

## Article

# Experimental Study and Modeling of the Effect of ESDD/NSDD on AC Flashover of SiR Outdoor Insulators

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**Abstract:** Pollution flashover occurs when soluble and nonsoluble materials cover the surface of an insulator, and this may ultimately cause a reduction in its performance. In this paper, the common type of sodium chloride (NaCl) was used as a soluble pollutant (ESDD) and kaolin as a nonsoluble pollutant (NSDD). Samples of silicone rubber (SiR) insulators were selected for this study and fabricated at the Advanced High Voltage Engineering Research Centre (AHIVREC) at Cardiff University. The samples were preconditioned and polluted according to standard specifications. Additionally, the AC voltage ramp technique was used to achieve flashover (FOV) voltage with different pollution levels. The aim of this work was to investigate the effect of nonsoluble materials on flashover characteristics to understand their interaction with dry-band arcs by using FOV electrical equations and experimental data. The test results show that the FOV voltage of the silicone rubber insulator substantially decreased with the increase in both ESDD and NSDD values. It was also identified from these results that the dry-band arcs were considerably influenced by both ESDD and NSDD levels. This impact can be quantified by determining the variation of discharge parameters ( $N$ ,  $n$ ). Based on the FOV equations and experimental data, a mathematical model was suggested, taking into account the effect of both ESDD and NSDD.

**Keywords:** pollution insulators; nonsoluble deposit density; flashover characteristics; arc parameters



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## 1. Introduction

One of the major problems facing HV electrical grid engineers is the disturbance generated by insulator arcing due to pollution flashover (FOV), especially in harsh environments [1,2]. Pollution FOV of insulators is a complex phenomenon and has become a significant aspect in the design of HV overhead lines and substations [2,3]. This phenomenon can be affected by many parameters such as insulator material, insulator profile, pollution level, and atmospheric conditions (air pressure, temperature, humidity, fog, rain, snow, ice, etc.) [1,3–6].

The chemical constitution of the pollution layer is one of the key factors affecting the FOV characteristics and performance of insulators [7,8]. Sodium chloride (NaCl) is commonly utilized as the key reference indicator for conductive pollution materials [9,10]. The pollution degree is defined by the equivalent salt deposit density (ESDD) and represents the concentration of NaCl that, when dissolved in demineralized water, gives the same volumetric conductivity as that of the natural deposit removed from a given surface of the insulator divided by the area of the surface, generally expressed in  $\text{mg}/\text{cm}^2$ . However, in the real field, the pollution constitution depends on the local environment where NaCl is not the predominant salt, as established by many researchers [7,8,11–15]. On the other hand, the pollution layer contains insoluble materials consisting mainly of ferrite, silica, and alumina [4,9,13,15–18]. The pollution index for insoluble or nonsoluble materials is

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