Boutre-Trans Project: 225kV AC Underground Cable Installed in the South-East of France

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ABSTRACT

In June 2014, the French TSO (Réseaux de Transport d'Électricité) conducted field tests on a 220 kV XLPE cable with a total length of 66 km in the south-east of France. A minor section and a major section with crossbonded sheaths were tested for the propagation of coaxial, intersheath and earth-return modes and the effect of cross-bonding was investigated. This paper gives details on the field test conditions and the cable system. The field test results are presented and commented. Propagation characteristics (attenuation, velocity, characteristic impedance) are estimated based on the field test results.

KEYWORDS

HVAC cable, electromagnetic transients, field tests, propagation characteristics.

INTRODUCTION

In general, field tests of transients in high voltage cables for cable model validation, are focused on coaxial and intersheath mode propagation, with the earth-return mode being neglected [1-7]. Studies have shown that current cable models used for simulating transients are accurate for coaxial mode propagation, but not accurate enough for intersheath modes. This has been generally associated to the fact that those models neglect the proximity effect on the metallic sheaths. The proximity effect has been investigated for the case of tight arrangements (e.g. submarine cables) [6-8], but it is not clear if the results also apply to systems with a separation between the phase cables (typical underground single-core coaxial cables). Also, the characteristics of the earth-return mode have not been well investigated [4].

The validation of cable models using field test results is based on a comparison of the time-domain responses and on the estimation of wave attenuation and velocity. This method however is not enough to understand what must be improved when a model does not provide the same results as the field tests. Also, a field measurement is affected by the complete measuring system, and this has to be considered for the model development and validation.

In June 2014, the French TSO (Réseau de Transport d'Électricité - RTE) performed field tests on the Boutre-Trans 220 kV cross-bonded cable installed in the South-East of France [9] with the objectives of improving the knowledge on the Boutre-Trans cable and validating its modeling. The tests were performed in a minor section with 1080 m and in a major section with crossbonded sheaths and 3953 m of length. Each separate mode (coaxial, intersheath and earth-return) was excited on the minor section of the cable and the propagation constants (attenuation, velocity and characteristic impedance) of the system were estimated. It is not possible to perform such tests with a major section, since the reflections at crossbonding points will generate additional modes superimposed on the excited mode.

This paper is organized as follows. Section I is for the introduction. Section II gives details on the cable and the measuring systems. Sections III and IV present the field test results for the minor section and major sections. Section V refers to the state-of-the-art techniques for modeling the cable and section VI presents the conclusion.

CABLE SYSTEM AND FIELD TEST CONDITIONS

Cable System

The Boutre-Trans cable is a cross-bonded 220 kV underground link installed in the south-east of France. The cable started operating in 2015 and is integrated in a project for reinforcing the electric grid in the PACA region (Province-Alpes-Côte d'Azur) [9]. The cable is composed of stranded enamel copper cores and aluminum foil sheath. The cable main insulation is cross-linked poly-ethylene (XLPE) and the outer insulation is of high-density poly-ethylene (HDPE). Each phase is installed in an HDPE tube embedded in concrete and buried into the soil. This protects the environment from the heat generated by the cable. A sample of the cable and the layout of the system are illustrated in Fig. 1. The Boutre-Trans cable has a total length of 66 km and is composed of 17 major sections with the metallic sheaths grounded at each major section. Surge arresters protect the first and last major sections of the cable from sheath overvoltages. The tests were performed on a minor section having a length of 1080 m with 2000 mm² core conductors and on a major section with a total of 3953 m and using both 2000 mm² and 2500 mm² conductors, as illustrated in Fig. 2.

Measuring System and Test Conditions

The surge tester used for the field tests is a Haefely-Axos-5, [10] used with a portable generator as a power source. The surge tester applies a 2 kV 1.2/50 µs voltage impulse, represented in Fig. 3. Wires connecting the source to the cable have an inductance estimated as 5 µH (1 µH/m for 5 m length).