Accelerator Vacuum Protection System

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Abstract. A new and elaborate automatic vacuum protection system using fast acting valve has been installed to avoid accidental venting of accelerator from experimental chamber side. To cover all the beam lines and to reduce the system cost, it has been installed at a common point from where all the seven beam lines originate. The signals are obtained by placing fast response pressure sensing gauges (HV SENSOR) near all the experimental stations. The closing time of the fast valve is 10 milli-second. The fast closing system protects only one vacuum line at a time. At IUAC, we have seven beam lines so one sensor was placed in each of the beam lines near experimental chamber and a multiplexer was incorporated into the fast closing system. At the time of experiment, the sensor of the active beam line is selected through the multiplexer and the Fast closing valve is interlocked with the selected sensor. As soon as the pressure sensor senses the pressure rise beyond a selected pressure, the signal is transferred and the fast valve closes within 10 to 12 millisecond.

1. Introduction
We have a 15UD PELLETRON Accelerator at IUAC. The ultra high vacuum (1.0 x 10^{-10} Torr) condition is maintained throughout the accelerator and seven beam lines. A combination of Ion pump & Getter pump is used to create UHV and the pumping stations are installed at various locations, keeping in mind the requirements of the distributed pumping, taking care of the conductance limitation of such a large vacuum system. The whole vacuum system is divided into individual sections using all metal pneumatic straight through valves. The closing time of these valves is approximately 100 milliseconds.

The operation of the valve is controlled by a valve controller which takes ‘vacuum ok’ interlock signal available from Ion pump controller from both side of the valve. When vacuum ok interlock signal from either side of the valve is failed, the controller closes the isolation valve immediately. The operation is shown in Fig. 1.

In addition to the all metal pneumatic straight through valves there are two high speed, spring actuated, all metal fast acting straight through valves. These valves are installed at the top and bottom side of accelerator for emergency closing, in case of catastrophic failure of ultra high vacuum system. The fast valve gets actuated by a coaxial presser sensor installed at critical locations. The closing time of these valves is approximately 35 milliseconds.

With the interlocks provided at all critical points, whole system is protected against any vacuum failure or accidental venting of the experimental chambers.
Fig. 1. Schematic of Valve operation

Fig. 2. Fast closing valve Installation and Test results
2. Fast acting vacuum protection system

With the available interlocks and fast acting valves, having response time of 35 ms, we have had few vacuum accidents resulting in vacuum disturbance inside the accelerator system. Most of the accidents happen from experimental chamber sides. So, to avoid accidental venting of the accelerator vacuum system from the experimental chamber end, a new and better vacuum protection system was designed & commissioned. The heart of the vacuum protection system is a fast acting valve installed at a common point from where all the seven beam lines originate. The system consists of a valve, control electronics & fast response pressure sensing gauges near all the experimental stations. The fast closing system couples with one sensor at a time [protects only one vacuum line at a time]. As soon as the pressure sensor senses the pressure rise beyond a selected pressure, the signal is transferred and the fast valve closes within 10 to 12 millisecond. The valve control electronics module and pressure sensors were procured from VAT. The standard components work with one pressure sensor only. So it was suggested to VAT to provide a multiplexing unit so as to enable same control electronics to couple with pressure sensors placed at different locations, as per requirement.

At IUAC, we have seven beam lines so one sensor was placed in each of the beam lines near experimental chamber and a multiplexer was incorporated into the fast closing system. At the time of experiment, the sensor of the active beam line is selected through the multiplexer and the Fast closing valve is interlocked with the selected sensor. The schematic of the system is shown in Fig. 2

2.1 Design of Fast Closing vacuum protection system

Fast closing system has three electronic modules (valve module, control module and HV sensor module), seven high vacuum sensor and one fast closing valve, one multiplexer unit which is the combination of sensor selector and switch box. One interface unit has been made which works between sensor selector box, CAMAC and control room beam line selector, for remote operation. Interface unit is connected with CAMAC, which sends signal to the valve module for open / close & read the status of valve and modules. If vacuum is OK on both the sides of the valve, the valve can be opened.

2.1.1 Test results

Actual test to test the efficacy of the system was done after commissioning the fast valve. In this test, accident conditions were simulated and two full range (atmosphere to 10⁻⁹ Torr) vacuum sensors G1 and G2 (one gauge at each side of the valve) were monitored before and after the vacuum accident, refer Fig 2. The valve functioned perfectly well and vacuum was protected in the desired line. The test result is as shown below.

|                      | Vacuum before accident | Vacuum after accident |
|----------------------|------------------------|-----------------------|
| Vacuum Gauge G1      | 1.0 x 10⁻⁷ Torr        | 7.6 x 10⁻⁸ Torr       |
| Vacuum Gauge G2      | 3.8 x 10⁻⁸ Torr        | 20 Torr               |
3. Off line testing of Fast Closing System

Complete setup for testing the closing time of valve is shown in Fig 3 below. All seven fast valve sensors were mounted on a small vacuum chamber. Initially valve was opened by pressing open switch and resetting the system. Then vacuum was created with the help of a turbo pumping system till vacuum reached $10^{-7}$ Torr. Then suddenly the system was vented. This drastic change of vacuum was sensed by HV sensor module and triggered control & valve module for closing the valve. One TTL high signal is available from HV sensor when it senses vacuum disturbance and it starts counter. One optical transmitter & a receiver is used to generate stop signal for the counter. When valve closes no light is received at the optical receiver and it sends low signal to stop counter. The counter shows 100509 count for 1 second. The valve test was done 10 times and the average closing time found is 11.6 ms.

![Off line Testing of Fast Closing System](image)

Fig 3. Valve timing test set up

References

[1] VAT Vakuumventile AG, Series 75 fast closing valve.