

# Effect of Environmental Pollution on the performance of Power Transmission lines: Insulator’s Flashover

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**Abstract:** *Damage to the Modern high voltage transmission lines due to Environmental Pollution is well recognized drawback in power system engineering. The damage can take several forms , most important of all is the degradation of the Insulators .This paper describes the various pollution types that are responsible for pollution flashover and how different types of Insulating materials were used to overcome the difficulty related to the environmental pollution with remedial measures to be taken while working with insulators under contaminated environment , because the high voltage insulators are the important part of the high voltage transmission lines in a country which is going to develop UHV power transmission lines.*

**Keywords:** EHV/ UHV, ESDD, IEC

## 1. Introduction

In recent years demand of electricity has enlarged significantly. Reliability of Modern Extra High Voltage and Ultra high voltage Power transmission system has been severely affected by Pollution Induced Flash over which occurs at Nominal operating Voltage .Insulation design for EHV/ UHV systems is based on lightning, switching overvoltage and also on contamination. Pollution is one of the main causes of contamination with arcing within the insulators [1] .The dielectric begins to fail when the pollutants that exist in the air will settle on the surface of the insulators and degrade the surface of the insulators by making it less hydrophobic. The pollution with humidity of fog, rain and dew forms a layer on the insulator’s surface which become conducting and facilitates the short circuit to occur .Thus, the electrical utility get affected until there is an adequate cleaning or maintenance . In other words ,the electrical characteristics gets severely affected degrading the insulators performance .Therefore, electrical companies should prevent the interruption of the service ,produced by contaminated insulators with their performance under polluted environment is one of the guiding factors for insulation coordination of high voltage transmission lines [3]. These flashovers can create line power outages for long durations .The problem of flashover with contamination was recognized in the past decades with most of the studies and research going today to improve the types of insulator’s and materials in insulators manufacturing units with the development of high voltage laboratories in India and around the world. The possibility of insulator’s flashover depends on the type of pollution and the time to which the insulators are subjected. During the last few years, significant change in the environmental conditions as well as industrial developments in various regions contributed to more contaminations, which could largely affect the high voltage power line insulators. Investigation of such issues getting really important for reliable performance of the Power Transmission lines.

## 2. Types of Pollution

The severity of flashover depends on Different types of contamination and the source of pollution. An increase in the pollution increases the leakage current on the surface of insulator for a much probable flashover .The mechanism of pollution of insulators mainly governed by gravity ,wind forces ,electrostatic forces, humidity , PM size and chemical properties of the insulators .

The following are the types of pollution affecting the insulators:

Contaminant	Source of Pollution
Salt	<ul style="list-style-type: none"> <li>Coastal areas</li> <li>Salt industries</li> <li>Salt from snow melting in Hilly Terrain.</li> </ul>
Cement	<ul style="list-style-type: none"> <li>Cement Plants</li> <li>Construction sites</li> </ul>
Fertilizers	<ul style="list-style-type: none"> <li>Fertilizer plants</li> <li>Fertilizers used in cultivated fields.</li> </ul>
Metallic	<ul style="list-style-type: none"> <li>Mining process</li> <li>Mineral handling process</li> </ul>
Coal	<ul style="list-style-type: none"> <li>Coal mining process</li> <li>Coal handling Process</li> <li>Coal burning/Brick kiln areas</li> </ul>
Defecation	<ul style="list-style-type: none"> <li>Roosts of Birds</li> </ul>
Smog	<ul style="list-style-type: none"> <li>Automobile emissions at Highways and crossings.</li> <li>Diesel engine emissions at railway yards.</li> </ul>
Smoke	<ul style="list-style-type: none"> <li>Wild fire</li> <li>Industrial burning</li> <li>Agricultural burning</li> </ul>

Table 1: Types of Pollution with their sources [2]

The three main types of the pollutions are highlighted in this paper that are:

### A. Marine pollution:

The insulators near the marine environment may get deteriorated due to the salted dew of the morning in these coastal zones. Thus, forming a layer on the surface of the insulators. With heat production internal to the insulators or by temperature rise of the place, the salt deposition with

evaporation of dew occurs on the surface. The layer become conducting under humid and rainy weather giving rise to flashover of the strings of insulators [2].The severity of pollution can be quantified in terms of the Equivalent Salt Deposition density (ESDD) in  $mg/cm^2$ .

The following table represents the insulator leakage distance to avoid flashover According to the IEC 60815 Standards:

ESDD ( $mg/cm^2$ )	Site severity based on pollution	Leakage distance (inch / $kV_{L-G}$ )
1. < 0.01	Very light	0.87
2. 0.01 – 0.04	Light	1.09
3. 0.04- 0.15	Medium	1.37
4. 0.15 – 0.40	Heavy	1.70
5. > 0.40	Very heavy	2.11

Table 2: Pollution severity based on ESDD [7]

#### B. Industrial Pollution:

Now a days ,Environmental pollution become severe with industrial revolution .The emission of pollutants form metallurgical, Electric power generating,oil refineries ,cement and fertilizer manufacturing industries gets deposited as a layer on the insulators surface due to wind, weight and electrostatic fields. The typical contaminant sources are smoke from agricultural waste, industrial burning, fossil fuels,also the dust from different industries.

#### C. Desert pollution:

In deserts, the insulators are being subjected to the contamination from the sand. The predominant pollution contents are sand and salty dust in the dry atmosphere. Sand storms can cause insulator material erosion. Thus high speed winds in the deserts can be considered a major source of contamination to the insulators to the nearby areas.

### 3. Mechanism of Pollution flashover

The pollutants get deposited on the surface of insulators over time from various sources of contamination discussed above.During wet conditions such as fog, due, mist and light rain the surface of the insulators become conductingwith

- Burning of agricultural waste.
- Brick kilns smoke and dust accumulation.
- Bird dropping on insulators surface.



Figure 1: Ceramic insulators [6]

leakage current starts flowing to the ground. Non-uniform heat generation over the string causes non uniform drying with wet and dry band formations due to non-uniform pollutant deposition. The inception of the partial arcs called scintillations elongates along the insulators string giving rise to the complete flashover.

### 4. Remedial measures

The effect of the pollution gets reduced with some measures to be taken care while working with the insulators such as:

- Coating: silicone grease, resistive glaze.
- Live line washing for insulators with substation equipment's.
- Telescope boom insulator washers are to be used to clean insulators before monsoon season.
- Extension of pin of insulators along the surface without sacrificing air clearance and creep age.
- Special design using different materials that are less prone to pollution flashover like Polymer/Non-ceramic Insulator (NCI),Ethylene Propylene di-monomer (EPDM), Glass instead of ceramics.
- Development of a novel field control element to improve pollution flashover of insulators.

### 5. Types of insulators used with working experience:

Over the period of time since 1960's lot of work have been done in the field to avoid the problem of pollution flashover with ceramic insulators. Three major types of insulators have been in service to ensure the reliability of electric supply which is discussed below:

#### A. Ceramic Insulators:

These types of insulators were used since 1830's have high degree of standardization with fairly stable electrical and mechanical strength.

Porcelain constitutes quartz and kaolin of first quality. Theses insulators are much largely affected by the environmental pollution such as:

### 6. Elimination of the pollution sources

#### B. Glass Insulators:

In India few of the transmission lines are employed with these types of insulators. They are good for remote areas having good contamination performance due to self-cleaning property.



Figure 2: Glass insulators[6]

### C. Non Ceramic Insulators:

They are in service since 1960's used on all transmission voltage levels have strong tension but low degree of standardization. These types of insulators have a much promising performance in case of environmental pollution but with mold growth because they get dirty due to strong electric field thus becoming low hydrophobic. Bird's droppings can damage the polymer rubber of insulators.

They have more resistive heating to dry the contaminated layer. Contamination flashover performance of NCI insulators is far better than the porcelain and EPDM insulators.



Figure 3: polymer insulators [6]

Research has been going on in the direction to reduce the environmental pollution. It is difficult to control and reduce the pollution sources such as desert, marine but the industrial pollution can be reduced to a significant limit so as to get a better and much reliable environment for the human development.

### 7. Discussion

Reduction in pollution flashover of the insulators depends on: type of pollution, types of insulators, and their maintenance. Better designs of the insulators using best materials are necessary to improve their contamination performance. The physical location of the place also affects the insulator performance under contamination which varies from place to place. Weather conditions of a place also influence in a very important way on the growth of the pollution levels in a region. Insulators performance significantly changes in the severe environmental conditions.

With the development of UHV power transmission networks in the country it's important to study, research and develop the insulators for best reliable and economical solution to the environmental pollution flashover of insulators.

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