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Results of Three-Year Operation of 220kV Pilot Superconducting Fault Current Limiter in Moscow Power Grid

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Abstract : Modern city electrical grids are forced to increase their density due to the increasing number of customers and requirements for reliability and resiliency. However, progress in this direction is often limited by the capabilities of existing network equipment. New energy sources or grid connections increase the level of short-circuit currents in the adjacent network, which can exceed the maximum rating of equipment–breaking capacity of circuit breakers, thermal and dynamic current withstand qualities of disconnectors, cables, and transformers. Superconducting fault current limiter (SFCL) is a modern solution designed to deal with the increasing fault current levels in power grids. The key feature of this device is its instant (less than 2 ms) limitation of the current level due to the nature of the superconductor. In 2019 Moscow utilities installed SuperOx SFCL in the city power grid to test the capabilities of this novel technology. The SFCL became the first SFCL in the Russian energy system and is currently the most powerful SFCL in the world. Modern SFCL uses second-generation high-temperature superconductor (2G HTS). Despite its name, HTS still requires low temperatures of liquid nitrogen for operation. As a result, Moscow SFCL is built with a cryogenic system to provide cooling to the superconductor. The cryogenic system consists of three cryostats that contain a superconductor part and are filled with liquid nitrogen (three phases), three cryocoolers, one water chiller, three cryopumps, and pressure builders. All these components are controlled by an automatic control system. SFCL has been continuously operating on the city grid for over three years. During that period of operation, numerous faults occurred, including cryocooler failure, chiller failure, pump failure, and others (like a cryogenic system power outage). All these faults were eliminated without an SFCL shut down due to the specially designed cryogenic system backups and quick responses of grid operator utilities and the SuperOx crew. The paper will describe in detail the results of SFCL operation and cryogenic system maintenance and what measures were taken to solve and prevent similar faults in the future.

Keywords : superconductivity, current limiter, SFCL, HTS, utilities, cryogenics
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