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Feature Article: Refrigeration and Cryogenic Technologies - The Operational Status of the Cooling System for the High Temperature Superconducting Cable Demonstration Project

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As part of the high temperature superconducting (HTS) cable demonstration project, HTS cables have been installed at the Asahi substation of Tokyo Electric Power Company, with investigations undertaken to characterize performance, practicality, reliability, and maintainability of HTS cables and cooling systems when connected to the grids. Three companies have undertaken the project, Tokyo Electric Power Company, Sumitomo Electric Industries, Ltd., and Mayekawa MFG. Co., Ltd., commissioned by the New Energy and Industrial Technology Development Organization (NEDO). Cooling system unit test and HTS cable connection tests undertaken prior to actual connection to power grids confirmed system reliability. Power grid connection was performed on 29th October 2012, and one year continuous operations launched. After connection to the power grid, the system has fundamentally functioned without human interaction, with day-to-day load changes and operational status of the cooling system remotely supervised in order to evaluate performance attributes such as cable heat loads, cooling capacities, etc. By the end of May 2013, around 210 days have passed since installation, and continuous trouble-free and stable operation was confirmed without the need for additional liquid nitrogen.

The cooling system is a Stirling cryocooler having a 1kW@77K cooling capacity, circulation pump, and reservoir tank. Sub-cool liquid nitrogen is employed as the coolant. Taking into consideration pressure loss and temperature control at the heat exchanger, two Stirling cryocooler units have been arranged in each column, with three columns operating in parallel. The circulation pumps have been arranged with two centrifugal units in parallel. One of the three columns of refrigerators and one unit from two circulation pumps are reserved. Considering the potential practicability of HTS cables, current Stirling cryocoolers do not provide sufficient capacity, efficiency and maintainability, and the need for further refrigerator development having greater capacities and enhanced performance is desired. Therefore, in parallel with demonstration trials undertaken since February 2011, this project has focused on the development of a Brayton-refrigerator, designed to aim for a cooling capability of 5 kW, COP 0.1.

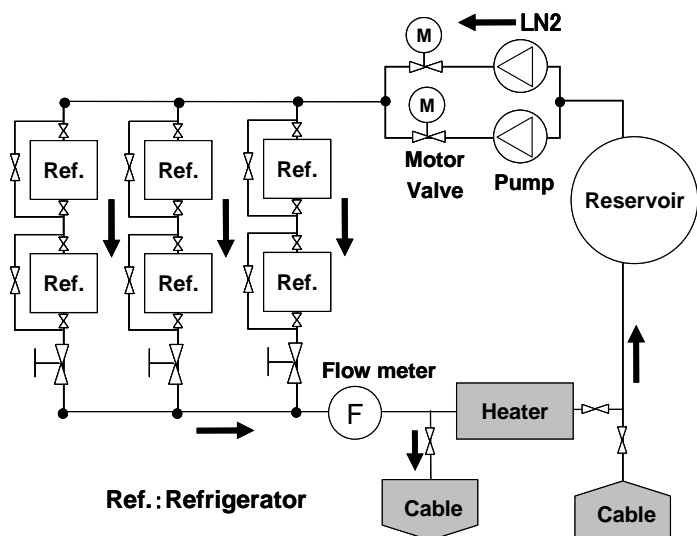


Fig. 1 System flow

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Since Stirling cryocoolers' maintenance intervals are 8000 hours, scheduled maintenance is required during the demonstration trials. This cooling system is equipped with a bypass line and an on-off valve in order to replace the refrigerator whilst maintaining cooling operations. Refrigerator maintenance for each unit commenced since April 2013. There were no significant changes in temperature, pressure, and volume flow of liquid nitrogen during or after the refrigerator replacement, thereby averting moisture from entering the liquid nitrogen system. Whilst refrigerator maintenance will be undertaken accordingly, future investigations are ongoing to characterize performance, practicality, reliability, and maintainability of HTS cable systems, with the acquisition of long-term operational data, including any observable changes between seasons (electric load, heat load).



Fig. 2 Cooling system

Finally, anyone interested in the everyday status of the HTS cable at the Asahi substation is directed to the following website.

<http://www.sei.co.jp/super/cable/jsssho.html>

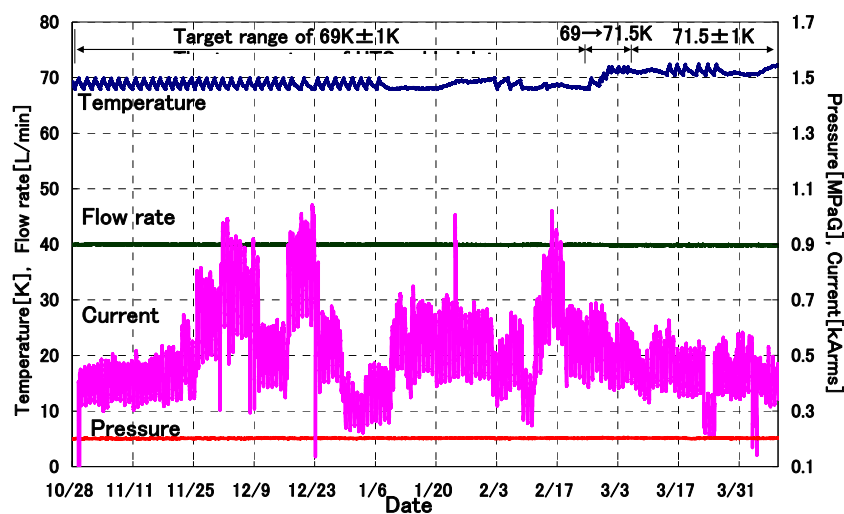


Fig. 3 Operational status of cable demonstration tests after connecting to power grids

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