Design of the Gas System for Hall A's Heavy Gas Cerenkov Detector

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The solenoidal large intensity device (SoLID) will have two Cerenkov detectors, which will use C_4F_{10} (heavy gas). This note presents the design of the gas system.

SoLID's Cerenkovs will use ~10,000 l (~150 Kg) of C_4F_{10} and operate at 1.5 atm. The operational pressure is high enough that changes in atmospheric pressure will have a minor effect on detector performance; large temperature changes may have a major effect.

The gas system is designed to purge and fill, recover and store, and maintain operations pressure. Additionally, the gas system design enables gas recovery—C_4F_{10} is transferred to a holding tank and stored for distillation and re-use.

To maximize recovery of C_4F_{10}, a vertical separation column will be used. Design considerations for this column are column height (vertical distance between the detector outlet and the vent bubbler), path length, and gas velocity in the column. Path length can be increased to provide more time for C_4F_{10} to separate from N_2. Gas velocity can be reduced by using a large diameter tube.

C_4F_{10} is a low pressure refrigerant supplied at saturation pressure. Mass flow controllers (MFCs), Fig. 1, meter gas flow (based on which the leak rate can be determined). Gas flow reversal valves, MV17 and MV18, allow gas flow to be directed correctly for fill and recovery operations. The oil-filled vent bubblers act as low pressure check valves during purge and fill operations. The heated-head recovery pump is used to transfer the C_4F_{10} to the return tank. A pump with heated head is required to prevent gas condensation in the pump during operations. Each detector is protected from an overpressure condition by an adjustable, proportional relief valve (PRV1 and PRV2 in Fig. 1), which will release gas at 1.8 atm, the system's passive overpressure protection.

The system also uses an independent, active overpressure and under pressure safety system. Pressure in each detector is monitored by a PHOTOHELIC pressure gauge with high and low limit pressure switches, Fig. 2. When the detector pressure exceeds the high limit, a solenoid valve de-energizes and closes to stop gas flow to the detector. When the detector pressure reaches the low limit, a solenoid valve shuts to isolate the only source of under pressure, the recovery pump, from the detector. The system safety isolation valves, SV01, SV02, SV03, and SV04, Fig. 1, also fail shut on power-loss to isolate the detectors from the gas system.

Table I shows the pressure signals and the transmitters used to monitor them.

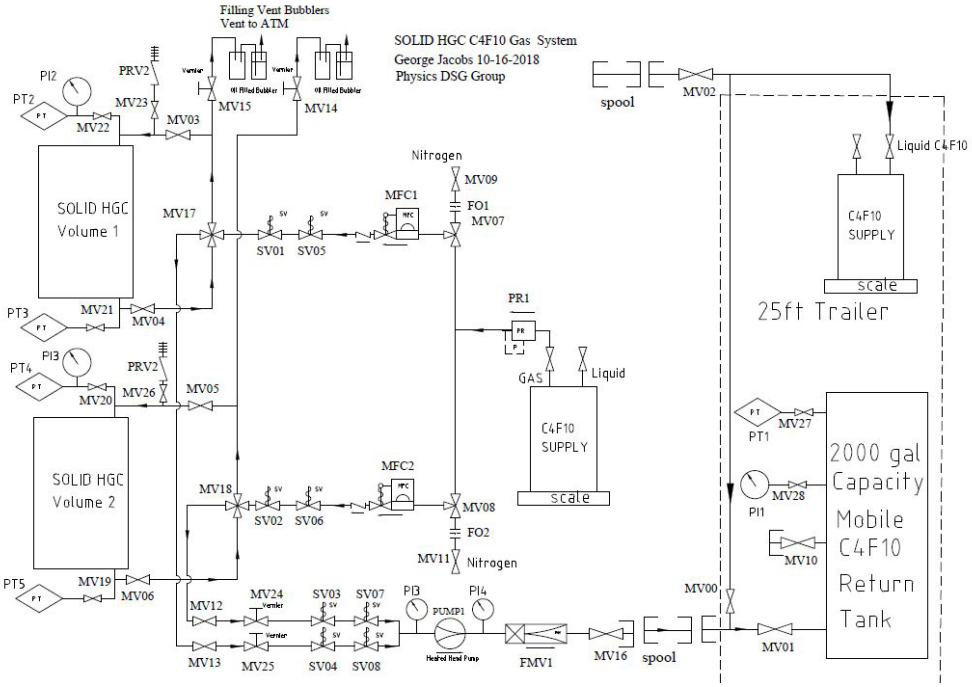

FIG. 1. Hall A SoLID heavy gas Cerenkov C_4F_{10} gas system P&I.

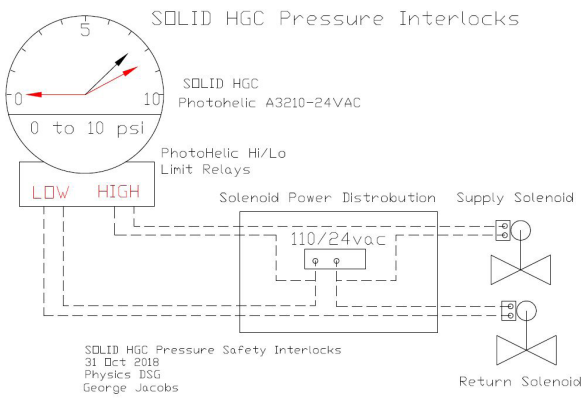

FIG. 2. Gas system pressure safety interlocks.

Signals	Type	Output	Range	Part number
PT1	absolute	4–20 ma	150 psig	Omega PX409-150GI
PT2	absolute	4–20 ma	15 psig	Omega PX409-015GI
PT3	differential	0–10 V	±10 InWC	Ashcroft CX3F0110P1I-WL
PT4	absolute	4–20 ma	15 psig	Omega PX409-015GI
PT5	differential	0–10 V	±10 InWC	Ashcroft CX3F0110P1I-WL

TABLE I: Gas system pressure instrumentation.

Detector pressure is monitored by absolute pressure transducers, whose outputs are used by the cRIO controller to open or close pressure control solenoid valves SV05, SV06, SV07, and SV08 (Fig. 1) according to preprogrammed limits, Table II.

Pressure control mode	High setpoint	Low setpoint
Normal operation	7.5 psi	7.2 psi
N_2 displacement	0.4 psi (20 torr)	0.2 psi (10 torr)
C_4F_{10} pressurization	7.5 psi	7.2 psi
C_4F_{10} recovery	0.4 psi (20 torr)	0.2 psi (10 torr)

TABLE II. Pressure control setpoints.

Pressure will be controlled within an operating band during fill and normal operation. Gas flow will stop at the upper operating band limit and then turns on at the lower pressure limit. Gas will flow at the preprogrammed flow rate until the high pressure setpoint is reached. At the high pressure setpoint the solenoid valve will shut, stopping gas flow.

Pressure control during recovery operation will prevent system pressure from dropping below atmospheric pressure and triggering the under pressure safety interlock. This setpoint is slightly higher than the pressure safety setpoint.

Distillation of recovered gas requires the Hall B C_4F_{10} distillation system. The trailer with the 2000 gallon storage tank and C_4F_{10} supply tank will be moved to building 96B, where the Hall B distillation unit will be used to recover the C_4F_{10} from the storage tank. The recovered C_4F_{10} will be stored in the supply tank as a liquid at saturation pressure. When needed, the tank will be moved to Hall A to refill the detector.

To conclude, this design has been approved.