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The Investigation of ESD Charge Transfers from Charged Insulator and the Safety Electrostatic Potential

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Abstract ***- The ESD charge transfers from charged insulator are investigated in this paper. Many factors including the electrode diameter, areas of charged insulator and the distance from charged insulator which influence the charge transfers have been investigated. It has been found that the charge transfers are maximum when the diameter of the electrode is 20mm, the areas of the insulator is about 200cm^2 under the same potential. The relationship between maximum charge transfers and the potential of charged insulator has been founded. The results show that the minimum potential of charged insulator which will ignite the flammable gases of minimum ignition energy of 0.2mJ is about 35kV.***

I. INTRODUCTION

Fires and explosions may be occur in the flammable atmosphere when the potential of charged insulator exceeds certain value. Many authors have studied the energy of discharges from charged insulator[1~2]. Y. Tabata et al. [3] reported that the hydrogen gases with ignition energy of several ten micro joules will be ignited when the potential of charged insulator exceeds 10 kV, and for gases with ignition energy of several hundred micro joules, the potential is 30kV. T. Tabata and S. Masuda[2] presented an equation with a coefficient k (k<1) for calculating the energy of discharge from charged insulator and estimated the minimum ignition potential of charged insulator to cause incendiary discharge. This paper concentrates on the study of ESD charge transfers from charged insulator and the minimum safety electrostatic potential.

II. EXPERIMENTAL METHOD

Many results showed that the charge transfers of 0.1μC in a single brush discharge from charged insulator may ignite flammable gases with minimum ignition energy of 0.2 mJ[1,4,5]. This paper experimentally investigated many factors which have an effect on the charge transfers such as electrostatic potential of the charged insulator, diameter of the discharge electrode, surface area of the charged insulator, distance between the surface of charged insulator and the grounded metal plate.

The testing insulator, a square plate with 3 mm thick, is discharged by static eliminator before charging it in order to charge uniformly. There are four nylon threads tied each corner of the insulator to prevent the fingers of operator from discharging with the charged insulator and contaminating the surface of insulator. The insulator is placed on a large grounded metal plate and fixed by plastics to avoid moving when rubbing by mohair sheet. The potential of the charged insulator plate is measured by a non contact electrostatic voltmeter. Discharges is produced by approaching the charged insulator plate to a grounded metal electrode which connected to a capacitor. The charge transfers are calculated by the formula $Q=CV$, C is the electrical capacity of the measuring system and V is the maximum voltage which recorded by a digital storage oscilloscope. The ambient temperature was 25±2°C and relative humidity was 30 ± 5% during all experiments.

III. EXPERIMENTAL RESULTS

A. Effect of the electrode diameter

Fig. 1 is the experimental results of discharges between polyvinyle chloride (PVC) plate with area of 14.1×14.1cm^2 and the electrodes with diameter of 18, 20, 30 and 50mm respectively. The potential of the PVC plate corresponding charge transfers of 0.1 μC is plotted on the ordinate. The diameter of electrodes is plotted on the abscissa. As shown in Fig.1, the potential of PVC plate with charge transfer of 0.1μC get minimum when the electrode diameter is 20 mm. It means under the same conditions the charge transfers are greater than that with other electrodes.

B. Effect of the area of charged insulator

The experimental results of discharge between charged PVC plates with area of 50, 100, 200, 300 and 400 cm^2 and the electrodes with diameter of 20 mm is shown in Fig.2. The charge transfers can not reach to 0.1μC although several hundred tests have been made with 50 cm^2 PVC plate. As shown in Fig. 2, when the area of PVC plate is 200 cm^2, the potential of PVC plate corresponding charge transfers of 0.1μC is lower than other plates. It can be seen that under the same conditions the charge transfers will be greater than that of others when the PVC plate area is 200 cm^2.

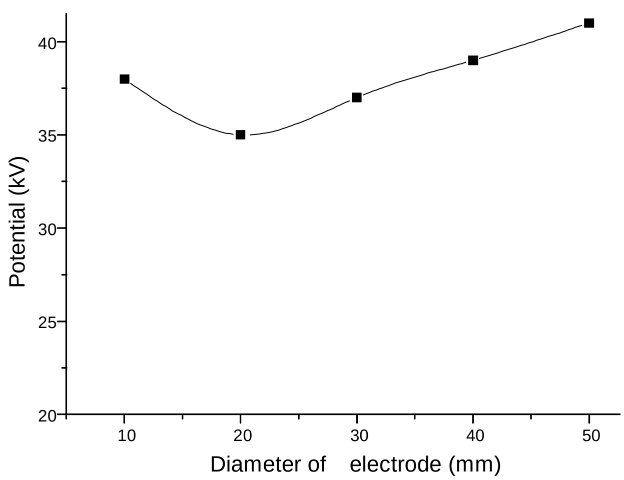

Fig. 1. The potential of PVC corresponding charge transfers of 0.1μC versus the diameter of the electrode

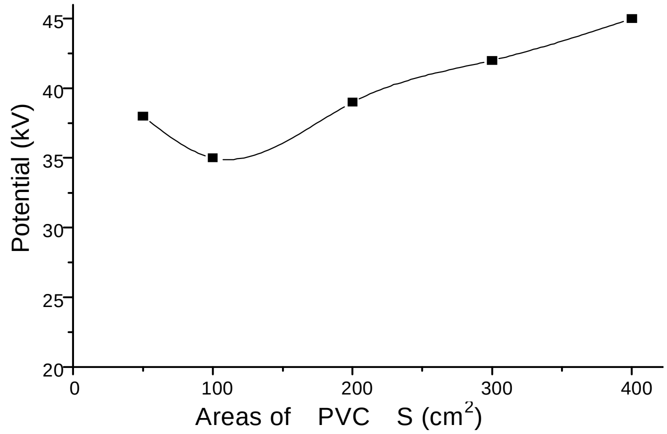

Fig. 2. The potential of PVC corresponding charge transfers of 0.1μC versus the areas of the PVC

C. Effect of distance from charged insulator to the grounded metal plate

Fig.3 indicates the results of charge transfers from 20×20 cm^2 PVC plate behind which there is a grounded metal plate which parallel to the PVC plate. The electrode diameter is 20mm. From Fig.3, it can be seen that the larger the distance from the charged surface of the PVC plate to earthed metal plate, the higher the potential of PVC plate corresponding charge transfers of 0.1μC. The rate of increase of potential tends to zero when the distance greater than 15cm. This means the influence of the earthed metal plate on the charge transfer can be neglected when the distance is greater than 15cm. The tests also show that when the distance is less than 4 mm, the charge transfers can not get 0.1μC if it is charged by rubbing.

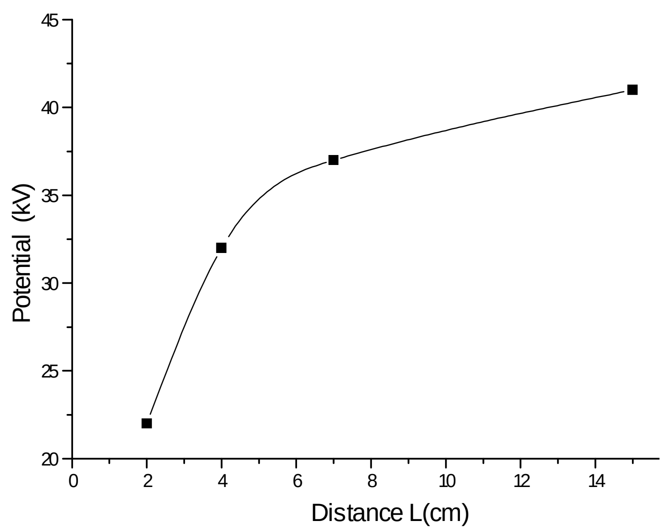

Fig. 3. The potential of PVC corresponding charge transfers of 0.1μC versus the distance from the PVC to the ground

D. The determination of minimum ignition potential

From the above experiments results it can be seen that the charge transfers will be greater when the diameter of electrode is 20mm, area of charged insulator is 200 cm^2, the plate is negatively charged and the relative humidity is less than 30%. The results under these conditions are shown in Fig. 4. The out envelope curve in Fig. 4 means no matter what size is the electrode, what area is the insulator and what relative humidity of the atmosphere is , the charge transfers in single discharge will not greater than that showed by the curve when the distance between charged surface of insulator and earthed metal is greater than 15 cm. This is called the maximum charge transfer curve versus potential of the insulator under optimum conditions. The potential of charged insulator corresponding charge transfers of 0.1μC is about 35 kV. That is to say the minimum electrostatic potential which will ignite the flammable gases with minimum ignition energy of 0.2mJ is about 35kV.

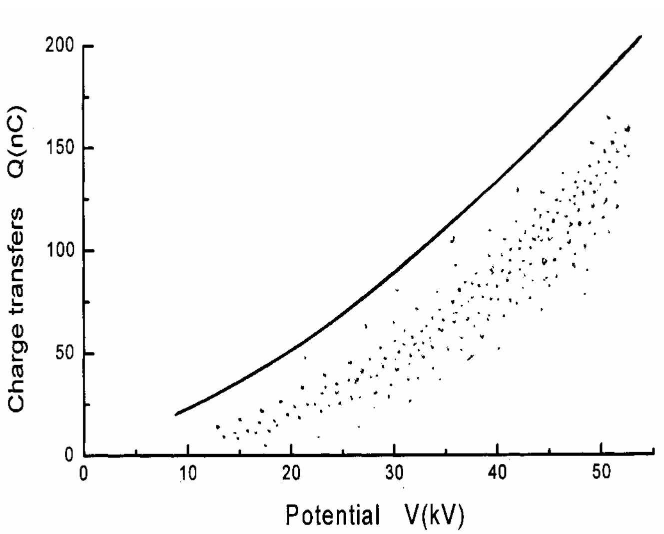

Fig. 4 Charge transfers as a function of the potential of the charged insulator plate

IV. CONCLUSION

This paper investigated the safety potential of charged insulator based on the charge transfers of 0.1μC as the ignition criterion for flammable gases with minimum ignition energy of 0.2 mJ. Many factors which have influences upon the charge transfers have been tested. The relationship between the maximum charge transfers and the potential of charged insulator had been founded. The minimum potential to ignite flammable gases with minimum ignition energy of 0.2 mJ is about 35 kV.

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