

§12. LHD Coil Performances Obtained by the First Trial Operation

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The superconducting magnets for the Large Helical Device (LHD) consists of two helical coils (H1 and H2), a pair of inner vertical (IV) coils, a pair of inner shaping (IS) coils, and a pair of outer vertical (OV) coils. We have two operational stages for LHD, Phase I and Phase II. The key parameter in Phase I is a central helical field of 3.0 T to be generated by the pool boiling liquid helium cooled helical coils. After plasma experimental research in Phase I, the next construction program for Phase II is expected to begin, where the field will be enhanced up to 4.0 T by the pressurized superfluid helium cooled helical coils. The construction and first trial operation of LHD on the eight-year Phase I project were finished on March 31, 1998 as previously planned.

Each helical coil consists of three layer-wound superconducting (inner, middle, and outer) blocks in order to make various magnetic field surfaces in the vacuum vessel. Each block has 150 turns and the total turns of one helical coil are 450. The superconductor is a 12.5 mm thick by 18 mm wide composite of NbTi-Cu monoliths and Al stabilizer. Short sample critical currents and recovery currents of all thirty-eight conductors used for the winding were measured in liquid helium at 4.4 K. All conductors were confirmed to have critical currents of 21 to 23 kA and recovery currents of 13 to 17 kA at the maximum field of 6.9 T in Phase I. The measured minimum critical currents of the conductors and the load line of the helical coils are shown in Fig. 1. The rated currents of the helical coils are 13.0 kA and 17.3 kA in Phase I and Phase II, respectively. The broken line represents critical currents estimated at 1.8 K.

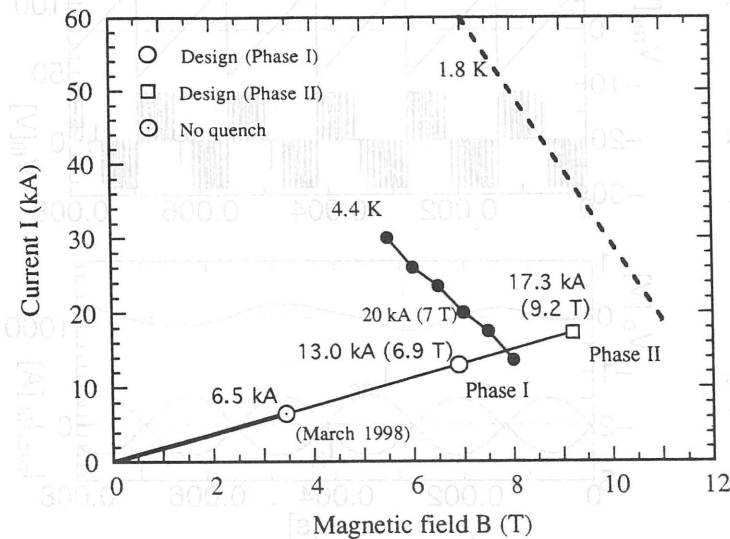


Fig. 1. Coil performances of helical coils for LHD

The poloidal coils were designed and fabricated in accordance with specifications of Phase II. They are operated in steady-state modes in Phase I but in very slow pulsed modes in Phase II. Each coil is a circular one, stacked with eight double-pancakes wound from cable-in-conduit conductors (CICCs). Both CICCs for the IV coils and the IS coils have a same conduit dimension of 23.0 mm by 27.6 mm, and that for the OV coils is 27.5 mm by 31.8 mm. Each CICC consists of 486 NbTi-Cu strands. Short sample critical currents of each conductor for the IV, IS and OV coils measured in liquid helium at 4.5 K were plotted in Fig. 2. The two IV coils were connected in series in the LHD cryostat. The same connections were utilized for the IS coils and the OV coils. The load lines of the IV-L coil and three kinds of poloidal coils and the rated currents in Phase II are also shown in Fig. 2. The IV-L coil with a stored energy of 68 MJ were excited to the rated current of 20.8 kA in Phase II without a quench.

Corresponding blocks of the two helical coils are connected in series, and they were excited to 6.5 kA by using three independent power supplies in the excitation test on the first trial operation. At the same time the IV coils were energized to 7.58 kA. The IS coils and the OV coils were excited to 7.97 kA and 9.09 kA, respectively in the opposite way as the helical coils. They are plotted in Figs. 1 and 2. All coils generated a combine stored energy of 230 MJ without a quench. The operation at the rated helical field of 3.0 T in Phase I is planned in December 1998.

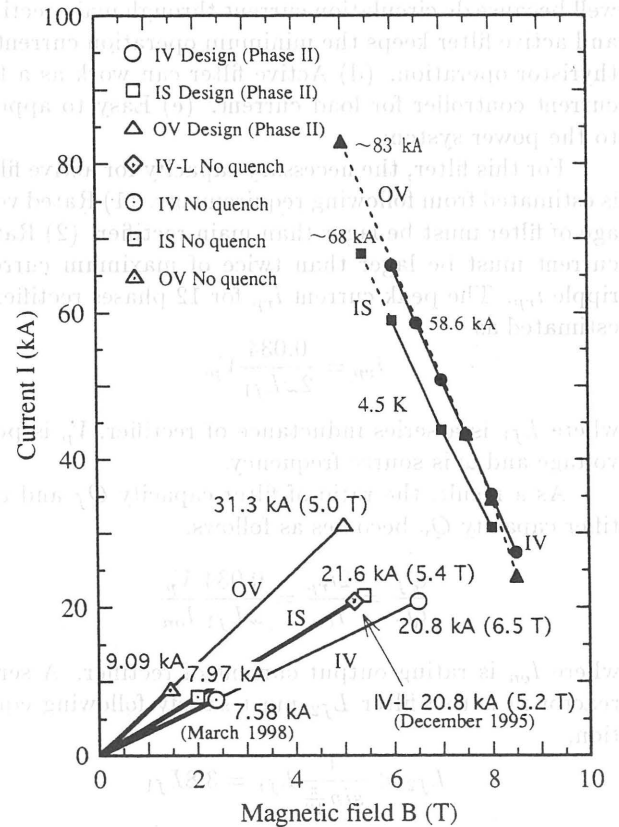


Fig. 2. Coil performances of poloidal coils for LHD