Development of a vacuum control system with a fast closing valve for the radioisotope production beamline

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Vacuum control is extremely important for radioisotope (RI) production that use ion beams accelerated by cyclotrons and linear accelerators. In particular, an interlock mechanism is crucial for protecting the experimental apparatus and accelerators in the event of vacuum deterioration due to leakage, to immediately close the gate valves of the beam line and stop the beam and vacuum pumps. In addition, during vacuum evacuation of the beamline, the vacuum levels and status of each vacuum pump should be monitored to control the sequence of state transitions. Previously, vacuum gauges and electric drive units for turbo pumps were placed separately, in a dispersed manner. Furthermore, the vacuum operation system was located in the beam-irradiation area. As a result, high radiation doses were generated when the beam irradiated the target, causing the vacuum system to malfunction or freeze. Another long-awaited feature is an interlock mechanism that detects vacuum degradation and closes the valve if the vacuum window between the He gas-filled RI production system and beam line is damaged because of thermal heating from beam irradiation.

To address these issues, we developed and implemented a novel vacuum control system (VCS) for the beamlines (C03, E7b, and E7V of AVF and E3b of RRC). To prevent radiation-induced malfunction and freeze, the VCS was installed outside the beam-irradiation area and designed for centralized control. Figure 1 shows a photograph of the VCS, and Fig. 2 presents a block diagram of the vacuum system. In the event of vacuum degradation, the cold cathode gauge first detects the issue and closes the fast closing valve (75.2, VAT Group AG) within 14 ms. Simultaneously, a beam interlock system (BIS)[1)] transmits the signal to the accelerator, triggering an immediate beam interruption. This BIS signal is simultaneously sent to the VCS, which then closes its header valves and triggers an emergency shutdown of the vacuum pumps. The BIS system, which protects the accelerator, is currently being upgraded to incorporate field programmable gate arrays (FPGAs). This upgrade achieves a response time of 129 μs, which is approximately 100 times faster than the conventional system. To achieve a compatible response speed, the VCS employs the compact RIO (cRIO-9054, National Instruments) as a controller running on the NI Linux Real-Time OS. The system was programmed using LabVIEW and configured as an experimental physics and industrial control System (EPICS) client I/O server. Since the measured vacuum levels and valve status are transmitted to an EPICS server by using process variables, the accelerator control system can monitor them in real time and download the stored data at any time. Additionally, a web server was implemented in VCS to enable HTTP access, allowing mobile tablets and external PCs to remotely monitor and control the system. The VCS has been completed and is currently operational in four experimental beamlines and is scheduled to be installed at the newly constructed RI production beamline of SRILAC.

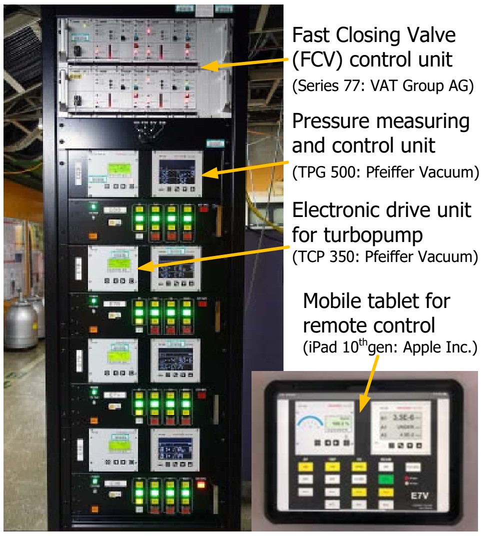

Fig. 1. Vaccum control system with a fast closing valve for the RI production beam line.

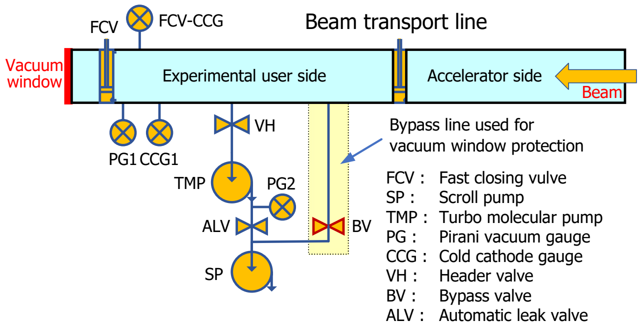

Fig. 2. Block diagram of the vacuum system.

Reference

1) M. Komiyama *et al.*, Proc. of the 19th Biennial International Conference on Accelerator and Large Experimental Physics Control Systems (ICALEPS 2023), Cape Town, South Africa, 2023-10, pp. 645–649.

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DOI:10.34448/RIKEN.APR.58-192