Improvements in cooling operations of the SAMURAI magnet

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The operational policy for the SAMURAI superconducting dipole magnet is that the magnet is cooled for each SAMURAI campaign experiment and warmed after the experiments in order to save operating time and thus extend the cryocooler maintenance cycle. In line with this policy, the magnet has been at room temperature since 2020. Cooling operation of the magnet was performed from 2022/5/9 to 2022/6/2 for the upcoming experiments. Previously, we reported on the first magnet cooling conducted in 2014.[1] This report describes the improvements made to the work environment and operating procedures since then.

The procedure for cooling is as follows:

(1) evacuation of the vacuum layers of the coil vessels,
(2) pre-cooling of the coils with liquid nitrogen,
(3) removal of liquid nitrogen,
(4) replacement of the inside of the coil vessels with gaseous helium,
(5) transfer of liquid helium into the coil vessels.

This series of operations are performed in parallel, shifting by one week for the upper and lower coils.

For (2), we have extended the liquid nitrogen inlet to be closer to the magnet (Fig. 1). As a result, the handling of liquid nitrogen filling was improved, the filling operation was reduced from three days to two days for a coil, and total liquid nitrogen was reduced from 7125 L (2014) to 5700 L (2022).

For (5), a new gaseous helium recovery port was installed near the magnet to facilitate recovery line preparation and effective collection of gaseous helium (Fig. 1(b)). We also introduced a 1000 L liquid helium container and a long transfer tube. Previously, more than five 250 L containers were needed to cool a coil. In practice, two containers were used one after the other, making it laborious to refill liquid helium and transport the containers from the RIBF building to the helium liquefaction building in the south area of the Wako campus. After introducing the 1000 L container, it was only necessary to transport one 1000 L and one 250 L container at a time. Furthermore, because of the long transfer tube, liquid helium could be poured from the containers placed on the floor (Fig. 2). In addition, as the container only needs to be exchanged once, the loss of liquid helium was reduced, resulting in a reduction in total liquid helium from 3145 L (2014) to 2237 L (2022). The filling process was also reduced for a coil from two days to one day.

One of the remaining issues to be improved would be to place the exhaust port near the magnet for gaseous nitrogen generated during pre-cooling. Currently, we use the port located in the ceiling of the elevator hall.

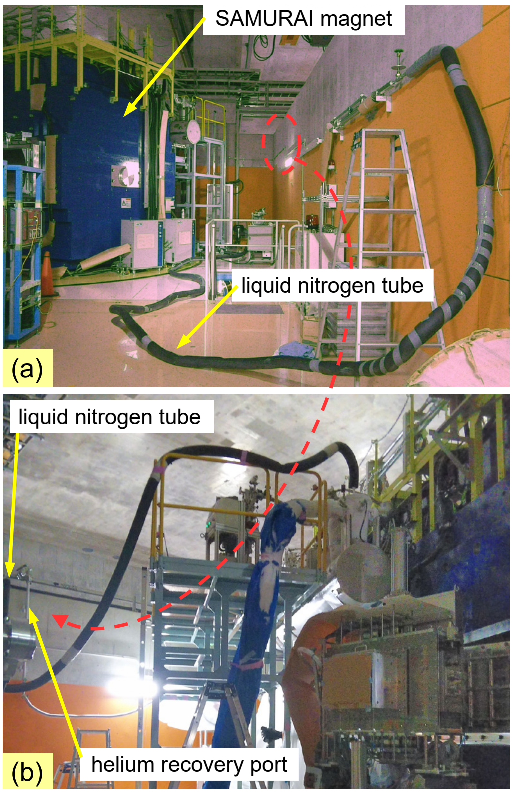

Fig. 1. The tube for liquid nitrogen and the recovery port for gaseous helium. (a) photo in 2014. There was no recovery port near the magnet. (b) photo in 2022.

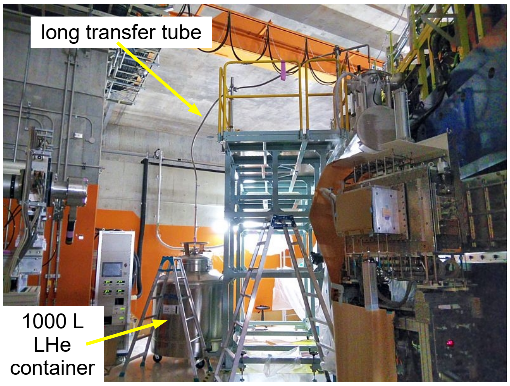

Fig. 2. Liquid helium transfer to the lower coil using the 1000 L container with the long transfer tube.

Reference
1) H. Sato *et al.*, RIKEN Accel. Prog. Rep. **48**, 201 (2015).

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