1. Introduction

The LHD superconducting system consists of a pair of helical coils (H1 and H2 coils), three pairs of poloidal coils (IV, IS, and OV coils), nine superconducting bus-lines, a helium liquefier and refrigerator in the 10 KW class, and six DC power supplies.

The LHD was not operated in 2015, because of a fire accident during maintenance. Therefore, the data analyses were carried out in the viewpoints of reliable operation of the large superconducting system. The results of the researches and the preparation for the next operation are summarized.

2. Modification and preparation for D-D experiments

In order to improve the reliability and robustness of the superconducting system, major and minor modifications have been carried out. The major modifications from the start of operation are shown in Table 1.

Table 1. Major modification of the superconducting system.

FY	Modification items
1999	Increase of He gas tanks
	Upgrade to double loop control systems
	Installation of heaters on the current leads
2000	Increase of He gas tanks
	Countermeasures for voltage drop of compressors
2001	Improvement of oil separators
	Reinforcement of turbine filters
	Upgrade to high-speed network
	Replacement of inlet filters of the poloidal coils
2002	Replacement to a general purpose PC control
2003	Increase of a recovery compressor
	Improvement of turbine control valves
2004	Recovery compressor powered by a private generator
	Improvement of a purifier
2005	Replacement of pneumatic valve control units for the valve-boxes.
2006	Installation of subcool system to the helical coil
	Main compressors powered by a private generator
2008	Replacement of PLC unit
	Error check of reflective memory
2012	Installation of a set of redundant compressors
	Replacement of the control system from VME to CompactPCI controllers.
2013	Replacement of all GFRP break of Poloidal Coils.
2013 -2015	Refreshment of the power supplies and the replacement of their control system

The radiation from LHD plasma in D-D experiments was taken into account in selection of material for the superconducting magnets and sensors in the LHD cryostat. However, some countermeasure and modification are needed for electrical devices in peripheral components such as Programmable Logic Controllers (PLC), power supply units, electropneumatic converters, and others. The helical coil quench detector units were moved from the main basement room to the power supply room for periodic overhaul in a factory. The control cabinet for the cold compressors was moved from the LHD main hall to the main basement room to prevent malfunction due to radiation from LHD. Some of electric device in the LHD main hall are planned to be covered with polyethylene blocks for radiation shield.

3. Research activities

We have promoted device-engineering researches toward next fusion devices using the LHD with focusing the improvement of the reliability of the LHD cryogenic system. The titles of the researches are listed in the following;

(1) Long-term operational performance of the LHD cryogenic system. (Mito, T. (NIFS))

(2) Lessons learned from the eighteen-year operation of the LHD poloidal coils made from CIC conductors. (Takahata, K. (NIFS))

(Imagawa, S.)