Failure Experience on 380 kV Joints and Terminations in Saudi Arabia Transmission Network

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ABSTRACT

Utilities are trying to minimize the impact of the interruptions caused by EHV power cable accessories through careful failure investigations that help to put in place enhancements to the cable system performance. Power transmission network of Saudi Arabia has faced multiple incidents of 380 kV joint and termination failures. Many lessons have been learned from these incidents which worth discussion among concerned parties.

This paper will show the results of long experience of handling 380 kV joint and termination failures in Saudi Arabian transmission network. It illustrates failure root causes, failure mechanisms, remedial actions and preventive measures.

KEYWORDS

EHV; Joints; Terminations; Accessories; Failures.

INTRODUCTION

EHV cable systems were introduced in Saudi Arabia since 1982. The first long circuit was an LPOF cable system and it was around 13 km long. Nowadays, most of the EHV cable circuits are XLPE and the maximum length is 23 km. The voltage levels for EHV grade that are available in the network are 380 kV and 230 kV. Due to the gradual growth of the network, the total cable system length has reached more than 850 km of EHV underground cable in circuit length. Saudi Arabian electricity network has suffered multiple interruptions because of EHV joints and terminations. Due to the severity of the consequences of such failures, close attention was given in order to study each case, find the root cause and take proper actions to avoid repetition and mitigate impacts.

This paper will summarize the lessons learned from these failures. In addition, two interesting study cases are shown. One study case is about joint failure investigation that led to replacement of many joints and the other is about handling systematic failures of terminations.

COMMON FAILURE CAUSES

Quality and reliability of a cable system is defined by an interconnected stages that are dependent on each other. First, manufacturing stage which covers the design of the components, manufacturing and factory testing. Second, installation stage that include procurement, shipping, installation and site testing. The last stage of the cable system journey starts when the cable is energized until the end of its service life. Mistakes in either of these stages will cause failures although some are more critical than the other. In the following context, important considerations and most common mistakes that have been recorded based on actual cases are summarized according to each stage.

Manufacturing

Different manufacturers have different accessory design. These variations have direct impact on the quality and reliability of the product. Normally, type tests are done to verify that a given product is suitable for certain application for defined period of time. However, some design deficiencies cannot be detected by type tests and will appear during the service life of the product. Good design should fulfill a satisfactory level of the following criteria:

- Proper choice of material is highly recognized because incorrect choice could cause unexpected degradation. For example, a bi-material reaction during service which leads to fast degradation and shorter life span.
- Reasonable installation easiness. Accessories that need very highly skilled workers, expensive preparations and special tools are not a good choice because they encourage the workers to make short cuts and ignore instructions. Moreover, difficult installation process consumes time and cost money.
- Clear Drawings and well developed instructions. Installing EHV accessories is a long and complex process. It is easy to make a mistake, forget a step or misinterpret an instruction. The accessory documentation should consider all of that.

Installation

Performance and longevity of any cable system is highly dependent on the splicer who installs joints and terminations. Cable splicer needs to be knowledgeable and well trained. Splicing work is a combination of general craft skills and special instructions that need to be followed carefully. It is established that installation errors are responsible for most of accessory failures. Although commissioning tests are applied to check the readiness of the cable system, some installation mistakes cannot be detected in early stages of the project. There are three main stages for any splicing work which are cable preparation, stress control unit application and closing of the splicing work.

Cable Preparation:

The first stage where the cable is prepared for stress control unit application. The most recurrent mistakes that have been recorded in this stage are the following:

- Insufficient cable straightening. This error leads to errors in measurements and stress control unit placement. In addition, If there is a slight bent on the cable at the stress control unit position, this causes non-uniform interfacial pressure around the cable which develops partial discharge.
- Measurement errors are very common and can cause failures especially at the semi-conductor cutback area.