Paper

by Yusreni Warmi

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Investigation of Lightning Performance on 150 kV Transmission Lines in West Sumatra in Indonesia

Yusreni Warmi, Koji Michishita

***Abstract*— Lightning is a natural phenomenon that can cause a disturbance in transmission lines. From the data of the Distribution and Load Control Center Sumatra (Sumatra P3B), the intensity of lightning disturbances in 150 kV transmission lines was very high in Indonesia, reaching 66%. The results of the investigation showed correlations between the occurrence of disturbances on 150 kV transmission lines and two factors, namely, the footing resistance of towers and the distance between the towers (SPAN).**

***Keywords*— Lightning performance, lightning strokes, transmission line, grounding resistance, span length.**

I. INTRODUCTION

Electric power transmission system in Indonesia is more dominantly using the overhead line than underground cable system. The overhead power transmission line is quite susceptible to lightning strokes due to high construction. In fact, the overhead line located in hilly areas will be much closer to the clouds, thus having more frequency of lightning strokes. West Sumatra in Indonesia is in areas of high lightning flash density. There is a transmission line of 150 kV from Payakumbuh to Koto Panjang in West Sumatra, passing the area whose average number of thunderstorm days per year (IKL) reached up to 165, and the possibility of direct lightning strokes to the transmission line including the strokes to the transmission tower is high [1]. This line is the trunk line between West Sumatra sub-system (Padang UPT) and Riau sub-system (Riau UPT). Therefore, it must have a high degree of immunity against lightning strokes.

According to the data from the Distribution and Load Control Center Sumatra (Sumatra P3B), the intensity of the lightning disturbance on the 150 kV transmission line is very high, amounting to 66% [2]. In addition to causing blackouts, lightning disturbances also cause damage to the insulator (flashover) on the transmission line. Even several broken insulators tripped the circuit breaker in Payakumbuh and Koto Panjang substations. Therefore, an evaluation should be conducted to determine lightning performance on 150 kV transmission lines of Payakumbuh - Koto Panjang in West Sumatra.

In this paper, the authors investigate the lightning disturbances and lightning performance on 150 kV the transmission lines in West Sumatra.

II. DATA INVESTIGATION

A. Map of Isokeraunic Level of West Sumatra

The tropical climate of Indonesia generally has high lightning events every year. Weather and lightning strokes in this area are influenced by the movement of the regional wind (monsoon) and the local winds (sea breeze/land breeze and valley breeze/mountain wind). Lightning strokes strongly depend on the topography condition of the lines. Figure 1 shows a map of the Isokeraunic level of West Sumatra. There is a 150-kV overhead transmission line between Payakumbuh - Koto Panjang, which is shown as the red line passing the mountainous area, where 156 towers (63 %) are located in hills, 51 towers (20.5 %) in rice fields, and 41 towers (16.5 %) in desserts/pastures. The temperature ranges between 33° C to 36° C, and thunderstorm is as many as 165 days per year [1].

Daerah = area, hari = day, tahun = year

Fig. 1. Map of Isokeraunic level [1].

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Fig. 2 shows data of the Isokeraunic levels, defined as thunderstorm days per month, from January to December 2010. This figure shows that high Isokeraunic levels were found in November, May, and April.

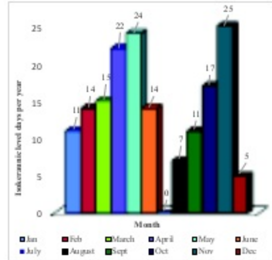

Fig. 2. Data for isokeraunic levels in 2010 [1].

B. Data of Disturbances

Based on the data from January 2010 until June 2014 provided by P3B Sumatra (UPT Padang), the causes of disturbance on the 150 kV transmission line are shown in Figure 3.

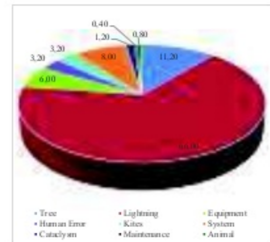

Fig. 3. Classification of the disturbances causes [2].

The most frequent cause of disturbance on the line is lightning, amounting to 66% of all disturbances. The determination that the cause of disturbances is lightning is based on observation of field evidence, such as flashover on the insulators or damaged conductors, in combination with weather conditions at the time of the disturbances.

C. Data of Lightning Disturbances

Fig. 4 shows the number of the lightning disturbances dependent on the occurrence months from January 2010 to June 2014. In this figure, it is shown that the high number of the lightning disturbances occurred in April 2011 and November 2012; within these months the Isokeraunic level also has a high value in figure 2.

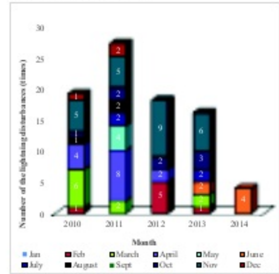

Fig. 4. The number of lightning strokes in occurrence months [2].

Fig. 5 shows the number of the lightning disturbances on the 150 kV transmission lines of Payakumbuh - Koto Panjang from 2010 to June 2014 dependent on the tower number.

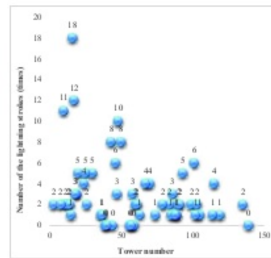

Fig. 5. The number of the lightning disturbances based on the transmission tower [2].

This data is taken from Padang UPT and is based on Pareto analysis. Figure 5 shows that the highest number of disturbances was found in tower number 16: 18 disturbances.

D. Data of Broken Insulator

Figure 6 shows the number of insulators that broke or burned from January 2010 to June 2014. This figure shows that the high number of insulators broken or burned by lightning occurred in May 2011 and November 2010, and the Isokeraunic level in May and November was also high, as presented in figure 2.

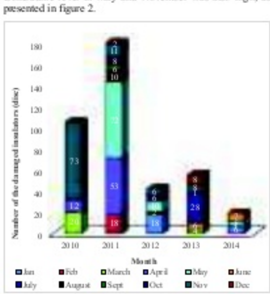

Fig. 6. The number of damaged or burned insulators based on the transmission tower in occurrence months [2].

The number of damaged or burned insulators caused by lightning is shown in figure 7, dependent on the tower number.

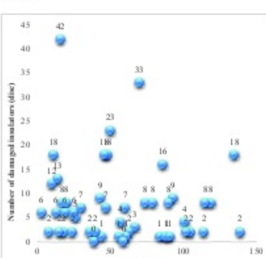

Fig. 7. The number of damaged or burned insulators based on the transmission tower [2].

In figure 7 shows that the highest number of isolator disturbances was found at the tower no. 16 with 42 discs.

E. Grounding Resistance

Figure 8 shows that the ratios of the number of lightning disturbances, the number of the towers in percent (%) and the grounding resistance for every 10 ohms.

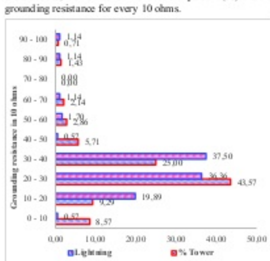

Fig. 8. The ratios of the number of lightning disturbances, the number of the towers and the grounding resistance in 10 ohms [2].

Figure 8 shows that 8.57% of all towers (140 towers) have the grounding resistance of 0 - 10 ohms with ratios of the number of lightning disturbances 0.57%. The highest ratios of the lightning disturbances occur at the tower with grounding resistance of 30 – 40 ohms with the number of towers 25% of all towers.

Figure 9, that the ratios of the damaged insulators and the number of the towers in percent (%) and the grounding resistance for every 10 ohms.

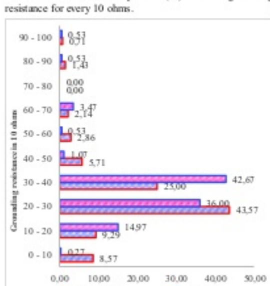

Fig. 9. The ratio of number of the damaged insulators, the number of the towers and the grounding resistance in 10 ohms [2].

In figure 9 shows that 8.57% of all towers have the grounding resistance of 0 – 10 ohms with ratios of the number of damaged insulator (0.27%). In this figure shows that the highest ratios of damaged insulators occur at the tower with grounding resistance of 30 – 40 ohms, with the number of towers 25% of all towers.

F. Distance between Tower (SPAN)

Figure 10, show that the ratios of the lightning disturbances, the number of the towers in percent (%) and the number of the SPAN length in 50 meters.

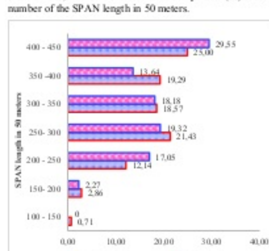

Fig. 10. The ratio of number of the lightning disturbances, the number of the towers and the number of the SPAN length in 50 meters.

Figure 10 shows that 2.86% of all towers (140 towers) have the SPAN length of 150 - 200 meters with ratios of the number of lightning disturbances (2.27%). The highest ratios of the lightning disturbances occur at the tower with the SPAN length of 400 – 450 meters.

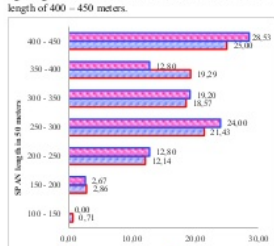

Fig. 11. The ratio of number of damaged insulators, the number of the towers and the number of the SPAN length in 50 meters.

Figure 11 shows that the ratios of the number of damaged insulators, the number of the towers and the number of the SPAN length in percent (%) for every 50 meters. In this figure shows that 2.86% of all towers have the SPAN length of 150 - 200 meters with ratios of the damaged insulators (2.27%). The highest ratios of damaged insulators occur at the tower with the SPAN length of 400 - 450 meters, with the number of towers 25% of all towers.

III. CONCLUSION

Based on these findings, the authors determined that there is a correlation between lightning performance and the footing resistance and span length of towers, namely;

- The highest ratio of the number of the lightning disturbances occur at the tower with grounding resistance 30 – 40 ohms and the SPAN length 400 - 450 meters.
- The highest ratio of damaged insulators occur at the tower with grounding resistance 30 - 40 ohms and the SPAN length 400 - 450 meters.

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