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# Electrical performance of composite material insulators: A review

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**Abstract**
In this paper, the results of tests on sixteen different composites materials insulators samples were presented. The results shows, that the grain size of composite materials affected the loss factor (Tan δ) of the insulators, (Tan δ) decreased with the decreasing in grain size and increased as the applied voltage increased. The capacitance C [F] of insulators decreased as the frequency increased and it's increased as the insulator length increased. Also the results show that the high percentages of raisin and Portland cement in composite insulators decreased. The paper presents results of the laboratory tests performed on polymeric insulators with and without bio contamination. It was observed that there is no effect of bio contamination on SR insulators, except that the part of insulator shed with algae formation lost its hydrophobicity and lot of scale formation was observed on all the insulators.

**Keywords:** transmission lines, loss factor

## Introduction

High voltage insulators have developed rapidly since early for more than 35 years, beginning with simple porcelain insulators [1]. Composite insulators recognized as excellent substrates for traditional glass and porcelain insulators [2]. They are light weight, better contamination performance, resistance to damage, and allow compact line designs [3]. In present time modern polymeric insulators are used, as well as the earlier materials. A classification of the main types of insulators is shown in figure [1].

Cylindrical shape or long – rod composite insulator typically is composed of a glass – fiber core rod, weather sheds, protective housing and end fitting. It is important to understand the factors contributing to insulator degradation in order to identify approaching end of life of insulator populations [4]. A number of parameters affect the working life of insulators such as pollution deposition; Insulators exposed to the environment collect pollutants from various sources. Pollutants become conducting when moistened are of particular concern [5].

It allow-core composite insulators are in use for more than thirty years. For line insulation the time period during which plastic materials are used as an alternative to ceramic rods or glass chains is even longer. However, due to the different fields of application of instrument insulators and line insulators the requirements and thus the demand on the quality is largely different. The polymeric insulators were developed and its improvement in design and manufacturing, in the recent years the insulators are more attractive to utilities [7]. Different polymers were used in the manufacture of composite polymeric insulators. Virtually all non-ceramic insulators consist of three main components: fiberglass reinforced resin rod system, metal end fittings, and polymeric weather sheds [7].

The weather shed is intended to protect the fiber glass rod from the environment and electrical surface discharges. Weather sheds are usually polymeric materials [7].

In order to determine the withstand voltage of the insulators specimens under service conditions, alternate 60 HZ sinusoidal voltage were applied simultaneously on the specimens as shown in figure (3) These voltage were increased at uniform rate, from (0) volts up to the breakdown of one of the insulators or even of the air.

During these test the temperature and relative humidity were kept at 24c° and 45%, respectively. It should be noted that all the electrical tests were conducted on specimens by the electric circuit shown in fig (4). Voltage applied range from 30 volts to 240 volts. Problems due to bio contamination of insulators have been reported in tropical areas in USA, Srilanka, Tanzania, Germany, Sweden, Japan, Mexico, Paraguay and New Zealand. Bio contamination in the form of algae is formed on the insulator surface in the cold countries especially on silicone rubber insulators. No systematic study has been done to investigate the long term performance of polymeric insulators with bio contamination. When fungi and other microorganisms colonize the surface of an insulator, they impede the drying of the insulator surface and thus there is a possibility of increased insulator degradation by enzymes secreted by fungal contaminants. Bio contamination causes concern among utility engineers because it is not understood fully. In the present work, algae was allowed to form on silicone rubber insulator. These insulators were then tested under salt fog condition for a period of 10000 hrs and the results are presented in this paper.

## Experimental Set Up and Test Procedures

In order to simulate bio contamination / algae formation on insulator the two commercially available SR insulators SR1 aLLLnd SR2 were used. Creepage length of both the insulator was maintained at the same value of 588 mm. Both the insulators were put in a septic tank for a period of 13 months. The cover of the septic tank was kept open and insulators were fully immersed in water. The average conductivity of water in the tank was 0.528

m mho /cm. Insulators were inspected every month. For the first three months there was no formation of algae/fungus on the insulators. Gradually there was a formation of fungus on both the insulators. At the end of 13 months there was a thick layer of algae, dark green in colour, on both the insulators. Photograph 1 shows the virgin insulator (SRV) and insulators with bio contamination. It can be observed that the formation of algae on the insulators was not uniform. Algae formation was observed on that part of the insulator which was exposed to sun regularly.

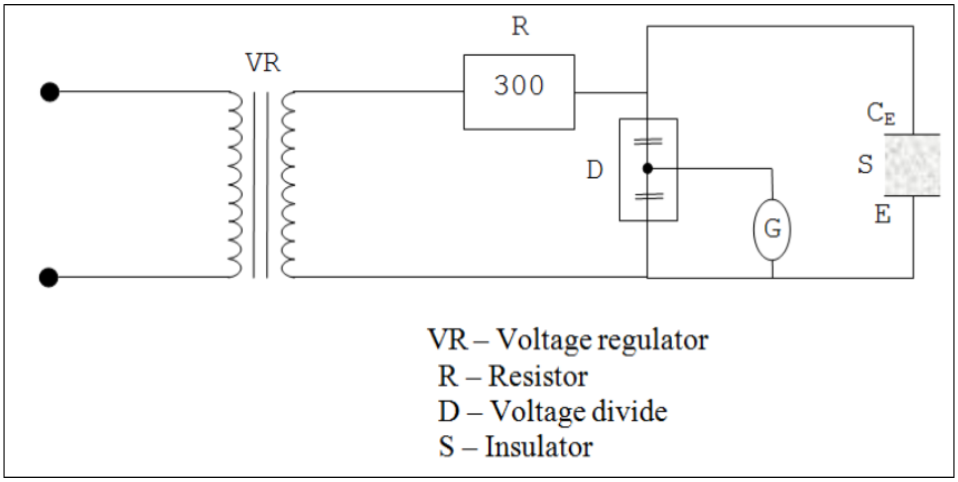


**Fig 1:** Test Circuit

### Dielectric Measurements

Measurement of dielectric constant (E) in static and alternating field's dielectric loss specific electrical conductivity in constant electrical field and electric strength for solid dielectric, determination of the capacitance [C] of plane electrical capacitor with test dielectric placed between its plats figure (3). The dielectric constant (E) is determined from the formula:

$$E= [kd/s]\ C = 0.2 \qquad \text{……… (1)}$$

Where

d = Thickness of the dielectric specimen
s = Area of its lateral face
k = A proportionality factor = 0.22
C = Capacitance [F]

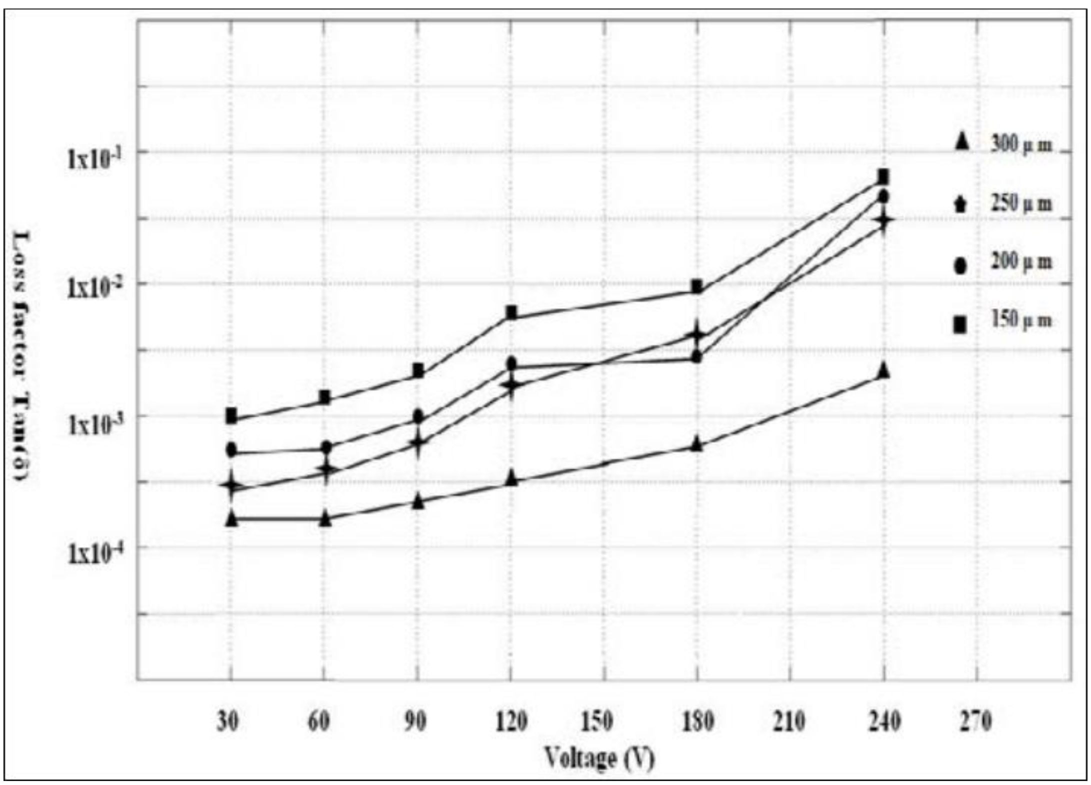


**Fig 2:** Relationship Graph

**Experiment Procedure**

Fresh leaves were cut into pieces less than 2 X 2 cm. The cutted leaves put into the steel drum then add water in it until all cutted leaves is drowned, then plug the power which start heating the coil. After sometimes as the temperature increases inside boiler drum which boiled the water, as when water start to boiled the steam get form which content extract of leaves which is then passes through the dome shape structure having SS Pipe connected between boiler drum and condenser. The steam start moving from boiler drum through SS pipe in condenser. In condenser the heated steam get cooled with the help of cooling water which is supply continuously from cooling unit which is connected separately, Then condense steam is from in water droplet of leaves extract. Then this water droplet is collected in collecting drum with the help of pipe. The extract contain Essential oil at top film and the flower water at bottom.

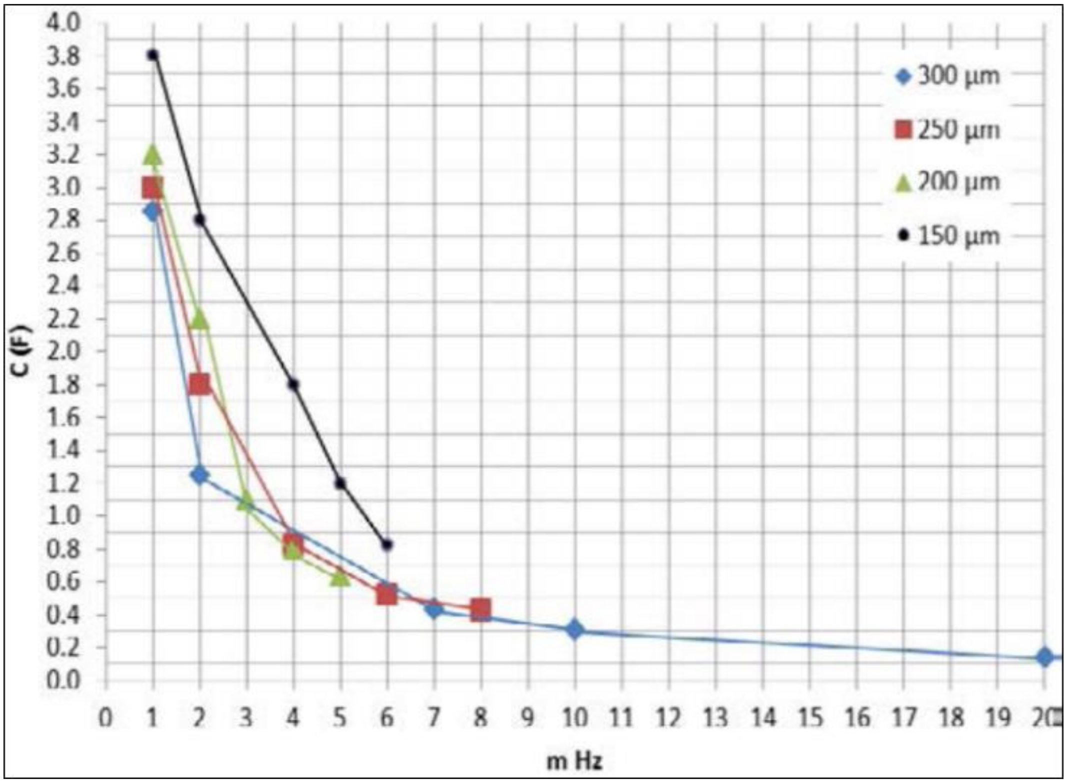


**Fig 3:** Capacitance of insulator over the frequency

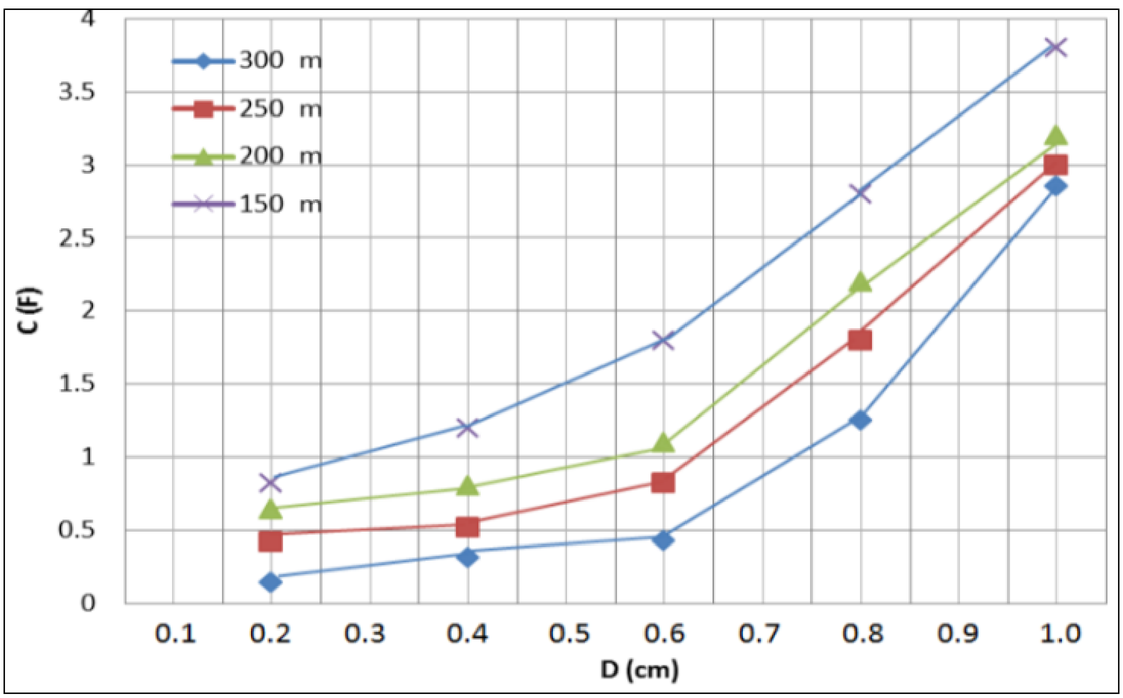


**Fig 4:** Capacitance of insulator over the length of insulator

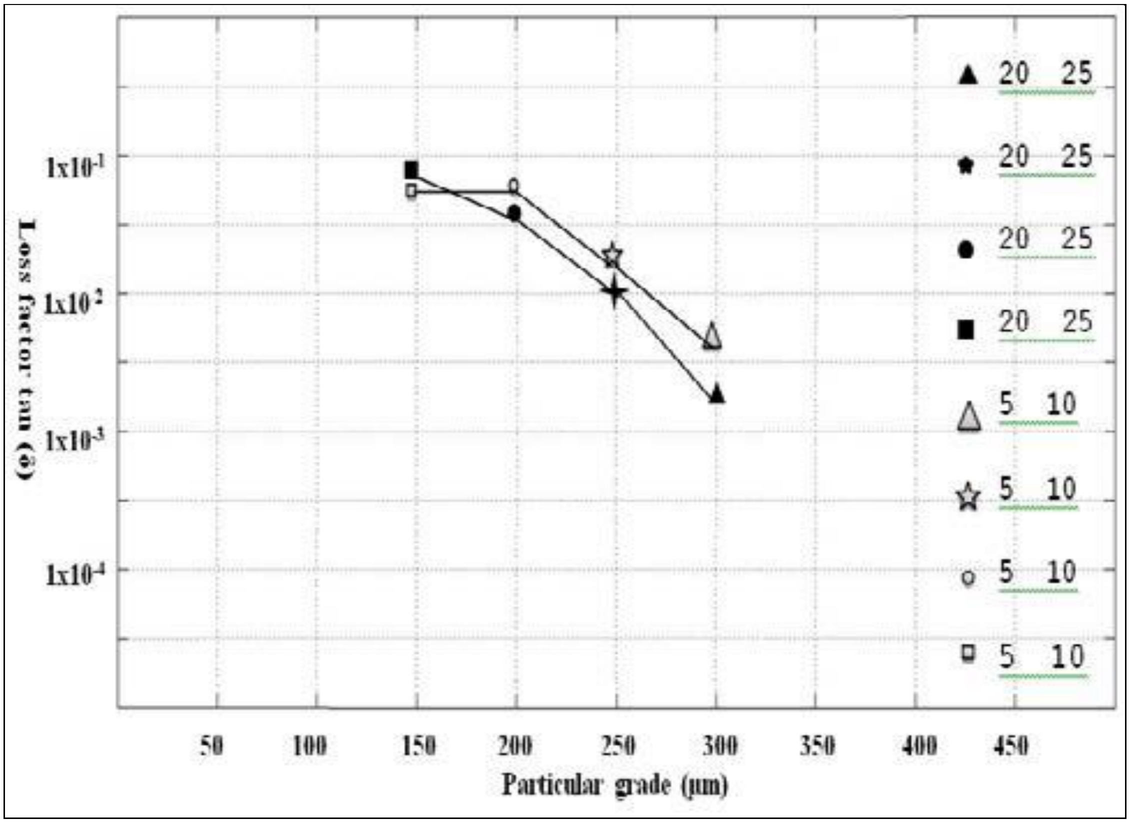


**Fig 5:** Relation between particles grade and tan δ at constant percent of cement and resin at: 270 volte, 50 Hz, Portland – cement 20%, Resin 25%

**Fig 6:** Insulators specimen under test

**Fig 7:** Insulators sample

**Table 1:** Composition of Insulator

| Specimen no. | Practical size | Resin % (by weight) | Portland % curr weight) |
|---|---|---|---|
| A | 150μ m | 10 | 5 |
| B | 150μ m | 15 | 10 |
| C | 150μ m | 20 | 15 |
| D | 150μ m | 25 | 20 |
| E | 200μ m | 10 | 5 |
| F | 200μ m | 15 | 10 |
| G | 200μ m | 20 | 15 |
| H | 200μ m | 25 | 20 |
| I | 250μ m | 10 | 5 |
| J | 250μ m | 15 | 10 |
| K | 250μ m | 20 | 15 |
| L | 250μ m | 25 | 20 |
| M | 300μ m | 10 | 5 |
| N | 300μ m | 15 | 10 |
| O | 300μ m | 20 | 15 |
| P | 300μ m | 25 | 20 |

**Conclusion**

The electrical test results reveal that under the same test condition, composite insulators with a fine organic calcium grain have alower (tan δ) as compared with other types of composites insulators, as a function of applied voltage figure (5), this due to the increased in grain boundary networks, which resist the flow of electrical current Portland cement percentage in composite affected the insulators properties as its increased. This due to the high percentages of (cao) in Portland cement figure (6).

1. Loss factor (tan δ) increased as the applied voltage increased.
2. Loss factor (tan δ) affected by the grain boundary network of the microstructure of composite insulators.
3. Organic Calasium materials act as good dielectric materials.
4. High percentage of Portland cement affect the loss factor (tan δ).
5. The performance of insulator affected by the types and dimension of insulator.

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