Type test and special tension test of 230kV XLPE submarine cable system

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A new 230kV AC transmission line will be installed in San Francisco area in 2015. The line consists of 5 km submarine route in length containing 4 km of marine route, 0.4 km of landfall section constructed by horizontal directional drill (HDD) at each end, and 0.8 km of underground on-shore section. The maximum water depth is 40m and the rated capacity is 400 MVA.

The specification of submarine cable is single core, 1400 mm^2 Keystone conductor, cross-linked polyethylene insulated, lead alloy sheathed, semi-conductive polyethylene sheathed and double copper wire armored submarine power cable with embedded optical fibers. The longitudinal water blocking materials are applied in the conductor and under lead sheath. In order to achieve the high transmission capacity, copper flat wires are applied for armoring instead of steel wires.

San Francisco is located inside the Pacific Rim. In order to endure the seismic tension more than 20 ton, the double copper wire armors are applied with contra-helical. Moreover, the prefabricated joint and armor clamps shall be installed inside the jointing manhole between the submarine and land cable. In order to confirm the mechanical, electrical and water blocking performance of these cable and accessories, the type test and tension test are specified and conducted prior to shipment.

The tension tests with straight and offset shape were performed for simulation of the installed cable configuration in off-shore and in manhole respectively. The straight tension test is conducted to confirm the soundness of submarine cable after loading of tension. The purpose of offset shape tension test is to check the soundness of armor clamp and to observe the residual cable core tension given to joint. On site, the cable offset will be made between the clamp and joint in order to provide slack and to reduce the seismic tension given to joint.

These tension tests were performed with 31 ton and 46 ton tension. 31 ton is the limitation of cable tension capacity by some design standard. If the cable tension capacity can increased be up to 46(=1.5×31) ton, the failure probability of cable by the seismic at magnitude 7.8 can be reduced from 20% to 9%. During the testing, the cable and armor clamps withstood 31ton and 46ton tensions with both straight and offset shape. After the tension test, the cable passed the 332kV ($2.5U_0$) for 30 min and no partial discharge was detected at 200kV ($1.5U_0$).

The type test is performed in accordance with CIGRE TB490 except the conductor temperature 105°C to satisfy both IEC 62067 and AEIC CS9. The cable sample was subjected to tensile bending test at 19.6 kN/m in accordance with Electra 171. In the loop of electrical type test, the submarine cable, land cable, SF6 gas termination, prefabricated joint, repair joint and armor clamp were installed. After 20 times heat cycle, the partial discharge test, lightning impulse voltage test followed by voltage test and examination of cable system are performed.

This high standard cable system design would contribute to the reliable operation for the supply of electricity.

Key words

Submarine cable; Keystone conductor; Seismic design; Copper wire armor; Armor Clamp