Discovery of a New Degradation Mechanism of Self-Contained Fluid-Filled Cables (SCFF or SCOF) and Development of Diagnostic Technology

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ABSTRACT

In recent years, some breakdowns of EHV SCOF cables, mainly caused by deterioration at joints and terminations, have occurred in Japan.

The cause of these defects is presumed to be partial discharge deterioration due to copper precipitates, and was confirmed by the decomposition investigation of the damaged joint and the like.

We have developed a new diagnosis method which evaluates the condition of SCOF cable joints and terminations by the combination of the concentration of dissolved copper in the oil measured by with the Dissolved Gas Analysis data.

KEYWORDS

SCOF cable, Deterioration, Dissolved Gas analysis, Copper compound, ICP diagnosis method, Partial discharge, Fire – prevention, dielctrophretic force, electric field analysis

INTRODUCTION

In Japan, about 4000 km of Self Contained Oil Filled cables (hereinafter SCOF cable) are in operation, and it is necessary to maintain their reliability in the face of progressive aging. Japanese electric utilities have been managing the condition of SCOF cable joints by way of periodic Dissolved Gas Analysis (DGA). However, some cable faults have still occurred at cable joints maintained by this method, and there is a need to improve the maintenance technology to prevent cable faults[1].

In some cases, when dismantling investigations of SCOF cable joints were conducted, insulation deterioration could not be precisely detected by the conventional DGA, which focuses on acetylene (C_2H_2) and total combustible gas (TCG), due to the position or the period of the defects.

Additionally, black depositions (oxidation sludge, copper sulfide, etc.) on insulation papers, which are different from paper carbonization by PDs, have been found.

Focusing on this phenomenon, a new PD deterioration process in SCOF cables and joints due to dissolved copper compounds in the oil was deduced. Based on the result, a new diagnosis for SCOF cable joints, the “ICP diagnosis method”, has been developed.

In this way, efforts are made to maintain high reliability in SCOF cables.

Fig. 1 Site of 2016 tunnel fire

Fig. 2 Black compound on insulation paper

CLARIFICATION OF THE PROCESS OF SCOF CABLE DEGRADATION AND DEVELOPMENT OF DIAGNOSTIC TECHNIQUE

(1) Clarification of the process of SCOF cable deterioration

A new degradation mode in SCOF cables has been found in joints in recent years. Black depositions were detected on insulation papers along gaps between rolled papers in dismantling investigations of faulty 275 kV terminations as shown in Fig. 2. Solidified oil combined with oxygen and/or sulfur (hereinafter oxidation sludge), and copper sulfides were detected by EDX, FT-IR, and Raman spectroscopic analysis. In PD tests of insulation paper with black depositions, the PD inception electric field of normal paper was 40 to 50 kV/mm, while that of paper with black depositions was 27 to 40 kV / mm [2].

Focusing on this phenomenon, a new PD deterioration process for SCOF cables, joints and terminations due to dissolved copper compounds in the oil was estimated as shown in Fig. 3, Table.1 and has been verified by various experiments [3].