Drift Chamber Gas PID Pressure Control Development

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The gas volumes of the CLAS12 drift chambers (DCs) are sealed with 0.001 inch-thick, aluminized Mylar windows. Since the ambient pressure varies, the gas pressure inside the detector volume must be controlled to maintain a safe differential pressure between the gas volume and the ambient pressure to prevent gas window rupture or detector damage; to this end, the differential pressure must be controlled to be within the safe operating range of 0–0.150 inH_2O.

The gas flow required by the DCs depends on the beam energy and beam current. The DC gas system uses a proportional-integral-derivative (PID) control loop to maintain the differential pressure of the detector's gas volume with respect to the ambient pressure. A valve controlled by the PID removes gas from the detector volume as needed, to maintain the differential pressure to be within a safe range, 0.075 ±0.050 inH_2O; this limit is slightly more stringent than needed.

For the development of the PID controller system, the gas control system is configured in the normal operation mode, except that the detectors are not installed. Figure 1 shows the test configuration of the gas flow. Pressure inside the bypass control volume, (whose volume of ~240 gal is much smaller than the detector volume of ~13,000 gal), is monitored. Gas is supplied by mass flow controllers located in the gas shed.

For this test, the gas bypasses the detectors and flows directly into the bypass control volume. Vacuum pumps in the gas shed provide the differential pressure required to remove gas from the bypass control tanks. A capacitance manometer sends a voltage signal to the PID controller, which in turn sends a voltage signal to the control valve according to the PID parameters.

An initial set of PID parameters was required to start the test. As a best guess, the choice was P=10, I=1 s, and D=0 s. Then P was varied to minimize the error between the setpoint and the actual pressure. Once the optimal value for P had been found, appropriate value for I was searched. Once an optimal value for I had been found, D was varied. Once the initial optimized values had been determined, tests were conducted to see how well the system responded to pressure transients.

To simulate pressure transients, increases and decreases in gas flows were made. The PID parameters were again varied, one at a time to further optimize the PID values. The final optimized PID values permit the fastest recovery from transients and minimize the error.

To conclude, tests performed have successfully controlled transients and maintained steady state operation setpoint.

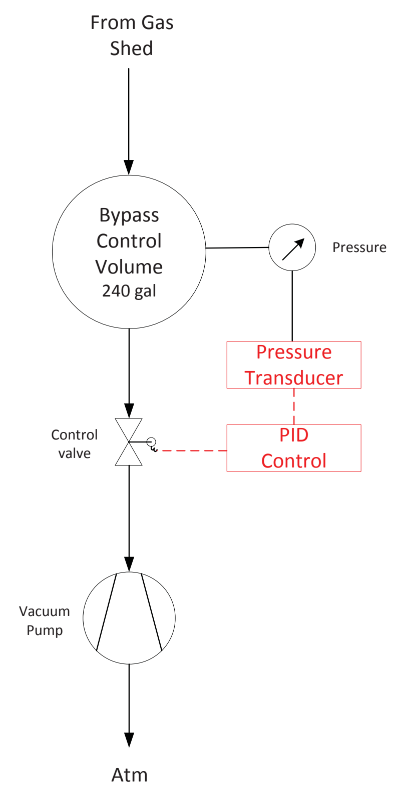

FIG. 1. Test configuration of the gas flow.