

Status of cryopumps in RIBF accelerator facilities (2016)

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The RIBF accelerator facilities consist of three injectors (RILAC/CSM, RILAC2 and AVF) and four ring cyclotrons (RRC, fRC, IRC, and SRC), and more than 80 cryopumps are used for the main evacuation of these facilities^{1,2)}. The status of cryopumps in these facilities is listed in Table 1. The number of cryopumps and current vacuum pressures are the same as in 2015.²⁾ However, some facilities were affected by malfunctions and temporary shutdowns of cryopumps or cryopump compressors. In this paper, we report some cryopump problems encountered in 2016.

In the cryopump of RILAC-RF #6, the temperature has been fluctuating above 20 K since November. Though helium gas in the cryopump was replaced for improving purity, the fluctuations of temperature did not subside. The cause has still not been identified. As in 2015, a malfunction occurred again in the compressor of RILAC2-DTL3 in July, which was assumed to be due to the influence of ambient radiation caused by an increase in beam intensity. Therefore, a substitute compressor was relocated from the AVF vault to the mezzanine floor. Further, a malfunction occurred owing to age-related deterioration in the compressor of I-36 (AVF injection BT line) in December. Because the cryopump and compressor had been in operation for over 27 years, we plan to install a new compressor or a turbomolecular pump in FY2017.

In the cryopump of RRC, frequent helium leakages caused by age-related deterioration have been recently occurring in some flexible hoses and couplings. A helium leak occurred in a flexible hose on the compressor side for VN-CRP11, and we replaced the flexible hose with a substitute hose. A helium leak occurred in some couplings for RS-CRP11, RS-CRP22, and RN-CRP11, and we replaced the O-rings with new ones. Though a helium leak occurred in the cryopump for RN-CRP21, this leak was not investigated. We will repair it in February 2017. In the cryopump of fRC, the compressor of RE-CRP1 stopped temporarily once in April owing to overload, but is now operating in the local control mode. Subsequently, a malfunction occurred in this cryopump in October, but its source is not clear. We will repair it in February 2017. Since some components of the compressor deteriorated

because of ambient radiation, the compressors of the IRC-NE valley were shifted a location just under the W-sector magnet in the summer of 2015.²⁾ However, the compressors of NEV-CP01 and CP03 stopped temporarily a few times in April. The radiation dose in this installed location may still be high. Therefore, these are offline from the IRC now. In the cryopump of SRC, many malfunctions and temporary shutdowns of the compressors frequently occurred in 2016 because some inverters and electrical components of the compressor deteriorated owing to ambient radiation and aging. A malfunction occurred in the compressors of RES1-CP02 and RES3-CP03 in December 2015, and two repaired compressors were reinstalled in August. Helium leakages occurred at RES2-CP03 in March and August, and helium gas was supplied accordingly. This leak has not been investigated in detail yet. The control boxes of a substitute compressor were replaced with a new box because of a malfunction in March. A malfunction occurred in the compressor of RES3-CP01 in September. This compressor is out of order now, and a substitute compressor has been installed. As listed in Table 2, some compressors stopped temporarily a few times in 2016, and almost all compressors are operating now in the local control mode. We plan to relocate the compressors to a location far from the region of high ambient radiation.

Table 2. Temporary shutdowns of compressors in SRC.

Device name	Month in which temporary shutdown occurred
RES1-CP04	February
RES3-CP02	February, April, and August
RES4-CP02	April and August
Substitute compressor for RES1-CP02	July
VLB2-CP01	August
VLB2-CP02	August

References

- 1) S. Yokouchi et al., *Accel. Prog. Rep.* **41**, 101 (2008).
- 2) Y. Watanabe et al., *Accel. Prog. Rep.* **49**, 142 (2015).

Table 1. Status of cryopumps in RIBF accelerator facilities.

	RILAC/CSM [*]	RILAC2 [*]	AVF [*]	RRC	fRC	IRC	SRC
Total volume (m ³) of facility	(72)	(6)	0.9	30	16	35	90
Number of cryopumps	13	9	2	14	6	14	22
Current vacuum pressure (Pa)	0.1–1×10 ^{-4**}	4–7×10 ⁻⁶	2×10 ⁻⁵	0.2–2×10 ^{-5**}	0.3–1×10 ⁻⁵	2–4×10 ⁻⁶	2–4×10 ⁻⁶
Number of times problems occurred in 2016	1	1	0	5	2	3	12

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^{*} Excluding ion sources and beam transport lines.

^{**} Vacuum leaks have been observed.