Chapter 9
Polymer Insulation in Nuclear Power Station

ABSTRACT

Nuclear power is giving an increasing share of power resource in China since it produces much less air pollution compared with power plant consuming fossil fuel. The power system insulation in nuclear power plant takes the risk of radiation. This chapter provides some basic research on the effect of radiation on different materials. The gamma-ray irradiation inhibiting surface charge accumulation on polyethylene is shown in this chapter. The quantity of surface charge is relative with the direction and the magnitude of voltage. Another interesting study presents the effects of atmospheric pressure on tracking failure of gamma-ray irradiated polymer insulating materials. Finally this chapter puts forward a research revealing that the Magnetic could influence the field tracking failure of gamma-ray irradiated polybutylene polymers.

INTRODUCTION

Polymer insulating materials are widely used in a large variety of applications in electrical and electronic devices. Once electric field applied between electrodes reaches the breakdown strength of gas, discharge can be introduced onto polymer surface (Du et al., 2008). As sufficiently intensive discharge lasts for a considerable time, the decomposed carbon products, with some parts of the channel carbonized, are progressive and rapidly deposit on the

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surface (Du et al., 2008). Once the carbonized products bridge the electrodes, dielectric surface breakdown that is termed tracking failure, occurs with a sudden decrease of resistance between the electrodes and a permanent loss of the insulation property (Du et al., 1995). The tracking failure has been found an important reason for polymer degradation which possibly results in severe damage to the devices (Sierota et al., 1998). Accordingly, from the viewpoint of safety, it is necessary to gain a good understanding of the behavior of tracking failure. A number of papers with respect to the behavior have been published, and the importance of such information for preventing fires, short-circuit and insulation failure has been proposed (Yoshimura et al., 1997).

Recently, polymers installed in electrical and electronic devices are required to be used in nuclear reactors and radiation facilities (Garrett et al., 2000; Chen et al., 1998; Lorenzi et al., 2009), where the materials are exposed to high energetic radioactive rays, such as gamma-ray, electrons and protons (Takada et al., 2006). For instance, outside and inside secondary shield in the containment vessel of 40-year old nuclear power plants, the maximum radiation dose rates are 0.01 Gy/ h and 1 Gy/ h. The dose rate in nuclear power plants varies widely from 10 μGy/ h to 10 kGy/ h with a potential of total exposure of 1000 kGy (Kyoto et al., 1992). The molecular structures of the polymers can be altered as a consequence of the irradiation through mechanisms like chain scission, oxidation and cross-linking (Du et al., 2009), which results in the variation of their insulation properties. It was reported that when polyethylene (PE) was exposed to 4 MeV electron beam for a total dose up to 2 MGy, its bulk breakdown strength was approximately twice comparing with PE irradiated under the same condition for a total dose of 1.5 MGy. In either case, the breakdown strength was higher than that of un-irradiated PE (Stark et al., 1955). On the contrary, the breakdown strength of polystyrene (PS) was observed decreasing from 63 kV/ mm to 51 kV/ mm as it subjected to radiation with total dose of 36 MGy (Goetzel et al., 1965). It is proposed that the dielectric strength is improved by irradiation for cross-linking type materials, but the conclusion for degradation type materials is opposite (Laghari et al., 1990).

Although radiation effect on bulk breakdown of polymers has been concerned, previous studies fell short of taking proper account of such effect on tracking failure. Du et al. investigated the resistance to tracking of gamma-irradiated polyethylene and modified polycarbonate under dc voltage, the