Degradation Mechanism of SCOF Cable Due to Cable Core Movement

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In Japan, electric power cables are applied up to 500kV and are important in power system configurations in urban areas. Among these applications, self-contained oil-filled (SCOF) cables account for 22%. Many SCOF cable facilities have started operating since the 1960s and 1970s.

Recently, we have experienced some SCOF cable breakdown accidents and considered that the breakdown in the Kansai Electric Power Company (KEPCO) area was caused by cable core movement. Therefore, we investigated the joint boxes that were broken and removed.

This paper introduces the degradation mechanism and maintenance procedure obtained from the investigation of the joint boxes that were broken and removed.

Many factors cause degradation of SCOF cables, namely, thermal expansion, negative oil pressure, oil leakage, and insulation impurities, among others. These might have caused partial discharge or overheating inside the SCOF cables, carbonizing the cable insulating papers, and finally degrading the electrical performance.

This study focuses on the cable core movement where relative displacement between the cable core and metal sheath occurred due to cable core longitudinal movement following thermal expansion and difference in the axial force. Cable thermal expansion is caused by load and ambient temperature changes. The difference in axial force is caused by some cable layout conditions such as steep slope and cable curve near joint boxes. We calculated the estimated cable core displacement.

Inside a joint box, old type semi-stop parts (which are applied to temporarily stop the oil during jointing works) can exert strong binding force on the cable core. Cable core movement can possibly disarray the laminated structure of the insulating paper locked by the semi-stop. Then, oil gaps are formed at the cable core, causing step partial discharge and eventual cable breakdown.

Cable core movement under some cable conditions, and strong binding force by the semi-stop parts might have all caused the breakdown accidents of the SCOF cable joint boxes (over 154kV) in the KEPCO area, except for defective design, manufacturing failure, assembly failure.

During the investigation of the joint boxes, evidence of cable core movement was found, for example, deformation in the semi-stop and disarray in the shielding layer. Disarray in the oil gap intervals and extensive carbonization were also found. The insulating layer thickness of the cable core was carbonized by more than 30%.

X-ray photography can confirm cable core movement inside the joint box. However, X-ray photography cannot confirm the carbonization that is the cause of the electrical performance degradation.

Dissolved gas analysis can confirm the occurrence of partial discharge inside the joint box. However, detecting the dissolved gas generated in the cable core by partial discharge is difficult using usual oil-sampling approach. Therefore, developing abnormality determination criteria are important.

Recently, new criteria that focus on various dissolved gas have been suggested, which are considered desirable in maintaining the SCOF cables.

We hope to prevent further SCOF cable breakdown by continuously investigating the removed joint boxes and considering and implementing as-needed maintenance procedures that address degradation due to the cable core movement and other deterioration.