Indirect Pipe Water Cooling Study for a 220kV Underground XLPE Cable System in New Zealand

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ABSTRACT

This paper describes a Proof of Concept Design Study for the indirect pipe water cooling of a 10.6km, 220kV double circuit underground cable connection installed on the Transpower NZ network between Brownhill and Pakuranga in Auckland, New Zealand.

The paper discusses the factors affecting buried XLPE cable joint design and the cooling pipe material selection for use in terrain having a change in elevation of up to 136m.

The system owner's reasoning to select a naturally cooled rather than water cooled circuit is provided. The circuits are now in operation.

KEYWORDS

EHV 220kV XLPE cable indirect pipe water cool design

INTRODUCTION

The New Zealand electricity network has developed over time from a number of isolated regions through to an interconnected grid. A particular focus was strengthening the transmission network into the city of Auckland which in 2003 comprised six 220kV overhead lines.

Transpower announced in October 2004 it was seeking a route for a proposed 400kV transmission line from Whakamaru, north of Lake Taupo, to Otahuhu in South Auckland, with the closing section requiring 10.5km of underground cable. The overhead component was to be rated at 1200MVA and the closing cable circuits were to have a nominal matching rating of 1000MVA.

During 2005 a number of detailed funding proposals were submitted to the Electricity Commission. However, in April 2006 the Electricity Commission issued a draft 'no decision' to Transpower's proposal. In May Transpower suspended its application and subsequently submitted an amended proposal.

The amended proposal described the construction of the overhead line as previously planned, but running initially at 220kV and only moving to 400kV operation when demand requires – estimated then to be around 2033 and to a different terminating substation, Pakuranga. In addition an overhead line to underground cable transition station was confirmed at Brownhill with two 220kV underground circuits. The ultimate rating at 400kV would be 2700MVA.

The reduction in the cable circuit operating voltage to 220kV and the requirement to match the eventual increased rating of the overhead line introduced a potential 'mismatch' when the overhead line voltage is increased to 400kV. To address this, forced cable cooling was suggested in the amended proposal.

Principally because of time constraints no detailed technical studies of applying forced cooling to the proposed Brownhill – Pakuranga circuits were undertaken prior to the submission of the amended proposal utilising four plastic pipes positioned adjacent to each trefoil cable circuit.

Wienstrom, an Austrian utility had previously adopted the approach proposed by Transpower. Most recently they have designed, installed and were in the process of commissioning cooling plant along with associated pipe connections to a number of 380kV fluid filled cable circuits installed between 1978 and 1986. In 2005 they commissioned a double circuit 380kV 600MVA (un-cooled) 1,040 MVA (cooled) XLPE cable circuit [1], this being the only example of a direct buried separate pipe water cooling XLPE cable system installed in the world.

The following information was provided by Wienstrom regarding their legacy fluid filled installations: -

a) Original planning envisaged the 380kV circuits running in an un-cooled state for 20 years. In reality, this period extended out to 30 years.
b) When the decision was taken to commission the cooling system an initial estimate of the capital costs was €2M, actual expenditure was circa €14M.
c) The design undertaken when the circuits were installed identified the need for two cooling stations. When the studies were reviewed and modern analytical techniques applied an additional cooling station was identified as being required. It was also noted that only one of the cable companies that installed the original circuits was still in existence.
d) Some compromises were made in the design of the cooling plants to minimise costs but the operation of the cooling plant will become critical to the cable circuit operation. In the event of failure then load shedding could become necessary.
e) The system was recently commissioned and problems were experienced with failed threads on the originally installed bronze alloy flanges.
f) Care should be taken in locating the cooling stations, particularly in residential areas.

Transpower NZ's 10.5km double circuit underground cable connection was to be directly buried with a naturally cooled target rating of 1750A and a force cooled (water cooled) target rating of 2900A. A tender was issued on this basis with an additional financial incentive for each additional 10MVA which the suppliers installed design could achieve.

The cable industry raised significant reservations and actively advised against the adoption of the Transpower forced cooling proposal with a particular concern being the application of legacy technology to XLPE insulated cable systems, specifically XLPE joints.