Status of cryopumps in accelerator facilities

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The vacuum pumping system of accelerator facilities [1)] consists of cryopumps for main evacuation, turbomolecular pump systems for high-vacuum evacuation prior to main evacuation, and rough pumping systems. In addition, two kinds of differential pumping systems are used for the evacuation of an additional chamber pumping system in the RRC and the IRC and for that of a sub-vacuum of resonator (sub-pumping system) in the IRC and the SRC. The status of cryopumps in accelerator facilities is listed in Table 1. Multiple cryopumps are used for the main evacuation of accelerator facilities, and several cryopumps are also used in some ion sources, beam transport lines, and other facilities. Cryopumps with a capacity of 10 m^3/s are used for resonators and valleys; 5 m^3/s, for a part of the resonators in RILAC and RRC; 4 and 2.3 m^3/s, for DTL and RFQ in RILAC2 and FT resonators in IRC and SRC, respectively. These cryopumps and its compressors are maintained regularly for every 10,000-12,000 h and 24,000-30,000 h, respectively. These current vacuum pressures are almost better than the design vacuum pressure of accelerator facilities. However, those of RILAC/CSM and RRC are worse than the design vacuum pressure at present because some vacuum leaks have been observed in each facility. These details of the vacuum leaks in 2015 are summarized in Ref. 2).

Many malfunctions caused by age-related deterioration have been recently occurring because almost all cryopumps have been in operation for over 10 years. Some cryopump's compressors of RILAC, RRC, fRC, IRC and SRC were recently replaced with new ones. Furthermore, some malfunctions of the cryopump's compressors, which were guessed to be an influence of an environmental radiation caused by an increase of beam intensity, have been frequently occurring; the number of malfunctioned compressors in RILAC2, IRC and SRC were respectively two, six, and one in the last three years. It is thought that because a dose in RILAC2, IRC and SRC were very high during a beam irradiation from a measurement of residual radioactivity [3)]. For example, the maximum dose rate was found to be 34 mSv/h at the neighbor of the G01 Faraday cup (SRC deflection beam line), and two cryopump's compressors of the IRC-NE valley have malfunctioned a few times in the last three years. These malfunctions were caused because some inverters and electrical components of the compressor deteriorated by environmental radiation. Therefore, all six cryopump's compressors of the IRC-NE valley and the NW resonator cavities and two cryopump's compressors of the SRC-resonator No.1 and No.2 cavities were relocated from the north side of the N-sector magnet to right under the W-sector magnet and from the south side of sector magnet No.1 to the west side of resonator No.2 in the summer of 2015, respectively. No malfunctioned compressors have been thus far.

Malfunctions caused by age-related deterioration and environmental radiation will increase in the future, and we have to take the following measures. First, standardize a maker and a model number of cryopumps and compressors. When a cryopump malfunctions accidentally, we can easily exchange a malfunctioned component with another facility's component as a substitute component. Second, shield and relocate cryopump's compressors to a place far from a higher environmental radiation for further high-energy beam intensity. Third, do not to use a compressor equipped with an inverter in the future. Several malfunctions of compressor occured because inverters of compressors deteriorated by environmental radiation. Forth, decrease the temperature of the rf shield for a cryopump with a water cooling system. Because the rf voltage of the resonator increases, the temperature of the rf shield and inside the cryopump increases.

Table 1. Status of cryopumps in 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 cryopump	13	9	2	14	6	14	22
Total pumping speed (m^3/s)	(56.3)	(16.2)	14	120	60	128	164.6
Design vacuum pressure (Pa)	1×10^{-5}	7×10^{-6}	5×10^{-5}	$3\sim4\times10^{-6}$	4×10^{-5}	1×10^{-5}	5×10^{-6}
Current vacuum pressure (Pa)	$1\sim7\times10^{-5}$ **	$4\sim7\times10^{-6}$	2×10^{-5}	$0.4\sim2\times10^{-5}$ **	$0.3\sim1\times10^{-5}$	$2\sim4\times10^{-6}$	$2\sim4\times10^{-6}$
Number of malfunctions *** (Influence of environmental radiation)	4 (0)	2 (2)	0 (0)	9 (0)	2 (0)	7 (6)	8 (1)
Number of replaced new compressors ***	1	0	0	5	1	1	3

* Excluding ion sources and beam transport lines. ** Vacuum leaks have been observed. *** Three years from 2013 to 2015.

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References

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