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[Invited] Future Cryogenic Switchgear Technologies for Superconducting Power Systems

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Advanced superconducting generators, cables and fault current limiters have allowed highly-integrated power distribution systems to become more compact and efficient. For the purpose of constructing parallel, multi-terminal cryogenic power systems, switching devices are required to offer protection and control. However, conventional switchgear which connects superconducting components to ambient temperature may lead to substantial heat leak. This heat leak could be significantly reduced if switchgear is designed to operate at cryogenic temperature. This paper evaluates the three conventional switchgear technologies: oil circuit breakers, SF6 circuit breakers and vacuum interrupters with respect to their potential for cryogenic implementations. Their cryogenic counterparts would require substantial changes in both dielectric media and structural design. Cryogenic liquids such as liquid nitrogen (LN2), liquid methane (LCH4), liquid natural gas (LNG), and liquid hydrogen (LH2) are promising candidate fluids for classical oil circuit breakers. We compare dielectric, thermal, and arc quenching properties of cryogenic liquids with those of oil circuit breakers. Similarly, a number of cryogenic gases are compared with SF6 gas concerning their performances. The challenges for cryogenic vacuum interrupters are material compatibility and fatigue. Besides dielectric media, structural designs of cryogenic circuit breakers also need special modifications to include thermal interface between cryogenic switching chamber and control devices in ambient temperature.

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