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Lessons Learned from the Eighteen-Year Operation of the LHD Poloidal Coils Made from CIC Conductors

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The Large Helical Device (LHD) superconducting magnet system consists of two pairs of helical coils and three pairs of poloidal coils. The helical and poloidal coils use composite conductors with pool cooling by liquid helium, and cable-in-conduit (CIC) conductors with forced cooling by supercritical helium, respectively. The poloidal coils were first energized with the helical coils on March 27, 1998. Since that time, the coils have experienced 50,000 h of steady cooling, 10,000 h of excitation operation, and seventeen thermal cycles. During this period, no superconducting-to-normal transition of the conductors has been observed, even during fast current discharge. The subsequent experience gained from eighteen years of operation has also provided further useful information regarding preventive design and maintenance of peripheral equipment and long-term changes in electromagnetic and hydraulic characteristics. First, the poloidal coil system has experienced events that have interrupted plasma experiments due to the malfunction of a quench detection system and an insulating break used in cryogenic piping. The malfunction of the quench detection system was caused by the noise from the plasma heating devices and the coupling current, which is an intrinsic property of a composite superconductor. This suggested that the noise for quench detection should be estimated before magnet operation. During the sixteenth cool-down, one of the breaks suddenly leaked helium, which was caused by the cracking of a plastic adhesive material between the FPR and the stainless-steel pipes. Further investigation is needed to clarify the age degradation and the creep behavior of plastic adhesive materials at cryogenic temperature. Second, the long-term monitoring of the electromagnetic and hydraulic characteristics of the coils has also been performed. Even though the AC losses slightly decreased during the first three years, the losses have remained unchanged in the fifteen years since. The pressure drops of coolant showed a tendency to decrease over the campaigns. The sudden increase in friction factor in the 15th campaign suggested that the compressor oil is a potential source of impurity gasses in helium coolant. These experiences would help in the design and maintenance of preventive measures for fusion magnets, including ITER and DEMO.

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