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Undergrounding the first 400 kV transmission line in spain using 2.500 mm^2 XLPE cables in a ventilated tunnel: the Madrid "Barajas" airport project

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Spanish Airport Authorities have launched a giant project at the Madrid "Barajas" airport to overcome actual capacity limitations and secure traffic opportunities that today are derived to other European airports. The expansion, planned to be completed by May 2004, has foreseen the construction of two new runways parallel to the existing ones, and a new terminal building connected via tunnel with a satellite building for airplane boarding. Each of the new runways has a length of 3.5 km requiring civil works across an area of more than 400 Ha. In front of such an enormous project, there exists a large number of infrastructures affected in major or minor ways.

RED ELÉCTRICA, the TSO and main owner of the transmission network in Spain, owns a double circuit 400 kV line connecting the substations "San Sebastian de los Reyes", "Loeches" and "Morata", three of the six substations that close the 400 kV ring around the city of Madrid and its metropolitan area. Interferences of overhead lines with airport operations are regulated by law and have two origins: the strict presence of steel towers and conductors in the physical surfaces defined for each runway take-off and landing routes, and the radio-electric interference of metallic parts (towers, conductors) with automatic navigation systems actually installed in high class airports (LLZ, GP, ILS).

In order to eliminate the mentioned interferences RED ELÉCTRICA will underground the double circuit 400 kV line along a route of 12.5 km. The existing OH line is equipped with a double bundle ACSR conductor of 547.30 mm^2 cross section per phase, and has two OPGW cables with 48 fibers each. Actual OH line rating, that will be met after under-grounding is 1390/1720 MVA (summer/winter). With such high power ratings, both XLPE cables and GIL (N_2 and SF_6 mixture) solutions have been analyzed during an extensive engineering phase. The adopted solution requires the use of 2.500 mm^2 XLPE cables installed inside a ventilated tunnel.

The underground link will consist in a mixture of cross bonded and single point bonded lengths. In particular five (5) cross bonding of 810 m minor section length, plus 2 sections (first and last) of around 200 m, single point bonded. Circuits will be installed in vertical configuration, with one cable circuit at each side of the tunnel, maintaining a phase separation of 500 mm. The operation of the cable circuits is affected by maximum allowable conductor temperature of XLPE cables and limited to 90ºC steady state. Heat generated by Joule and dielectric losses of the cable circuits will be dissipated by convection to the air inside the tunnel. In order to extract the heat generated by the circuits, a forced cooling system has been designed. The system includes 5 fan stations along the route with 3 fans at each location (1 spare) that will push fresh air inside the tunnel. The system is controlled by a Real Time Thermal Rating (RTTR) control system, implementing distributed temperature sensing with 3 Fiber Optic cables, able to continuously measure upper oversheath cable and top of tunnel temperatures along the route.