

## 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 (AHIVEC) 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



**Citation:** Slama, M.E.A.; Krzma, A.; Albano, M.; Haddad, A.M. Experimental Study and Modeling of the Effect of ESDD/NSDD on AC Flashover of SiR Outdoor Insulators. *Energies* **2022**, *15*, 3782. <https://doi.org/10.3390/en15103782>

Academic Editors: Zhijun Zhang and Huahong Zheng

Received: 12 April 2022  
Accepted: 13 May 2022  
Published: 20 May 2022

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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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## **Table of Contents Experimental Study And Mathematical Modeling Of Flashover**

1. Understanding the eBook Experimental Study And Mathematical Modeling Of Flashover
  - The Rise of Digital Reading Experimental Study And Mathematical Modeling Of Flashover
  - Advantages of eBooks Over Traditional Books
2. Identifying Experimental Study And Mathematical Modeling Of Flashover
  - Exploring Different Genres
  - Considering Fiction vs. Non-Fiction
  - Determining Your Reading Goals
3. Choosing the Right eBook Platform
  - Popular eBook Platforms
  - Features to Look for in an Experimental Study And Mathematical Modeling Of Flashover
  - User-Friendly Interface
4. Exploring eBook Recommendations from Experimental Study And Mathematical Modeling Of Flashover
  - Personalized Recommendations
  - Experimental Study And Mathematical Modeling Of Flashover User Reviews and Ratings
  - Experimental Study And Mathematical Modeling Of Flashover and Bestseller Lists
5. Accessing Experimental Study And Mathematical Modeling Of Flashover Free and Paid eBooks
  - Experimental Study And Mathematical Modeling Of Flashover Public Domain eBooks
  - Experimental Study And Mathematical Modeling Of Flashover eBook Subscription Services
  - Experimental Study And Mathematical Modeling Of Flashover Budget-Friendly Options

6. Navigating Experimental Study And Mathematical Modeling Of Flashover eBook Formats
  - ePub, PDF, MOBI, and More
  - Experimental Study And Mathematical Modeling Of Flashover Compatibility with Devices
  - Experimental Study And Mathematical Modeling Of Flashover Enhanced eBook Features
7. Enhancing Your Reading Experience
  - Adjustable Fonts and Text Sizes of Experimental Study And Mathematical Modeling Of Flashover
  - Highlighting and Note-Taking Experimental Study And Mathematical Modeling Of Flashover
  - Interactive Elements Experimental Study And Mathematical Modeling Of Flashover
8. Staying Engaged with Experimental Study And Mathematical Modeling Of Flashover
  - Joining Online Reading Communities
  - Participating in Virtual Book Clubs
  - Following Authors and Publishers Experimental Study And Mathematical Modeling Of Flashover
9. Balancing eBooks and Physical Books Experimental Study And Mathematical Modeling Of Flashover
  - Benefits of a Digital Library
  - Creating a Diverse Reading Collection Experimental Study And Mathematical Modeling Of Flashover
10. Overcoming Reading Challenges
  - Dealing with Digital Eye Strain
  - Minimizing Distractions
  - Managing Screen Time
11. Cultivating a Reading Routine Experimental Study And Mathematical Modeling Of Flashover
  - Setting Reading Goals Experimental Study And Mathematical Modeling Of Flashover
  - Carving Out Dedicated Reading Time
12. Sourcing Reliable Information of Experimental Study And Mathematical Modeling Of Flashover
  - Fact-Checking eBook Content of Experimental Study And Mathematical Modeling Of Flashover
  - Distinguishing Credible Sources
13. Promoting Lifelong Learning
  - Utilizing eBooks for Skill Development
  - Exploring Educational eBooks
14. Embracing eBook Trends
  - Integration of Multimedia Elements

- Interactive and Gamified eBooks

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