Prequalification test of the complete 1200 m HTS DC cable system.

First Victor **SYTNIKOV**, Andrey **KASHCHEEV**, Mikhail **DUBININ**, Victor **KARPOV**, Timofey **RYABIN;** R&D Center @ FGC UES, (Russia), vsytnikov@gmail.com, Kashcheev_AV@ntc-power.ru, Dubinin_MV@ntc-power.ru, Karpov_VN@ntc-power.ru, ryabin@ntc-power.ru

ABSTRACT

Prequalification test of all the components of the high-temperature superconducting direct current cable line was carried out as a part of the project to create a superconducting cable line with a capacity of 50 MW for the power system of St. Petersburg. The experimental stand included several cable lengths with joints and current leads, a reverse cryostat, a cryogenic system, a converter station and a control and monitoring system. The total length of the cryogenic line exceeded 1200 meters. The report presents the results of cryogenic and electrical tests. Some emergency modes of the cryogenic system were studied. The possible time of cable operation in various accidents in the cryogenic system was estimated.

KEYWORDS

Superconducting Cables, Electrical Network, Critical Current, Cryogenic System, Emergency Mode.

INTRODUCTION

Superconducting cables are the most developed and advanced area of superconductivity application in electric power industry in current time. Superconducting cables have evident benefits when transmitting large power flows through electrical networks in comparison with traditional ones. This fact stimulated the development of a large number of designs of cables for the transmission of tens to hundreds of megawatts. A large number of experimental cable lines was created with a length reaching hundreds of meters [1] Two types of cryostats are basically applied to create a circulation of liquid nitrogen in those projects: the flexible corrugated cryostats [2, 3] and systems with rigid pipes [4].

Recently, superconducting DC cables have attracted increasing interest. They are designed to create powerful long transmission lines of electrical energy [5] and HTS cable lines to connect substations at distribution voltage [6, 7]. This leads to the need to solve such problems as: the reliability of the cryogenic system of the cable line, maintaining the specified parameters of the liquid nitrogen, maintaining the parameters of vacuum insulation, monitoring the level of heat load. In the framework of the project of creation of 2500 m HTS DC cable line for the St. Petersburg power system, electrical and hydraulic characteristics of the line were determined and the most credible emergency modes and accidents of the cryogenic system were analyzed. As a result a hardware and software complex with a system of interlocks and protection of the HTS DC cable line was developed.

SUPERCONDUCTING CABLE LINES IN A POWER SYSTEM

High-temperature superconducting cable lines (HTS CL) are an innovative development that allows solving a significant part of the problem of energy supply to consumers. In electrical networks, it is possible to create a circuit with the use of AC and DC superconducting cables.

However, long-distance cable transmissions are possible only with the use of DC lines, since any, including superconducting, AC cable lines have a length limitation, due to the occurrence of charging currents, which lead to a decrease in power at the far end of the line.

$$Ic=U\omega C_0 L, \qquad [1]$$

Where U is phase voltage, ω is circular frequency, C_0 is capacitance, and L is line length.

As a result, the length of AC cable lines does not exceed several tens of kilometers.

THE PROJECT "HTS CABLE LINE FOR THE ST. PETERSBURG POWER GRID"

The St. Petersburg HTS DC cable project is designed to connect "Tsentralnaya" 330 kV Substation and "RP-9" 220 kV Substation. The cable length is 2500 m, and the liquid nitrogen cryogenic circuit is 5000 m. By using HTS DC cable line for interconnection of two substations allows implementation of reversible power mode and provides an increase of reliability of power supply to consumers without the occurrence of unacceptable (emergency) electric regimes and without increasing the fault-currents levels. The cable line consists of six factory cable lengths (Fig.1), two end joints (current leads), five transmissions joint, two converter substations, cryogenic system, control, monitoring and protection systems. The content and objectives of the project have been described in sufficient detail in the references [8, 9]. General characteristics of the cable line are shown in Table 1.

Table 1 – The main characteristics of HTS Cable line

Transmitted power	50 MW
Rated voltage	20 kV
Rated current	2500 A
Working temperature	66-80K
Length of cable	2500 m
Type of converters	12-pulse
Possibility of reverse	Provided
Cooling capacity of cryogenic plant	12kW @ 70k
Pressure of liquid nitrogen	up to 1.4MPa
Flow rate of liquid nitrogen	0.1 ÷ 0.6 kg/s

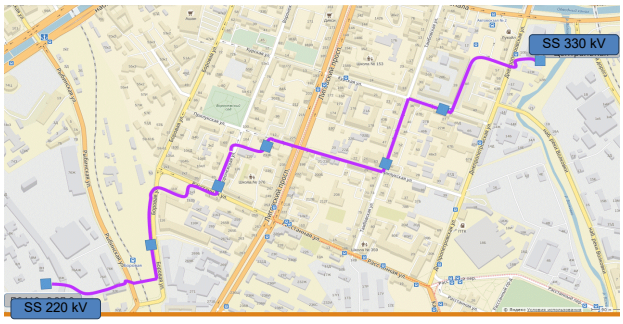

Fig.1. Scheme of laying of cable lines in St. Petersburg.