Type Tests and Special Tension Tests of 230kV XLPE Submarine Cable System

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ABSTRACT

A new 230kV AC transmission line will be installed in the San Francisco area in 2016. The line consists of a 5km submarine route and a 0.8km underground on-shore section. Since San Francisco is located in the Pacific Rim. To ensure the acceptable performance against seismic events, the submarine cable and accessories have to withstand tensile force derived from seismic analysis of the cable. Hence, contra-helical double copper wire armor will be applied to the submarine cable, and in addition, prefabricated joint and armor clamp will be used at the transition joint manhole for the submarine and land cable. To confirm the mechanical, electrical and water blocking performance of the cables system, type tests and special tension tests were performed.

KEYWORDS

submarine cable; keystone conductor; seismic design; copper wire armor; armor clamp

1. INTRODUCTION

The city of San Francisco city, lies at the tip of a peninsula in the North-western U.S., is isolated from larger transmission networks and depends upon transmission lines from across the bay or over land from the south. It is also part of the Pacific Rim which is a seismically active area, presenting significant challenges to the goal of providing reliable electric service following a large earthquake.

New buried transmission cables on land within the city of San Francisco are costly to construct and extremely disruptive within the urban core. In addition, land cable routes considered for the project that is the subject of this paper must traverse areas with high potential for liquefaction during earthquake.

To improve reliability of the transmission system, Pacific Gas & Electric has decided to install a new 230kV line in the bay east of the San Francisco peninsula (Fig. 1). The detailed 230kV cable system is summarized in Table 1. To confirm the performance of the transmission line, the cable and accessories were subjected to various type tests and tension tests in accordance with CIGRE TB490, AEIC CS9[1,2] and customer-specified design tension

Fig. 1: Location of New Transmission Line

Table 1: 230kV Cable System

Normal system voltage	230kV
Maximum system voltage	245kV
Basic Impulse voltage	1050kV
Rated Power per circuit	400 MVA (1050 A)
Power Frequency	60 HZ
Daily load factor	85 %
Emergency current (at 105°C)	458 MVA
Short circuit fault current	40kA for 13cycles
Number of circuits	1
Grounding (submarine portion)	Solid bonding
Maximum sea water depth	30m

This paper reports the summary on the type test and special tension tests for the 230kV cable system including submarine/land cables and their accessories.

2. TYPE TEST ITEMS

Type test items are summarised in Table 2.

Special tension tests consisted of straight and offset configurations. These tests were designed to address large tensile forces in the submarine cable resulting from ground displacement predicted by the seismic analysis. The required tension value exceeded normal design and these tests were not specified in any standard. Hence, these test methods were developed as special tension tests. Straight tension tests and offset tension tests were performed for simulation of the installed cable configuration at an off-shore section and transition manhole. Straight tension tests were conducted to confirm the soundness of submarine cable after tensile loading. The purpose of the offset-shape-tension test was to verify the soundness of the armor clamp and to measure residual cable-core tension given to the joint. The offset shape is applied to the cable between the clamp and joint. This shape is designed to reduce the seismic tension transferred to joint less to a level below our criterion. In addition, these tension tests were used to gather data on the mechanical properties of the cable at high strain which influence the cable tension demand from the seismic analysis.

Tension tests were conducted twice with the 303kN and 453kN tension. 303kN is the expected cable tension demand from the seismic analysis. In order to account for uncertainties in the design conditions (e.g., soil properties