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Reliability of Rod plane gap Arrangements as calibration Devices Under Direct Current High Voltages at High Altitudes over sea Level

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Abstract. This article presents the standard deviation which was calculated from experimental data obtained in laboratory tests for breakdown voltage direct current in both polarities at high altitude above sea level. For the tests rod gap-plane arrangement was used at three different profiles for the rod electrode. The standard deviation is reported in terms of absolute humidity, the profile of the electrode tip used and the electrode gap. The tests were carried out at the Laboratory of High Voltage ESIME Zacatenco Instituto Politecnico Nacional located at an altitude of 2240 meters.

Keywords: rod-plane arrangement, absolute humidity

1 Introduction

To measure DC voltages previously voltmeters of areas were used. The estimated error, considering that there is no fiber in the air, is up 5%, but before fibers presence abnormal values can occur up to 30% the magnitude of the average breakdown voltage [1]. Because of its wide dispersion in the values of rupture in the presence of fibers and dust particles, when used with direct current tensions, led to investigate alternative techniques. In 1989 it settled in the International Standard IEC-60 [2] square rod-square rod arrangement as an alternative in the measurement of high voltage direct current. In addition to this arrangement provides a smaller dispersion in their values of rupture, abnormal values are not breaking in the presence of fibers. The limitation presented by these arrangements is that the linearity of the breakdown voltage specific moisture is lost for values greater than 13 g/m3[2-7]. In order to have an option that offers a lower standard deviation values of rupture and at the same time a wider range of linearity, it was decided to investigate the characteristics of top-level arrangements [7].

The various existing research in order to define the limits of linearity of these arrangements are at sea level, so it requires study and analysis at different altitudes, especially large, since the effect of marbling humidity and altitude influences the rate of discharge which modifies in turn, the limits the linearity of such arrangements. In this paper, standard deviation values were used by using rod-plane arrangement for DC voltages with both polarities at a value of air density of 0.77, corresponding to an altitude of 2240 meters. We analyze the effect of humidity and the clear and the profile of the tip electrodes used during laboratory tests.

2 Methodology

The experimental arrangement for carrying out laboratory tests was a rod-plane arrangement, we used three different profiles for the electrode tip, these being the following characteristics: the three electrodes were made of brass, a square electrode of 0.20 mhand, another cylindrical with tapered end (36º) and a third also cylindrical but with hemispherical end (radius of 0.01 m). The plane electrode is made of iron with dimensions 0.9X1.4 m2.

Tip electrodes were connected to a source of direct current while the electrode plane landed. For each electrode gap was a series of 10 shots and calculated the average value of the electrodes.

For positive polarity the interval of the clear between the electrode tip and the plane ranged from 0.20 m to 1.00 m with increments of 0.20 m. To the clear negative polarity was from 0.03 m to 0,036 m with increments of 0.03 m.

The measurement of breakdown voltage is conducted through a resistive divider, and weather conditions (humidity, temperature, pressure) were recorded for each series of ruptures. The relative humidity was measured with a conventional hygrometer. Absolute humidity ranged from 5.4 to 14.20 gr/m^3 and was calculated using the steam tables of British Standard

3 Results

Figures 1 and 2 show the standard deviation of the values of breakdown voltage with positive polarity, for arrangements tapered tip-plane, square toe flat hemispherical tip. It is noted that as the absolute humidity increase and the clear between the tip and the plane electrode, the standard deviation tends to decrease. According to these values of standard deviation, the tapered tip-plane arrangements and point-plane square are reliable tools for measuring DC voltage at high altitude. Their peak values of standard deviation for the entire clear in the study are less than 5%. Although the arrangement hemispherical tip-plane presents reliable values of dispersion for the clear of 0.40 m, 0.80 m and 1.00 m are not recommended for the above purpose and that gaps of 0.20 m and 0.60 m, the maximum dispersion are 8.1% and 7.8% respectively. The results published on sea level (δ = 1.0) by other authors [6, 7, 9] indicate that the standard deviation exceeds 5% for values greater than 13 g/m3, while at high altitude, as can be seen in the figures, the results remain reliable.

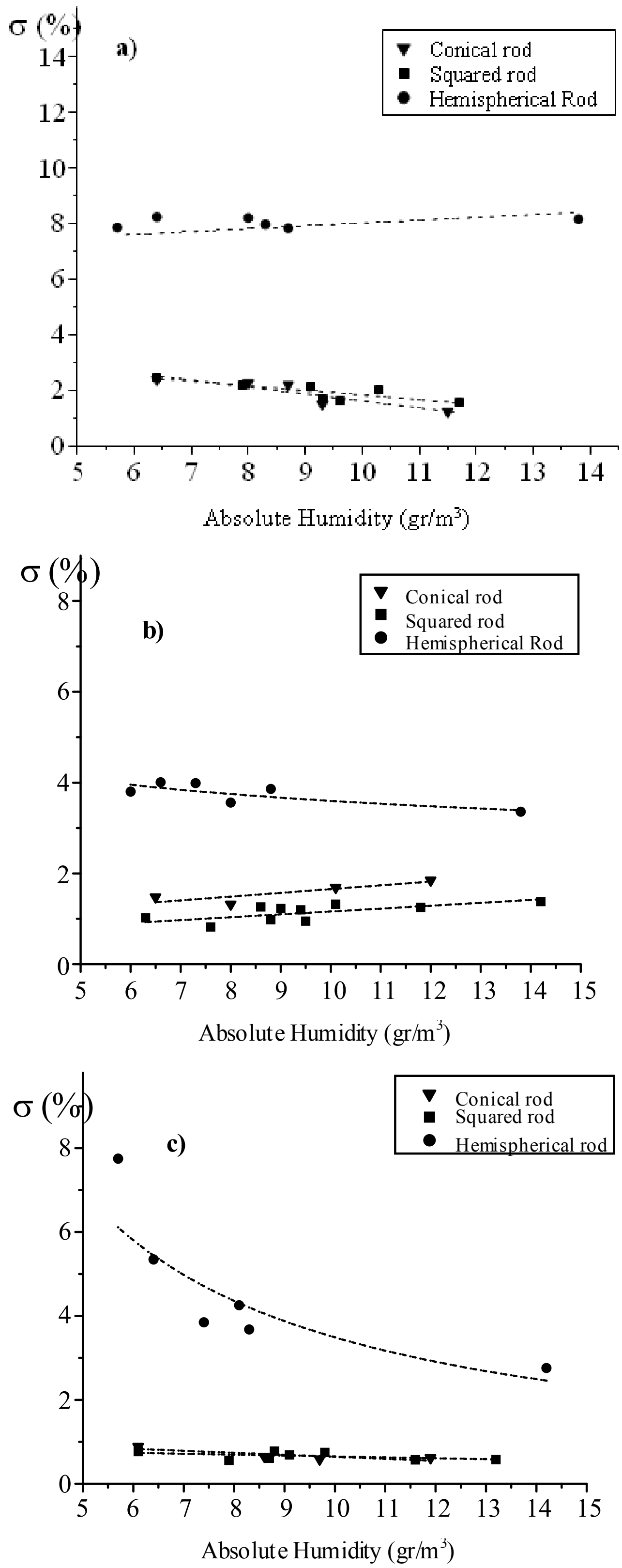
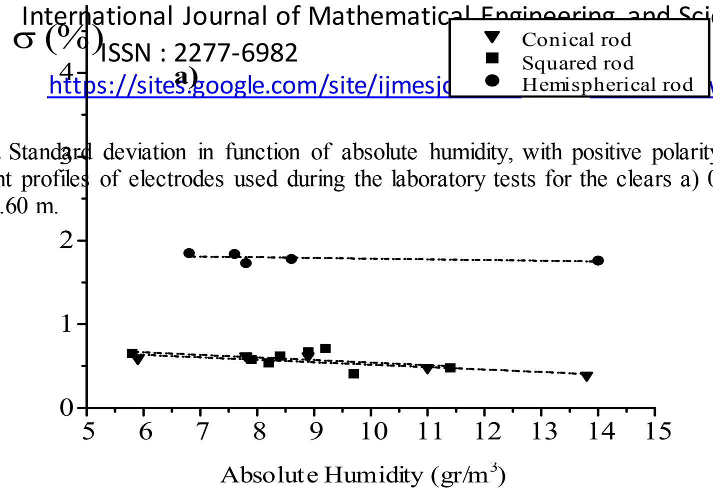

a)
σ (%)
Conical rod
Squared rod
Hemispherical Rod
Absolute Humidity (gr/m3)
b)
σ (%)
Conical rod
Squared rod
Hemispherical Rod
Absolute Humidity (gr/m3)
c)
σ (%)
Conical rod
Squared rod
Hemispherical rod
Absolute Humidity (gr/m3)

Fig. 1. Standard deviation in function of absolute humidity, with positive polarity for the three different profiles of electrodes used during the laboratory tests for the clears a) 0.20 m, b) 0.40 m, c) 0.60 m.



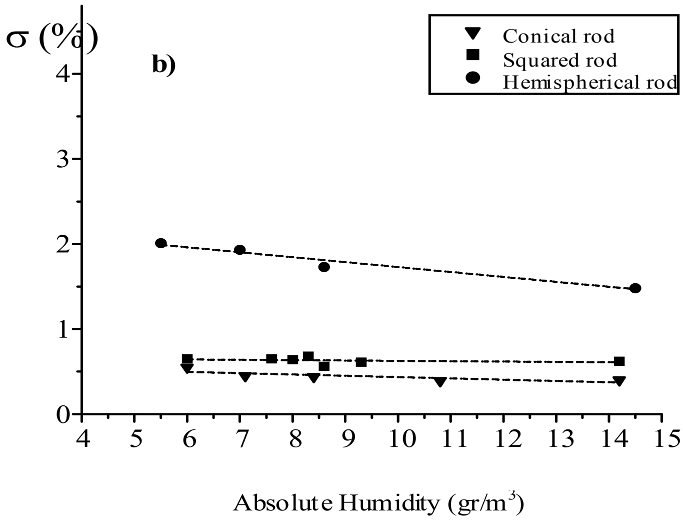
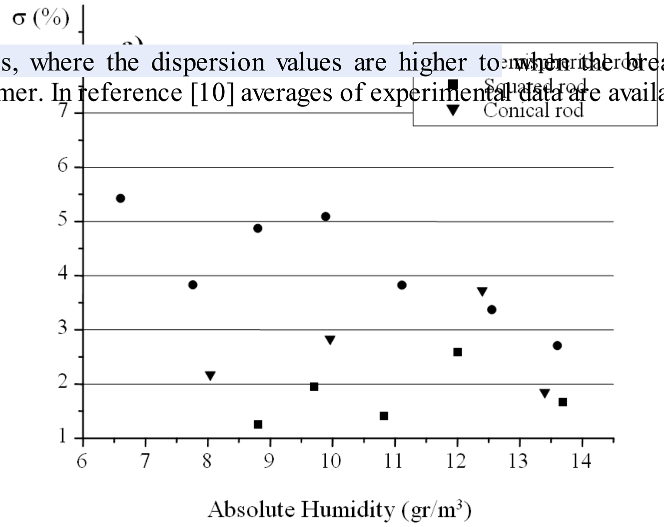
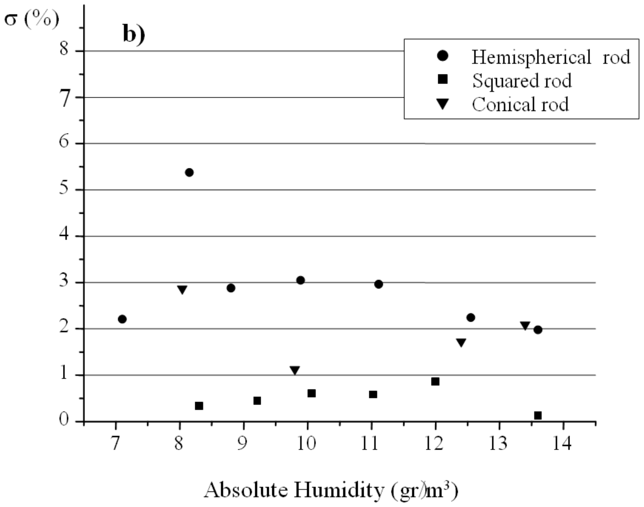
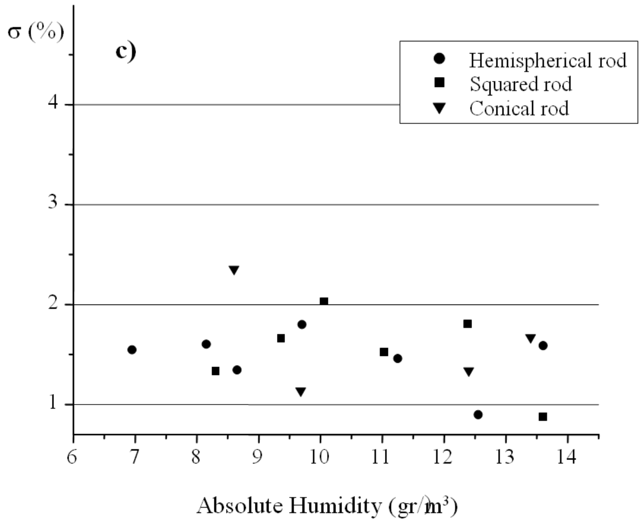


Fig. 2. Standard deviation in function of absolute humidity, with positive polarity for the three different profiles of electrodes used during the laboratory tests to clears of a) 0.80 m and b) 1.00 m.

Figures 3, 4 and 5 show the values of standard deviation, with negative polarity, for the three arrangements used for laboratory test. As in positive polarity, the dispersion of the results decreases when increasing separation interelectrodic. To clears of 0.03 m 0.06 m for the tapered tip-plane arrangements and hemispherical tip-plane spark breakdown occurred and not streamer, which is reflected in the standard deviation curves, where the dispersion values are higher to when the break is presented by streamer. In reference [10] averages of experimental data are available







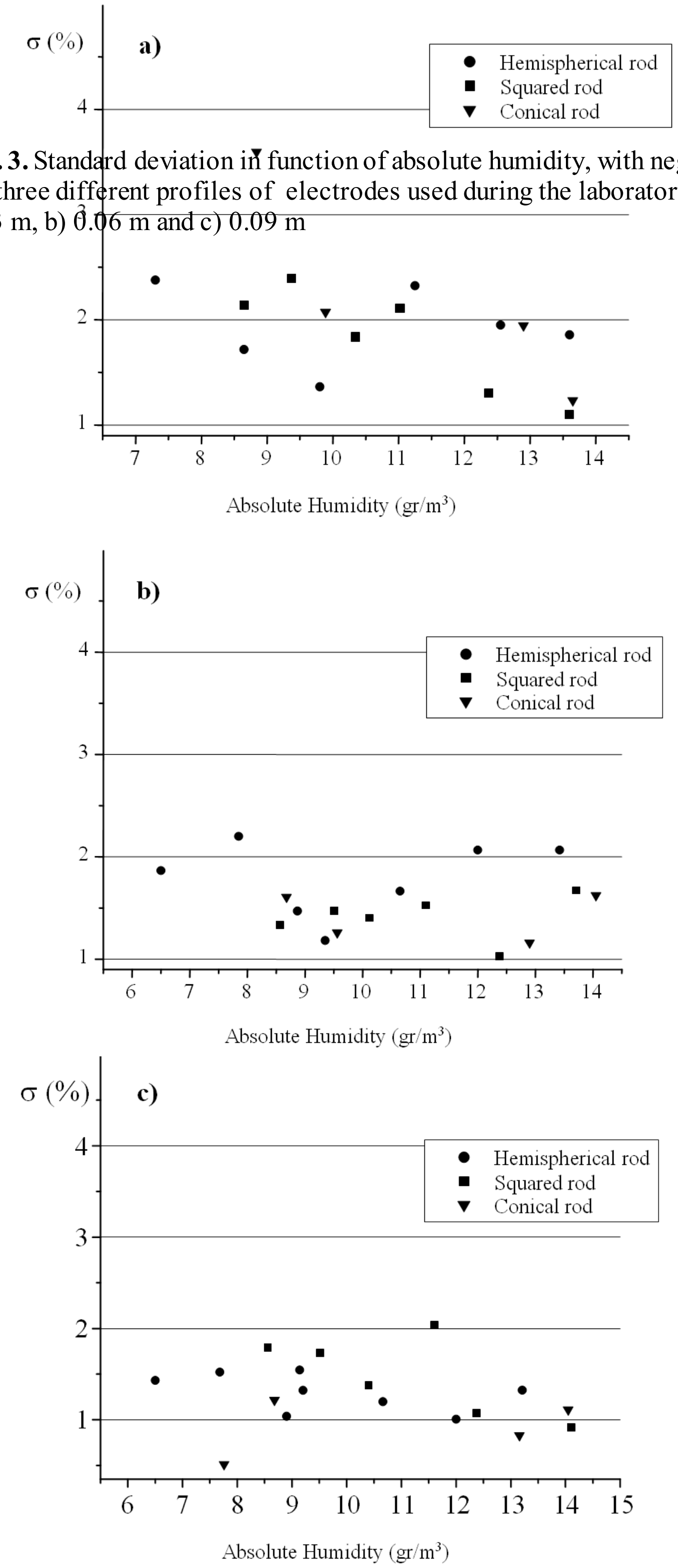


Fig. 3. Standard deviation in function of absolute humidity, with negative polarity, for the three different profiles of electrodes used during the laboratory tests to clears a) 0.03 m, b) 0.06 m and c) 0.09 m

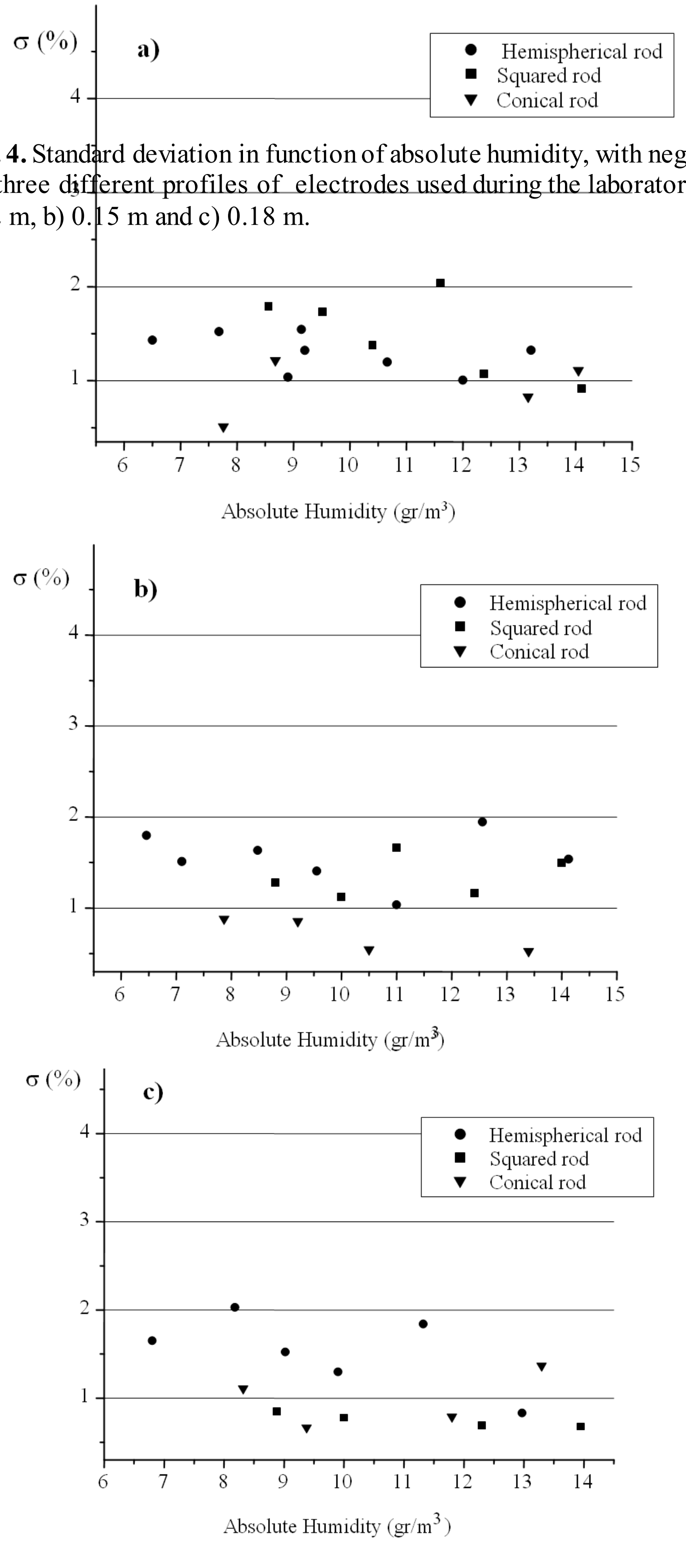


Fig. 4. Standard deviation in function of absolute humidity, with negative polarity, for the three different profiles of electrodes used during the laboratory tests to clear a) 0.12 m, b) 0.15 m and c) 0.18 m.

Fig. 5. Standard deviation in function of absolute humidity, with negative polarity, for the three different profiles of electrodes used during the laboratory tests to clears a) 0.21 m, b) 0.24 m and c) 0.30 m.

For longer distances to 0.06 m, the break was by streamer and like the square toe-plane arrangement ,the values presented are reliable (<5%) so that the three arrangements can be used as a reliable tool for measuring high direct current voltage when the break is by streamer.As in sea level the arrangement that has a higher confidence interval is the square point-plane arrangement. In this arrangement the break was by streamer from 0.03 m, while for the other two arrangements of this separation was by spark which makes the discharge very unstable and the standard deviation value is greater than 5 %.

4 Conclusions

For positive polarity, both plane tapered tip as the tip square-plane arrangements are a good alternative for measuring high voltages at high altitude above sea level, not the hemispherical tip-plane arrangement, which has standard deviation values up to 8.1%. For negative polarity, the three arrangements presented in this paper are a good alternative for the purpose mentioned. In general, the dispersion of the values of rupture is small (2%), however due to the behavior of the square point-plane arrangement shown in this article and at the sea level reported by other authors with positive polarity and polarity negative, this arrangement is recommended as a tool in the measurement of high voltage direct current in both polarities at low and at high altitudes. The square point-plane arrangement shows a wider interval of linearity of the breakdown voltage against absolute humidity and electrode separation.

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