breaker, it is hoped that it can prevent malfunctions that result in damage to the Power Breaker and other components at the substation (Holly dkk., 2023; Levan's dkk., 2022).

Research on testing the performance of the Power Breaker 20 kV at the Net Cubicles of the Senayan PLTMG Substation is limited to testing before and after the operationalization of the Power Breaker 20 kV Net Cubicles located at the Senayan PLTMG Substation during February 2023 in the form of contact resistance testing, Insulation resistance testing, simultaneity testing, and testing trip relay.

RESEARCH METHODOLOGY

The research was conducted at PT PLN (Persero) UP2D Jakarta PLTMG Senayan Substation on Jalan Pelajar RT.7/RW.7, Grogol Utara, Kebayoran Lama District, Jakarta, Special Capital Region of Jakarta 12210 (Amrina dkk., 2022; Liam dkk., 2023; Saskia dkk., 2023). The research was conducted in February 2023 and consisted of several stages, as shown in Figure 1 below, namely

1. Study of Literature by collecting theories related to research on Power breakers 20 kV performance testing.
2. Observation at the test location by carrying out inspections related to late trip

disturbances at the Power Breaker 20 kV Net Cubicles at the Senayan PLTMG Substation.

3. Measurement of contact resistance, insulation resistance, simultaneity testing, and relay trip testing on the Net Cubikel Power Breaker and measuring partial discharge indoor cable termination.
4. Analyze the measurement data and provide conclusions regarding the results of the tests carried out to be able to determine the feasibility of the Power Breaker Jakarta PLTMG Senayan Substation.

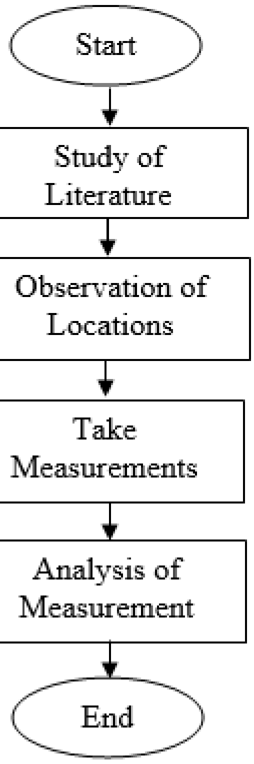

Figure 1. Flowchart of Research Methods

The contact resistance measurement method shown in Figure 2 is as follows:

1. Position the test equipment cable according to the Power Breaker contacts (top-down).
2. Positioning the 20 kV Power Breaker contact in the incoming state (open).
3. Installing the cable for grounding.
4. Perform tests with a current injection of 100 A alternately for R, S, and T.

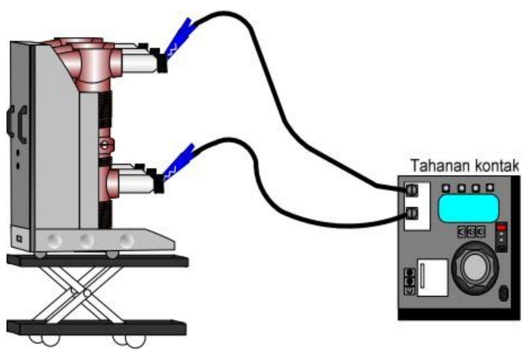

Figure 2. Contact Resistance Measurement

The method of measuring the insulation resistance shown in Figure 3 is as follows:

1. Positioning the 20 kV Power Breaker contact in the open state.
2. Position the test equipment cable according to the Power Breaker 20 kV contact.
3. Check the top-down phase contacts (Ra-Rb, Sa-Sb, and Ta-Tb).
4. Checking the top phase contacts (Ra, Sa, Ta)-Ground.
5. Checking the lower phase contacts (Rb, Sb, and Tb)-Ground.
6. Measuring insulation resistance with a 5 kV injection.

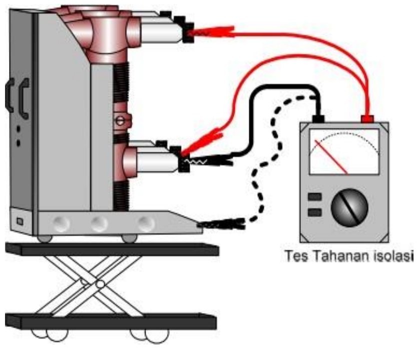

Figure 3. Insulation Resistance Measurement

The simultaneity testing method shown in Figure 4 is as follows:

1. The test equipment cable has been installed on all Power Breaker contacts.
2. Position the (+) and (-) cables according to the trip coil and open coil selector switches.
3. Closing Time (Power Breaker Off/Open Condition): Position the switch sequence in Open Condition (C).
4. Opening Time (Power Breaker On/Open Condition): position the sequence switch in the Open (O) condition.

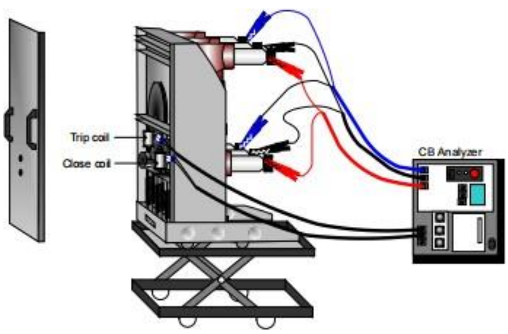

Figure 4. Simultaneous Testing

The trip relay test method shown in Figure 5 is as follows:

1. Positioning the 20 kV Power Breaker contact in the open state
2. Installing the cable into the test block
3. Do a test with the settings taken from the relay.

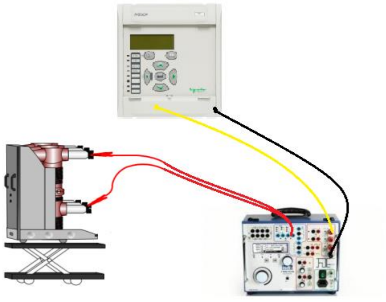

Figure 5. Testing Trip Relays

RESULT AND DISCUSSION

The resistance occurs at the meeting point of several conductors, which causes resistance. The purpose of measuring contact resistance is to find out the minimum contact resistance value so that the Power Breaker can operate properly.

Table 1. Contact Resistance Measurements

Netto Cubicle		**Contact Resistance (μΩ)**		
		R	S	Q
Before	netto	225.9	221	220
After		25,8	24,1	24,4

From table 1, it can be seen that the results of the Power Breaker contact resistance of 20 kV Net Cubicles obtained in phases R, S, and T are quite different before and after Maintenance, meaning that the Power Breaker contact device installed before Maintenance was in poor and very good condition and safe after Maintenance (Auliani dkk., 2023; Mustafiyanti dkk., 2023). If the value obtained before Maintenance exceeds the predetermined standard, which is above 100, it is necessary to repair the clamps and clean the contact surface, then retest. After Maintenance, the value obtained is still below the predetermined standard, which is below 100 and is categorized as very good and safe.

Insulation resistance testing aims to prevent leakage currents in the windings which can cause interference with the Power Breaker

Table 2. Measurement of Insulation Resistance Before Maintenance

Insulation Resistance	**Before Maintenance (MΩ)**		
	R	S	Q
AB	492	774	940
A-GROUND	85.4	87,1	85,2
B-GROUND	365	336	345

Table 3. Measurement of Insulation Resistance After Maintenance

Insulation Resistance	**After Maintenance (GΩ)**		
	R	S	Q
AB	129.8	132,2	120.5
A-GROUND	138,1	153,1	110
B-GROUND	168.7	131.6	134.8

Basically, testing the Power Breaker insulation resistance is to find out the value of the leakage current that occurs between the upper terminal, lower terminal, and ground (Mulyasari dkk., 2023; Noer dkk., 2023; Wanti dkk., 2023). The position of the Power Breaker when testing the insulation resistance is in the open state. In this insulation resistance test, there are three measuring points: the point between the upper and lower terminals, the point between the upper terminal and the ground, and the point between the lower terminal and the ground.

Limits of Power Breaker insulation resistance according to VDE standards (catalog 228/4) The minimum amount of insulation resistance at operating temperature is calculated as "1 kilovolt = 1 megaohm.". Allowable leakage current per kV = 1 mA. As can be seen in Table 2 and Table 3, after the insulation resistance values are obtained, the leakage current can be calculated by dividing the voltage by the insulation resistance, with an injection voltage of 5000 volt.

The test results show that each phase has a different Insulation capability. This can occur due to being influenced by the conditions in each insulator (Al Maarif dkk., 2023; Utami dkk., 2023). If the insulator has a lot of dirt or dust attached to it, it will affect its insulation ability. However, the difference in these values does not affect Power Breaker as long as the results or values obtained are still above a predetermined standard.

Table 4. Simultaneous Measurements Before Maintenance

Simultaneity		Before **Maintenance** (ms)		
		R	S	Q
Open	netto	43.05	43	41.55
Closed		54,4	54,15	54.75

Table 5. Simultaneous Measurements After Maintenance

Simultaneity		After **Maintenance** (ms)		
		R	S	Q
Open	netto	43,1	43.25	43,4

Closed	52.35	52.05	52,2

The results of the insulation resistance test for the Net Cubicles Power Breaker in phases R, S, and T were still above 20 M each before and after maintenance and were categorized as good and safe according to VDE standards (catalogue 228/4) for re-operation. The average value obtained is far below the permissible leakage current, which is 1 kV = 1 mA.

Test to determine the speed of working time and the simultaneity of the Power Breaker contacts when the Power Breaker works to open or close contacts in each phase (Fadiyah dkk., 2023; Ranal dkk., 2023). This simultaneous measurement aims to avoid spikes in the load current on the phase that has the highest simultaneous time on one of the phases.

From the test results obtained at the Power Breaker 20 kV Net Cubicles, the results obtained before Maintenance were carried out for delta time calculations, or the difference in time when Power Breaker Open was 1.45 ms and when Power Breaker Open was 0.6 ms, while the results after the delta time calculation Maintenance, or the difference in time when Power Breaker Open is 0.3 ms and when Power Breaker Open is 0.3 ms, which means that the Net Cubicles synchronization results are better after Maintenance. According to the SPLN and the ABB manufacturer's reference, before and after maintenance, the results of the simultaneity test are categorized as good and safe to operate again.

Testing the trip relay function aims to ensure that the relay protection system in the cubicle is still functioning properly or not because the relay functions to order the Power Breaker to trip when there is a disturbance in the cubicle. In this test, a relay trip test and OC trip time were carried out for MOC, GF, and MGF with Relay Tool Test Sets.

Table 6. Measurement of trip relay before maintenance

TEST	2X (secs)	3X (secs)	5X (secs)	MOMENT (sec)
OC	1,612	0.975	0.665	0.154
GF	1,236	0.795	0.585	0.143

Table 7. Measurement of Trip Relay After Maintenance

TEST	2X (secs)	3X (secs)	5X (secs)	MOMENT (sec)
OC	1,498	0.932	0.645	0.135
GF	1.195	0.778	0.565	0.125

From the test results obtained for the Net Cubicles Power Breaker, the results obtained before maintenance were categorized as different from the settings set by the relay, with 2x the OC setting current reaching 1,612 (sec), which exceeded the time set by the relay settings, so it can be said that the Power Breaker was a disturbance (Fiqih dkk., 2023; Hermansyah dkk., 2023; Pamuji & Limei, 2023). And when, after maintenance, the results of the protection test or relay test are categorized as safe because, for 2x, the OC setting current reaches = 1,498 (sec), still below the setting set by the relay,

CONCLUSION

From this study, it was concluded that with maintenance, the values of contact resistance, insulation resistance value, simultaneity, and trip relay showed good condition of Power Breaker 20 KV Net Cubicles, and disturbances that might appear at Power Breaker 20 KV Net Cubicles could be avoided.

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