Development of a 500kV PPLP MI cable system for HVDC applications

Byung-ha **CHAE** (1), Sung-yun **KIM** (1), Eui-hwan **JUNG** (1), Hyun-sung **Yoon** (1), Chae-hong **KANG** (1), Su-kil **Lee** (1), Seung-ik **JEON** (1) LS Cable & System, Korea
bhchae@lscns.com, sykim13@lscns.com, sikemaro@lscns.com, yoon1216@lscns.com, chkang@lscns.com, sglee@lscns.com, sijeon@lscns.com

ABSTRACT

LS Cable & System already developed HVDC ±250kV mass-impregnated type kraft cable system with a conductor cross-section of 900 mm^2 flexible joints and out-door terminations in 2008. This HVDC submarine cable system was successfully established between Jindo and Jeju island in Korea. Based on this experience, a HVDC 500kV PPL paper MI cable system, including land joint and outdoor-termination, was developed by LS Cable & System. In order to prove the mechanical and electrical performances for this system, a type test was carried out according to CIGRE recommendations. A full scale cable system has been tested successfully. And additional load cycle and polarity reversal tests on the cable system showed a higher performance compared with a similar mass impregnated paper cables.

KEYWORDS

HVDC transmission line; Submarine cable; Polypropylene laminated paper; rigid joint; Outdoor termination

INTRODUCTION

This paper describes the development of the DC 500kV Polypropylene Laminated (PPL) Paper mass-impregnated type cable system for HVDC transmission lines. As you known, conventionally mass-impregnated type cables have only insulating layer with a kraft paper which is impregnated with a high-viscosity insulating compound. However, the PPL paper consists of a layer of extruded polypropylene (PP) film and two layers of the kraft paper. Due to the PP film and its combination with kraft papers, the PPL paper insulation has higher electrical performance of both impulse and DC breakdown strengths as well as a lower dielectric loss than the kraft insulation paper. In addition, the PPL paper MI cable system allows higher maximum conductor temperatures than the kraft paper insulated MI cable system due to advantage of oil drainage characteristics. It is allowed to decrease in insulation thickness and reduce the total thermal resistance of the cable. It is the most economic type of lapped insulation cable for HVDC transmission.

CABLE DESIGN

To transmit 3GW by 500kV bipole, the cable consists of a 2,500 mm^2 Cu keystone conductor, the polypropylene laminated paper insulation with higher dielectric strength, lead and polyethylene sheath.

The keystone shaped copper conductor has a copper filling factor of over 98%. The individual profiled wires are made in an extrusion process rather than wire drawing for better dimensional control and better conductivity.

The insulation is made of high-density paper with a layer of extruded polypropylene (PP) film and two layers of the kraft paper and a high-viscous mineral-based insulation compound. The paper density is over 0.9 g/cm^3. The paper thickness and lapping parameters such as gap width and tension are designed to provide optimum electric strength at high bending performance.

The lead sheath and double polymer-sheaths are applied in a combined continuous process and provide perfect water-tightness and good mechanical protection of the cable core. A pressure reinforcement of galvanized steel tapes is applied between the PE sheath and the PVC sheath.

The overall cable diameter is approx. 135 mm and cable weight is 55 kg/m respectively.

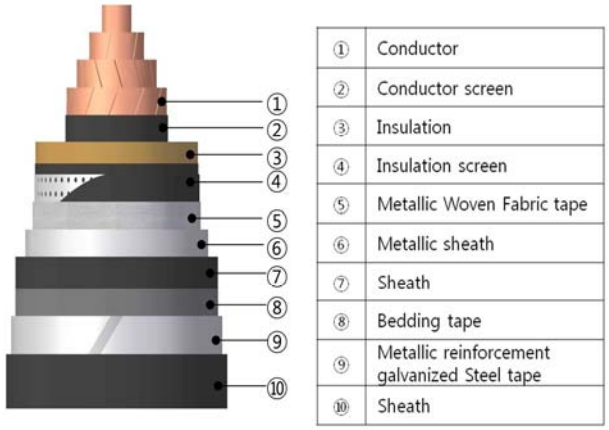

Fig. 1 Appearance of the power cable

DIELECTRIC DESIGN

As mentioned, PPL paper is used in this HVDC 500kV dielectric design. PPL paper consists of a combination of PP film and kraft paper. The DC electric field distribution changes very smoothly in accordance with the distribution of the resistivity (ρ). Since the specific resistivity (ρ) of PP is much higher than of kraft paper, the DC stress is mostly imposed on the impregnated PP film with its high dielectric strength. This makes PPL paper insulation having as higher electrical performance of impulse and DC breakdown strengths as well as lower dielectric loss than the pure kraft insulation paper. In addition, the PPL paper MI cable system allows a higher maximum conductor temperature than the kraft MI cable system due