# PRELIMINARY CHARGED DIELECTRIC BARRIERS


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### ABSTRACT

The effectiveness of using preliminary charged barriers made of materials with electret properties for increasing the dielectric strength of air gaps with markedly non-uniform fields is shown. With an increase of the area of the charged surface of the barrier its strengthening effect increases.



**Keywords:** non-uniform field, electrical breakdown, dielectric barriers.


### I. INTRODUCTION

In high-voltage insulating equipment barriers (shields) of insulating sheet material are placed in front of needle-pointed electrodes with a small radius of curvature to increase the dielectric strength. In this case the dielectric strength of the discharge gap increases considerably, approaching the strength of a gap with a uniform electric field. An analysis of studies of the barrier effect in air [1-4] shows that the strengthening effect of the barrier consists in obstructing the path of movement of the charged particles in the gas, as a consequence of which the space charge, spreading along the barrier, equalizes the field between the electrodes.

The present work shows the effectiveness of using barriers of preliminarily charged dielectric materials for increasing the dielectric strength of air gaps with markedly non-uniform fields.

The experiments were conducted with the use of needle-plane electrodes at a constant voltage.

A rod with a diameter of 0.004 m having an end in the form of a cone with a radius of curvature of the vertex of $5\cdot 10^{-4}m$ served as the needle and a disk with a diameter of 0.15 m with rounded edges served as the plane. The electrodes were made of brass, a constant inter-electrode spacing S = 10 cm was maintained in the experiments.

### II. MAIN PART

Polymer films with a thickness of $50\mu m$ made of polyvinylidene fluoride (PVDF, dielectric constant $\varepsilon = 3.5$, volume resistivity $(\rho - ohm\cdot m)$ and polyethylene terephthalate (lavsan,

$\varepsilon = 3.5, \rho = 10^{15}\, ohm\cdot m$ ) which have electret properties [5,6], were used for making the pre-charged barriers. Electrification of the indicated dielectric films was done in a field of corona-forming needle electrodes by the "isothermal charge deposition" method [5]: the films being electrified were placed on the surface of the plane electrode and around the needle electrodes located at a distance of 5-6 mm from the upper surface of the films, a direct-current corona was ignited. The area of the charged surface of the barrier was varied by changing the number and location of the corona-forming electrodes.

The charged surface area of the investigated specimens was determined by the electrographic method [7]. A developer consisting of small glass beads coated with bakelite (carrier) and carbon black as a pigment was used for developing the positively charged sections. The negatively charge sections were developed by means of a carrier of beadlike chromium sulfate crystals and a pigment, also of carbon black. The electrograms showed that a charge corresponding to the polarity of the corona-forming electrode forms on the surface of the specimens: negative in the case of negative polarity and positive in the case of positive polarity.

The surface charge density of the electrified section of the films was determined by the method of "induction with compensation of the electret potential difference", consisting in the following [8]. A plane copper electrode-probe with an area of $10^{-4}m^2$, on which a charge is induced from the charged surface of the electret, is periodically shielded by means of a four-blade impeller rotating in the gap between the electret and probe. Therefore the value of the induced charge on the probe periodically changes, which leads to the occurrence in the probe-electret circuit of a pulsating voltage $U_p$ proportional to the value of the effective surface charge density of the electret. Then $U_p$ is compensated by an external constant voltage of opposite polarity $U_k$. The value of $U_k$ found experimentally, permits calculating the value of the effective charge density of the electret $Q=(\varepsilon\varepsilon_0 U_k)/l$, where $l$ and $\varepsilon$ are the thickness and dielectric constant of the electret, $\varepsilon_0$ is the dielectric constant of free space.

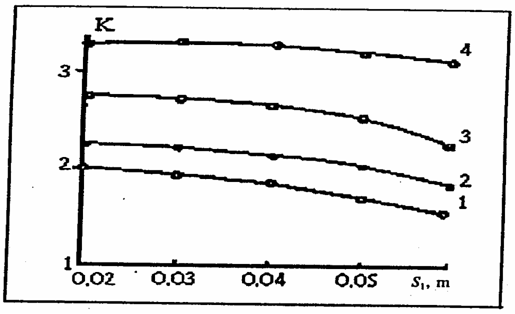


Fig. 1. Dependence of the strengthening factor *K* on the location of the lavsan film barrier in the absence of a preliminary charge (1) and for various diameters of the charged area *d*, m:
2) 0.015-0.02; 3) 0.03-0.035; 4) 0.08-0.1

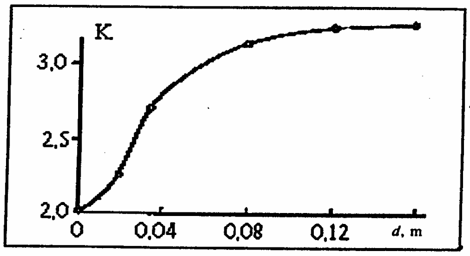


Fig. 2. Dependence of the strengthening factor *K* on the diameter of the pre-charged surface area of the lavsan film barrier.

After holding the specimens in the zone of the corona-forming electrodes for 10 min the maximum charge density on the surface of PVDF and lavsan differed little and was $+10^{-4} C/m^2$ for the positive corona and $-5\cdot 10^{-4} C/m^2$ for the negative.

Barriers of the investigated materials were placed between the electrodes and the dielectric strength of the gap was determined as a function of the distance $S_1$ between the barrier and needle. The value of the discharge voltage after each change of position of the barrier was determined as the arithmetic mean of the results of five measurements. A special experiment established that the dielectric strength of the discharge gap with a broken-down barrier does not differ within the scatter of the measurements from the strength of a gap with a new (not broken down) barrier. Therefore the barriers changed only on changing their location.

The results of the experiment showed that regardless of the charged state of the surface of the barrier made of the investigated materials, the maximum value of the strengthening factor *K* (ratio of the breakdown voltage of the gap with a barrier to the breakdown voltage without a barrier) is observed with the barrier located at a distance from the needle $S_1=0.2S$. For values $S_1=(0.2S-0.6)S$ in the case of a positive needle the dependence of *K* on the location of the lavsan barrier with various diameters of the area of the positive charged surface is shown in Fig. 1. The pre-charged barriers are distinguished by considerable strengthening of the discharge gap compared with the barrier in which a preliminary charge is absent.

With increase of the diameter *d* of the area of the charged surface of the barrier its strengthening effect increases. In this case the region of location of the barrier in the gap for which large values of the strengthening factor are maintained broadens considerably.

Figure 2 shows the dependence of *K* on the diameter of the charged surface area of the lavsan film barrier.

The location of the barrier corresponds to maximum strengthen of the discharge gap $S_1$=0.2S. The observed increase of the value of *K* with increase of the diameter of the charged area in the region 0.02-0.06 m is explained by an increase of the effect of equalization of the electric field by the barrier in the barrier-plane gap. As the diameter of the charged surface approaches the diameter of the opposite plane electrode, increase of the value of *K* slows. A further increase of the diameter of the charged surface (greater than the diameter of the plane electrode) does not lead to an increase of the value of *K*.

Analogous results were obtained with PVDF film barriers.

## III. CONCLUSION

For providing reliable stability of the charged state, barriers of dielectric materials having electret properties can be more effective for increasing the dielectric strength than barriers of the dielectric materials usually used.

## REFERENCES


1. *N.F. Voloshchenko*, “Effect of barriers on dielectric strength of air gaps”. Elektrichestvo. no. 3, pp. 21-26, 1946 (in Russian).

2. *N.N. Nikolayevskaya*, “Mechanism of the barrier effect in air in the case of a pulsed voltage” in: Transactions of Leningrad Polytechnic Institute. High-Voltage Equipment, no. 1, pp. 288-300, 1954 (in Russian).

3. *P. Bening*, Dielectric Strength of Insulating Materials and Structures, Moscow, Leningrad, 1960 (in Russian).

4. *E.A. Oganesov*, Candidate Dissertation Abstract: Some Problems of an Experimental Study of the Barrier Effect in Air Under a Constant Voltage, Baku, 1970 (in Russian).

5. *G. Sessler* (editor), Electrets, Moscow, 1983 (in Russian).

6. *G.A. Lushcheikin*, Polymer Electrets, Moscow, 1984 (in Russian).

7. *A.V. Ivanov*, Candidate Dissertation Abstract, Use of Electrography for Investigating Space and Surface Charges, Moscow, 1971 (in Russian).

8. *A.I. Mamedov, M.A. Kurbanov, Ya.M. Bagirov and M.G. Shakhtakhtinskii*, Electret Effect in Composite Polymer-Ferro piezoelectric Systems, Baku, 1987 (in Russian).