# Study on the Mechanism of Buffer Layer Ablation on High Voltage XLPE Insulated Cable with Corrugated Aluminium Sheath Structure

Lei **JIANG**, Yue **XIN**, Xiyuan **ZHAO**, Wenbo **YAN**, Ruifeng **YAO**, Jinghui **GAO***, Lisheng **ZHONG**; Xi'an Jiaotong University, China, jianglei950705@stu.xjtu.edu.cn, 1362454966@qq.com, Zhaoxiyuan@stu.xjtu.edu.cn, 354865412@qq.com, yrf831143@stu.xjtu.edu.cn, gaojinghui@mail.xjtu.edu.cn, lszhong@mail.xjtu.edu.cn

Changshun **WU**, Juanjuan **YANG**; Shanghai Intelligent Service and Technology Co, Ltd, China, wuchangshun@istcw.com, yangjuanjuan@istcw.com

## ABSTRACT

*Aluminium (Al) corrugation is one of the mainstream sheath structures in HV XLPE insulated cables, owing to its good bending performance. Recently, the reliability of cables with such a corrugated Al sheath has been suspected, since the buffer layer ablation was reported in the failure cables with such a sheath structure. This work attempts to investigate the underlying mechanism of such a phenomenon through reproducing the ablation on sheath-buffer-layer model sample. The results show that both electric discharge process and electrochemical corrosion can lead to the phenomenon of ablation.*

## KEYWORDS

High voltage XLPE insulated cable, corrugated aluminium sheath, ablation on sheath and buffer layer, electric discharge, electrochemical corrosion

## INTRODUCTION

With the acceleration of global urbanization, the amount of power cable and the voltage grade in urban power network are gradually increasing, which puts forward higher requirements for the reliability of cable operation. However, some problems, such as buffer layer ablation, have occurred in HV XLPE insulated cables, which seriously affected the stability of cable system.

At present, there are few articles about the buffer layer ablation in power cable, and the mechanism of the ablation is still unclear, which hinders the relevant accidents prevention. Charles Q. Su analyzed the ablated failure cases of three 230 kV XLPE cables, and the result shows that if the amount of copper wire in gold cloth is less, it will cause local overheating in the cable, resulting in the ablation [1]. Sverre Hvidsten built a stress-induced electrochemical degradation (SIED) model to explain the corrosion phenomenon around the conductor screen in the middle voltage cables [2-3]. K. Steinfeld built a new type of model sample (Al wires, semi-conductor and XLPE insulation) and studied the long time aging behavior of polymer insulated cables [4]. Knut Brede Liland and S. M. Helleso calculated the axial diffusion rate of water vapor around the buffer layer in the cable by Comsol [5-7].

In this paper, the mechanism of buffer layer ablation in HV cable is studied from the aspects of failure cable cases study, possible cause analysis, finite element simulation and ablation reproducing experiments. The experiments explore the effects of electric discharge process and electrochemical corrosion. The results of this paper could provide reference for cable design and cable fault analysis.

## FAULT CASE STUDY

Ablation places on the Al sheath and buffer layer were found in a HV cable with a life span about 10 years.To investigate the underlying mechanism of such a phenomenon, the ablation morphology was observed. Moreover, structure of the failure cable and buffer layer was studied.

Fig. 1 shows the morphology of the ablation places on buffer layer. It can be seen that there are some white powders around the ablation points on the buffer layer. In order to find out the source of these powders, the section of buffer layer was observed by optical microscope. The buffer layer in HV cable is composed of fluffy cotton, water blocking powder and non-woven fabric. In the process of buffer layer production, carbon black is usually added to fluffy cotton and non-woven cloth, which could improve electrical conductivity of the buffer layer and homogenize the electric potential between insulation screen and Al sheath. Moreover, the main ingredient of water blocking powder is sodium polyacrylate and excessive amount of sodium hydroxide is usually added during the process-cycle.

The Al sheath is cut in half and its inner surface is presetned in Fig. 2 and it can be seen that there are some black carbonization traces and corrosion traces on the corrugated Al sheath.

### Possible mechanism

The morphology observation shows that the ablation is often accompanied with carbonization and corrosion traces. After exploring the structure and the operating environment of HV cable, it is considered that the ablation phenomenon may arise from electric discharge and electrochemical corrosion.

The tiny gap between the Al sheath and the buffer layer could generate a high field strength, which can carbonize the surface of buffer layer and make it attach to the sheath. As the surface of the buffer layer is destroyed, the internal water blocking powder would leak out and cause the formation of white powder.

Furthermore, the precondition of discharge is the bad contact between the buffer layer and the corrugated Al sheath. As water blocking powder is weak alkaline, Al sheath could react with it when moisture invades in the cable. As a result, the electrochemical corrosion would provide defects and the initiation site of discharge formed in this way. These two mechanisms are discussed in detail throughout the following paper.