# GAP-FACTOR APPROACH IN NON-UNIFORM FIELD AIR GAPS

BY

Dr. N.M. FARRAG


## ABSTRACT:

Method to determine the sparkover voltage for various gap geometries is described. The results indicate that a numerical coefficient of an empirical nature such as gap factor can be developed.


## INTRODUCTION:

Gap-factor is a numerical device which describes the geometery of any particular configuration. Because of the time and expense involved in high-voltage tests on large structures, any method of extrapolating the known results is economically valuable and of a considerable aid to design. This powerful technique has been developed by Paris[1]. Leroy, Gallet, Kosztaluk, and Kromer[2] have been suggested that, the experimental determination of the gap-factor for any configuration at one spacing enables the well-established rodplane data to be extrapolating for that configuration for other spacings. This paper reports experiments for both positive lightning and switching impulses to represent the sparkover voltage of the air gaps by numerical calculation of the gap-factor for different geometries, e.g. rod-plane, toroid-plane, and sphere-plane air gap configurations. The plane electrode was earthed. Gap lengths of 150 mm, 300 mm were attempted.

## EXPERIMENTAL PROCEDURES

### APPARATUS

A six-stage impulse generator of maximum output 330 kV was used to generate both lightning and switching positive impulses (1.2/50 µS and 60/2500 µS impulse shape respectivily). Gap lengths of 150 mm and 300 mm were attempted. The gap configurations were a hemispherically tipped rod of 19 mm diameter against an earthed plane, a toroid of 30 cm diameter against an earthed plane, and a sphere of 75 mm diameter against an earthed plane. Sparkover probability measurements were obtained from 50-60 impulses at each test voltage level. Fig. 1, shows the experimental arrangement for a rod-plane gap.

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Suez Canal University, College of Engineering, Dept. of Electrical Engineering, Port - Said.

## RESULTS AND DISCUSSION:

Gap-factor decreses with increasing divergence of the electric field distribution and increases with increasing convergence as shown in Figure 2 for both positive lightning and switching impulses. Similar results were obtained by Gallet[3] for gaps up to 10 m. He showed experimentally for rod-rod gaps up to 10 m that the gap-factor was given by:

$$K = 1 + 0.6h/(h + d)$$

Where K was the gap-factor, h was the length of the earthed rod, and d was the gap length. Figure 2, shows also that, the mean sparkover gradient increases linearly with increasing the gap-factor. The linear variation of spakover gradient with gap-factor was also found for more complex structures (Paris and Cortina[4]) Paris[1] (1967) propsed an empirical formula for rod-plane gaps for positive switching impulses was given by:

$$V_s = G\ d^n \ \text{kV (Paris}^1\text{)}$$

Where $V_s$ was the sparkover voltage. He reported data obtained with an impulse shape 120/4000 µS for longer gaps of up to 6.8m length. The parameters G, and n were 500 and 0.6 respectively. These parameters were 400 and 0.75 with great satisfaction with the experimental results obtained for the various gap configurations under investigation. It was found from the results that; the ratio of the positive switching-impulse sparkover voltages for dissimilar configurations was independent of the gap length. By taking as a base the sparkover voltage for the rod-plane gap configuration, which can be empirically represented(± 5% error)by:

$$V_s = 400\ d^{0.75} \ \text{kV}$$

for positive lightning impulses and approximately, also valid for positive switching impulses.

The sparkover voltage for any other configuration ($V_s$) can be given by:

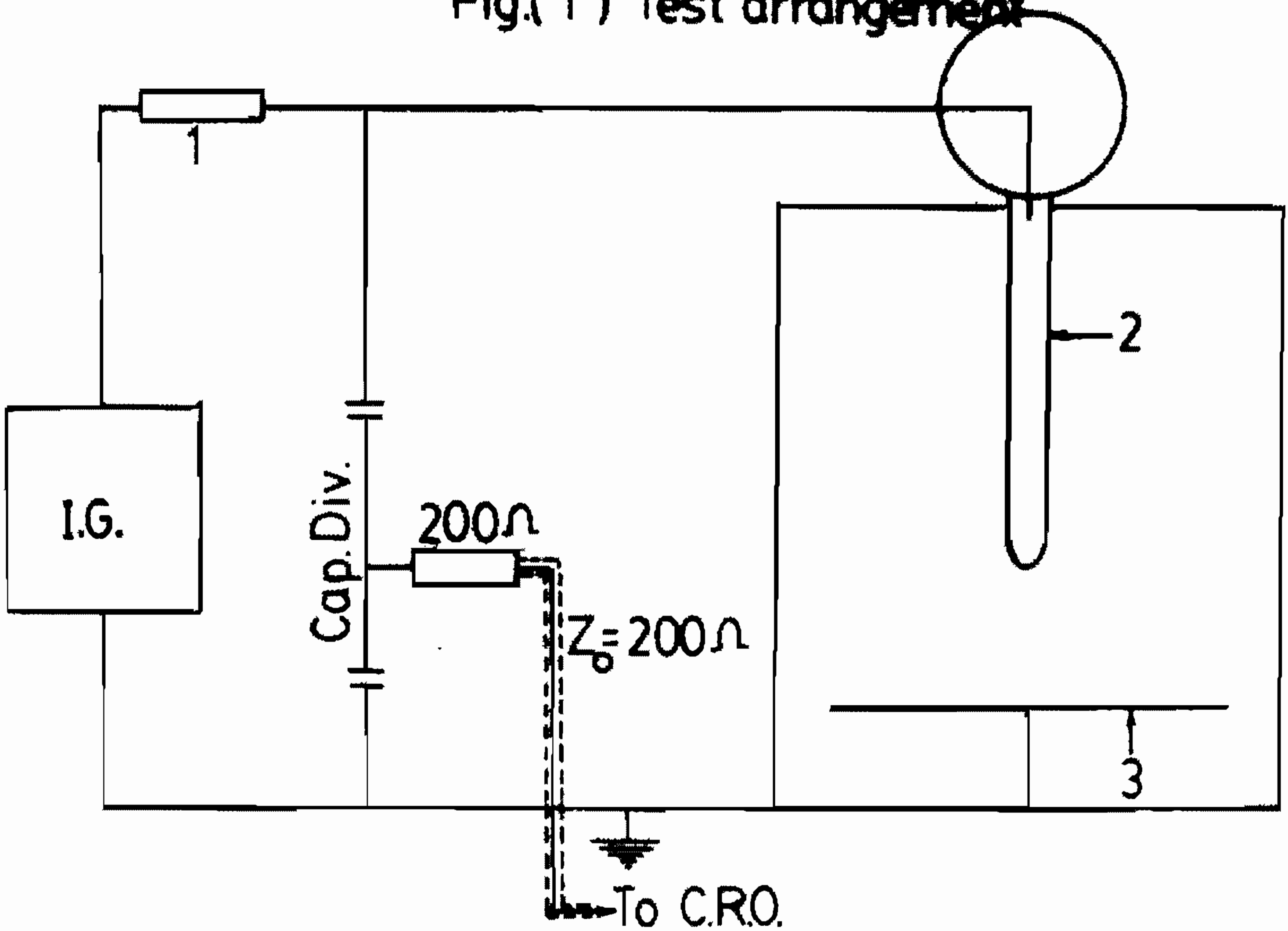
$$V_s = 400\ K\ d^{0.75} \ \text{kV}$$

where K is the gap factor for that configuration, and d is the gap length in meter. It is not possible to determine the gap-factor from the electrostatic field distribution, or to relate it to the physical development of the discharge (some useful attempts have been made by Schneider and Weck[5]; and Garcia[6]).

## REFERENCES


1. Paris, L. (1967). IEEE Trans. PAS-86,936.
2. Leroy, G., Gallet, G.Kosztaluk, R., and Kromer, I.L.(1974). Rev. Gen. del' Electricité.
3. Gallet, G. (1974). Bull. CIGRE Group 33, Vol. II.
4. Paris, L. and Cortina, R. (1968). IEEE Trans., PAS-87,947.
5. Schneider, K.H., and Weck, K.H.(1974). Electra, No. 35, 25.
6. Garcia, H.N. (1975). Int. Symp. Hochspannungstechnik, Zurich.

Fig.( 1 ) Test arrangement




1 External wavefront resistor
2 High-voltage electrode
3 Earthed plane electrode

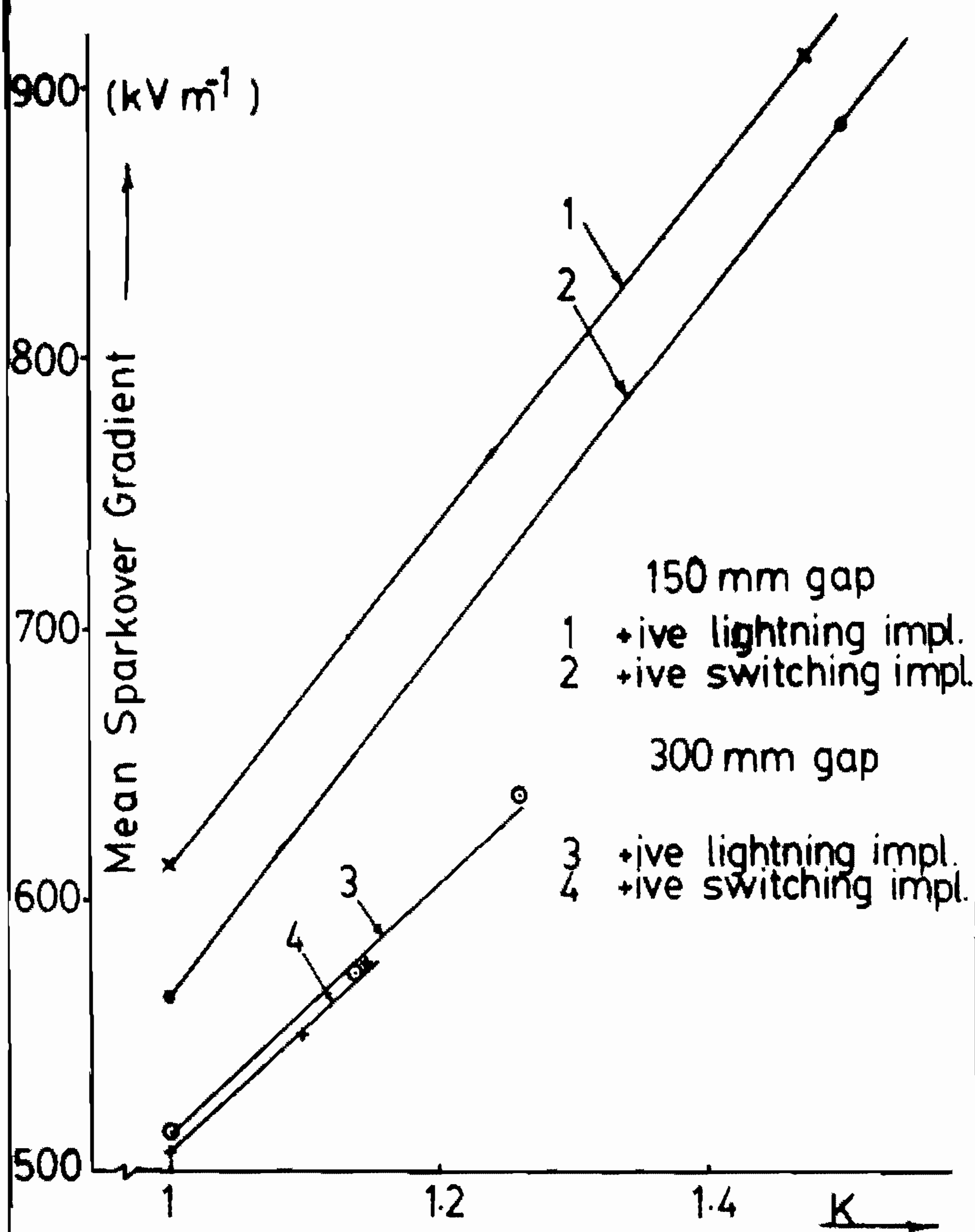



Fig.( 2 ) Relation between mean sparkover gradient and gap factor ( K ).