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Hall D Drift Chamber Gas Control System

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This note presents an overview of the Hall D Drift Chambers' Gas Control System (GCS) and its three critical functions: providing gas mixture for desired gas gain and resolution of the detectors, distributing the mixed gas to the drift chambers, and interlocking the system to prevent over-pressurization.

Hall D has two tracking detectors, the Central Drift Chamber (CDC) and the Forward Drift Chamber (FDC). The CDC has a single gas volume that is shared by all 3522 straw tubes. The FDC has 24 cells, each cell composed of a wire-board sandwiched by two cathodes. The FDC has four packages – six cells to a package.

CDC and FDC use an Ar and CO_2 mixture in the proportion 50%:50% and 40%:60%, respectively. The gases are supplied by separate bottles and mixed in the required proportion by GCS, which is instrumental to the quality of the generated signal.

The heart of GCS is the Allen Bradley L35E CompactLogix Programmable Logic Controller (PLC), which is located on the rear of the gas panel on the main platform in Hall D. L35E monitors three Ashcroft IXLdp pressure transducers, and controls two Brooks (Model 0254) flow controllers and 35 electronic solenoid valves. An Allen Bradley 1734 AENT Point IO system in the gas room is an Ethernet extension of the L35E processor.

Gas mixing is done in the gas room, Fig. 1, by the two Brooks flow controllers, one for CDC, the other for the FDC. Each Brooks flow controller is connected to two flow valves, one for Ar and the other for CO_2. Mix ratios for each detector are programmed into the Brooks flow controllers.

The pressure threshold for the mix tanks is set to be between 7—12 psi; L35E maintains the tanks within the defined range. The lower pressure limit is based on the flow rate and the number of gas exchanges each detector was designed to have. The upper pressure limit was chosen to keep the gas system below 15 psi because, per Jefferson Lab section 6151 of the ES&H manual and ASME codes, a piping system above 15 psi requires more stringent safety controls. GCS monitors the pressures in the CDC and FDC mix tanks and sends a signal to the Brooks flow controller to either turn the flow ON, (4 mA), or OFF, (20 mA).

Through the serial communications line for display on the EPICS GUI, GCS monitors the flow rates of the two Brooks flow controllers, which are configured as shown in Appendix A. The mixed gas, for the CDC and for the FDC, is sent through a series of valves to the gas panel for distribution, Fig. 2. Gas is distributed to the CDC and to each individual cell of the FDC. See Appendix B for a detailed diagram.

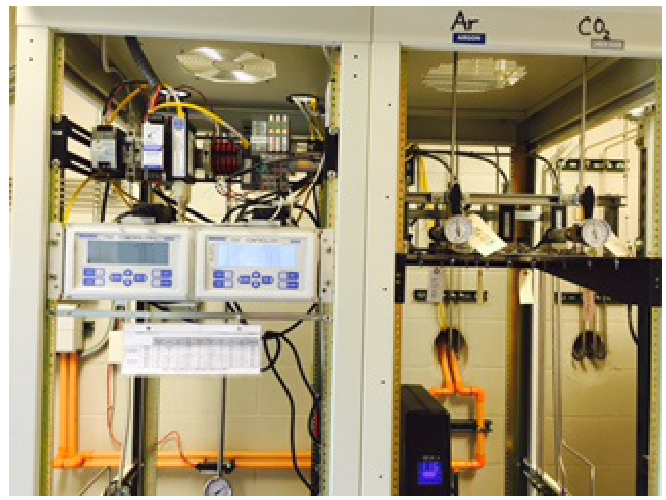

FIG. 1. Hall D gas room.

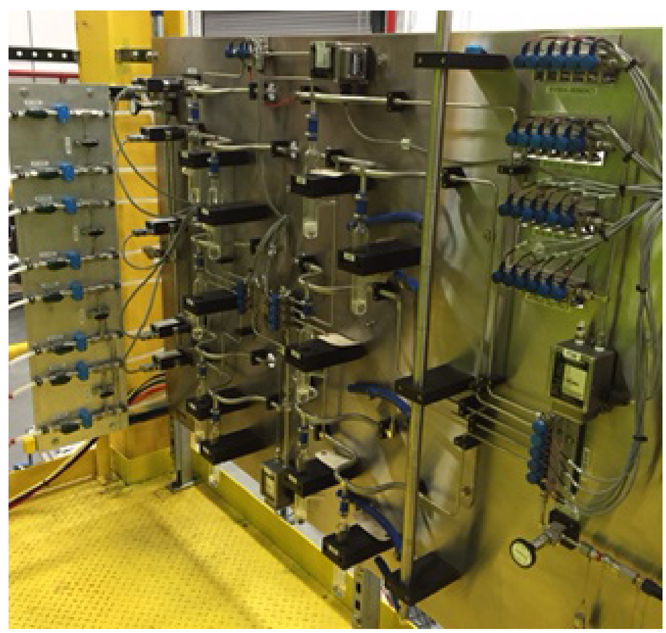

FIG. 2. Hall D gas panel.

To minimize the number of pressure transducers, a series of PLC-controlled solenoid valves, three for the CDC and 32 for the FDC, are used to allocate pressure measurement locations to the transducers.

For the CDC, three solenoid valves controlled by L35E are assigned to a pressure transducer on the gas panel. Pressure of the input, of the gas volume of the detector (normally ~100 Pa), and of the output are measured. The pressure inputs to the transducer cycle through at 0.2 Hz.

The FDC has one pressure transducer for measuring the input and output pressures of the four packages, using eight solenoid valves, and one transducer that measures the pressures of the 24 cells, using 24 solenoid valves. The cell pressure is ~58—68 Pa. Input to the transducers is cycled at 0.2 Hz.

To prevent over-pressurization, the CDC has a mineral oil bubbler present as a first line of defense. The level of the mineral oil is set to the height that will start bubbling at the corresponding pressure acting as a fail-safe relief valve. Since the CDC is a single gas volume, the bubbler is considered to be adequate protection against over-pressurization. Additionally, in case of over-pressurization, GCS will stop gas flow.

For the FDC, each of the four packages has an over-pressure bubbler that will protect against over-pressurization of all of the 6 cells in a certain package. However, a problem arises when the difference in pressure (ΔP) is large (~10 pa) from cell to cell within the same package. If a cell is at a lower pressure than the adjacent cell, the cathode foil from the higher pressure cell could expand and push the cathode foil of the lower pressure cell onto the wires of the wire-board causing damage to the FDC, which is difficult to remove and repair. To solve this problem, the controls system is designed such that, if ΔP becomes too large, the flow to that package will be stopped.

To conclude, GCS plays not only a critical role in the performance of the drift chambers, but also in the protection of these detectors. The designed gas system has been commissioned and has been running smoothly for over an year.

APPENDIX A: HALL D GAS CONTROL SETTINGS

Brooks controller	Mass flow controller #	Measurement units	Set point full scale	Set point rate
CDC, 3	5	l/m	6 l/m	1.00 l/m
FDC, 4	6	sccm/min	500 sccm	100 sccm
	7	sccm/min	500 sccm	100 sccm
	8	sccm/min	500 sccm	100 sccm
	9	sccm/min	500 sccm	100 sccm

APPENDIX B: DIAGRAM OF THE HALL D CDC AND FDC GAS CONTROL SYSTEM