

## 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, turbo-molecular pump (TMP) systems, rough pumping systems (mechanical booster pump + rotary pump [RP]), additional chamber pumping systems, and sub-pumping systems.<sup>1)</sup> 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 2022. Table 1 lists the number of malfunctions in the vacuum pumping systems from 2018 to 2022. The vacuum pumping systems were stable to maintain and manage in 2021 and 2022, and most malfunctions of each unit were less frequent than in other years.<sup>2)</sup>

There was only one CRP (pump) malfunction, such as abnormal noise, vibration, and helium leakage, and the reason for this decrease is unclear. Furthermore, only one CRP compressor in the SRC malfunctioned due to a high environmental radiation dose. The reason for this decrease is due to the use of the existing old CRP compressor (model: C30V), which has a higher radiation resistance than the new CRP compressor (model: C30VRT), as long as possible. However, because the existing C30V is fewer and has been discontinued by the manufacturer, we plan to relocate eight of 13 compressors to a location far from the region of high environmental radiation (from the SRC-northeast area to the SRC-south area) in 2023.<sup>2)</sup> Two new CRP compressors (model; C30VRT and F-50L) were purchased as spare units due to the existing discontinued CRP compressors (model; C30V, CRC-874, and P-875CA) of the AVF, SRC, RRC, fRC, and IRC. In the CRP system of AVF, RRC, and SRC, some helium leakages have occurred in some flexible hoses and couplings which were repaired by installing new parts.

Only one TMP (pump) and one power supply have malfunctioned due to age-related deterioration, such as abnormal noise, vibration, and circuit board failure, and the reason for this decrease is also unclear. In the

update of large TMP systems (5000 L/s), we plan to replace the large TMP of the RILAC No.4 tank with a set of medium TMPs (800 L/s, 1100 L/s, and 2400 L/s) in 2023.

Five malfunctioned RPs were also caused by age-related deteriorations. Some oil leaks in the small RPs were repaired as usual by installing new O-rings and seals.

Age-related deteriorations also caused four malfunctioned TPG controllers. There were no malfunctioning TPG controllers when power was restored following an electrical power outage in August and October 2022.<sup>2)</sup> Three malfunctioned gauges were replaced by spare units due to a contamination of the sensor head.

Almost all vacuum leaks at the RIBF were caused by age-related deterioration and were repaired by installing new parts, applying a repair material, or re-welding. For example, multiple water leaks from the water-cooling parts in the RRC or SRC cavities were repaired by re-welding. 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 for the first time in 2014 and was repaired for the third time with a sealing agent. Vacuum leaks of multiple flange welds in the AA6 chamber, installed in the fRC-IRC beam transport line, and in the RILAC cavities No.2 and No.6 were also repaired with a sealing agent. Faraday cup of the C21 chamber, a slit of A01 chamber and an O-ring of the AVF-RF No.2 were replaced with spare units or new O-ring. Finally, a vacuum leak due to beam loss damage occurred at a beam duct of the magnetic deflection channel No.3 in the SRC in December and is still under consideration.

### References

- 1) Y. Watanabe *et al.*, RIKEN Accel. Prog. Rep. **50**, 154 (2016).
- 2) Y. Watanabe *et al.*, RIKEN Accel. Prog. Rep. **55**, 67 (2021).

Table 1. Number of malfunctions from 2018 to 2022.

		Number of units	2018	2019	2020	2021	2022
CRP <sup>a</sup>	Pump	> 80	4	6	7	6	1
	Compressor					8	5
TMP <sup>b</sup>	Pump	> 138	3	8	4	1	1
	Power supply					4	1
RP <sup>c</sup>	Pump	> 146	5	3	7	1	5
TPG <sup>d</sup>	Controller					5	4
	Gauge	> 160	4	6	9	7	3

<sup>a</sup> Includes a compressor. <sup>b</sup> Includes an attached power supply. <sup>c</sup> Excludes an oil leak. <sup>d</sup> Includes a controller, Pirani, and cold cathode gauge.

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