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Performance Evaluation of Insulation in 10 kV Switchgear through Partial Discharge Analysis

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ABSTRACT

Switchgear acts as the heart of the power distribution and transmission system, namely in the medium voltage system. If the switchgear insulation does not function properly, the risk of interference, equipment damage, and even accidents that endanger human safety can increase. One of the problems that often occurs in insulation is a phenomenon known as partial discharge (PD). PD is an electrical discharge that occurs in the insulating material and is often a sign of damage or defects. Although PD does not always immediately cause failure, if left unchecked, continuous PD activity can damage the insulating material and cause more serious damage. Partial Discharge testing uses a device called Ultra TEV plus 2. The TEV method focuses on measuring transient voltages caused by partial discharges on the surface of an insulator or within electrical equipment. Essentially, PD emits electrical signals that can be measured as voltage changes. Meanwhile, with the ultrasound method, ultrasonic sensors are installed near the electrical equipment being monitored. When PD occurs, the sensors capture the ultrasonic waves produced and convert them into signals that can be further analyzed. After measurements are taken using the TEV and Ultrasound methods, the results are compared with standard TEV values. It was found that a moderate level of internal PD is likely to occur at the measurement locations of the upper busbar and the CT compartment of Cubicle 10BBC08, as well as the R, S, T phase cables of Cubicle 10BBC09. A high level of internal PD is likely to occur at the measurement locations C2, C3, and C5 on the Bus duct of Cubicle 10BBC10.

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1. INTRODUCTION

In the world of electricity, switchgear plays the heart of power distribution and transmission systems. All of these systems rely on equipment that can control and protect the flow of electricity, and this is where switchgear plays a crucial role. In medium-voltage systems, such as 10 kV switchgear, if insulation is not functioning properly, the risk of interference, equipment damage, and even accidents that endanger human safety can increase [1]. One common problem with insulation is a phenomenon known as partial discharge (PD). PD is an electrical discharge that occurs within the insulating material and is often a sign of damage or defects. While PD does not always cause immediate failure, if left untreated, persistent PD activity can damage the insulating material and lead to more serious damage. Therefore, it is crucial to monitor and analyze PD as part of the insulation performance evaluation of switchgear. By analyzing partial discharge, we can gain valuable insights into the condition of the insulation. Through appropriate measurement techniques, such as waveform measurement and frequency analysis, we can identify the patterns and characteristics of PD that occur [2]. This allows us to detect problems early, allowing us to take preventative measures before further damage occurs. This study aims to evaluate the insulation performance of 10kV switchgear through partial discharge analysis. By conducting PD measurements and analysis, we hope to better understand the insulation condition and the factors that influence it. The results of this study are expected to assist in developing more effective maintenance strategies, thereby improving the reliability of the power distribution system. Amidst the increasing demand for electrical energy and the complexity of electrical systems, ensuring equipment such as switchgear operates in optimal condition is becoming increasingly important [3], [4], [5].

Combining TEV and ultrasound detection were able to develop a better diagnostic method to understand the operational status of 10kV and 400V switchgear. By using these two techniques together, insulation condition evaluation can achieve a higher level of accuracy and provide a clearer picture of potential risks. Therefore, evaluating insulation performance through partial discharge analysis is not only a relevant step but also essential for maintaining the reliability and safety of electrical systems [6], [7].

2. METHOD

This study utilized two PD detection methods: Transient Earth Voltage (TEV) to detect internal PD and ultrasound to detect surface PD. The combination of these two methods is expected to provide accurate and comprehensive results in evaluating the insulation condition of 10 kV switchgear.

Tests were conducted on several 10 kV switchgear cubicles, namely 10BBC08, 10BBC09, 10BBC10, as well as the busduct system. The Ultra TEV Plus 2 instruments used, with two primary detection methods: TEV and ultrasound. Each test point included the R, S, and T phase cables, the overhead busbar, the Current Transformer (CT) room, and the Circuit Breaker (CB) room. Measurement results were analyzed based on manufacturer standards with the following limit values: Normal <20 dB, Alarm 20–29 dB, and Dangerous >29 dB [8].

2.1 TEV Method

The TEV method focuses on measuring transient voltages generated by partial discharges on the surface of insulators or within electrical equipment. Essentially, PDs generate electrical signals that can be measured in the form of voltage changes. Research by Wei et al. noted that the TEV method is highly effective for testing switchgear devices connected to the power grid [9].

Figure 1. TEV sensor.

The TEV sensor in Figure 1 operates on the basic principle that when a partial discharge (PD) occurs, electromagnetic waves and transient voltages are generated. When PD occurs, the unstable electrical current can cause voltage fluctuations that can be detected on the surface of the electrical equipment. Therefore, the TEV sensor is specifically designed to capture these signals, providing information on the presence and intensity of PDs. After the initial measurements, actual inspections and repairs were conducted at points where high PD activity was detected, followed by retesting. The research flow diagram is shown in Figure 2.

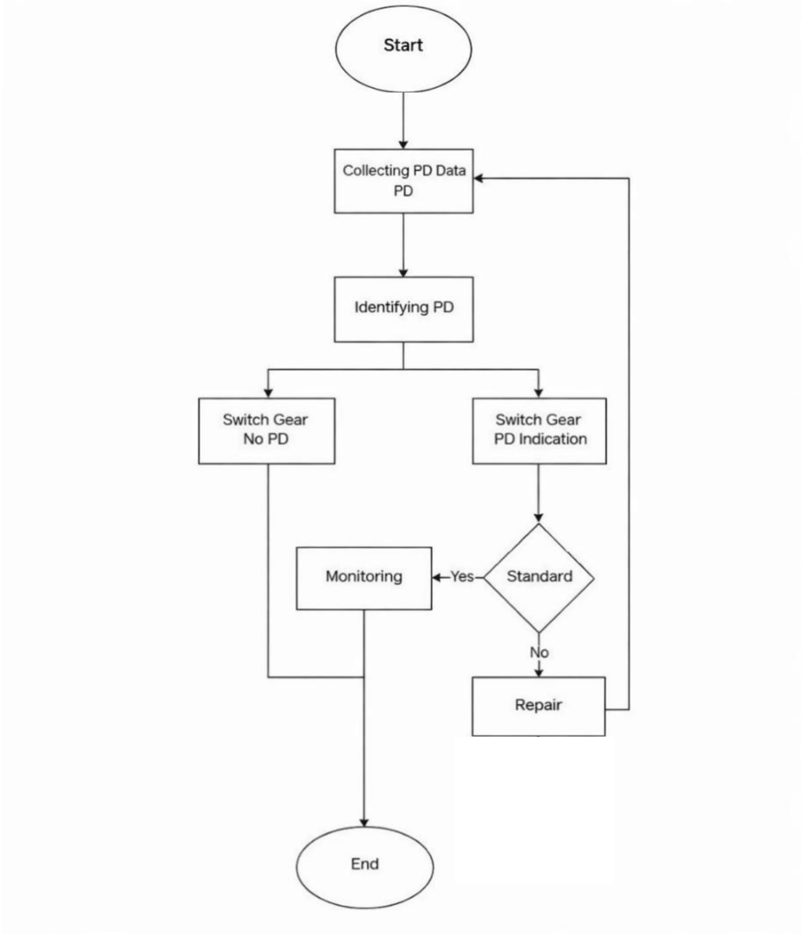

Figure 2. Research flowchart.

2.2. Ultrasound Method

In addition to TEV, ultrasonic methods are also invaluable, particularly in detecting and mapping PD sources through the ultrasonic sound waves generated during the discharge process [9]. The combination of these two methods can provide a more complete and accurate picture of insulation conditions. When partial discharge (PD) occurs, this phenomenon generates ultrasonic acoustic waves that propagate through the insulation material and the surrounding air. These sound waves have a frequency higher than the human ear can hear, typically above 20 kHz [10]. To detect these sound waves, specially designed ultrasonic sensor, as shown in Figure 3.

This sensor captures the ultrasonic waves generated by the PD and converts them into an electrical signal that can be analyzed. By analyzing these signals, technicians can determine the location and intensity of the PD. Ultrasound methods offer a non-invasive way to detect PD. Ultrasonic sensors are installed near the electrical equipment being monitored. When a PD occurs, the sensor captures the resulting ultrasonic waves and converts them into a signal that can be further analyzed. PD testing position on 10kV switchgear cubicle using TEV and Ultrasound methods shown in Figure 4.

Figure 3. Ultrasound sensor.

Figure 4. PD testing position.

Ultrasound measurements are performed using sensors specifically designed for this purpose. Data obtained from the sensors are then analyzed to identify PD patterns and characteristics. This analysis process can include signal processing, frequency analysis, and mathematical modeling, all aimed at improving detection accuracy and providing clearer information about the insulation condition, as shown in Figure 5.

Figure 5. PD test location on a bus duct using the TEV and Ultrasound methods.

During the data collection process, several critical points were selected as measurement locations to ensure comprehensive coverage. These points include the R-phase cable, the S-phase cable, and the T-phase cable, which are the main current-carrying paths. Additionally, measurements were also taken at the overhead busbar, the Current Transformer (CT) room, and the Circuit Breaker (CB) room, all of which are critical elements in the medium-voltage distribution system.

From the TEV and ultrasound test data, traces of partial discharge indications can be observed, which are then evaluated based on the applicable standards. If the test results fall outside the established standards, we can determine whether the system is hazardous and requires immediate repair or is still in a safe condition for normal operation [11]. If repairs are necessary, we can analyze the insulation condition and determine the necessary actions to completely eliminate the partial discharge indication.

3. RESULT AND DISCUSSION

This section discusses the measurement results and data collection using ultrasound and TEV methods. The data to be explained are the figures and partial discharge patterns recorded in the cubicle.

3.1 Test Results on 10 kV Medium Voltage Switch Gear Cubicles

The results indicate the possibility of moderate and high levels of partial discharge. The results shown in Table 1 are based on measurements and analysis using the Ultra TEV Plus 2 instrument and ultrasound sensor.

Table 1. Measurement results using the TEV and ultrasound methods.

No. Cubicle	Name	Measurement Location	Measurement results using the TEV method	Measurement Results Using the Ultrasound Method
10BBC08	Aeration Fan C	R-phase cable	Low Level	Noise
		S-phase cable	Low Level	Noise
		T-phase cable	Low Level	Noise
		Upper busbar	Middle Level	PD
		CT Room	Middle Level	PD
		CB Room	Middle Level	Noise
10BBC09	Lighting Trans	R-phase cable	Middle Level	PD
		S-phase cable	Middle Level	PD
		T-phase cable	Middle Level	PD
		Upper busbar	High Level	Noise
		CT Room	High Level	PD
		CB Room	Middle Level	PD
10BBC10	Office Building Transformer B	R-phase cable	Middle Level	Noise
		S-phase cable	Middle Level	Noise
		T-phase cable	Middle Level	Noise
		Upper busbar	High Level	Noise
		CT Room	High Level	PD
	Busduct	CB Room	Middle Level	Noise
		C1	Middle Level	Noise
		C2	High Level	PD
		C3	High Level	PD
		C4	High Level	Noise
		C5	High Level	PD

Table 1 shows the indications of the TEV and ultrasound methods at several main points tested, especially on the upper busbar and CT room.

The following graph shows indications of partial discharge using the TEV method. Table 1 shows indications of partial discharge at several points tested. The results indicate the possibility of moderate and high levels of partial discharge. These results are based on analysis from the ultra TEV plus 2 tool.

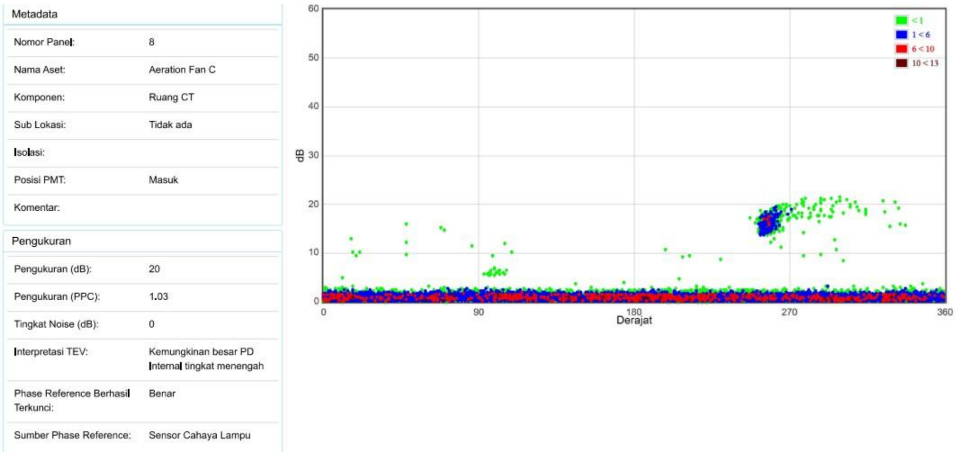

Figure 6. Graph of measurement results of 10BBC08 CT room using the TEV method.

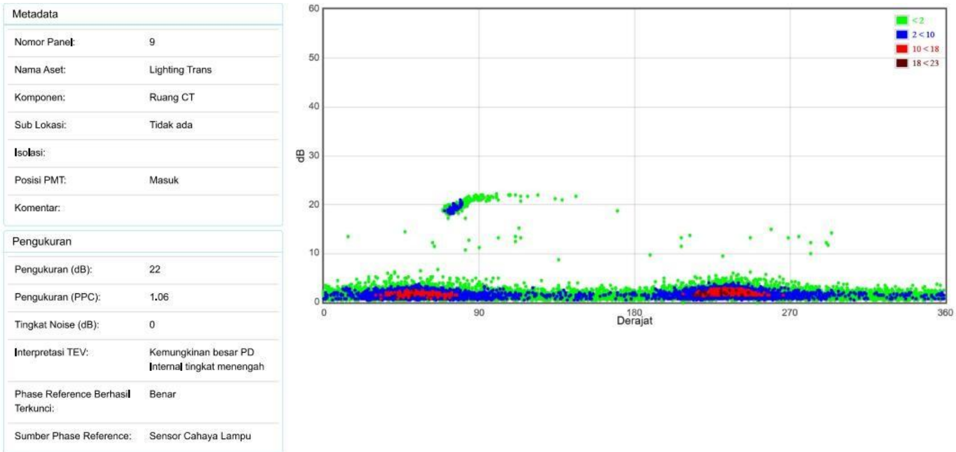

Figure 7. Graph of measurement results of 10BBC09 CT room using the TEV method.

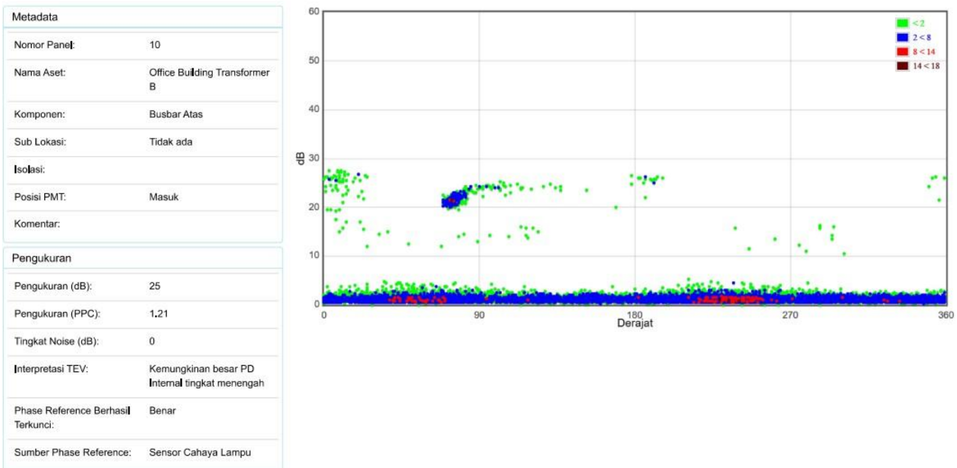

Figure 8. Graph of the results of measuring the 10BBC10 upper busbar using the TEV method.

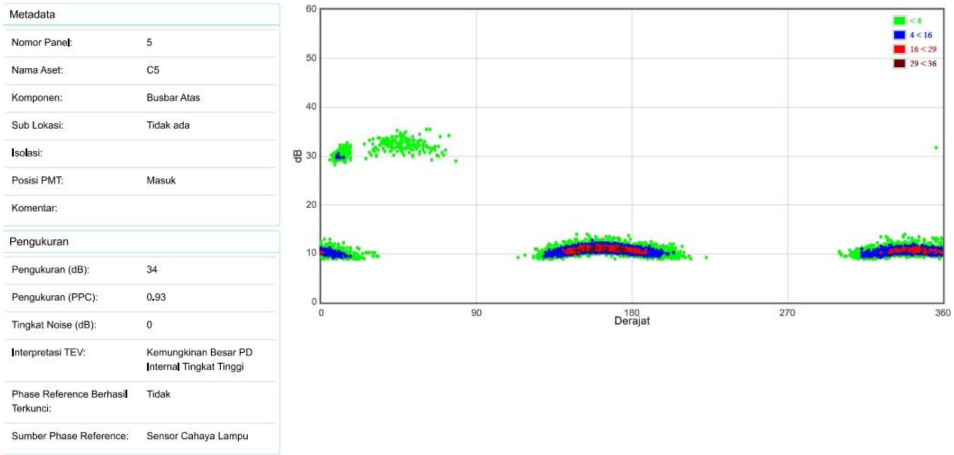

Figure 9. Graph of bus duct C5 measurement results using the TEV method.

The results indicate the possibility of moderate and high levels of partial discharge. These results are based on analysis using the Ultra TEV Plus 2 instrument. Several graphs also show partial discharge in the 10kV switchgear cubicles 10BBC08, 10BBC09, and 10BBC10.

The PD activity level classification based on the manufacturer's TEV standards is shown in Table 2.

Table 2. Classification of PD activity levels based on TEV standards.

Category	Value Range (dB)	Information
Normal	< 20	Doesn't require attention
Alarm	20–29	Possible intermediate PD
Danger	> 29	High PD level – needs immediate improvement

4. CONCLUSION

Initial test results indicate a number of critical points in switchgear cubicles 10BBC08, 10BBC09, and 10BBC10, as well as in the bus duct system. This study successfully evaluated the insulation performance of 10kV switchgear using TEV and ultrasound methods to detect partial discharge (PD). Initial measurement results indicate moderate to high levels of PD activity at several critical points in cubicles 10BBC08, 10BBC09, 10BBC10, and the bus duct system. The TEV method is effective in detecting internal PD, while the ultrasound method is more accurate in capturing PD on the external surface. A comparison between the two methods shows that using both together provides more comprehensive and accurate detection results. Based on these results, actual inspections of the physical condition of the insulation are then carried out, predicting a number of damages such as sharp and imperfect busbar shapes, torn or thinned cable insulation, loose or dirty CB connections, and asymmetrical busbar positions that stress the bushing insulation.

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REFERENCES

[1] W. Lifang *et al.*, “Distribution Network Voltage Arc Suppression Method Based on Flexible Regulation of Neutral Point Potential of the New Grounding Transformer,” *Frontiers in Energy Research*, vol. 10, no. 1, Feb. 2022, doi: 10.3389/fenrg.2022.803142.

[2] H. Cheng, W. Hao, X. Zhu, and Z. Fang, “Optical signals measurement of discharge plasma in air switch cabinet using a fluorescent optical fiber as the sensor,” *Physica Scripta*, vol. 99, no. 8, p. 085019, Jul. 2024, doi: 10.1088/1402-4896/ad5ed5.

[3] X. Hao, B. Zhang, Z. Liu, X. Li, X. Shi, and X. Han, “Comparative Study on Multiple Methods for Partial Discharge Detection of Gap Defect in Medium Voltage Switchgear,” *Journal of Physics: Conference Series*, vol. 2774, no. 1, p. 012064, Jul. 2024, doi: 10.1088/1742-6596/2774/1/012064.

[4] B. Hu *et al.*, “A Partial Discharge Study of Medium-Voltage Motor Winding Insulation Under Two-Level Voltage Pulses With High Dv/Dt,” *IEEE Open Journal of Power Electronics*, vol. 2, pp. 225–235, 2021, doi: 10.1109/ojpel.2021.3069780.

[5] G. Li, X. Li, Y. Ren, D. Yang, and B. Lu, “Study on Partial Discharge Characteristics of Nano-SiO2 Modified Epoxy Resin for 10kV solid insulated switch-gear,” in *2021 IEEE 5th Advanced Information Technology, Electronic and Automation Control Conference (IAEAC)*, IEEE, Mar. 2021, pp. 554–558. Accessed: Mar. 30, 2026. [Online]. Available: https://doi.org/10.1109/iaeac50856.2021.9391049

[6] Y. Li, C. Gong, Y. Liu, T. Li, Q. Dai, and D. Zhang, “The features of infrared thermal image in distribution switchgear and fusion diagnosis,” in *Sixth International Conference on Information Science, Electrical, and Automation Engineering (ISEAE 2024)*, SPIE, Sep. 2024, p. 107. Accessed: Mar. 30, 2026. [Online]. Available: https://doi.org/10.1117/12.3037607

[7] Y. Li, Y. Gao, C. Gong, T. Li, Q. Dai, and dongying Zhang, “Multi-parameter fusion diagnosis for medium and lower voltage switchgear cabinet based on UHF and Infrared Camera Method,” Wiley, Apr. 2024. Accessed: Mar. 30, 2026. [Online]. Available: https://doi.org/10.22541/au.171281475.55221987/v1

[8] J. Miao, J. Wu, W. Liu, F. Huang, and Y. Wu, “Optical arrangement method of lighting units in switchgear based on partial discharge luminosity distribution characteristics,” *Journal of Physics: Conference Series*, vol. 2387, no. 1, p. 012010, Nov. 2022, doi: 10.1088/1742-6596/2387/1/012010.

[9] L. Zhao, “Design of Insulation Online Monitoring and Anti-Condensation Control System for Distribution Switchgear,” *Academic Journal of Engineering and Technology Science*, vol. 4, no. 2, 2021, doi: 10.25236/ajets.2021.040207.

[10] H. Yu, H. Huang, R. Xu, and W. Mo, “A method for testing partial discharge characteristics of switch cabinet based on improved particle swarm algorithm,” *Journal of Physics: Conference Series*, vol. 2728, no. 1, p. 012067, Mar. 2024, doi: 10.1088/1742-6596/2728/1/012067.

[11] Adhelia Wulandari and Endi Permata, “Perbaikan Kebocoran Gas SF6 Pada Pipa Fleksibel GS Busbar 1 Fasa S Pada GIS Labuan 150 KV PT. PLN (PERSERO) ULTG Rangkasbitung,” *Jurnal Teknik Mesin, Industri, Elektro dan Informatika*, vol. 2, no. 1, pp. 47–59, Feb. 2023, doi: 10.55606/jtmei.v2i1.1225.