COMPARATIVE STUDY OF THE EFFECT OF DISCHARGES IN CABLES *

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SUMMARY

Many peculiar and interesting characteristics of the detectable and measureable ionization discharge currents in paper-insulated cables were discovered. Among the more important is the fact that the insulation is a complex dielectric including solid, liquid, and gaseous materials, in which crystal and amorphous structures may change from time to time with changes in potential gradients, temperatures, chemical products of corona discharge, etc. Ionization discharge starts at a certain voltage impressed upon the cable and increases with the voltage, at first rapidly, then at a decreasing rate. In practically all cables the ionization discharge intensity, as directly measured with a bridge, will occur at voltages below those at which any change in power factor is noticeable. In many cases power factor remained constant, or decreased slightly with increasing voltage, but the ionization discharge intensity, although of low value, increased in proportion to the applied voltage raised to a power greater than unity.

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Comparative studies and results indicate that the falling off characteristic of the ionization discharge with time is due to ionization discharges which are fixed locally in certain gaseous voids in the cable insulation. The cumulative rise of discharge current for the first minute is a phenomenon that has had no parallel which would suggest an explanation. When the ionization discharges do not fall off during the first 30 minutes it is believed that the discharges in the gaseous voids or spaces migrate or shift in their locality. Oil is drawn into electric fields, but special experiments showed that ionization discharges disrupt and scatter oil films in the vicinity of the discharges. Distribution of cable oil or compound is thus effected. This conclusion was arrived at by studies of thin transparent films of mixtures of saturant and air in which electric fields and ionization discharges were active. The increase in power factor did not follow the increase and decrease in ionization discharge immediately. The change in power factor may be due to an end result of previous time-ionization phenomena.

Practically all solid cables showed a certain amount of ionization discharge upon cooling from an elevated temperature down to some critical temperature above the normal ambient value. When a cable is in the process of deterioration, or when a local hot spot is present, the ionization discharge intensity at this particular interval of the cooling may reach intense values.

The impregnation of the paper and interlayer spaces often improves with use, due to redistribution of the saturant, infiltration of oil from joints, terminal potheads, etc.

Oil-filled cables were found to contain no ionization discharges either at operating temperatures or ambient temperatures.

New cables which have recently been manufactured, and have not been in use, nor out of the lead presses in the factory for more than one or two weeks often give ionization discharges which are greater in intensity than those occurring with these same cables, or like cables, when they have been allowed to stand or have been put into actual use. They show formation of voids upon cooling. These characteristic ionization discharges in new cables may in some cases result in slight damage to certain parts of the surface of the insulated paper before they shift or disappear, due to better distribution of the saturant. Although the power factor remained constant for varying voltage, the ionization discharge intensity increased with voltage.

Insulated wires may show considerable ionization discharge within the porous structure of the insulating material, particularly in the case of weather-proof wires, and also in the case of rubber-covered wire, to a certain extent, when the rubber has aged considerably. The existence of the ionization discharges in these pores evidently increases the potential gradient in the solid dielectric portions of the insulation in rubber insulation which has aged to a considerable extent.

Ionization discharges of considerable proportions will exist between the surface of wire insulation and a flat metal contact plate at potential gradients considerably below the value necessary for visible corona discharge, and investigation indicates that this invisible corona has a small but definite deteriorating effect upon the rubber insulation at the line of contact. The physical effect may be that of corona cutting on a small scale.