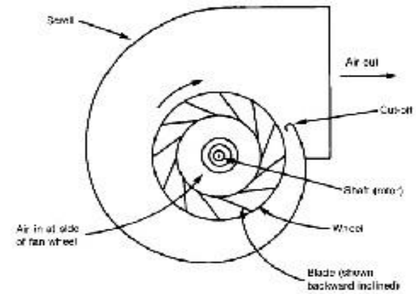
Blower Background



All commercial PAPR systems utilize a blower as part of the design. Blowers are capable of high flow and deliver a higher-pressure differential than a conventional fan. Our goal is to deliver between 3 and 10 CFM with good output pressure. On the drawing on the right you can see that this type of blower pulls from the inlet and discharge is a 90degree discharge using a centrifugal impeller

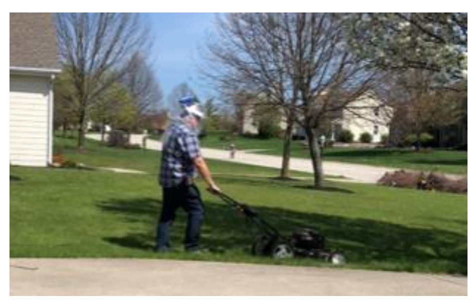
Blower Selection

Our final selection is shown here with an attached diffuser/deflector. It is a Foxconn 90mm Blower designed for small form factor Dell computers. It has the right CFM and adequate pressure output and is lightweight. It is a PVB120G12H-P01 J50GH-A00 J50GH 0J50GH 12V 0.75 4Wire Compatible for DELL OptiPlex 790 390 990 SFF CPU Fan Cooling Fan. It is 146grams.

Initially we evaluated a 70mm blower but it did not provide the needed flow with our selected filter. The CFM for blowers are rated with no filter and it drops significantly when the filter is added to the inlet. For example: the GDStime blower is rated at 38CFM but we only saw 11 CFM at 12 volts with the Miller filter. We jumped to a GDSTIME 120mm blower to guarantee enough output. At the time we were using a Miller meter, that drastically underestimated the flow, to determine flow rate. Once we built a full prototype and experienced the impact of weight, we re-evaluated the priority on weight and moved to the smaller and lighter Foxconn 90mm blower. With a calibrated flow measurement, we were able to determine that perhaps a smaller fan could be used. The GDStime blower is 232grams.

Initial testing

Once a prototype was assembled using the 90mm Foxconn blower and Miller filter we conducted some stress tests wearing the mask. These tests were intended to see how the CO2 levels were maintained when doing a strenuous activity. These are not substitutes for a more clinical environment test but were intended to give an early indication of any issues. The CO2 levels in the front of the mask were periodically monitored using a Using a CO2 ppm meter periodically during the activity. it was determined that the airflow needed to be focused toward the front of the mask to reduce the CO2 levels during exertion. A small Diffuser/Defector attached to the output of the blower improved airflow to the front of the mask and reduced the CO2 levels.



https://www.ebay.com/itm/Carbon-Dioxide-Meter-CO2-Detector-Indoor-Air-Quality-RH-Meter-0-2000ppm-rateRange/193507135104?hash=item2d0dec8e80:g:GcgAAOSw8L9e30wF

A finger pulse/O2 meter was not used because prior test showed a long lag and not much sensitivity to the CO2 environment.

Establishing accurate flow

Determining the actual CFM of a given blower was a challenge initially we used a meter form the Miller welding PAPR. There are available for about $10 and initially we though that it would be a good indicator of achieving the required 6CFM flow since that is how it is used. It was eventually determined that the flow was being underestimated by that meter. This was determined using a stop watch and measuring the time it took to fill a standard 30 gallon garbage bag. It was determined that the Miller meter was not responsive enough to measure the desired flow range 3-10 CFM. Using the stop watch and bag method the flow rate was accurately determined. The volume of the bag was determined by this estimation method and using the height and width of the uninflated bag.

$$V = w^3 \left(h/(\pi w) - 0.142 \left(1 - 10^{(-h/w)} \right) \right)$$

https://en.wikipedia.org/wiki/Paper_bag_problem.

Meter refinement

Obviously, It is not convenient to use a bag for all tests. This Sensirion SFM3000 Flow meter was utilized. It was calibrated against the bag flow estimation and the Miller meter. With these measurements it is possible for a given blower and filter combination to predict airflow by input voltage and to convert the measurement of the Sensirion flow meter to CFM. This proved very helpful to understand the true airflow rates.

PAPR regulations require some type of flow QC check to understand the state of the blower and filter. This is the purpose of the Miller meter (left). As stated, we found that the meter was not calibrated for our device and we needed to adjust its sensitivity. The diameter of the ball was measured and the ball 3D printed in a series of different fill factors to find the right weight. The cap of this style meter is easy to remove and reapply so we used this to develop our version of the QC check. A 0.25gram 12.5mm ball was what was needed to measure the 6CFM from our system.

<u>Blower performance</u>

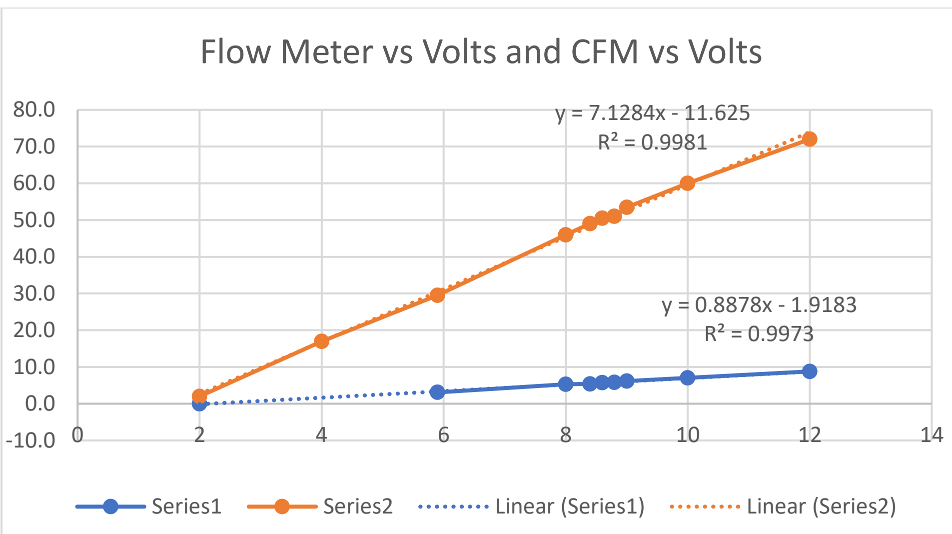
Figure 1:

time to fill (sec)	CFM*	LPM*	SFM3000	Volts	
21.35	8.78575	248.7847	72	12	8.8
26.57	7.059682	199.9079	60	10	7.1
30.58	6.133936	173.6937	53.5	9	6.1
32.17	5.830766	165.1089	51	8.8	5.8
32.96	5.691012	161.1515	50.5	8.6	5.7
34.7	5.405641	153.0707	49	8.4	5.4
35.4	5.29875	150.0439	46	8	5.3
61	3.075012	87.07465	29.5	5.9	3.1

- From bag testing

CFM estimate from equation and Sensirion measurement

Figure 2:



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With these two charts one can use volts to estimate the CFM on a system with a fresh filter or use these two equations to solve for the CFM as a function of SFM300 meter reading on any condition system.

First equation from curve fit says:

SFM3000=7.1284*Volts – 11.625 So:

Volts=(SFM3000+11.625)/7.1284

Second equation from curve fit is:

CFM=(0.8878*Volts-1.9183) – [Convert Volts to CFM for a clean filter]

Substituting. you get….

CFM=(0.8878*((SFM300+11.625)/7.1284))-1.9183 – [Convert SFM300 measurement to CFM for any condition filter and Foxconn blower]

Other considerations:

The PVP-D(Backpack) concept has to use a hose to connect to the Face Shield/Hood. There is considerable loss in the hose. While se intend to mitigate that by using a larger diameter hose it seems that the pressure drop will make the Foxconn less desirable in this configuration.

Conclusion:

The Foxconn blower can deliver up to 8.8CFM with a clean filter and is adequate for the job. The GDStime blower may be a better design choice when weight is not as critical and a higher output is needed. The GDStime blower can deliver up to 10.9 CFM at 12.3 volts.

For the PVP-P (top of head) and PVP-B (Back of head) based design where the weight must be carried on the head, it is recommended to use the Foxconn blower. For the PVP-D (backpack) design the GDStime may be a better choice.

Revision History			
Revision	Date	Who	Description
0	9/22/2020	Bob Senzig	Creation