Restoration of SRC vacuum leakage

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During beam operation with over 800 particle nA ^{70}Zn on December 11, 2022, the vacuum level in the SRC[1] deteriorated and the operation could not be continued. Owing to the vacuum level gradient in the SRC, it was inferred that the leak originated near MDC3, which is the last magnetic channel[2] in SRC extraction.

Therefore, the survey was first conducted from the downstream side of the MDC3. Although the exact location of the leak could not be found owing to the high residual radiation and the narrow and secluded location of MDC3, discoloration of the copper beam duct, carbonization of the polyimide tape, and blackening of the coil insulation epoxy resin were observed as shown in Fig. 1(a). This indicated that the beam duct was considerably heated.

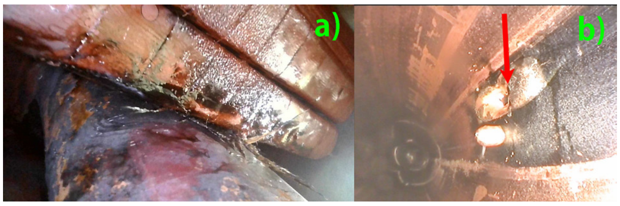

Fig. 1. Outside view of the downstream side of MDC3 (a) and the inside of the beam duct (b). Melting point is indicated by the red arrow.

Next, we entered the acceleration resonator no. 4 and examined the inside of the beam duct from the upstream side of MDC3 using a fiberscope. As shown in Fig. 1(b), we found a spot melted by the beam on the right side of duct. To close this hole, the MDC3 had to be removed from inside the SRC body, which was an extensive repair job.

The ceiling shield iron plate of the SRC was removed such that the crane hook could reach the work area. Further, resonator no. 4 on rails was pulled to the outside of the SRC, where the frequency tuning mechanisms were removed by the crane. As there was no more obstacle to the removal the MDC3, it was slowly pulled out from inside the sector magnet while being lifted up by the crane and moved onto the stage where the MDC3 was to be repaired. A local clean booth was assembled and repair work was performed in it because the removed MDC3 was significantly radiated. Figure 2(a) shows a photograph of the hole in the beam duct of MDC3 from the outside, which was rendered visible by cutting and removing the stainless steel cover attached to the outside of MDC3. Figure 2(b) shows the area around the hole that was cleaned and polished with a paper file following the removal of debris in the beam duct. The size of the hole was approximately 2 mm, and the extent of inward bulging of the molten area was considered to be approximately 7 mm in the direction of beam axis.

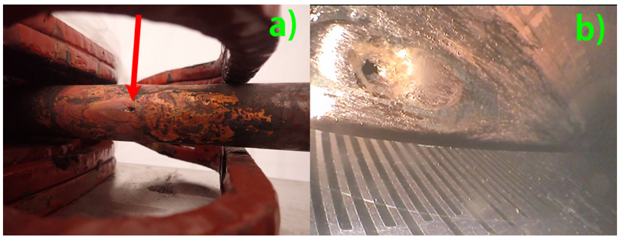

Fig. 2. Photographs of the hole made by the beam.

As the MDC3 cannot be disassembled because the coil and copper duct were integrally cured, we decided to arc spot weld a 1 mm-thick copper patch all the way around. The copper duct with the patch welded and repaired is shown in Fig. 3(a). The damaged insulators of the coils were also repaired as depicted in Fig. 3(b) and their integrity was confirmed by measuring the inslulation resistance. Four thermocouples were mounted on the copper duct to measure temperatures and detect large beam losses. The restoration work was completed at the end of May 2023 by returning the MDC3 to SRC and performing a vacuum leak check.

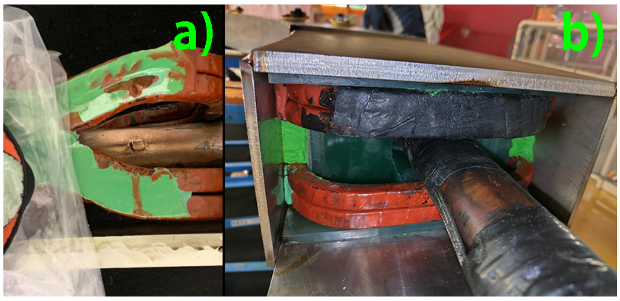

Fig. 3. Photo of MDC3 after repair work.

The cause of the beam hitting the duct is not clear; however, it is most likely that the RF voltage of the upstream accelerator, fRC, became unstable. The baffle slit on the SRC extraction was excessively thin, the ^{70}Zn beam did not stop, and the interlock did not work. Therefore, we are currently working on improving the RF stability of fRC and replacing the baffle slit with 10 mm thick.

References
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