# INVESTIGATION ON TRANSITION JOINT MATERIALS AND ELECTRIC FIELD IN DIFFERENT LAYERS OF JOINT INSULATION

Pranav **JOHRI**, C.C. **REDDY**, Indian Institute of Technology Ropar, (India), 2017eem1009@iitrpr.ac.in, reddy@iitrpr.ac.in

## ABSTRACT

*The authors aim to evaluate the electric stress experienced by the layers of an AC transition joint, which connects an oil-paper insulated cable with a cross-linked polyethylene insulated cable. Past researches and utility statistics suggest that the majority of failures in such a joint tend to initiate on the paper cable side, hence the authors have chosen to model and analyse the same. Dielectric spectroscopy has been done to measure the dielectric properties, in particular relative permittivity of materials that form the inner layers of the joint and its dependence on temperature and electric field. The simulation results have been obtained to evaluate the effect of the measured material properties on the resultant electric field. The effects of thermal ageing and load conditions on the electric field distribution have also been investigated.*

## KEYWORDS

Transition joint, dielectric spectroscopy, thermal ageing.

## INTRODUCTION

The reliability of oil-impregnated paper insulated cables has been well known for years. Even today, they continue to exist in the distribution and transmission cable networks operated by power utilities worldwide. However, the advantages associated with the modern dry polyethylene insulated cables have also been well established, therefore nearly all new power cables belong to the latter category. The presence of both these types of cables makes their jointing inevitable; consequently a large number of transition joints are now under operation. Unlike factory jointing, these joints have to be made on-site and this is just one of the factors that contribute to a high failure rate in such joints. The paper cable side of the joint is more vulnerable to initiation of failure as suggested by researches in the past [1]. Therefore, in an attempt to study the breakdown phenomenon in transition joints, this investigation on the material properties and their influence on resultant electric field distribution has been carried out.

## SAMPLE PREPARATION

Sheet samples were prepared of materials that are used as layers on paper cable side of a standard transition joint design. Some of the samples were kept in a hot air oven at 70°C to investigate the effect of thermal ageing on permittivity and its consequence on field distribution.

## EXPERIMENTAL SETUP

Dielectric spectroscopy was performed on the prepared samples under conditions of temperatures and electric fields, which these materials are expected to experience during the operation of the joint. The *novoControl Technologies GmbH & Co.KG* dielectric spectrometer was used for this purpose. The samples were subjected to temperatures ranging from ambient temperature to a maximum temperature of 70°C as mentioned in the literature [2]. The maximum value of applied electric field was 10kV/mm as these investigations pertain to a 6.6 kV transition cable joint. Dielectric properties, namely relative permittivity, conductivity and tan delta were measured and acquired using the software *winDETA*; being alternating cables, relative permittivity of insulation assumes greater significance. Linear regression analysis was performed to fit an appropriate function of electric field and temperature to the obtained relative permittivity data.

## EXPERIMENTAL RESULTS

The following section presents the results obtained from the dielectric spectroscopy. Since relative permittivity tends to affect the field distribution more in case of ac cables, its value and behaviour with changing electric field and temperature has been dealt with greater attention. The results have been expressed as three-dimensional plots of relative permittivity with respect to electric field and temperature.

### Oil Impregnated Paper

A cellulose based dielectric material impregnated with silicon oil at high pressure for improved dielectric strength, used as the primary insulation in paper cables. The following function is obtained on performing the linear regression analysis of the relative permittivity data:

$$\epsilon_r(T, E) = 2.46 . e^{0.0068T} . e^{0.027E} \qquad (1)$$

Where $\epsilon_r$ denotes relative permittivity, T denotes temperature (°C) and E denotes electric field (kV/mm).

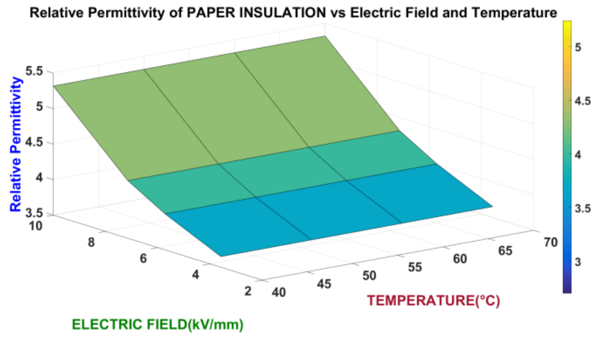


**Figure 1: Relative Permittivity of PAPER INSULATION vs. Electric Field and Temperature**

### Oil Blocking Tube

It is a cross-linked polyolefin material which is placed above the oil-impregnated paper insulation in the joint design and heat-shrinked. It acts as an oil barrier, preventing the migration of oil to the polymeric cable side of the joint. It is the only material which has got a negative temperature coefficient as per the spectroscopy results.The following function is obtained on performing the linear regression analysis of the relative permittivity data: