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The Hall B Low Threshold Cerenkov Counter Gas System

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This note discusses the C_4F_{10} gas system used for the Low Threshold Cerenkov Counter (LTCC).

The LTCC uses C_4F_{10} gas as the radiator gas. The gas system supplies the gas while maintaining detector pressure within allowable limits. Each of the six detectors, one per sector, has an internal volume of 7,200 L and requires ~80 Kg of C_4F_{10} to fill. Total system volume, including the pressure control tank, is 51,300 L and requires ~500 Kg of C_4F_{10} to fill.

The LTCC gas system comprises a gas supply unit, PID pressure control, gas metering, active pressure protection, passive pressure protection, and C_4F_{10} distillation and recovery units.

C_4F_{10} is supplied to the system from a container (500 Kg) located in Bldg. 96B, the gas shed. The fill level of the container is monitored by a scale with local and remote readout. The gas system requires a minimum of ~225 Kg in the container to operate. Gas flows from this container into the hall via a 300 ft long, temperature controlled, stainless steel tube. Additional gas is stored in 500 Kg containers outside of the building.

A PID control loop, shown in Fig.1, maintains a constant pressure in the pressure control tank attached to the exhaust lines of each sector. A differential pressure transducer sends a pressure signal to the National Instruments CompactRIO PID control, which then sends a signal to control a downstream solenoid valve that is connected to pumps in the gas shed. The solenoid valve controls pressure by allowing for the removal of gas from the control tank, gas is pumped to the return tank at the gas shed. A minimum gas flow is required for the PID control to function properly.

The use of PID pressure control minimizes the loss of C_4F_{10} and prevents air contamination in the detector due to atmospheric pressure changes. A signal closes the control valve to prevent detector pressure from going sub-atmospheric, sucking in air, and thereby damaging the mirrors. The control valve opens to prevent the detector pressure from going too high and venting C_4F_{10} to atmosphere.

The LTCC valve panel, Fig. 2, is located on the forward carriage, level one. At the panel, connections are made between: C_4F_{10} shed supply line and supply manifold, forward carriage N_2 supply line and supply manifold, and the return line from each of the six detector sectors to the return manifold, which is connected to the pressure control tank.

The panel is home to the gas supply mass flow controllers, the active pressure protection solenoid valves, and the flow reversal valves. The flow reversal valves permit the recovery of the C_4F_{10} prior to removal of a detector sector for maintenance. The panel design permits simultaneous filling of some

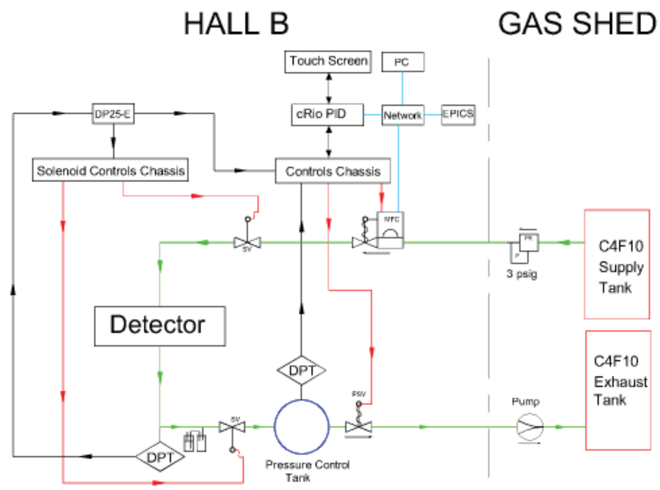

FIG. 1. LTCC gas controls diagram. Red lines are power, blue are network, black are signal, and green are gas flow.

FIG. 2. LTCC valve panel located in Hall B's forward carriage, level one.

detectors and C_4F_{10} recovery of others.

At the C_4F_{10} mass flow controller supply manifold on the valve panel, the gas is metered to each of the six sectors by individual mass flow controllers. Each sector is supplied with a constant flow of C_4F_{10} in order to remove any contaminants and maintain detector pressure within the allowable range.

Each of the six detectors are connected to the pressure control tank in parallel. This results in each detector operating at different pressures due to the different detector heights and distances from the control tank. Solenoid valves are installed in each detector supply and return line in order to minimize any gas loss or air contamination during a pressure transient.

Each sector has a pressure transducer and a process controller with relays. If the detector pressure increases to the high set point, the high set point relay opens and de-energizes the gas supply solenoid valve, preventing the gas flow from further increasing the detector pressure. If the detector pressure decreases to the low set point, the low set point relay opens and de-energizes the gas return solenoid valve. This prevents detector pressure from decreasing due to gas removal from the sector. In either case, when the pressure returns to normal, the relay closes and opens the solenoid valve. Pressures are shown in Fig. 3.

FIG. 3. Pressure readout.

Oil-filled bubbler assemblies, Fig. 4, are attached to the exhaust line of each detector. Each bubbler assembly consists of three parts: an overpressure bubbler, an under pressure bubbler, and an oil trap volume. When the pressure inside the detector exceeds the oil column height of the bubbler, gas is vented out via the overpressure bubbler. When the pressure inside the detector drops to less than the oil column height of the bubbler, air is sucked into the detector via the under pressure bubbler. The oil trap connects the detector to the over and under pressure bubblers. Any oil carryover would be collected in the oil trap volume, protecting the inside of the detector.

FIG. 4. Oil-filled bubbler assembly.

C_4F_{10} is a greenhouse gas that has no commercial use, is no longer manufactured in the Americas, and therefore must be manufactured specifically for our application, making it expensive at $135 per Kg. For this reason, the gas is recycled by a distillation process which removes air and moisture from the gas in the return tank so it can be re-used.

The distillation unit is located in the gas shed. Gas from the return tank located on the concrete pad at the gas shed is first pumped through molecular sieve filters that removes water vapor from the gas. The gas then flows into the distillation unit where liquid N_2 is used to condense the C_4F_{10}, while venting out the air and any other gasses that do not liquefy in the unit.

The unit is operated in batch mode. When the return tank pressure reaches 20 psi, the distillation unit is started. When the vacuum in the return tank reaches 20 in. Hg, the process is complete and the recovered gas is transferred to the supply tank. Once all the liquid is transferred, the unit is vented to the vacuum in the return tank in order to save the remaining C_4F_{10} in the unit that could not be transferred.

During normal gas system operation, the distillation unit is required to operate three days a week to maintain the return tank pressure below 20 psi. Operation of the distillation unit is a manual process which requires trained, experienced operators.

The LTCC gas system operation requires trained operators to fill the detectors, recover gas from a detector, replenish the C_4F_{10} supply tank, and operate the distillation unit. Once the system is filled and operating normally, operating parameters are monitored by EPICS screens and the alarm handler.

The LTCC gas system has been implemented and will be tested in the near future.