

Status of vacuum pumping systems in accelerator facilities

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A vacuum pumping system in the RIBF accelerator facility comprises cryopump [CRP] systems, turbomolecular pump [TMP] systems, rough pumping systems (mechanical booster pump + rotary pump [RP]), additional chamber pumping systems, and sub-pumping systems.^{1,2)} In addition, module-type vacuum gauges (total pressure gauge [TPG] controller combined with two gauges) are used in almost all vacuum pumping systems. In this study, we report the malfunction status of a vacuum pumping system encountered in 2024. Table 1 lists the number of malfunctions and spare units purchased in the vacuum pumping systems from 2018 to 2024. The vacuum pumping systems were stable to maintain and manage in 2024.

Four CRP malfunctions occurred such as abnormal noise, vibration, and helium leakage. Furthermore, three CRP compressors have malfunctioned due to age-related deterioration, such as electric leakage, and circuit board failure, but there was only one CRP compressor malfunction in the SRC. The one reason for this decrease in the SRC is because we have relocated all compressors to a location far from the region of high environmental radiation (from the SRC-south area to the SRC-north area) in the summer of 2023 and 2024.¹⁻³⁾ A new panel type CRP is under manufacturer for an update of the RRC-CRP. In addition, eight new CRP compressors will be purchased as spare units until the end of March 2025 due to the existing discontinued CRP compressors of the RILAC and all cyclotrons. Multiple spare units of the CRP compressors have been prepared little by little, but these spare units are still not sufficient.

One TMP and three power supplies have malfunctioned due to age-related deterioration, such as bearing damage, and circuit board failure. There were two out of three malfunctioning TMP power supplies when power was restored following an electrical power outage in August and October 2024. One new large TMP (5000 L/s) was purchased as spare unit for the RRC,

but as in the case of CRP, the spare unit is still not sufficient.

Only one small RP (<2000 L/s) also has malfunctioned due to age-related deterioration, such as electric leakage. All large RPs (≥ 2000 L/s) in the rough pumping systems have been in operation for over 18 years. Two large RPs have malfunctioned within the past five years, so we plan to purchase a new large RP as spare unit in 2025.

Four TPG controllers also have malfunctioned due to age-related deterioration, such as circuit board failure. As in the case of TMP, there were three out of four malfunctioning TPG controllers when power was restored following an electrical power outage in August and October 2024.

Almost all vacuum leaks at the RIBF were repaired by installing new parts or applying a repair material. For example, a vacuum leak of stainless bellows between the resonator No.2 cavity and a main chamber of the S-sector magnet in the RRC occurred again and was repaired for the twice with a sealing agent, as in 2022.²⁾ A deteriorated O-rings at the air-pressure pipes of shorting plate in the RILAC #6 cavity and at the main angle valve for the TMP in the drift-tube linac 3 [DTL3] cavity of the RILAC2 were replaced with new parts. Finally, a vacuum spike (a sudden increase of vacuum pressure and an immediate return to original vacuum pressure) occurred multiple times at the AVF or RRC. At the time, each cyclotron was running, but no beam tuning was being performed. The cause remains unclear, but careful observation will be necessary during future operations.

References

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- 2) Y. Watanabe *et al.*, RIKEN Accel. Prog. Rep. **56**, 76 (2023).
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Table 1. Number of malfunctions and spare units purchased from 2018 to 2024.

Pump types		Number of units used	Number of malfunctions (Number of spare units purchased)						
			2018	2019	2020	2021	2022	2023	2024
CRP ^a	Pump	> 80	2 (0)	3 (0)	4 (0)	6 (0)	1 (0)	6 (0)	4 (0)
	Compressor		2 (0)	3 (2)	3 (2)	8 (2)	5 (3)	5 (5)	3 (2)
TMP	Pump	> 138	3 (2)	5 (0)	2 (0)	1 (1)	1 (0)	4 (1)	1 (1)
	Power supply		0 (3)	3 (4)	2 (0)	4 (5)	1 (0)	2 (0)	3 (0)
RP ^b	Pump	> 146	5 (1)	3 (3)	7 (0)	1 (2)	5 (0)	10 (1)	1 (2)
TPG	Controller	> 160	4 (0)	3 (0)	3 (5)	5 (4 ^d)	4 (8 ^d)	9 (1)	4 (2 ^d)
	Gauge ^c		0 (0)	3 (10)	6 (0)	7 (0)	3 (0)	7 (3)	2 (0)

^a Excludes a He gas leak. ^b Excludes an oil leak. ^c Includes a Pirani, and cold cathode gauge. ^d Number of circuit boards purchased as spare units.

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