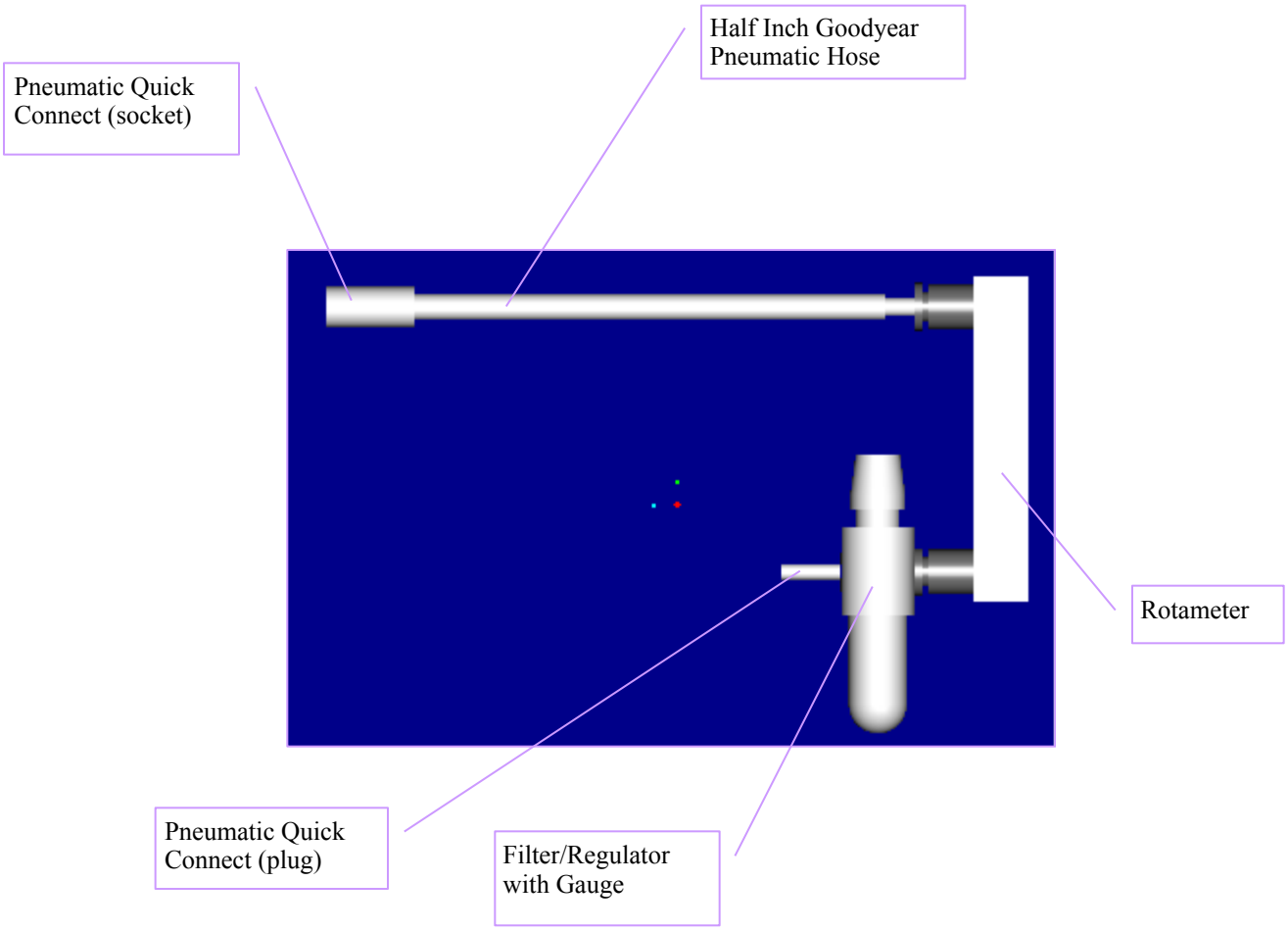
Procedure for Measuring the Airflow of the VCD-Seq. 8.

This procedure documents the method and apparatus for measuring the average air consumption and the peak air flow for the VCD-Seq. 8.

Apparatus:

A Dwyer Rotameter (S/N 00006405) was used to measure the flow. As shown below, the flow meter had a number of pneumatic components on it to allow for connecting to the machine and regulating the pressure. The particular filter/regulator used is a Wilkerson CB6-03-000B J95 with a 0-160 psi gauge marked "Not for Verification."



Brief Theory:

The equation for volumetric flow when using a Rotameter is:

Eq. (1)
$$Q = C_R(A_T - A_F)\left[\frac{2gV_F}{\rho A_F}(\rho_F - \rho)\right]^{1/2}$$

Where: C_R = Rotameter coefficient (typically between .6 and .8)

A_T = Cross-sectional area of the tube (at the float position)

A_F = Effective float area

V_F = Float volume

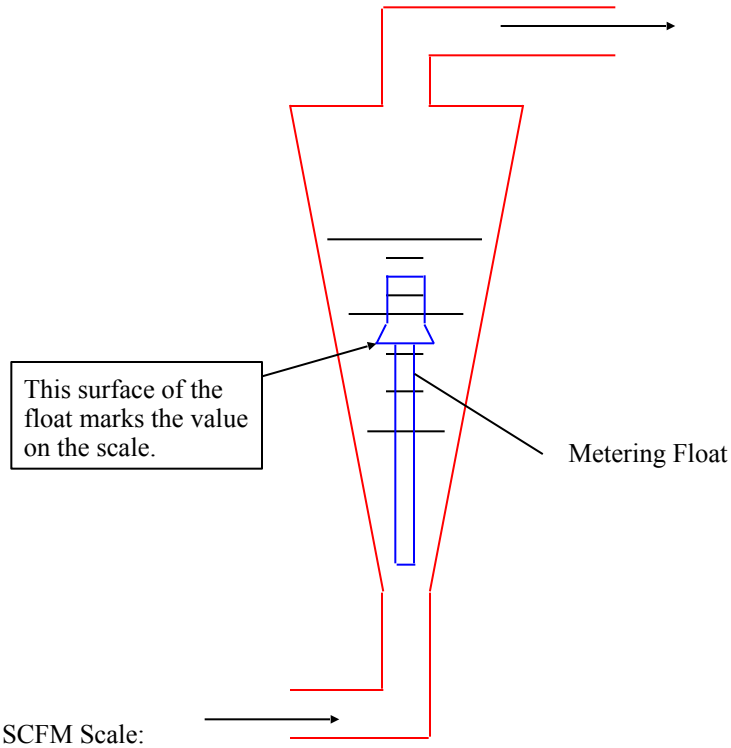
ρ_F =Float density

ρ = Fluid density

Q = Volumetric flow

This equation is not required when using the rotameter, but it is a useful reference. It is important to note that the value C_R is affected by changes in the fluid viscosity and density.

Rotameter Diagram:



SCFM Scale:

The scale of the Rotameter is valid at atmospheric conditions only. For our purposes we will neglect any variations in the temperature or the specific gravity of the actual air that we use. We will only concern ourselves with the pressure variations.

Pressure Correction:

$$Q_2 = Q_1\left(\frac{P_1}{P_2}\right)^{1/2}$$

Eq. (2)

Where Q_1 = Observed flow meter reading

Q_2 = Actual flow corrected for pressure (SCFM)

P_1 = Actual absolute pressure (14.7 + regulator pressure on apparatus)

P_2 = Standard atmospheric pressure, 14.7 psi

Measurement Procedure:

The flow meter is to be connected to the machine in an inline fashion at the air input quick connect. The air drop is connected to the flow meter and the flow meter is then connected to the machine (actual order does not matter). For the readings to be accurate the flow meter must be held vertical and the pressure must be set as precisely as possible. The pressure should be set at 90 psi, unless the input pressure can not support this. In this case use a pressure above 80 psi with a corresponding gauge marking for accuracy. This pressure should be noted when recording measurements.

The machine should be loaded with a typical quality pattern and zeroed. While one person holds and watches the flow meter, the other person starts the machine. Peak flow is the maximum reading the flow meter obtains while the measurements are being taken. The peak flow can occur at the start of the machine or board, or in the middle of a run. So it is important to watch the meter at all times. The dynamics of the meter are not taken into account for these readings. So the actual peak flow may be slightly lower than the value on the meter. As the machine runs, the flow constantly fluctuates. Besides occasional spikes, the readings will typically fall between two measured values. These values give us the “Typical High” and “Typical Low” readings. The machine should run at least one board or window when performing the measurements. Also as many machines as possible should be measured.

Once the data is taken, these flow values read off the meter need to be converted to the actual flow in SCFM using the pressure correction factor shown above. Once all of the data is converted into SCFM the peak flow values need to be converted into CFM @ 90 psi. We can accomplish this conversion through the following:

$$P_3V_3 = P_2V_2$$

Substituting volumetric flow (Q) for the volume (V) and rearranging, we get:

$$Q_3 = \frac{P_2Q_2}{P_3}$$

where:

Q_2 = Corrected flow in SCFM

Q_3 = Compressed flow at supply pressure (CFM)

P_2 = Standard atmospheric pressure, 14.7 psi

P_3 = Absolute supply pressure (14.7 + 90)

When multiple machines are measured, the peak flow is the highest value of all of the machines. The average consumption is found by averaging all of the typical high's and low's.

For the VCD/Seq. 8 machine, the inserter and the sequencer were measured together initially. Then the inserter was measured in dry cycle with the sequencer portion of the machine off. The two sets of values were subtracted to determine the consumption and flow of the sequencer alone. It is important to note that adding the second sequencer drop to the machine does not change the machine consumption rate.