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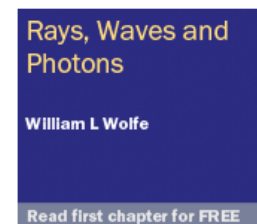
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Analysis of Effect Electric Field Strenght on Safe Distance Below Main Substation Busbar 150 kV

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Abstract. This research is to analyze the effect of electric field strength on the safe distance under the 150kV substation busbar. The research was conducted at 150 kV substation Rancaekek, substation Rancakasumba, substation Cikasungka. The electric field exposure threshold value according to SNI, ICNIRP, IRPA/INIRP and WHO is 10kV / m for the working community. The lowest distance of the busbar conductor to the ground surface is 7.5m. Measurements and calculations of transverse electric field strength from busbar 1 to busbar 2. The height of the test point is 0 m to 2.3 m from the ground surface.. From the results of the calculation of the electric field, strength obtained that the shortest minimum safe distance is 7.48 m, while the highest minimum safe distance is 7.88 m. From the results of the measurements of the electric field From the results of measurements of electric field strength obtained that the fastest duration of electric field exposure was 4.42 hours while the longest electric field exposure duration was 5.75 hours. From the calculation of the electric field, strength obtained that: the fastest duration of electric field exposure is 7.56 hours while the longest duration of electric field exposure is 7.91 hours.

1. Introduction

Electricity consumption has increased over several periods. The electric and magnetic fields of the power system have become important problems. The reason for this is that people discuss health issues that might be caused by the electric and magnetic fields [1].

The International Commission on Non-ionizing Radiation Protection (ICNIRP) has published new publications about the publication of work that is safe against EMF power frequencies. By Following the ICNIRP of 2010 for 50Hz frequency, the threshold value of the electric field assessment is 5kV / m for the general public and 10kV / m for the working community, while the threshold value magnifies the magnetic field by 200 μ T for the general public and 1000 μ T for the working community. [2]. By following IRPA / INIRP 1990, WHO 1989 and SNI 04-6950-2003 for electric and magnetic field threshold values for low frequencies, electric field threshold values are 5kV / m for the general public and 10kV / m for the working community, immediately the threshold value of the magnetic field consideration is 0.1mT for the general public and 0.5mT for the working community [3][4][5].

The average value of the electric field strength at the 110kV substation was 3.6kV / m and the high strength value of the electric field was 15.5kV / m [6]. The intensity of the electric field is more than 10kV / m in most areas of the substation 500kV; Exceeds ICNIRP threshold value [7]. Electric field above 10kV / m has been obtained under a 230 kV transmission. Therefore, there is no serious problem for people who live around the transmission line [8].



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Electrophysical effects related to extra-high voltage for lighting regulation in the field of personnel in substations. The Reverse capacitive current flowing to humans. This capacitive current distribution is used to measure the effectiveness of protective clothing against electric fields [9]. The aim of the research, testing and calculation of the electric field strength at the 150kV substation with double busbar, 6 horizontal conductors, 6.5m busbar distance, and 3.75m phase distance [10].

2. Methodology

2.1. Busbar

The research sites in 3 main substations are the Rancakasumba substation, the Rancaekek substation Cikasungka substation. Table 1 shows the substation parameters.

Table 1. Parameter Main Substation

Description	Rancakasumba Main Substation	Rancaekek Main Substation	Cikasungka Main Substation
System Voltage	150 kV	150 kV	150 kV
System Busbar	Double Busbar	Double Busbar	Double Busbar
Conductor	AAC 'Lupine' 1x1267 mm ²	AAC 'Lupine' 1x1267 mm ²	AAC 'Lupine' 1x1267 mm ²
Diameter Conductor	46,30 mm	46,30 mm	46,30 mm
Phase Distance	3,75 m	3,75 m	3,75 m
Busbar Distance	6,50 m	6,50 m	6,50 m
Busbar Height	8,75 m	8,75 m	8,75 m

As table 1 the busbar height is 8.75 m, compared to the calculated minimum safety distance of 8.6m, the safe distance below the busbar is not safe for workers if the worker's height is reduced.

Based on consideration of safe distance, how to operate an electric field measuring instrument, and range. limited electric field, the researchers limit the area of measurement and calculation of the electric field from 0 cm to 230 cm from the average surface of the land. researchers in measurement.

2.2. Lowest Andongan

The lowest andongan of the busbar conductor to the ground is needed as one of the variables in the calculation of the electric field strength under the busbar substation. The lowest andongan measurement of the busbar conductor measurement is carried out in the center of the main substation busbar goal. The Implementation of the direct method of measurement is to see the measurement results of the measuring instrument. The measurement starts from the busbar conductor 1 to busbar 2 just below the busbar conductor. Measurements were made in each phase of the busbar conductor with the Laser Distance Meter as shown in Figure 1. Figure 2 shows the lowest andongan.



Figure 1. Laser Distance Meter



Figure 2. Lowest Andongan

2.3 Measurement of Electric Field Strength

Measurement of electric field strength is carried out under the busbar substation according to the measurement point. The measurement point is shown in Figure 3.

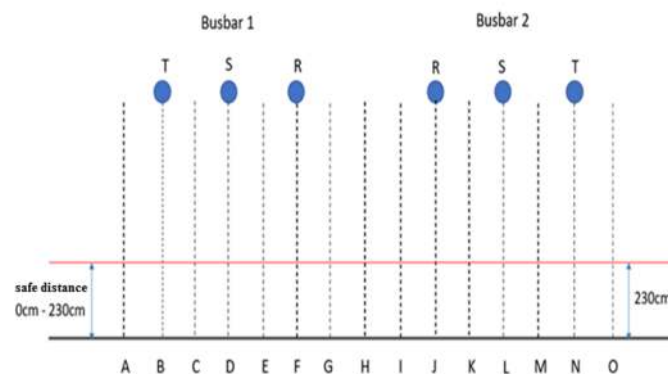


Figure 3. Measurement Point

In Figure 3 it is explained where the point group is divided into 11 measurement points at 10cm intervals for example, A group of points consists of A0 to A23. The implementation of the direct method of measurement is to see the measurement results of the measuring instrument. The measurement starts from busbar 1 to busbar 2, which is from point A to point O below the busbar conductor.

3. Result and Discussion

Based on SNI 04-6950-2003 concerning limits on exposure to electric fields during working days for working people is 10kV / m. This value will be exceeded at a different test and measurement point height for each substation, both in measurement and calculation. From the value of the exposure limit of this electric field strength, we can calculate the minimum safe distance and duration of exposure to the electric field strength allowed by each substation.

3.1 Rancakusumba Main Station

3.1.1. Based on Measurement

- Minimum Safe Distance

From the results of the measurement of the electric field strength, the value of 10kV / m will be exceeded at an altitude of m 1.3 m from the ground surface ($\leq 6.2\text{m}$ from the busbar trunk). With the

minimum safe distance discussed in point 4.3 which is 8.6m, and the busbar trunk 7.5m should be a distance of m 6.2m from the busbar carriage does not meet the safe distance. But based on the results of measurements of electric field strength, the distance > 6.2 m from the busbar carriage is still below the 10kV / m value. If the ideal height of an Indonesian male is 168cm [17], then the minimum safe distance is below the busbar of the Rancakasumba substation $6.2\text{m} + 1.68\text{m} = 7.88\text{m}$. So the busbar carriage must rise by $7.88\text{m} - 7.5\text{m} = 1.38\text{m}$

- Duration of exposure to the allowable electric field strength

Based on SNI 04-6950-2003, the duration of exposure to electric field strength for working people $t \leq 80 / E$ and the ideal height of Indonesian men 1.68cm (rounded up 1.7m), then to obtain the duration of exposure to electric field strength required a maximum value of electric field strength at an altitude of 1.7m from ground level (5.8 m from the busbar trunk) both from measurements and calculations. From the results of the measurement of the electric field strength at an altitude of 1.7m from the ground surface, the maximum value of the electric field strength at H17 point is 15.33kV / m, so the permitted duration.

$$t \leq 80/E \rightarrow t \leq 80/15,33 \rightarrow t \leq 5,21 \text{ hour}$$

3.1.2 Based on Calculation

- Minimum safe distance

From the calculation of the electric field strength, the value of 10kV / m will be exceeded at an altitude of ≥ 1.3 m from ground level ($\leq 6.2\text{m}$ from the busbar trunk). With the minimum safe distance discussed in point 4.3 which is 8.6m, and busbar trunk 7.5m distance should be $\leq 6.2\text{m}$ from the busbar trunk does not meet the safe distance. But based on the calculation of the electric field strength, the distance > 6.2 m from the busbar trunk is still below the value of 10kV / m. If the ideal height of an Indonesian male is 168cm, then the minimum safe distance is below the busbar of the Rancakasumba substation $6.2\text{m} + 1.68\text{m} = 7.88\text{m}$. So the busbar carriage must rise by $7.88\text{m} - 7.5\text{m} = 1.38\text{m}$

- Duration of exposure to the allowable electric field strength

From the calculation of the electric field strength at an altitude of 1.7m from the ground surface, the maximum electric field strength at H17 point is 10.54kV / m, so the duration of exposure to the electric field is allowed.

$$t \leq 80/E \rightarrow t \leq 80/10,54 \rightarrow t \leq 7,59 \text{ hour}$$

3.2 Rancaekek Main Station

3.2.1 Based on Measurement

- Minimum safe distance

From the measurement of the electric field strength, the value of 10kV / m will be exceeded at an altitude of ≥ 1.3 m from the ground surface (m 6.2m from the busbar trunk). , 5m distance should be $\leq 6.2\text{m}$ from the busbar trunk does not meet the safe distance. But based on the results of measurements of the electric field strength, the distance > 6.2 m from the busbar trunk is still below the 10kV / m value. If the ideal height of an Indonesian male is 168cm, then the safe distance is below the busbar of the Rancaekek substation $6.2\text{m} + 1.68\text{m} = 7.88\text{m}$. So the busbar carriage must rise by $7.88\text{m} - 7.5\text{m} = 1.38\text{m}$

- Duration of exposure to the allowable electric field strength

From the measurement results at an altitude of 1.7m from the ground surface, the maximum electric field strength value at H17 point is 13.89kV / m, so the duration of exposure to the electric field is allowed.

$$t \leq 80/E \rightarrow t \leq 80/13,89 \rightarrow t \leq 5,75 \text{ hour}$$

3.2.2 Based on Calculation

- Minimum safe distance

From the results of the calculation of the electric field strength, the value of 10kV / m will be exceeded at an altitude of m 1.7 m from ground level ($\leq 5.8\text{m}$ from the busbar trunk). With the minimum safe distance discussed in point 4.3 which is 8.6m, and the busbar trunk 7.5m should be a distance of 8 5.8m from the busbar carriage does not meet the safe distance. But based on the results of the calculation of the electric field strength, the distance > 5.8 m is still below the value of 10kV / m. If the ideal height of an Indonesian male is 168cm, then the safe distance is below the busbar of the Rancaekek substation $5.8\text{m} + 1.68\text{m} = 7.48\text{m}$. So with a 7.5m busbar it is still safe.

- Duration of exposure to the allowable electric field strength

From the calculation of the electric field strength at an altitude of 1.7m from the ground surface, the maximum electric field strength value at point H17 is 10.11kV / m, so the duration of exposure to the electric field is allowed.

$$t \leq 80/E \rightarrow t \leq 80/10,11 \rightarrow t \leq 7,91 \text{ hour}$$

3.3 Cikasungka Main Station

3.3.1 Based On Measurement

- Minimum safe distance

From the measurement of the electric field strength, the value of 10kV / m will be exceeded at an altitude of ≥ 1.2 m from ground level ($\leq 6.3\text{m}$ from the busbar trunk). With the minimum safe distance discussed in point 4.3 which is 8.6m, and the busbar trunk 7.5m distance should be $\leq 6.3\text{m}$ from the busbar trunk does not meet the safe distance. But based on the measurement results of the electric field strength, the distance > 6.3 m from the busbar trunk is still below the 10kV / m value. If the ideal height of an Indonesian male is 168cm, then the safe distance is below the busbar of the Cikasungka substation $6.3\text{m} + 1.68\text{m} = 7.98\text{m}$. The busbar carriage must rise by $7.98\text{m} - 7.5\text{m} = 1.48\text{m}$

- Duration of exposure to the allowable electric field strength

From the results of the measurement of the electric field strength at an altitude of 1.7m from the ground surface, the maximum electric field strength value at point H17 is 18.06kV / m, so the duration of exposure to the electric field is allowed.

$$t \leq 80/E \rightarrow t \leq 80/18,06 \rightarrow t \leq 4,42 \text{ hour}$$

3.3.2 Based on calculations

- Minimum safe distance

From the calculation of the electric field strength, the value of 10kV / m will be exceeded at an altitude of ≥ 1.3 m from ground level ($\leq 6.2\text{m}$ from the busbar trunk). With the minimum safe

distance discussed in point 4.3 which is 8.6m, and busbar trunk 7.5m distance should be $\leq 6.2\text{m}$ from the busbar trunk does not meet the safe distance. But based on the calculation of the electric field strength, the distance $> 6.2\text{ m}$ from the busbar trunk is still below the value of $10\text{kV} / \text{m}$. If the ideal height of an Indonesian male is 168cm, then the minimum safe distance is below the busbar of the Cikasungka substation $6.2\text{m} + 1.68\text{m} = 7.88\text{ m}$. So the busbar carriage must rise by $7.88\text{m} - 7.5\text{m} = 1.38\text{m}$

- Duration of exposure to the allowable electric field strength

From the calculation of the electric field strength at an altitude of 1.7m from the ground surface, the maximum electric field strength at the H17 point is $10.57\text{kV} / \text{m}$, the permitted duration is as follows:

$$t \leq 80/E \rightarrow t \leq 80/10,57 \rightarrow t \leq 7,56 \text{ hour}$$

4. Conclusion

In this research shows that the higher the test / measuring point the greater the electric field strength (the closer the busbar conductor the greater the electric field strength). This is seen from the results of measurements and calculations of electric field strengths obtained that: for the height of the test / measuring point 2.3 m from the ground surface, the maximum electric field strength is obtained between busbar 1 and busbar 2. Minimum safe distance and duration of exposure to electric field strength - each substation varies depending on the voltage. Minimum safe distance and duration of exposure to electric field strength can be seen from the calculation results and measurement results. For the minimum safe distance if from the results of the measurement of the electric field strength obtained that: the shortest minimum safe distance is 7.88m in substation Rancakasumba and substation Rancaekek while the highest minimum safe distance is 7.98m in substation Cikasungka . Whereas From the results of measurements of the electric field strength obtained that: the shortest minimum safe distance is 7.88m in substation Rancakasumba and substation Rancaekek while the highest minimum safe distance is 7.98m in substation Cikasungka. For the duration of the electric field strong exposure From the results of the measurement of the electric field strength obtained that: the fastest duration of electric field exposure was 4.42 hours in the substation Cikasungka while the longest duration of the electric field exposure was 5.75 hours in the substation Rancaekek. Whereas From the results of the calculation of the electric field strength obtained that: the fastest duration of electric field exposure was 7.56 hours in substation Cikasungka while the longest duration of electric field exposure was 7.91 hours at substation Rancaekek

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