The Wiener Netze 400 kV Cable Dataset for Cable Rating Calculation Validation

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ABSTRACT

This paper describes the Wiener Netze 400 kV cable dataset for thermal rating calculation validation. The content of the dataset, i.e. the quantities it contains, and the way it was obtained are discussed. Furthermore, some findings from the analysis of the dataset are presented. The aim is to provide a dataset that facilitates and advances validation and further investigation of models for dynamic current rating calculations of high voltage cables, for conventional analytical and numerical as well as data-driven methods.

KEYWORDS

High Voltage Cable System, Thermal Rating, Modelling Validation

INTRODUCTION

The energy system is undergoing the greatest transformation in its history. The ambitious climate targets, the associated massive expansion of renewable energies, the digitalisation of the electrical grid, the realisation and implementation of power-to-X, e-mobility and energy storage solutions pose new challenges for the electrical grid and its components. This is especially true for high voltage cables, which are not only an integral part but are also experiencing an unprecedented increase in the electrical grid. Determining the thermal ratings of these existing and new cable systems is more important than ever for their operation today, as cable systems tended to be operated cold in the past, but now, due to intensive grid expansion and changing load profiles, are increasingly approaching their operating limits. Furthermore, dynamic line and cable rating methods are becoming more crucial for achieving efficiency gains [1]. All this places high demands on the cable rating calculation methods.

In addition to the established analytical method for thermal rating calculations, numerical methods, especially in the form of the finite element method, have been increasingly used for years. However, compared to the analytical method, the numerical method is not standardized. CIGRE WG B1.87 is currently working intensively to provide a guidance document for the finite element mehtod, but it will not be possible to start a revision by the IEC committee until the technical brochure has been completed, which is not expected before the end of 2024. However, the successful implementation of the energy transition increasingly requires accelerated solutions in all areas.

Furthermore, data-driven modelling approaches, especially machine learning, are more frequently finding their way into the modelling of energy systems. Although these methods offer great potential, there is currently limited suitable validation methods, as well as a lack of reference projects. One reason for this is that the know-how for data-driven modelling is currently still mainly found in universities and research institutes, which usually do not have access to the sensitive operating data of the grid operators.

In the course of a 4-year research project on the use of artificial intelligence in the thermal rating of high voltage cables, Wiener Netze realised a 400 kV cable test setup under real conditions and subjected it to a variety of stationary and dynamic loads. In the process, more than 90 different parameters such as current, power, temperatures at different positions, but also climate and soil parameters were recorded over a period of more than three years. In total, more than 70 million data points were recorded, from which Wiener Netze compiled and published a dataset with a time resolution of 15 mins. The dataset is accessible free of charge and is intended to enable cable engineers but also research institutions to create and validate calculation methods and models for cables, be they analytical, numerical or data-driven. This paper presents and describes this dataset and discusses findings on the measured parameters from the three years of operation.

400 KV CABLE TEST SETUP

The cable used has a segmented copper conductor with a cross section of 2500 mm², an XLPE insulation, a copper wire screen with a cross section of 246 mm² and a lead sheath with a cross section of 1498 mm². The dimensions according to the cable data sheet are included in the dataset.

The three phase cable system is laid in a non-touching trefoil formation with a phase distance of 270 mm in a thermally stabilized concrete block with a width of 1200 mm and a height of 600 mm. During construction, samples were taken from each concrete delivery. These samples were then analysed and their relevant properties measured. The results of these measurements are given in **Table 1** below.

Table 1: Measurement results from thermal backfill

	Unit	# 1	# 2	# 3	# 4
Density wet	g/cm³	2.03	2.05	1.97	2.01
Density dry	g/cm³	1.88	1.87	1.84	1.86
Water content	%	7.9	9.6	7.1	7.8
Thermal conductivity	W/(m·K)	2.29	2.29	2.29	2.22

This block stands on a 100 mm thick concrete base at a depth of 2700 mm and is covered with a layer of self-compacting concrete and another layer of stone-free excavated material of about 1000 mm each. At the end, a road profile was also created along the entire length of the cable trench. Overall, the test setup has a length of 30 m, whereby the measurement plane, in which all of the temperature and moisture sensors are placed, is located in the middle.

The placement of the sensors included in the dataset and their abbreviations are shown in **Fig. 1**. To verify measurements, both optical fibers and Pt100 elements were installed at the four measuring positions in the middle of the cable trench. In the dataset, only the Pt100 measurements are included. Pt100 sensors were also installed in the soil in a horizontal plane to the cable system center as well as in a distance of 6 m to the cable trench to capture the thermally unaffected soil. In addition, moisture sensors were installed in 200 mm distance to the trench.