Helium Gas Regulation System for the Light-Ion Guide Gas Cell

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Abstract

This is a proof-of-concept project to show that it is possible to construct a cost-effective helium gas regulation system for TAMU Cyclotron Institute's light-ion guide gas cell, using store ordered components. By purchasing the individual necessary parts, we designed and constructed a system that was less expensive than purchasing a pre-constructed system from a manufacturer, and could easily be scaled larger or smaller to accommodate any number of gas bottles. Utilizing LabVIEW software, I was able to write a program that allows the system to be controlled remotely, and an automation program that causes the system to change immediately between bottles, whenever one is almost empty, allowing the system to supply a constant flow of helium gas for several days. Although both the construction and the programming of the system can be seen as rough and unrefined, due to the time-restraints placed on me, the project adequately proves that the concept is valid and entirely possible, as the system is fully functional and able to fulfill its intended purpose.

Construction

In our construction of the physical system, outside of the wiring, we utilized five Swagelok Low Pressure Diaphragm Valves connected to five Humphrey 24 VDC Solenoid Valves, five ProSense TM electronic Pressure Transmitters (four rated to measure between vacuum and 4000 psi and fifth rated to measure between vacuum and 60 psi), four Praxair TM Dual-Stage Gas Regulators, and various Brass tube fittings purchased from Swagelok. The Swagelok diaphragm valves are pneumatically controlled and have factory installed switches that indicate when the valves are closed. The Humphrey solenoid valves provide compressed air when 24 VDC is supplied.

The system can be separated into two sections: 1) the regulators that connect to each of the bottles, and 2) the helium gas manifold, which each of the regulators are connected to by a length of polypropylene tubing. The regulator, which is mirrored across each of the bottles, was constructed by fitting a brass tee containing one of the pressure sensors rated to measure up to 4000psi, between the regulator's main body and its inlet pressure gauge (see Figure 1). The helium gas manifold was constructed by connecting four brass tees together so that their middle openings are parallel, and then attaching two brass elbows, one parallel to the four tees at one end and one perpendicular to them at the other end (see Figure 2). After constructing this section, the pressure sensor, rated from vacuum to 60 psi, was attached to the perpendicular elbow, and the five Swagelok valves were connected to the parallel openings, and oriented so that four of them controlled the helium gas coming into the manifold while fifth controlled the helium gas exiting the manifold.

Figure 1 – Gas regulator system shown for a single helium bottle comprised of a Praxair Dual-Stage Gas Regulator, a Swagelok brass tee and a (0 - 4000 psi) ProSense electronic Pressure Transmitter.

The Swagelok diaphragm valves that control the flow of helium gas into and out of the manifold are pneumatic. Each of the Swagelok valves is connected to its own Humphrey solenoid valve, which in turn provides the compressed air from a common building compressed air source. When compressed air is provided by the Humphrey valve, the Swagelok valve opens and when the compressed air is released, the Swagelok valve closes. By using pneumatically controlled Swagelok diaphragm valves, this allows the option to place the Swagelok valves and gas manifold on the light ion guide high voltage platform while operating the Humphrey valves and computer system at ground potential, if so desired.

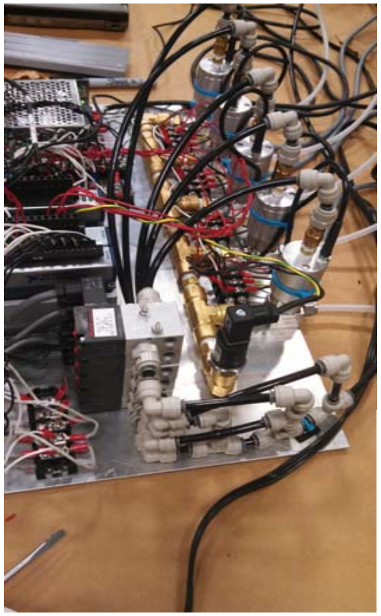


Figure 2 – Gas manifold system comprised of four Swagelok brass tees, two elbows and compression fittings, five Swagelok diaphragm gas control valves and a (0 - 60 psi) ProSense electronic Pressure Transmitter

In the wiring of the system, we utilized a 24-Volt DC power supply, six toggle switches, seven LEDS and three different National Instruments Logic Modules. Along with wiring those components, the Prosense pressure sensors, the Swagelok valves and the solenoid valves must be supplied with power, and connected to their respective logic modules. The Humphrey solenoid valves are connected to a NI9472 8-Channel Digital Outlet Module, the Swagelok valves are connected to a NI9422 8-Channel, 24V Sinking/Sourcing, Chanel-to-Channel Isolated Digital Input Module, and the pressure sensors are connected to a NI9201 8-Channel, 12-Bit Analog Input Module. The modules used for the Swagelok valves and the pressure sensors read the voltages sent from them, for use in the programming, while the module connected to the solenoid valves sends voltage into the valves, to open and close it, as instructed by the programming.

For visual indication on the front panel (see Figure 3), LEDs were wired to each of the five Swagelok valves, so that whenever a valve is closed, the corresponding LED will light up. At the center of the front panel, switches were wired to each of the solenoid valves so that, when power is supplied to the switches, they could be used to control the valves in a "Local Mode" of operation. The switch on the left allows the user to choose between Local and Computer controlled modes of operation. LEDs were wired to each of the switch's positions, so that they would light up to indicated the current mode of operation that the system is in.

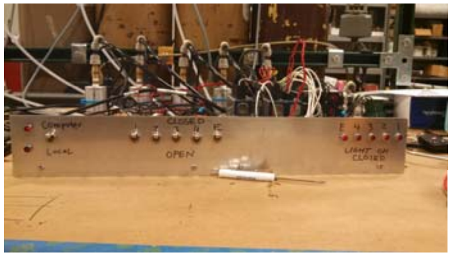


Figure 3 – Front panel assembly comprised of six toggle switches (one for Local/Computer control mode and five for the control of each valve in Local mode) and seven LED lights to indicate when each valve is closed and the Local / Computer control mode position.

Programming

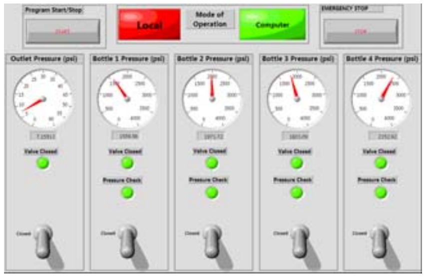
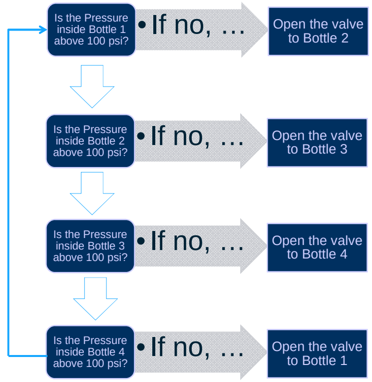


Figure 4 – "Virtual" front panel written with LabVIEW software.

Utilizing LabVIEW software, I was able to construct and program a virtual panel of controls that allows the remote monitoring and control of the system. On this remote panel, I programmed a virtual pressure gauge for each of the pressure sensors, which converts the voltage (0 – 10 VDC) sent from the pressure sensor into psi, and a toggle switch for each of the Humphrey solenoid valves, which will send a signal to the valve to open or close. I programmed three different types of virtual LEDS on to the remote pane. The two square LEDs at the top center of the panel indicates which mode of operation the system is in (Local or Computer), while the top row of five round LEDs, acts just like the group of five LEDs located on the front panel, indicates whether its respective valve is closed or not, by being green when closed and red when open. The bottom row of four LEDs is used to indicate when the pressure in that respective bottle is below 100 psi; the LED will turn red when the pressure is below 100 psi.

Along with the visual components of my programming, I also created an automation program that is turned on and off using the Program Start/Stop button located at the top left, which automatically changes the helium gas bottles whenever one reaches a pressure below 100 psi. The program, when activated, works by checking the pressure in each of the bottles in a repeating, ascending sequence, and sensing whether the bottle has a pressure above 100 psi, by using the second row of round LEDs as determinants. If the pressure in a bottle is found to be less than 100 psi, the program will then open the valve for the next bottle in the sequence. In the case for the fourth bottle, when it falls below 100 psi, it will open the first bottle in the sequence, creating a loop. In order for the program to work, prior to starting the program, it is necessary that at least one of the valves is open. While the program is active, the toggles on the remote panel are disabled, and the valves cannot be opened or closed using them; to use the toggles to open or close the valves, you must first turn the program off. In order to ensure a constant, continued flow of helium gas, the program is constructed so that is does not close any valves when being turned off or on; but it will open valves, when turned on, if the preceding bottle is empty or below 100 psi.



Automation Program Flow Chart

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