## §14. Design of Superconducting Current Feeder System for LHD

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The design concepts for an SC current feeder system for LHD are as follows. (1) Fully stabilized SC properties should be satisfied when a rated current of 31.3 kA (for OV coil) flows. (2) The withstand voltage of the current feeder system should be higher than that of the SC coils of the main experimental device. (3) The system should be able to maintain its rated current carrying capacities for 30 minutes, whenever the coolants supplied to the current feeder system are stopped.

The SC current feeder system requires excellent reliability and safety exceeding that of the coils of LHD, because the stored magnetic energy of the coils must be extracted through the SC busline when the coils quench. The SC busline should be flexible, because the installation routes from coils to their power supplies have bends. The minimum bending radius is designed to be 1.5 m, because of the regal restrictions on the height, width, and other parameters of road freight in Japan. The specifications for the SC busline for LHD are listed in Table I.

To decrease the heat load into the SC busline, an 80 K helium gas channel is installed as a thermal shield on the actual SC busline for LHD. The overall configuration of the SC busline is shown in Fig. 1. The vacuum-insulated transfer line consists of five corrugated stainless steel tubes assembled coaxial. A pair of SC cables is covered with insulation layers to satisfy the requirements for electrical insulation between the cables and the surrounding corrugated tubes. Liquid helium flows through the innermost channel to the peripheral terminal and then returns through a second inner channel as two-phase helium. The fourth channel is the 80 K helium gas channel, and the third and fifth channels are vacuum insulation spaces.

The electromagnetic force on most parts of the SC busline is 9 kN/m. But the maximum magnetic force becomes 34.8 kN/m at the peripheral terminal near the main device, because the leakage magnetic field of 1 T influences the SC cables. Therefore, the SC cables wrapped together with Kevlar binding tape strong enough to withstand the maximum force. The strength of the Kevlar binding tape was 144 kN/m.

Figure 2 shows a cross-sectional view of the experimental layout for LHD and the routes of the SC buslines. Nine busline will be installed in the current feeder system. The routes are designed to have no sharp bends.

Table I. Specifications of SC busline for LHD.

| Items | Specifications |
|---|---|
| Number of SC busline | 6 (for helical coils)<br>3 (for poloidal coils) |
| Rated current | 32 kA |
| Rated withstanding voltage | 5.7 kV (in 80 K gas helium) |
| Minimum bending radius | 1.5 m |
| Length of SC bus line | 45 - 65 m |
| Heat load into SC bus-line | 0.3 W/m (from 80 to 4.2 K)<br>3 W/m (from 300 to 77 K) |
| Type of cryogenic tubes | five corrugated tubes<br>(with thermal shield) |

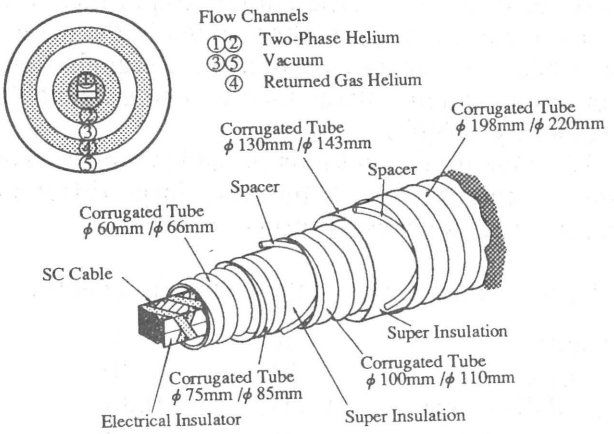


Fig. 1. Configuration of a flexible SC busline for LHD.

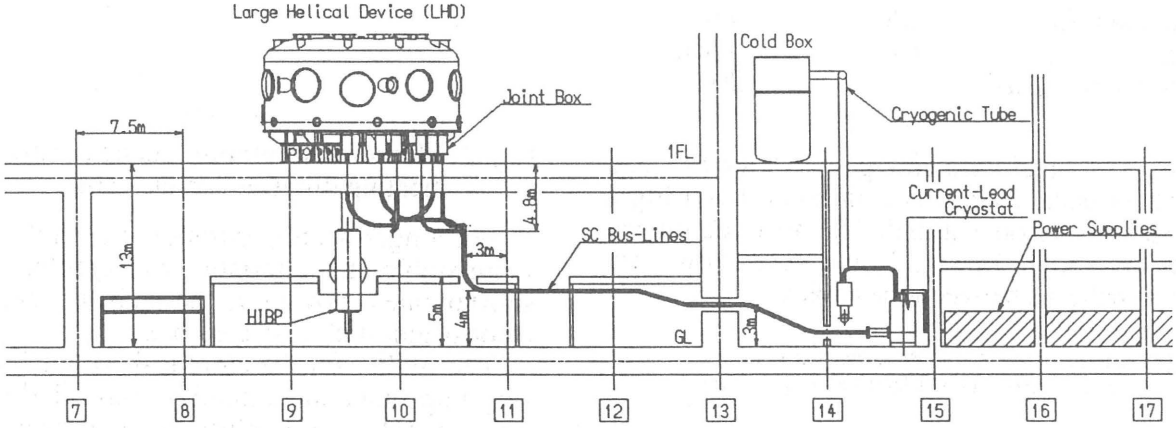


Fig. 2. Routes of SC busline for LHD.