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<center>論 文 内 容 要 旨</center>

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学位論文題目	Study on Diagnostic Techniques for Detecting Degradation of Underground Transmission Cables using Chemical Analysis Methods （化学分析手法を用いた地中送電ケーブルの劣化を検出する診断技術の研究）		

内容要旨

Underground power transmission cables used to carry more than 66 kV in Japan are mainly of two types: cross-linked polyethylene insulated vinyl sheath cable (CV Cable) and oil-filled cable (OF cable). The increase in aged CV cables exceeding 30 years can be assumed in future, and most OF cables are aged cables exceeding 30 years.

The degradation and defects presumed through aged cables are mainly long-term degradation and natural degradation (the "presence" of initial defects is "long-term degradation"). The difference between long-term degradation and natural degradation is the presence or absence of initial defects. In their degradation, insulation breakdowns due to water trees occur several times every year throughout the year at 66 kV or more. The degradation process because of water trees has not been sufficiently elucidated due to complicated factors. Moreover, long-term and natural degradation other than that due to water trees has hardly been studied because there is hardly any insulation breakdown accident in both CV and OF cables. However, a possibility exists that insulation breakdowns due to never-before factors occur in the future because of the increase in aged cables. Moreover, the degradation diagnosis that has been put to practical use did not consider chemical degradation. As a result, diagnostic accuracy was sometimes worse. Therefore, the degradation of each insulating material of CV and OF cables was considered to be not discussed from a chemical point of view. Moreover, it was considered that diagnostic accuracy could be improved by developing a degradation diagnosis method based on a chemical point of view.

The purpose of this study is to elucidate the long-term and natural degradation of the insulating materials from the chemical point of view, and to establish new degradation diagnostic methods.

Thermal oxidative degradation of cross-linked polyethylene and ethylene propylene rubber, which are insulating materials for CV cables, is the first focus. The degradation process was clarified in terms of the increase and decrease tendencies on carbonyl group and antioxidant in the materials. Degradation diagnostic methods were developed to determine the lifetime of

cables based on the increase and decrease tendencies. Moreover, the degradation tendency of used cables was investigated by these diagnostic methods. In conclusion, thermal oxidative degradation was confirmed to be one of the breakdown factors of CV cables.

Ions that are one of the causes of water tree degradation in CV cable insulation were the second focus points. First, qualitative analysis methods of ions in water trees were developed to be able to qualitatively analyze monatomic ions and polyatomic ions. Using the methods, the ion types in water trees were elucidated to affect the development speed, shape, breakdown origin, and insulation performance. The hazardousness assessment methods for water trees were established based on the results. In these methods, the hazards based on the electrical characteristics and development speed were determined from the types and distribution areas of electrolytes.

Black parts on insulating paper confirmed in used OF cables is the last focus. First, the black parts were confirmed to be deposits of organocopper compounds through qualitative analysis. Moreover, these compounds were confirmed to be the cause of insulation breakdown. Therefore, the degradation process was clarified through simulation tests of the process and analysis of the black parts in used cables. The methods for diagnosing degradation by performing insulation oil analysis were developed based on this result. In addition, the degradation tendency of used cables was confirmed by the developed degradation diagnostic methods.

In this study, the long-term and natural degradation of the insulating materials was elucidated from the chemical point of view, and new degradation diagnostic methods were developed. It is expected that the results of this study will be an important reference for equipment maintenance considering long-term and natural degradation with more underground transmission cables aging further in the future. Moreover, the importance of discussing degradation from a chemical point of view has been demonstrated through this study.