P2.12 EMISSION CURRENT FROM STATIC DISSIPATOR DEVICES UNDER RAIN AND WIND CONDITIONS

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Abstract - The experimental study of emission current from the lightning protection devices is presented. Emission currents were measured using switching impulse voltage. A metal screen was used to provide simulation of a charged cloud. Measurements of emission current from a Franklin Rod and three configurations of static dissipation devices were conducted in the high voltage laboratory under different environmental conditions. The measurements of emission current were conducted for: no rain or wind, with low and high wind, and with light and heavy rain.

The generated switching impulse in this test had a time-to-peak of 250 µs and a time-to-half-value of 2000 µs, both positive and negative polarity. Measurements were taken at 3 m and 4 m air gap spacing from the metal screen to the test device. The presented emission current is averaged from three measurements for the same voltage magnitude and polarity of the applied impulse. For each of the three devices, four different levels of voltages were applied from 800 kV to 1100 kV at positive and negative polarity.

From the conducted study of the emission current of four lightning protection devices, several conclusions were stated. The study shows emission current is highest for the heavy rain condition. The applied wind speeds up to 2 m/s did not have an impact on emission current. The Franklin Rod showed the lowest measured emission current for all study cases.

1. INTRODUCTION

Emission current from the device has an impact on the space charge around a dissipation device. Larger emission current cause a higher space charge showing improved performance of the dissipation device. Changes in emission current and space charge distribution is related to several factors. These factors include geometrical configuration of the terminal, ground terrain, polarity of the charged cloud, and environmental conditions including rate of wind and rain. Laboratory simulation of these conditions may be set for several types of terminals for a comparison of the measured emission current.

A study plan is developed and implemented for recording the emission current of several types of dissipation terminals. Switching impulse voltage is applied on a simulated cloud in order to produce space charge in the air around the test terminal.

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Measurements are taken at the time of applied switching impulse voltage and peak emission current for all measurements are presented in the paper.

2. TEST SETUP

The measurement system of emission current in the tests is shown as a diagram in Fig. 1. Emission current is measured using a small impedance grounded and in series to the dissipation terminal. A large metal screen placed above the terminal and energized with positive and negative switching impulse voltages of different magnitudes for the development of space charge at the terminal. Tested terminals include a Franklin Rod and TerraStat® models TS100, TS400, and TS500.

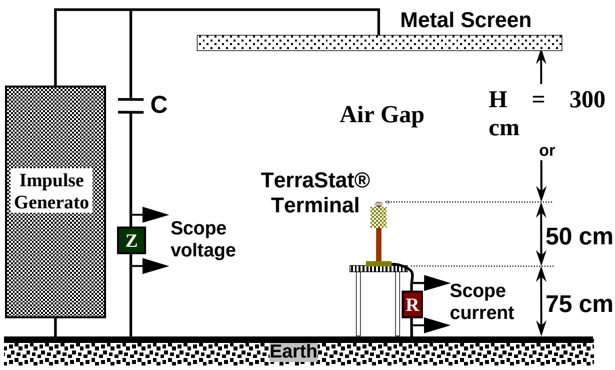
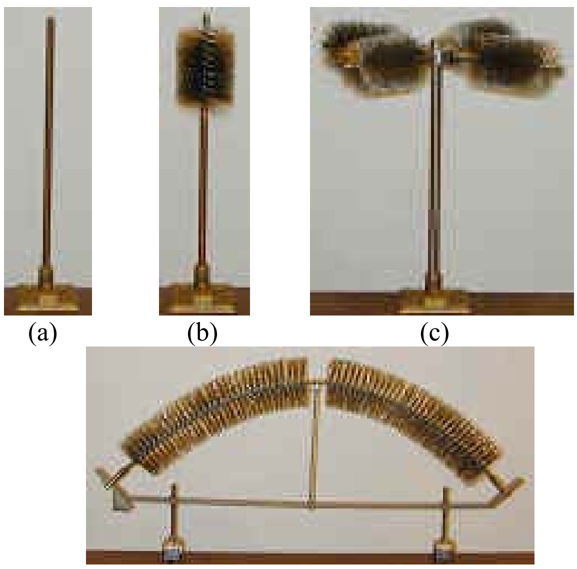


Fig. 1 - Diagram of the measurement system for the terminals under test.



(a) (b) (c)

(d)

Fig. 2 – Static dissipator devices
(a) Fraklin Rod, (b) TS100, (c) TS400, (d) TS500

The generated switching impulse in this test had a time-to-peak of 250 μs and a time-to-half-value of 2000 μs, for both positive and negative polarity. A metal screen "cloud" above the tested terminals is energized with this shape of switching impulse voltage.

At each of the 300 cm or 400 cm air gap spacing, a total of 3 switching impulse voltages at a specific magnitude were applied for positive and negative polarity. The following switching impulse voltage magnitudes were applied for the four terminals:

- Air gap
  - H = 300 cm
  - H = 400 cm
- Positive and Negative Switching Impulse
  - 800 kV
  - 900 kV
  - 1000 kV
  - 1100 kV
- Wind conditions
  - No wind
  - Low wind (1 m/s)
  - High wind (2 m/s)
- Rain conditions
  - No rain
  - Light rain (1 mm/min)
  - Heavy rain (2 mm/min)

3 MEASURED EMISSION CURRENTS FROM TESTED DEVICES

Averaged peak emission currents from the measurements are presented.

3.1 Emission Current from Positive Impulse Voltage at the Metal Screen

As shown in Fig. 3 and Fig. 4, the "baseline" measurements with no wind and no rain will provide a point of comparison for the study of impact on emission current due to wind and rain conditions. The baseline measurements provide emission current for each type of terminal as expected. The Franklin Rod exhibits the lowest emission current while the TS500 shows the highest emission currents.

Presence of low wind and high wind shows practically no change in the emission current measurements as seen in Fig. 5 and Fig. 6. As the contribution of particulate matter in the air gap is small, the space charge is not changing in the presence of wind up to 2 m/s. The dry air is due measurements performed in an indoor laboratory environment. Fig. 7 and Fig. 8 show emission current does change under different rain conditions.

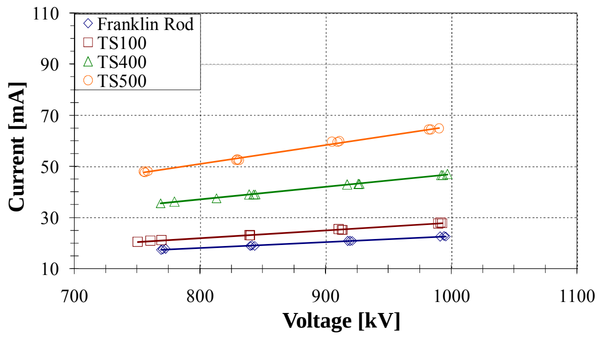


Fig. 3 - Peak Emission Current vs. Positive Impulse Voltage at the Conducting Screen, 3 m Air Gap, No Wind, No Rain.

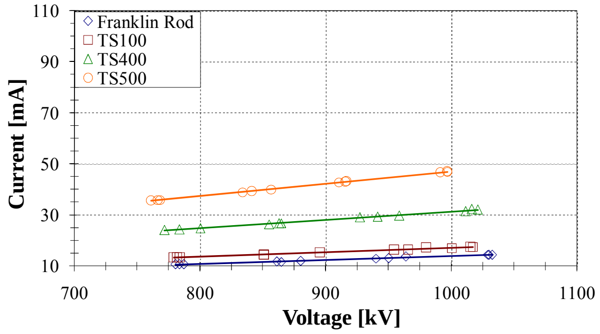


Fig. 4 - Peak Emission Current vs. Positive Impulse Voltage at the Conducting Screen, 4 m Air Gap, No Wind, No Rain.

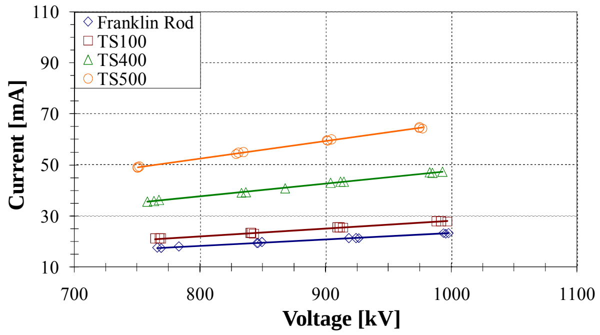


Fig. 5 - Peak Emission Current vs. Positive Impulse Voltage at the Conducting Screen, 3 m Air Gap, Low Wind, No Rain.

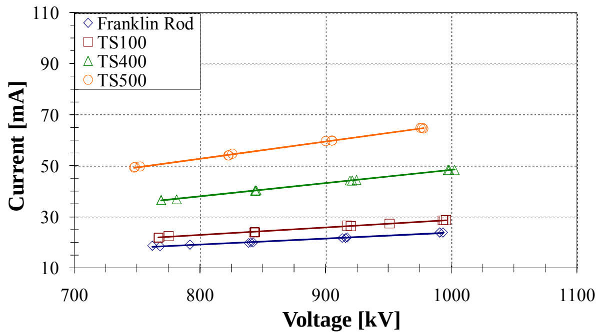


Fig. 6 - Peak Emission Current vs. Positive Impulse Voltage at the Conducting Screen, 3 m Air Gap, High Wind, No Rain.

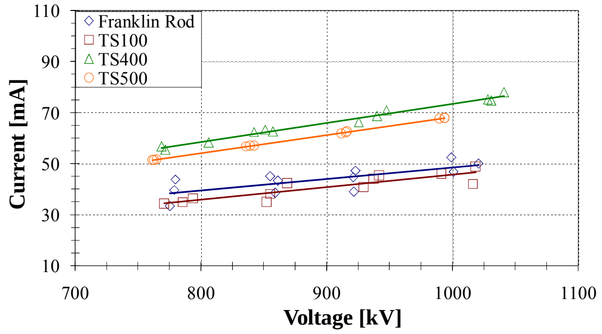


Fig. 7 - Peak Emission Current vs. Positive Impulse Voltage at the Conducting Screen, 3 m Air Gap, No Wind, Light Rain.

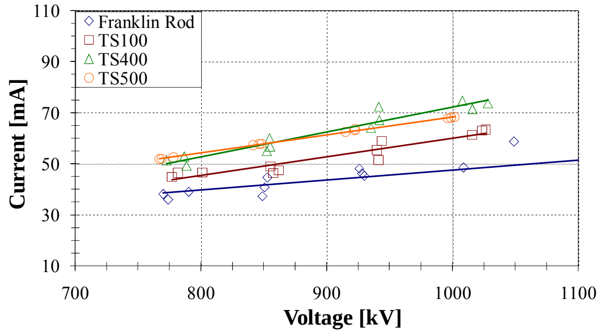


Fig. 8 - Peak Emission Current vs. Positive Impulse Voltage at the Conducting Screen, 3 m Air Gap, No Wind, Heavy Rain.

3.2 Emission Current from Negative Impulse Voltage at the Metal Screen

Recording of the emission currents for negative impulse voltages at the metal screen includes a higher contribution of emission current as compared to the positive polarity case. During the application of a negative impulse voltage at the metal screen, emission current spikes can appear. Measurement of peak emission current does not include contribution due to emission current spikes.

Fig. 9 and Fig. 10 show measured peak emission current as negative impulse voltage at the metal screen, with no wind and no rain. Results are similar compared to the positive polarity case with higher measured emission currents at negative polarity of impulse on the metal screen.

The applied negative switching impulse voltage on the metal screen under wind conditions also show no significant change in emission currents. Wind speeds up to 2 m/s present in a dry air gap did not change the measurements of emission current regardless of polarity.

Rain conditions show a change in emission current measurements shown in Figs. 11-12. The highest emission current measured compared to all cases, is found in the TS400 in heavy rain condition

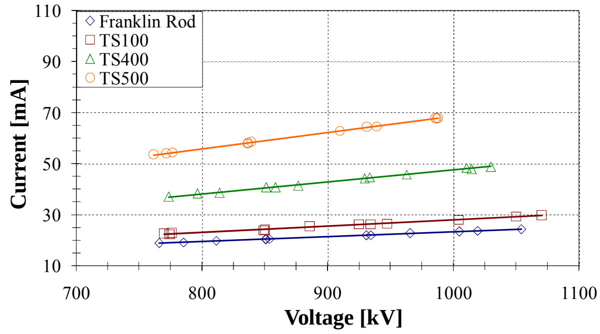


Fig. 9 - Peak Emission Current vs. Negative Impulse Voltage at the Conducting Screen, 3 m Air Gap, No Wind, No Rain.

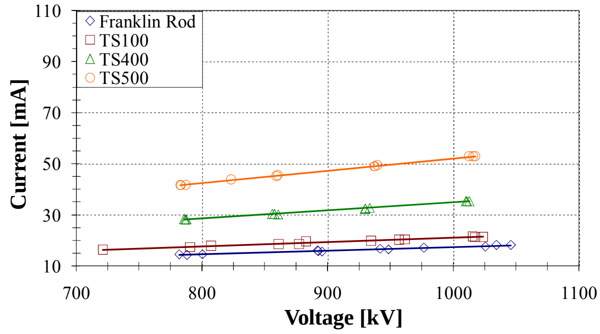


Fig. 10 - Peak Emission Current vs. Negative Impulse Voltage at the Conducting Screen, 4 m Air Gap, No Wind, No Rain.

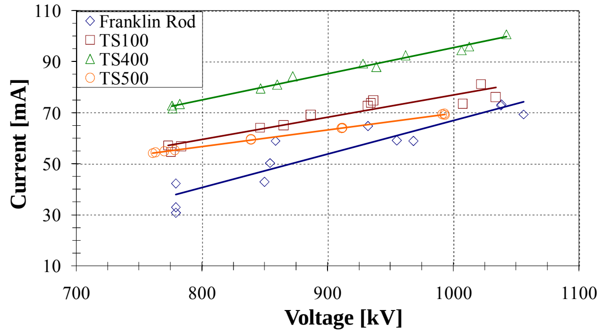


Fig. 11- Peak Emission Current vs. Negative Impulse Voltage at the Conducting Screen, 3 m Air Gap, No Wind, Light Rain.

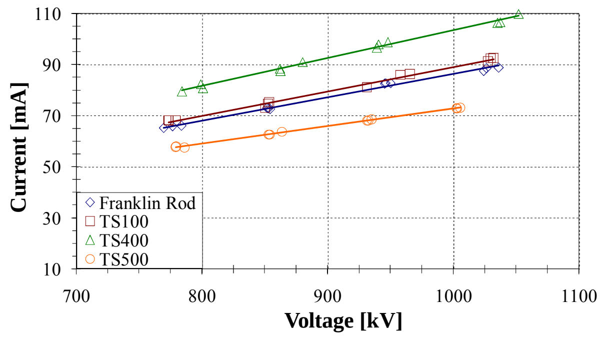


Fig. 12- Peak Emission Current vs. Negative Impulse Voltage at the Conducting Screen, 3 m Air Gap, No Wind, Heavy Rain.

3.3 Comparison of Emission Current at Positive and Negative Impulse Voltage at the Metal Screen

The magnitude of the emission current at negative polarity voltage impulse at the metal screen is higher than magnitude of the emission current at positive polarity voltage impulse at the metal screen for the 4 m and 3 m air gap. At positive polarity voltage impulse at the metal screen create a negative charge, emitted from the terminal.

When the metal screen is energized with negative polarity voltage impulse, a positive charge is developed from the terminal. At negative polarity voltage impulse at the metal screen, the emission current spikes form positive charge streamers at the terminal. The positive streamers appear more intensive for the Franklin Rod, where the electrical stress is the highest, and therefore the Franklin Rod are more attractive to lightning discharges than the TerraStat devices.

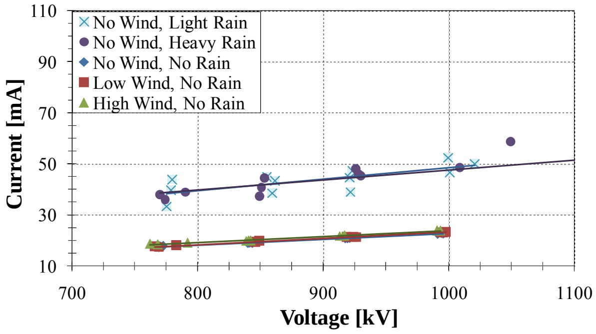


Fig. 13 - Peak Emission Current vs. Positive Impulse Voltage at the Conducting Screen, 3 m Air Gap, Franklin Rod.

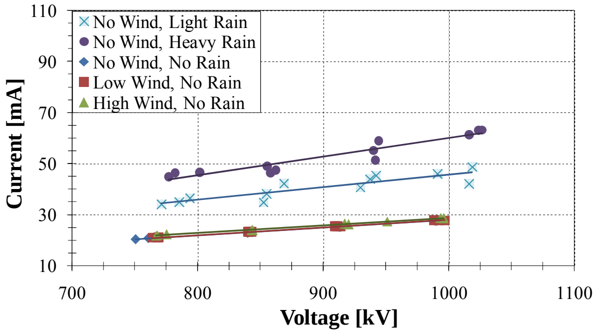


Fig. 14- Peak Emission Current vs. Positive Impulse Voltage at the Conducting Screen, 3 m Air Gap, TS100.

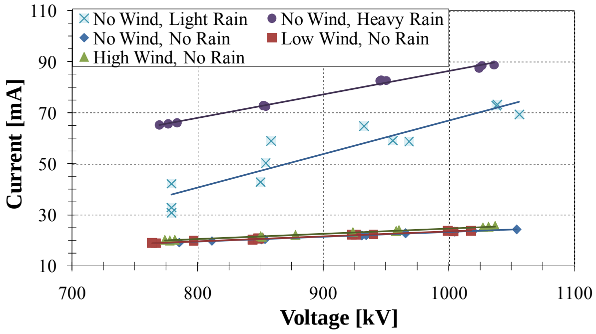


Fig. 15- Peak Emission Current vs. Negative Impulse Voltage at the Conducting Screen, 3 m Air Gap, Franklin Rod.

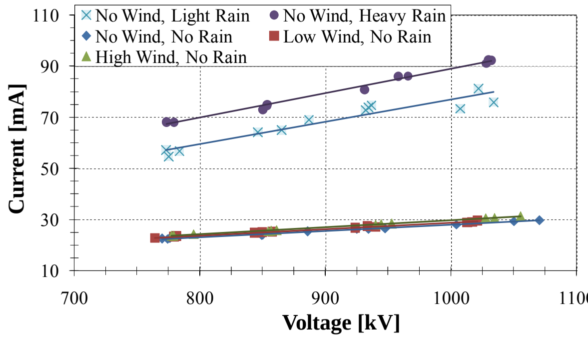


Fig. 16- Peak Emission Current vs. Negative Impulse Voltage at the Conducting Screen, 3 m Air Gap, TS100.

3.4 Comparison of Emission Current for Wind and Rain Conditions

Environmental conditions of wind and rain in Figures 13-16 show results for this study, with the most consistent results that come from the TS100 and Franklin Rod when considering the rain conditions. Presence of wind in the air gap shows no significant change in emission current.

Presence of water droplets due to rain conditions shows a significant change in emission current measurements. This change in the emission current under rain condition is highly dependent on configuration and orientation of the terminal. Rate of rain also shows a change in emission current.

4. CONCLUSION

Based on the conducted study of the emission current from the Franklin Rod and 3 tested terminals manufacted by Alltec Corporation, the following conclusion could be stated:

- Emission current depends on the electrical field stress, therefore is higher for the 3 m air gap compared to the 4 m air gap, even for wind and rain conditions.
- In most cases, the lowest emission current was obtained for the Franklin Rod and the highest emission current from the TS400 and TS500.
- As the emission current is larger for the TS400 and TS500, a more uniform space charge will develop around these terminals.
- The TerraStat® models tested show a higher performance for emission of the space charge when compared to the Franklin Rod.
- Rain conditions, including rate of rain, leads to significant change in emission current.
- If rate of rain is a factor in emission current measurement, further study should include combinations of rain and wind.
- Additional studies should be performed for wind speeds much greater than 2 m/s.

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5 REFERENCES

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