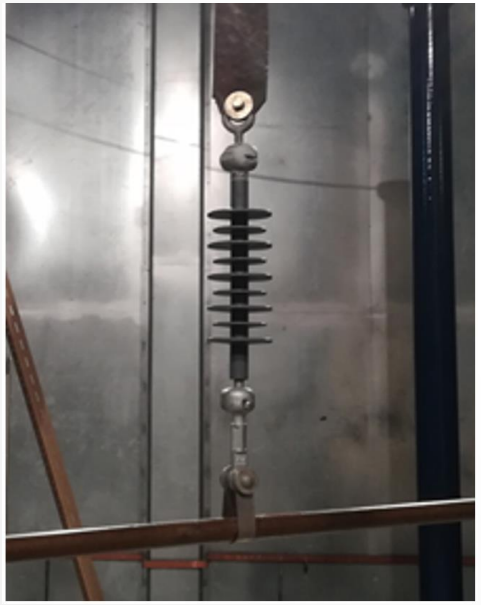
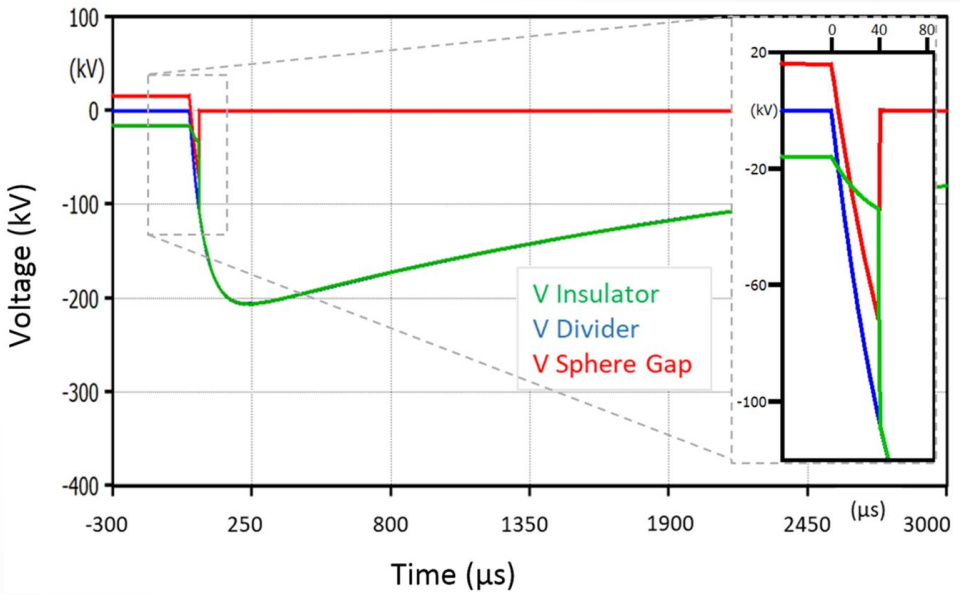
PERFORMANCE OF COMPOSITE OUTDOOR INSULATOR UNDER SUPERIMPOSED DIRECT AND SWITCHING IMPULSE VOLTAGES

CINERGIA MEETING





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- P-G fault and healthy pole
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- Comsol geometry and results
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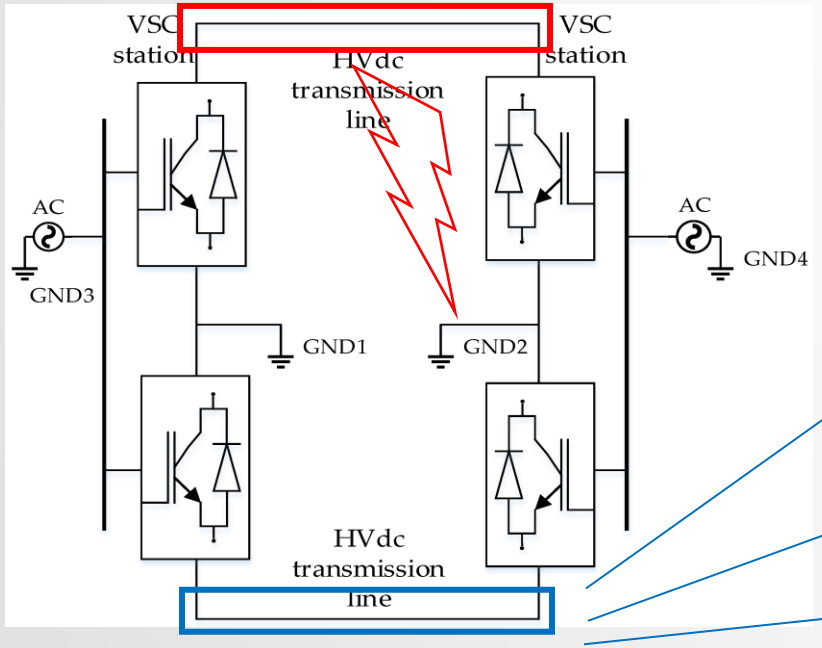
- Conclusions and future work

HVDC P-G FAULT: HEALTHY POLE AFFECTED



HVDC bipolar scheme

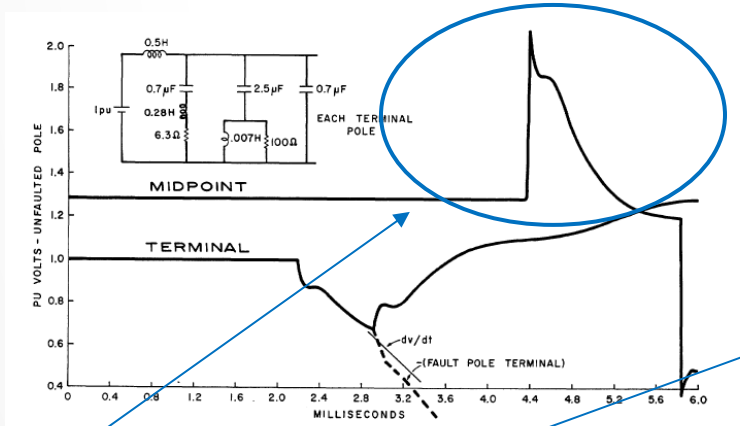
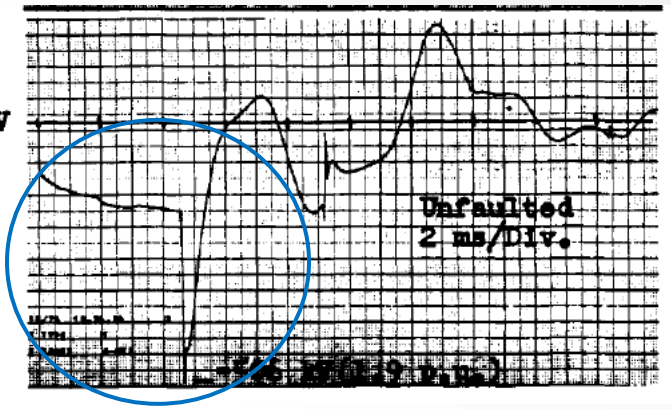
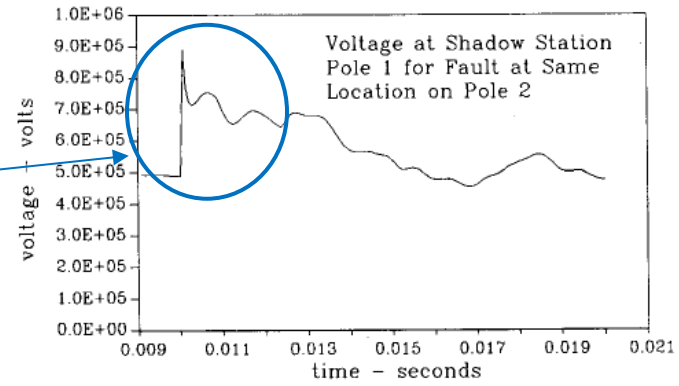


Fig. 9. Voltages on positive pole for midpoint fault on negative pole; Celilo I–Sylmar termination (capacitive to wavefront).





[1] R. Muzzammel et al., "MT–HVdc Systems Fault Classification and Location Methods Based on Traveling and Non-Traveling Waves—A Comprehensive Review," Appl. Sci., vol. 9, no. 22, Art. no. 22, Jan. 2019, doi: 10.3390/app9224760.

[2] N. G. Hingorani, "Transient Overvoltage on a Bipolar HVDC Overhead Line Caused by DC Line Faults," IEEE Trans. Power Appar. Syst., vol. PAS-89, no. 4, pp. 592–610, Apr. 1970, doi: 10.1109/TPAS.1970.292606.

[3] G. T. Wrate et al., "Transient overvoltages on a three terminal DC transmission system due to monopolar ground faults," IEEE Trans. Power Deliv., vol. 5, no. 2, pp. 1047–1053, Apr. 1990, doi: 10.1109/61.53120.

[4] D. J. Melvold, P. C. Odam, and J. J. Vithayathil, "Transient overvoltages on an HVDC bipolar line during monopolar line faults," IEEE Trans. Power Appar. Syst., vol. 96, no. 2, pp. 591–601, Mar. 1977, doi: 10.1109/T-PAS.1977.32370.

RAIN CONDUCTIVITY RANGE

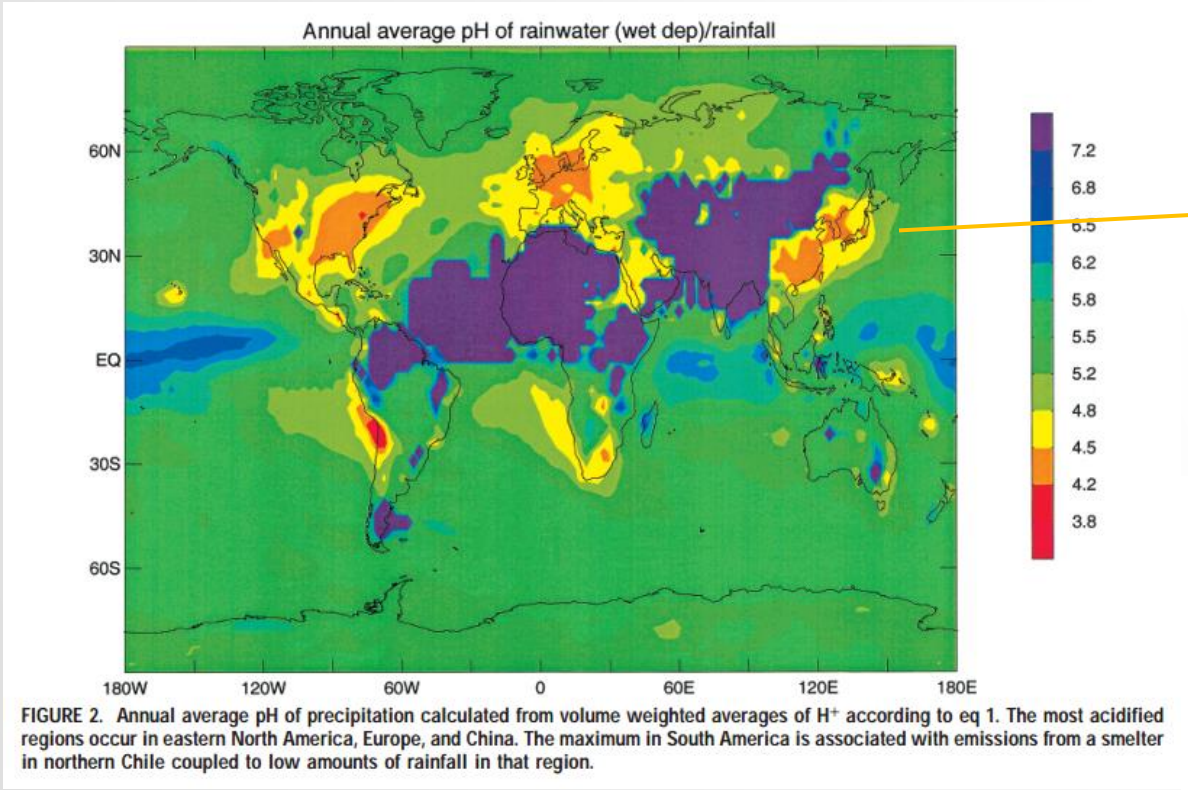


FIGURE 2. Annual average pH of precipitation calculated from volume weighted averages of H^+ according to eq 1. The most acidified regions occur in eastern North America, Europe, and China. The maximum in South America is associated with emissions from a smelter in northern Chile coupled to low amounts of rainfall in that region.

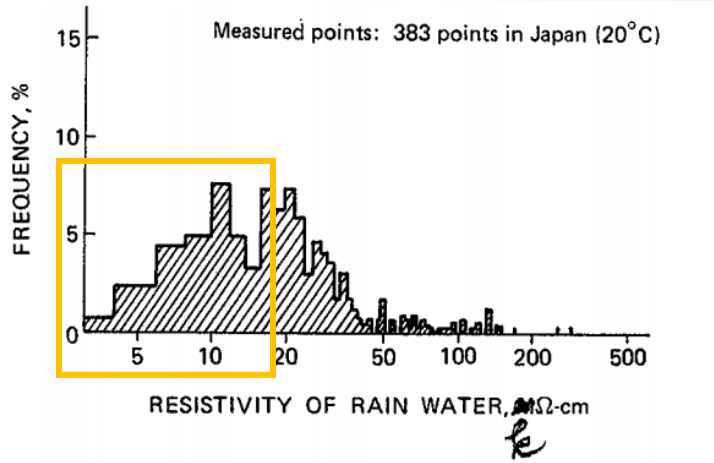


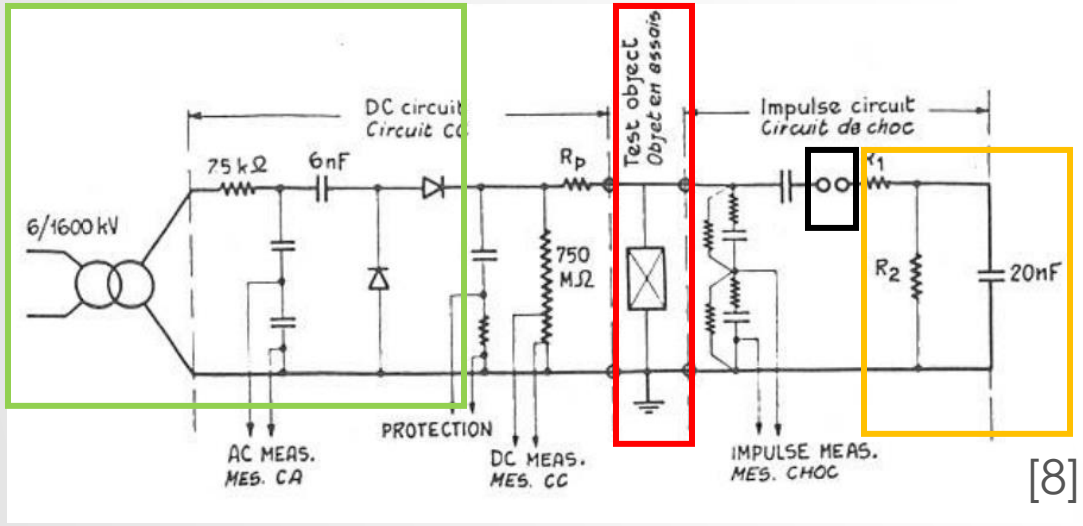
Fig. 9 Distribution of resistivity of rain water

TABLE III
RAIN TEST DATA

Rain rate (mm/min)	*Application time* (min)	*Standard conductivity* (μS/cm)	*Applied Conductivities*	(μS/cm)	(kΩ·cm)
Vertical 1.5±0.5 Horizontal 1.5±0.5	≥ 15	100±15	σ_1	96.2	10.4
			σ_2	160.8	6.2
			σ_3	354	2.8
			σ_4	527	1.9

[5] H. Rodhe, F. Dentener, and M. Schulz, "The Global Distribution of Acidifying Wet Deposition," Environ. Sci. Technol., vol. 36, no. 20, pp. 4382–4388, 2002, doi: 10.1021/es020057g.
[6] T. Fujimura and K. Naito, "Electrical Phenomena and High Voltage Insulators," Nov. 1982
[7] D. Pinzan, F. Branco, M. A. Haddad, M. E. A. Slama, M. Albano, R. T. Waters, H. Leite, "Performance of Composite Outdoor Insulator under Superimposed Direct and Switching Impulse Voltages," IEEE Trans. Power Deliv., 2020, doi: 10.1109/TPWRD.2020.3003980

TEST CIRCUIT



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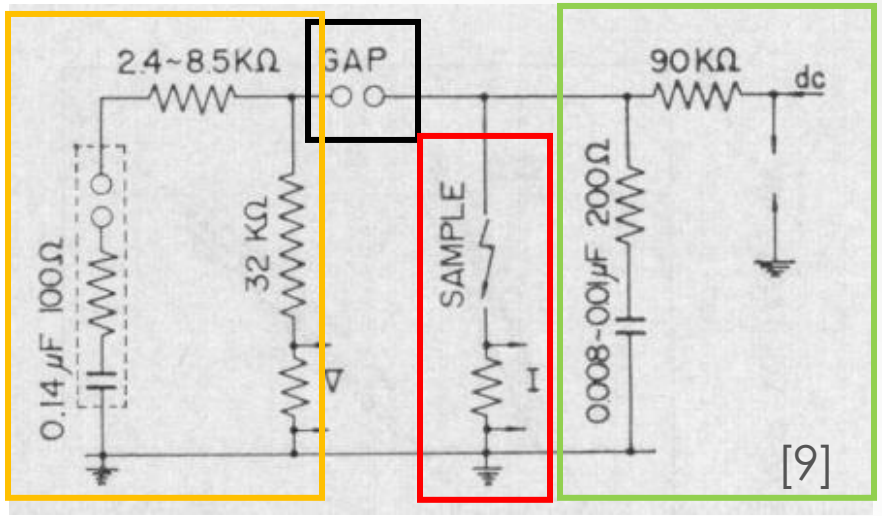
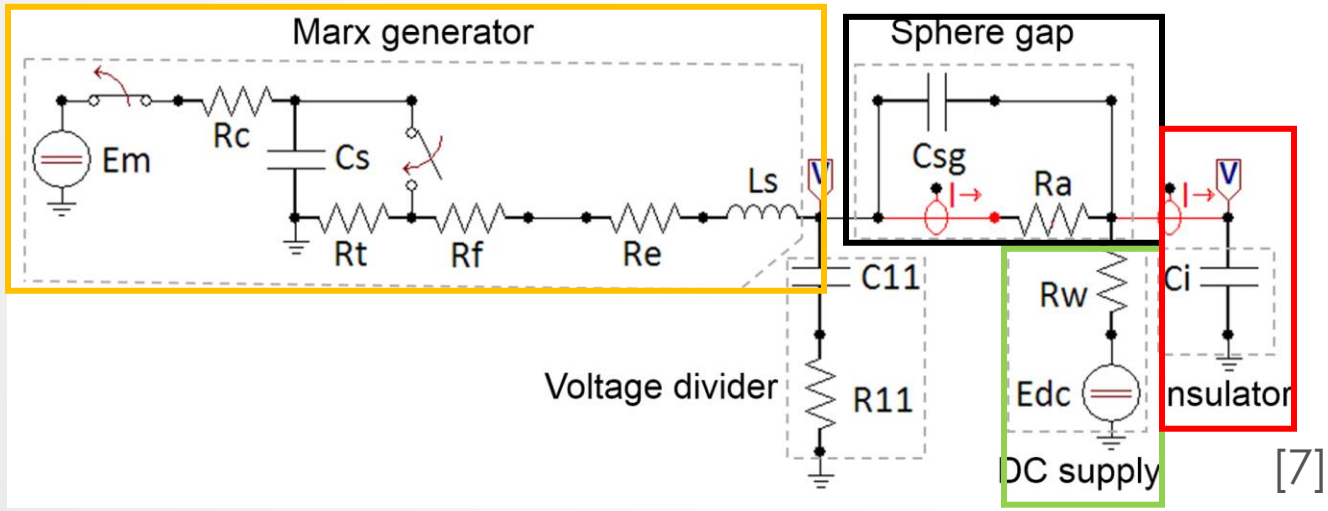


[9]



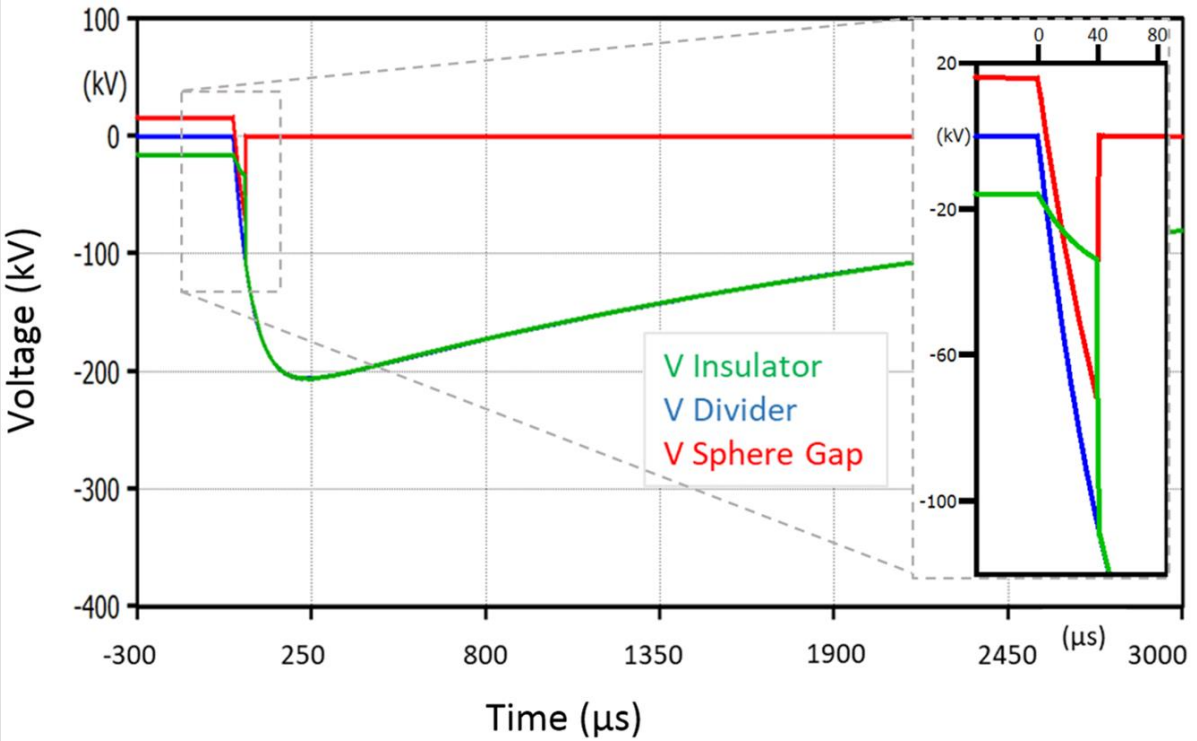
[7]

[7] D. Pinzan, F. Branco, M. A. Haddad, M. E. A. Slama, M. Albano, R. T. Waters, H. Leite, "Performance of Composite Outdoor Insulator under Superimposed Direct and Switching Impulse Voltages," IEEE Trans. Power Deliv., 2020, doi: 10.1109/TPWRD.2020.3003980

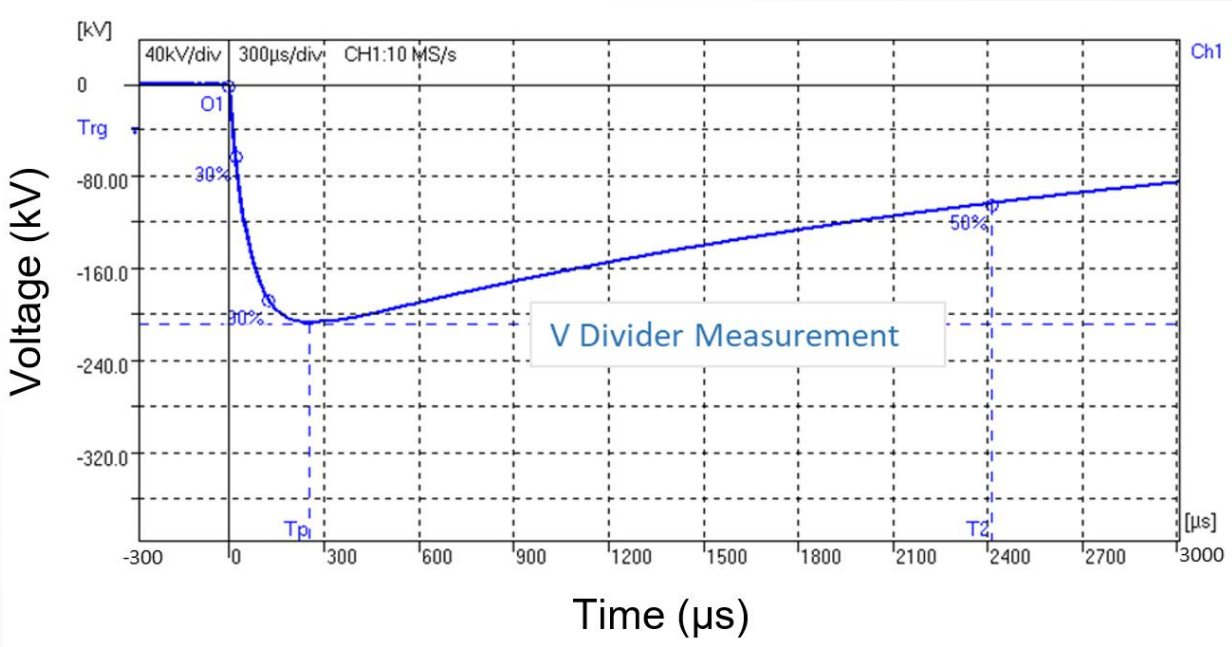
[8] R. Cortina, G. Marrone, A. Pigini, L. Thione, W. Petrusch, and M. P. Verma, "Study of the Dielectric Strength of External Insulation of HVDC Systems and Application to Design and Testing," presented at the International Conference on Large High Voltage Electric Systems, Paris, 1984.

[9] Y. Watanabe, "Influence of Preexisting DC Voltage on Switching Surge Flashover Characteristics," IEEE Trans. Power Appar. Syst., vol. PAS-87, no. 4, pp. 964–969, Apr. 1968, doi: 10.1109/TPAS.1968.292071.

EMTP/ATP RESULTS

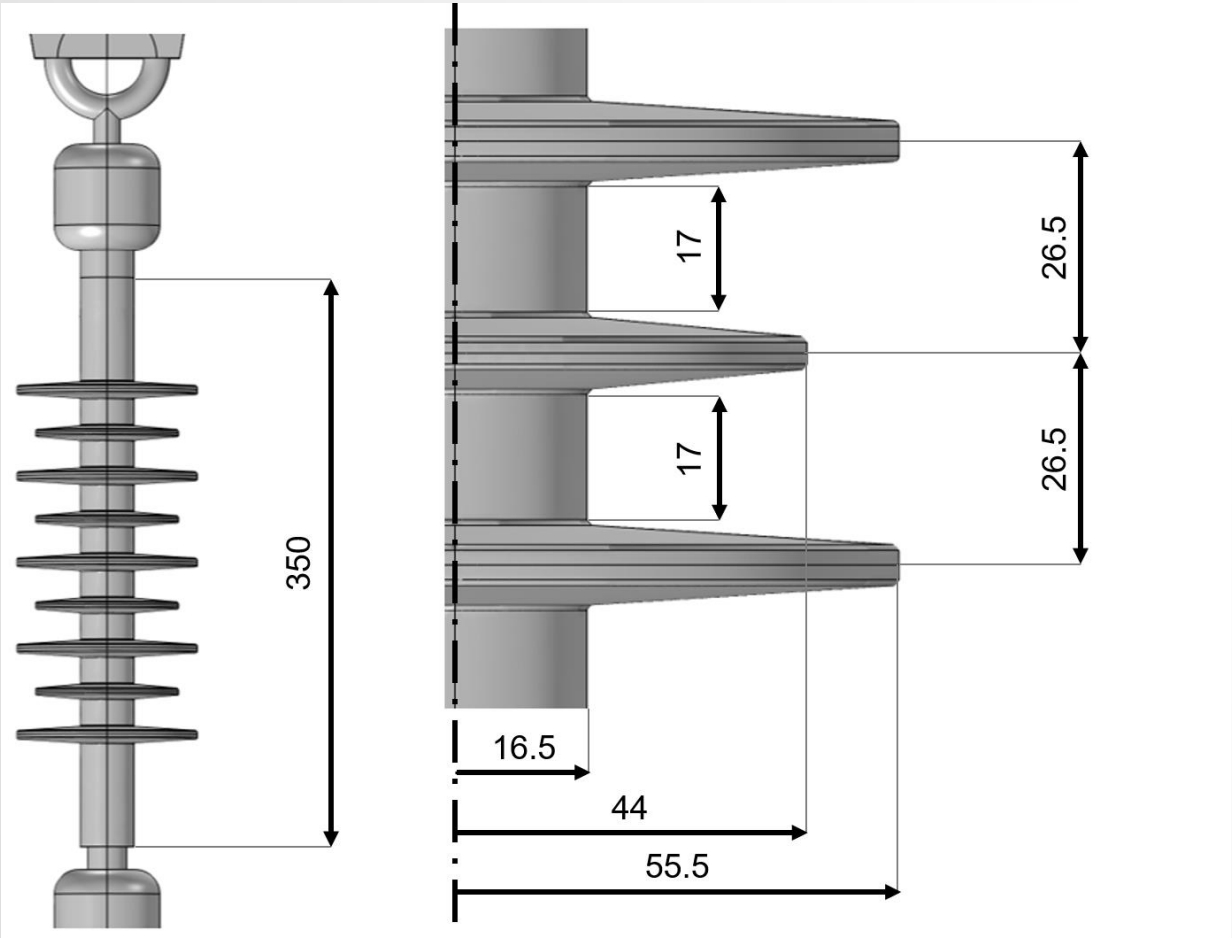


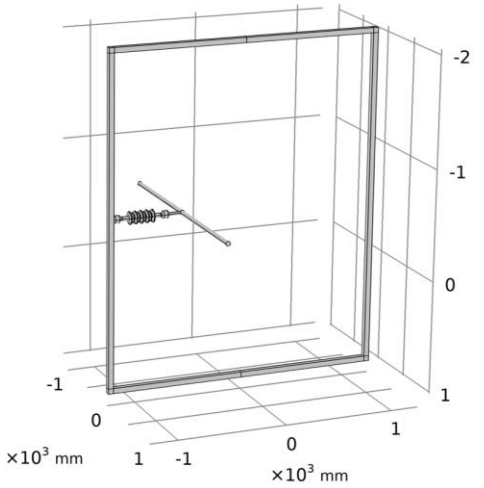
DIVIDER MEASUREMENT

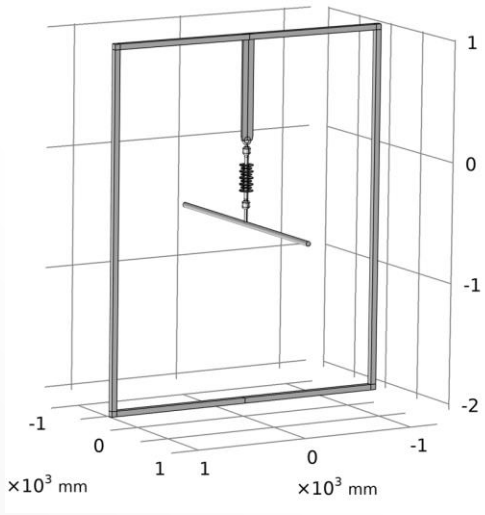


[7] D. Pinzan, F. Branco, M. A. Haddad, M. E. A. Slama, M. Albano, R. T. Waters, H. Leite, "Performance of Composite Outdoor Insulator under Superimposed Direct and Switching Impulse Voltages," IEEE Trans. Power Deliv., 2020, doi: 10.1109/TPWRD.2020.3003980

COMSOL GEOMETRY

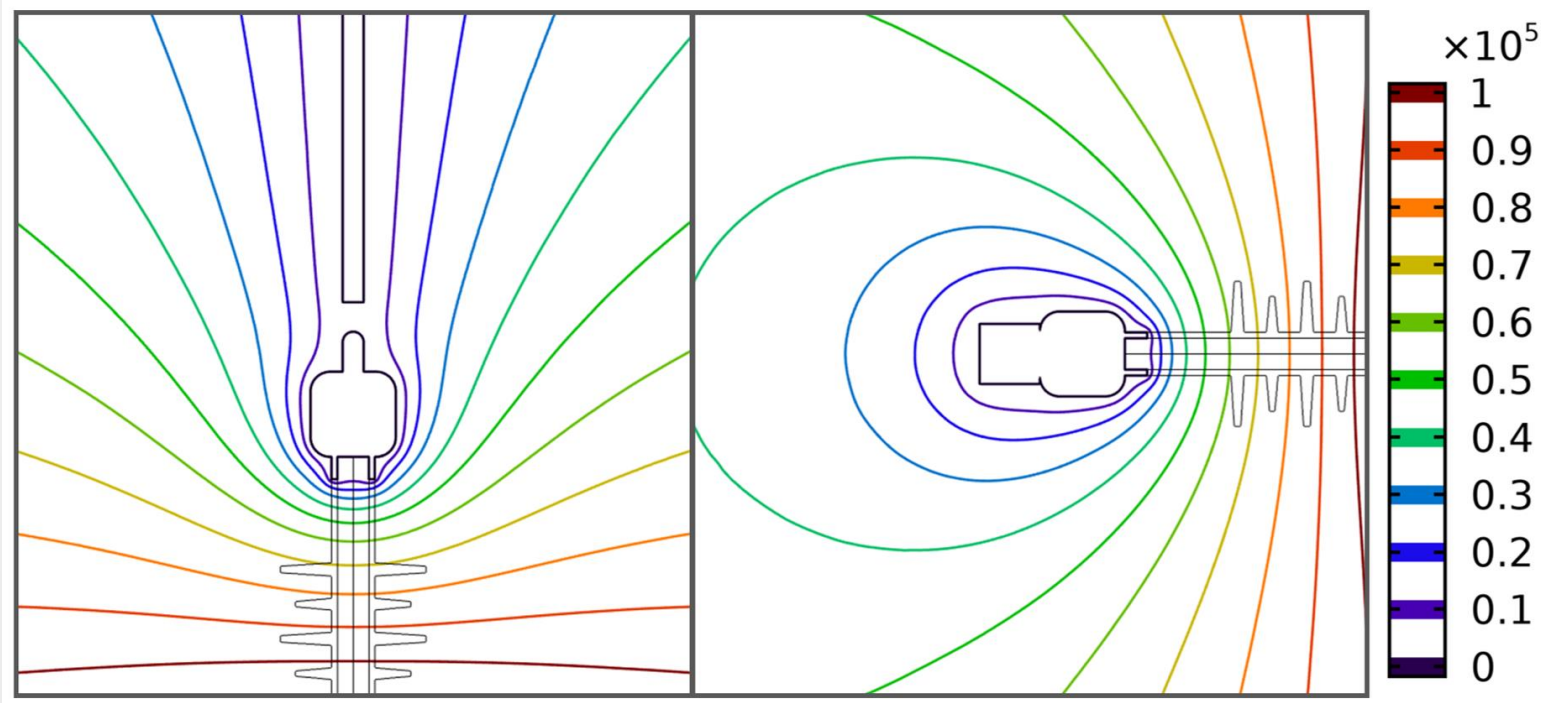






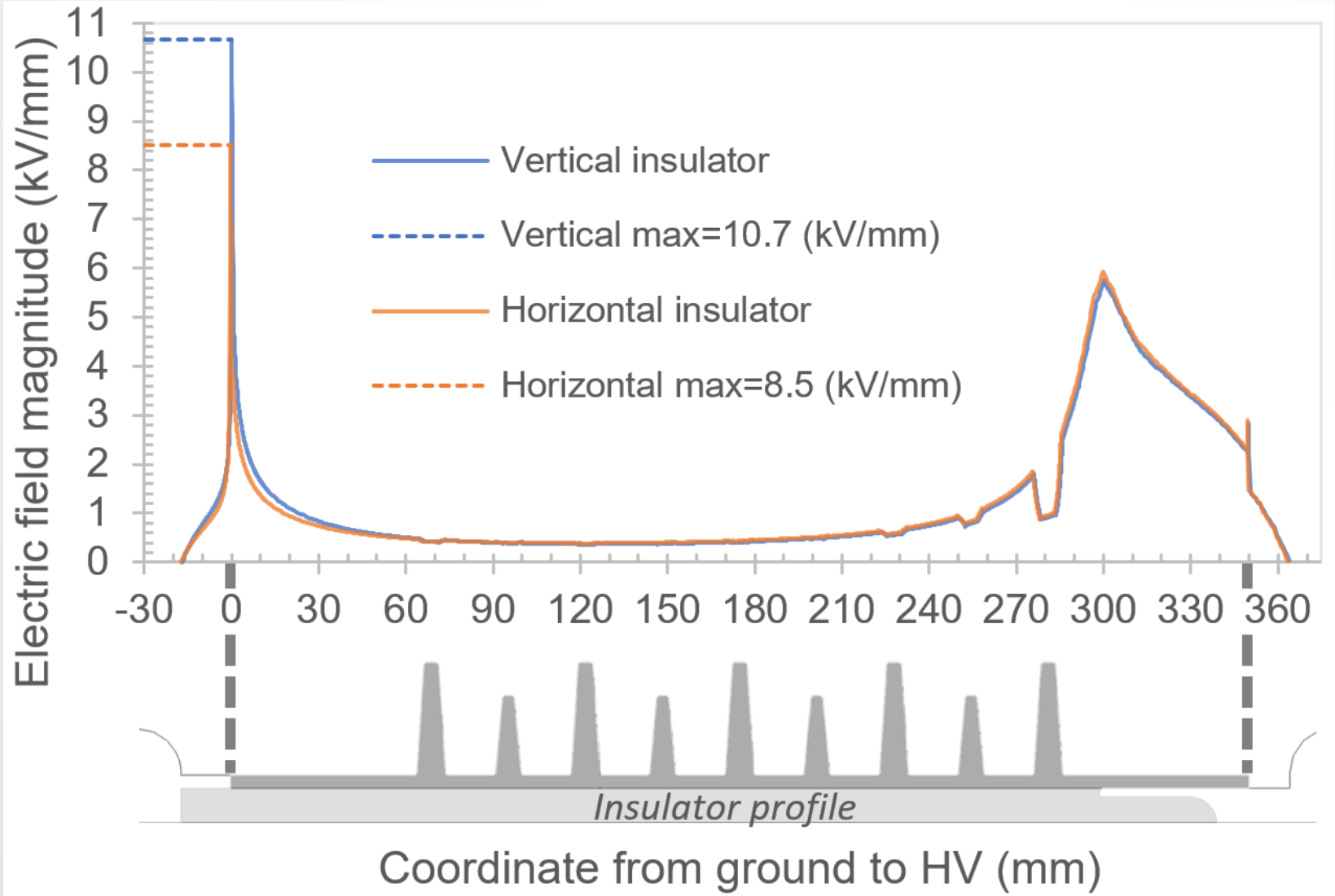
[7] D. Pinzan, F. Branco, M. A. Haddad, M. E. A. Slama, M. Albano, R. T. Waters, H. Leite, "Performance of Composite Outdoor Insulator under Superimposed Direct and Switching Impulse Voltages," IEEE Trans. Power Deliv ., 2020, doi: 10.1109/TPWRD.2020.3003980

COMSOL RESULTS – EQUIPOTENTIAL LINES (V)



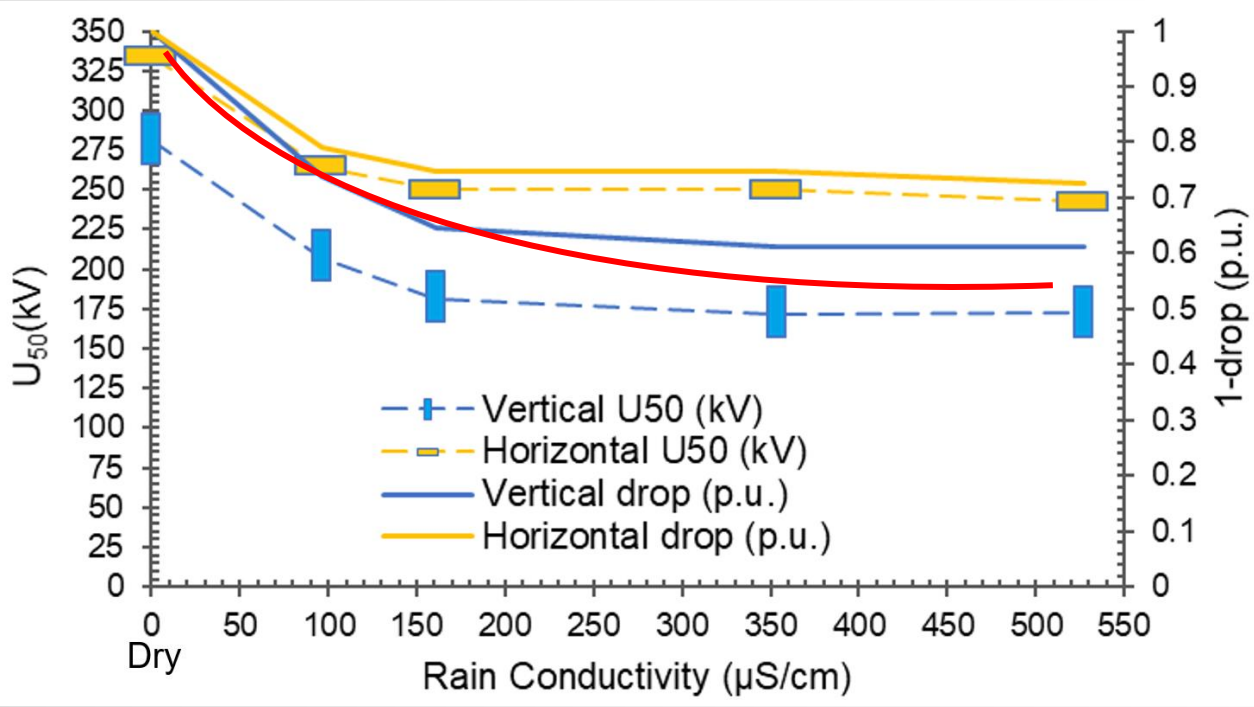
[7] D. Pinzan, F. Branco, M. A. Haddad, M. E. A. Slama, M. Albano, R. T. Waters, H. Leite, "Performance of Composite Outdoor Insulator under Superimposed Direct and Switching Impulse Voltages," IEEE Trans. Power Deliv ., 2020, doi: 10.1109/TPWRD.2020.3003980

COMSOL RESULTS – K NORM ALONG CD

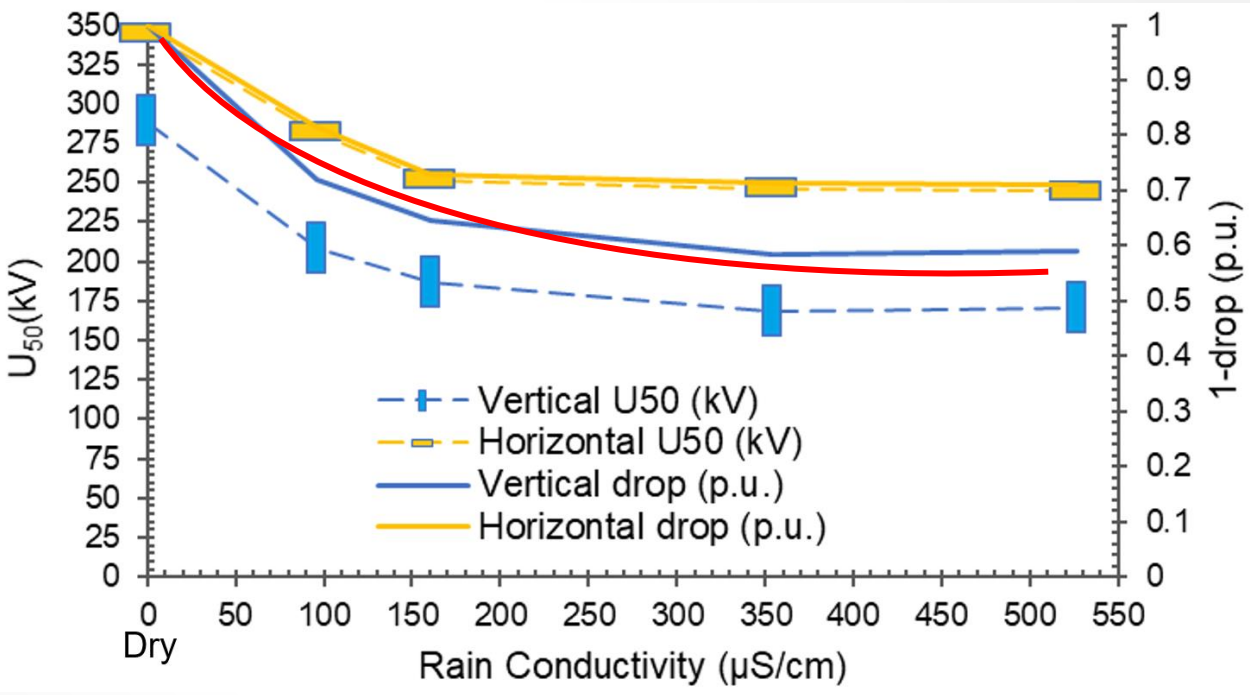


[7] D. Pinzan, F. Branco, M. A. Haddad, M. E. A. Slama, M. Albano, R. T. Waters, H. Leite, "Performance of Composite Outdoor Insulator under Superimposed Direct and Switching Impulse Voltages," IEEE Trans. Power Deliv ., 2020, doi: 10.1109/TPWRD.2020.3003980

MAIN TEST RESULTS



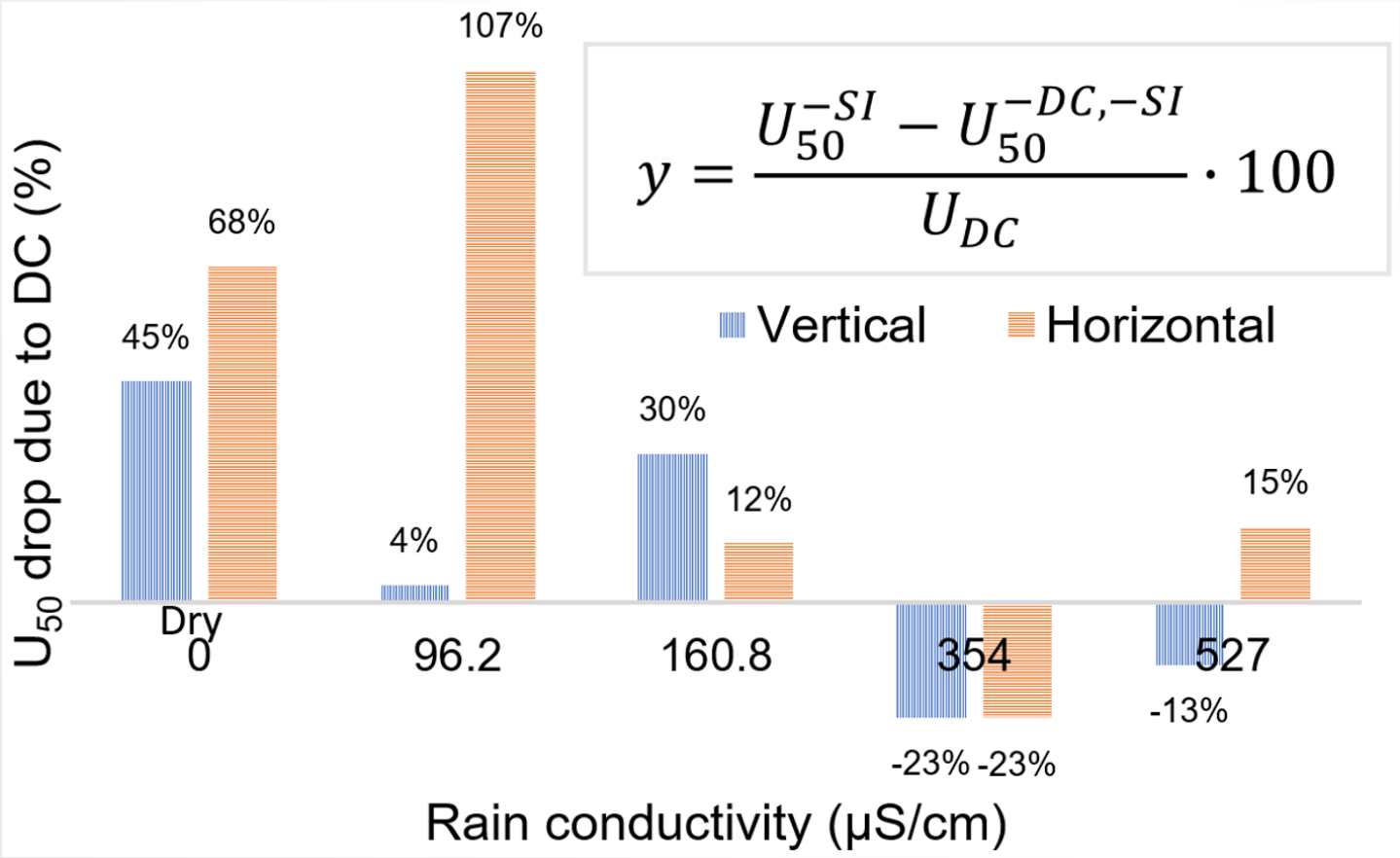
5(b) –SI only



5(c) –DC & –SI

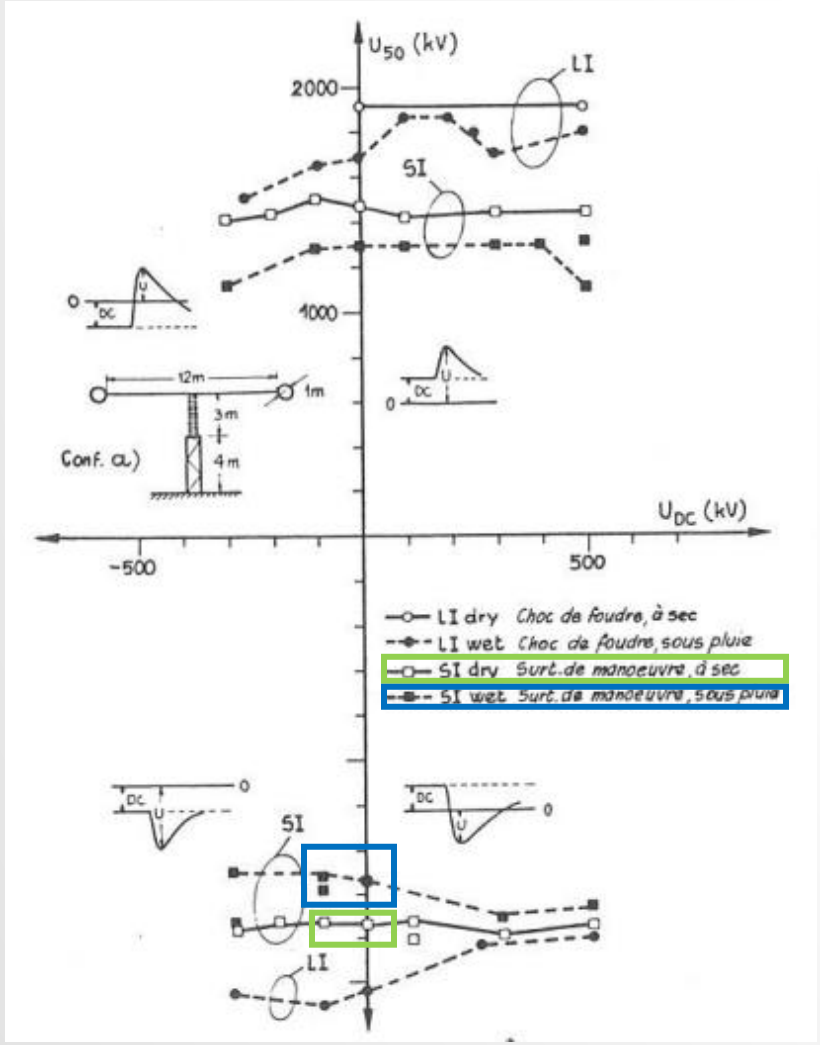
[7] D. Pinzan, F. Branco, M. A. Haddad, M. E. A. Slama, M. Albano, R. T. Waters, H. Leite, "Performance of Composite Outdoor Insulator under Superimposed Direct and Switching Impulse Voltages," IEEE Trans. Power Deliv., 2020, doi: 10.1109/TPWRD.2020.3003980

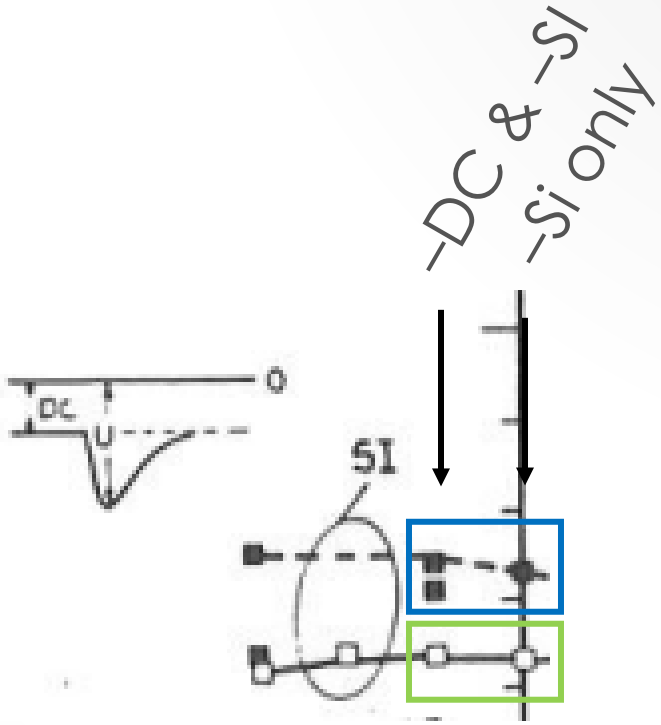
INFLUENCE OF DIRECT VOLTAGE



[7] D. Pinzan, F. Branco, M. A. Haddad, M. E. A. Slama, M. Albano, R. T. Waters, H. Leite, "Performance of Composite Outdoor Insulator under Superimposed Direct and Switching Impulse Voltages," IEEE Trans. Power Deliv., 2020, doi: 10.1109/TPWRD.2020.3003980

DRY AND RAIN: CORTINA ET AL. RESULTS





[8] R. Cortina, G. Marrone, A. Pigini, L. Thione, W. Petrusch, and M. P. Verma, "Study of the Dielectric Strength of External Insulation of HVDC Systems and Application to Design and Testing," presented at the International Conference on Large High Voltage Electric Systems, Paris, 1984.

DRY ONLY - WATANABE ET AL. RESULTS

–Si only
–DC & –SI

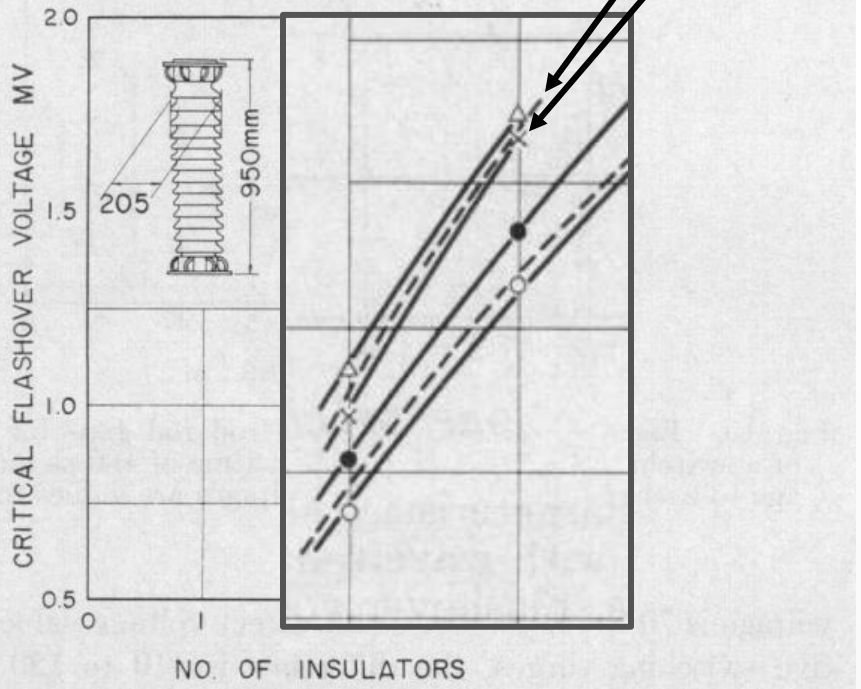


Fig. 13. Flashover characteristics of 205- by 950-mm cylindrical-post insulator stacks for application of a switching surge with wavefront time of 180 μs and a dc voltage to the same electrode.

–Si only
–DC & –SI

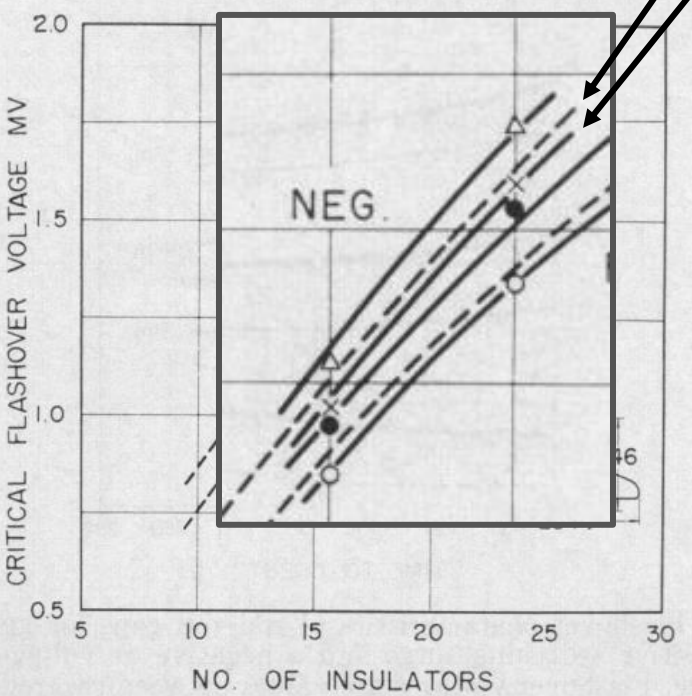


Fig. 11. Flashover characteristics of 254- by 146-mm suspension insulator strings for application of a switching surge with wavefront time of 180 μs and a dc voltage to the same electrode.

[9] Y. Watanabe, "Influence of Preexisting DC Voltage on Switching Surge Flashover Characteristics," IEEE Trans. Power Appar. Syst., vol. PAS-87, no. 4, pp. 964–969, Apr. 1968, doi: 10.1109/TPAS.1968.292071.

CONCLUSIONS

- Test method is provided
- In most cases, the superimposition more severe than SI only
- However, under studied conditions, not likely to occur in operation, because test SSF is much larger than line SSF
- Conductivity range seems sufficient up to 150uS/cm

FUTURE WORK

- Need to study under pollution
- Same electrodes as in field

THANK YOU

QUESTIONS?