Glove Box Instrumentation Specifications

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This document will act as a list of the technical specifications and other useful information for the insertion system instrumentation.

Since the glove box, cross, rod seal, etc., require a steady supply of Low Argon & Krypton Nitrogen (LAKN), there are many valves, flow meters, pressure gauges, and other feedback instrumentation to facilitate the requirements of the insertion system. A schematic of the gas flow system is show in Figure 1. A photograph of the nearly completed gas box is shown in Figure 2.

1 Solenoid Valves

In total, there are 8 solenoid valves used in the system (V1-V8). The valves are manufactured by Asco Inc, and operate on 24 VDC; all valves have PTFE seals and discs with a 316 SS body, and are rated as water-proof and explosion-proof. Valves V1-V7 are Asco part number 8262G220T, and V8 is 8210G87V.

2 Needle Valves

Five needle valves exist on the system, labeled as NV1-NV5; they are used for controlling the flow rates through various locations (rod seal, Oxygen monitor, etc.). They are all identical, Swagelok part number SS-3NBS4, $\frac{1}{4}$" tube fitting, stainless steel, severe service needle valves. It is foreseen to introduce a metering valve on the line feeding the glovebox to prevent a large flow of gas when first pressurizing the glove box.

3 Pressure Transducers

Pressure measurement is accomplished with 6 pressure transducers labeled as G1-G6. These transducers are Wika model E-10. All of the transducers are explosion proof, made from stainless steel, and feature a 1-5 VDC linear output signal as opposed to the 4-20 mA signal normally found on transducers, they operate on 24 VDC. Since the various areas of the glovebox will experience different pressure ranges and require differing sensitivities, the gauges are not all identical in their full scale ranges. All gauges used have an accuracy of about 0.25% of their full scale range.

- G1 – Range: 0-100 psi. Since G1 monitors the input pressure from the LAKN supply, it necessitates a much higher range than the rest of the gauges and also will never experience vacuum.
- G2,G3,G5,G6 – Range: -30 inHg to +30 psi. Gauges G5 and G6 will experience vacuum as well as positive pressure, and it was decided to make G2 and G3 composite ranges as well for interchangeability purposes. Currently, G3 is a Bourdon tube gauge, but a transducer has been ordered and will be installed by April 2007.
- G4 – Range: 0-5 psi. During operations the glovebox is maintained at a pressure of approximately 2 mbar over atmosphere, thus we required a gauge that had sufficient sensitivity to accurately measure the pressure inside of the glovebox. The glovebox will never experience vacuum under normal conditions, so, there was no need for a composite gauge, and this small range affords the accuracy that we need.

4 Flow meters

In order to gain feedback about the eficacy of our purging operations, it is imperative to know the flow rate through various components. Specifically, we require a minimum flow rate through the glove box in order to remove any Rn emanated from the components. The rod seal is also continuosly purged to remove any Oxygen that may be trapped in the joints between rods, and also to remove any Radon emanated by the O-rings in the sliding seal. In order to facilitate these measurements, five flow meters were purchased from Sierra Instruments, they are all part number 824S-2-OV1-PV2-V1. The specifications are as follows:

- 24 VDC input, 0-5 VDC linear output
- Range: 0-4 SLPM
- Input pressure: Four flow meters at 6 psi input, one at 75 psi input (FM1, due to high pressure at output stage of P1)
- Seals: Vition, Body Material: 316 SS
- $\frac{1}{4}$" Swagelok fittings

5 Oxygen Monitor

For safety reasons, as well as some concerns over Oxygen contamination of the scintillator, a feedback device was required to measure the amount of Oxygen in the glove box. The Oxygen monitor is installed on the exhaust line of the glove box; since it requires a higher pressure than the 2 mbar present in the glovebox, a vacuum pump (Section 6) is used to pull the exhaust gas from the glovebox and pass it through the Oxygen monitor (there is a needle valve used to partially bypass the Oxygen monitor). The device chosen was an Advanced Micro Instruments Model 65, its specifications are as follows:

- Sensor made from Zirconium Oxide, a non-depleting method which does not require replacement of the sensor over time
- Range: 0-25% Oxygen
- Input: 7-28 VDC (we use 24VDC), Output: 0-2.5 VDC linear
- $\frac{1}{4}$" Swagelok fittings

6 Vacuum Pumps

As mentioned in Section 5, a vacuum pump is used to provide the necessary inlet pressure for the Oxygen monitor; additionally, we require the ability to evacuate the cross in order to remove all remnants of Oxygen from its volume. Since we do not require a very low vacuum or very high pumping speeds, it was decided to use two small diaphragm pumps for the job. The pumps themselves are identical; they are manufactured by Air Dimensions Inc., and are part number B162-FP-HHO. The specifications are as follows:

- All wetted parts are made of 316 Stainless Steel with Teflon diaphragms
- Power Requirements: 12 VDC, 2A
- Size: 8.4 in x 2.4 in x 4.2 in

The pumps are of the dual head variety and they are connected in series for both pumps. Connecting them in parallel would allow for a faster pump out of the cross, but it would not reach a low enough vacuum.

7 Strain Gauge

The procedure for the operation of the system calls for a method to weigh each rod before and after it enters the inner vessel, comparison of the two weights affords the ability to find any rods that might be leaking. Thus, we have installed a load cell underneath the rod storage assembly; each rod is simply placed into this location and the weight recorded. The load cell of choice was in Omega's LC601 series of beam load cells and has a capacity of 5 lbs. The specifications are:

- All stainless steel construction

- Excitation voltage: 12 VDC
- Output: $2\frac{mV}{V}$, thus for a 12 V excitation, the output range is 0 - 24mV.
- Overload protection stops in all four directions

8 Liquid Monitor

In the spirit of redundancy, we have employed a backup method for determining if the pressure inside of the cross has become insufficient to keep the PC level inside of the IV fill tube. In the event that G5 **and** G6 fail to observe the pressure change, there is a ternary mechanism for doing so: if the pressure drops low enough, PC will begin to rise into the cross as the header tank begins to drain. In order to detect this event, a float switch has been custom fabricated at Virginia Tech to perform this task. The device is simply a donut shaped float with an internal magnet, this float surrounds a $\frac{1}{4}$" tube which contains a reed switch. When the float rises, it trips the reed switch and causes an alarm.

It was also decided to incorporate a "sweeper arm" onto the bottom of the liquid monitor. If visual inspection of the interior of the cross (via the quartz viewports) is not permitted, we still want a method to ensure that there is nothing in the path of the gate valve to prevent it from closing. With this sweeper arm, one can simply twist the liquid monitor assembly from side to side to verify that the gate valve is unobstructed.

9 Check Valves

Four check valves are employed in the insertion system for to protect against over, and in one case under, pressurization. Two of the check valves (CV1 and CV4) were available commercially and the other two were custom built at Virginia Tech(CV2 and CV3). CV1 and CV4 were purchased from Generant Corporation, they are all Stainless Steel with Viton seals, and have nominal crack pressures of 0.21 bar. CV1 is part number CV-375-S-V-3 ($\frac{3}{8}$" pipe fitting) and CV4 is part number CV-500-S-V-3 ($\frac{1}{2}$" pipe fitting).

CV2 and CV3 are essentially identical, except that CV2 is an over-pressure relief with the glovebox at its inlet and the vent at its exhaust, whereas CV3 is an under-pressure relief with CR4 at its inlet and the glovebox at its exhaust. They both have delrin bodies, with Delrin spheres and Viton O-rings as the seals. They are designed to have a crack pressure of approximately 3 mbar.

10 Regulators

Three regulators are used throughout the system to provide control over the pressure applied to various components. All three regulators are nearly identical, the only difference being that R2 has a lower inlet pressure and smaller control range. The regulators are from the Swagelok KLF series of high sensitivity diaphragm sensing pressure regulators. The specifications are:

- All 316 SS body
- Two port configuration ($\frac{1}{4}$" FNPT)
- Teflon seats
- $C_v = 0.20$
- Captured vent
- Alloy X-750 diaphragm

The differing specifications for the regulators are given below:

- R1 sets the supply pressure for the entire gas flow system, with its inlet connected to the LAKN supply. R3 sets the pressure inside of the cross, thus it will require a higher control range than R2 would, it was decided to make it identical to R1 for interchangeability purposes. The maximum inlet pressure for R1 and R3 is 248 bar, and the outlet control range is 0 to 0.68 bar. The part number for both R1 and R3 is KLF1CRA415E60000.
- Since R2 sets the pressure inside of the glovebox it required a much finer control range than the other two, so, it has a maximum inlet pressure of 1.0 bar, and a control range of 0 - 0.13 bar. The part number for R2 is KLF1BCA415E60000.

11 Tether Meter

In order to position the radioactive source off axis, there exists a hinged rod which can be bent up to 90° by pulling on a $\frac{1}{4}$"Teflon "tether" tube. A subroutine in the insertion system control software allows the user to input the desired location of the source and will return the number of rods before, and after the hinge rod and how much of the tether to pull back up into the glove box in order to bend it to the required angle. In order to measure the amount of the tether tube that has been inserted into the detector, as well as withdrawn in order to rotate the hinge, we required a device that could facilitate this task.

Since the stringent cleanliness and safety requirements imposed by the Borexino experiment made commercially available instruments unfit for the task, a custom device was designed, tested, and built at Virginia Tech (see Figure 3). The tether meter consists of a set of follower wheels (one of them knurled) through which the tether tube passes; movement of the tether causes two wheels to rotate, one of them connected to a rotary encoder. The rotary encoder used is a Grayhill 62A11-01-050S 32 position rotary encoder. A small circuit resides in the electronics box to facilitate decoding of the signals and interconnection to the data acquisition system. The decoder chip used is the Agilent HCTL-2022 quadrature decoder IC, driven by a Fox Electronics 10 MHz TTL clock.

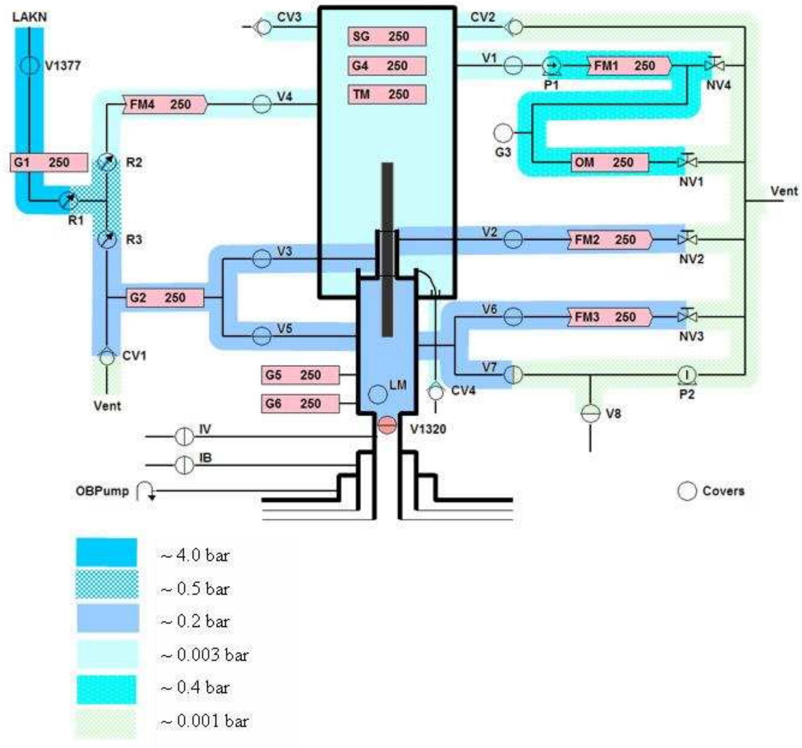

Figure 1: Schematic of the gas flow and instrumentation for the insertion system

Figure 2: The "gas box" that houses almost all of the gas glow instrumentation

Figure 3: Tether meter housing installed below the tether storage drum. The device can be unmounted from this location and placed directly on the tube seal for an exact measurement of the legnth of the tether below the tube seal