Tech Corner

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What Is Backpressure?

When a pump is working to move air, it must overcome the forces that resist air movement. These forces include things like gravity and air density, internal pump/motor friction, resistance caused by the length and diameter of the tubing used and the resistance caused by any medium that the air is drawn through, such as filters or chemical sorbents. The sum total of all these forces is called backpressure, and it is a measure of how hard the pump has to work. Any time a pump is working, it is always working against some level of backpressure.

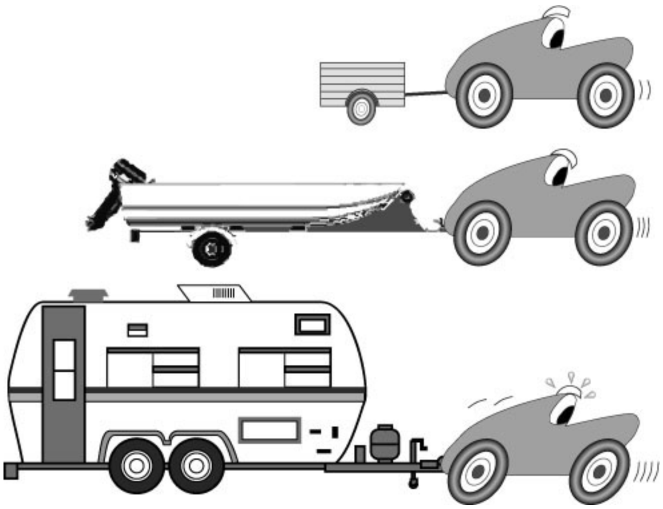
In the case of personal monitoring pumps, some of these resistances are constant from sample to sample, such as the tubing size and the internal friction. But the component that can change significantly from one sample to another is the sample media, the resistance of which can be quite different from one media type to another type to another.

How does backpressure affect a personal monitoring pump?

A personal monitoring pump has to work against varying amounts of backpressure, and in some cases it has to work harder than others do. Consider the following examples.

1. A small car is pulling a small utility trailer carrying four bags of fertilizer. The trailer and its contents weigh 500 lbs.
2. The same small car is pulling a trailer holding a medium sized pleasure boat. The trailer and boat together weigh 2500 lbs.
3. The same small car is pulling a large travel trailer. The trailer weight is 5000 lbs.

In the three examples above, the small car is tasked with pulling trailers of three different sizes. The car has to work harder to pull the boat than it does to pull the small utility trailer, and even harder to pull the travel trailer. We know the relative difficulties, because we know the weights of the trailers.



A personal monitoring pump is working to move air against backpressure caused by the resistance of the sample media. The pump is like the car in the above examples. The different types of sampling media with varying resistance to flow are like the trailers. The heavier the trailer, the harder the car has to work. The higher the backpressure, the harder the pump has to work.

What causes the sample media types to have different backpressures?

The level of backpressure of a sample media type is directly correlated to its resistance to airflow. Consider our three most popular filter cassettes listed below.

1. Dust filters of 5 micron PVC, 37 mm in diameter.
2. Metals (e.g., lead) filters of 0.8 micron MCEF, 37 mm in diameter.
3. Asbestos filters of 0.8 micron MCEF, 25 mm in diameter.

The filter descriptions usually provide three pieces of information. These are the membrane material, the pore size in microns (i.e., micrometers, abbreviated as μ m) and the diameter in millimeters (mm). The pore size represents the typical size of the pores (the holes or passageways) in the material. The PVC membrane with 5-micron pore size has much larger pores than the MCEF material at 0.8 microns. As one would expect, the smaller the pore size the higher the flow resistance and therefore the higher the back pressure. Also, the smaller the diameter, the higher the flow resistance and back pressure. The three filters listed above are listed in the order of increasing backpressure. The dust filter with the large pore size and large diameter produces the lowest backpressure. The metals filter has the same diameter, but its smaller pore size makes it more restrictive and gives it a higher backpressure than the dust filter. The asbestos filter has the same pore size as the metals filter, but its smaller diameter produces a higher backpressure.

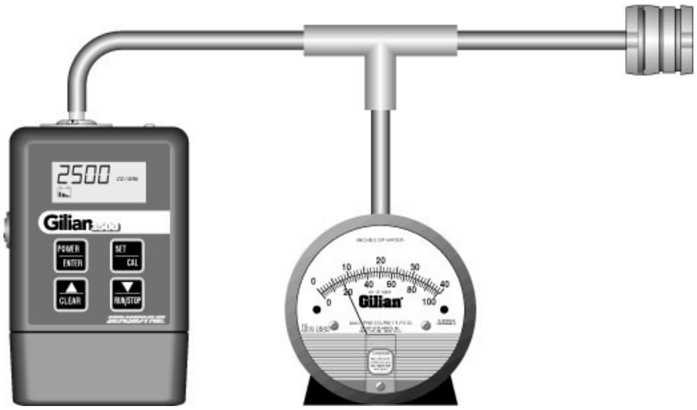
Does the flow rate also affect the level of backpressure?

The faster the airflows, the harder it becomes to overcome the resistance in the sampling media. As the rate of flow is increased the backpressure will also increase. Consider this example. You are walking along Clearwater Beach at the edge of the surf on the hard sand. You break into a jog and begin to run along the water’s edge. At this point life is altogether pretty good. Now let’s add some backpressure. Step into the water up to your waste and walk along parallel to the beach in the waste high water. Its much harder to walk than it was on the hard sand. Now try to break into a jog. You’ll find that running in the waste deep water is virtually impossible. The resistance of the water increased as you tried to increase your speed.

How do we measure backpressure in personal monitoring pump applications?

Science has given us a handy method for measuring backpressure. We make use of a natural property of air (or any gaseous medium). Unlike a solid or liquid, air can be compressed into high-pressure containers like SCBA bottles. It can also be decompressed producing a low-pressure area, and this is the property that allows us to measure the level of backpressure in our sampling system.

To make this measurement we tap into the sample line that connects the sample media to the pump, and we add a device called a manometer (See figure). As the pump pulls air against the resistance of the media, it produces a low-pressure area inside the sample line. The higher the backpressure, the lower the air pressure in the sample line becomes. The manometer can report a backpressure level by measuring the extent of the low-pressure area inside the sample line. The earliest manometers made this measurement by displacing water in a "U" shaped tube, so the manometers we use today report the level of back pressure in inches of water. The higher the number, the higher the backpressure.



What does this backpressure measurement tell us?

The backpressure measurement can tell us if our pump is working properly, or it can tell us if the sampling task is within the pump's ability to operate. All of our Gilian pumps have specifications for flow rates vs. backpressures that tell us the maximum load that the pump will endure for eight hours. A measurement of the back pressure of a specific filter cassette at a specific flow rate along with the pump specifications can give us an idea of how long the pump can run under those conditions. This can be used to determine the proper flow rate ahead of time and prevent a pump from dying prematurely in the field.

For example, suppose we are sampling for asbestos using a GilAir 5 pump. We have been sampling at 2 liters per minute (LPM) with no problems, but we would like to increase the flow rate to get a larger sample volume. Can we sample at 5 LPM? The pump specification table in the Gilian catalog lists a maximum backpressure for the GilAir 5 at 5 LPM to be 8 inches of water for an eight-hour run. A backpressure chart for this type filter appears in the catalog and shows a backpressure of 30 inches of water at 5 LPM. Obviously, the pump cannot operate at that level of backpressure. However, using the two charts, we can see that the pump can handle up to18 inches at 4 LPM and 23 inches at 3 LPM over eight hours and that the filter back pressure drops to 25 inches at 4 LPM and 18 inches at 3 LPM. From this we can conclude that the pump will handle the cassette at 3LPM, but probably not 4 LPM. Remember also that the filter backpressure will increase as the filter collects airborne dust, so the backpressure will increase to some extent during the sample. We conclude that we can sample at 3 LPM, but probably not any higher. We can also see from the catalog charts that the Gilian HFS 513 personal pump will handle higher back pressures and allow a slightly higher flow rate, and we can understand why asbestos clearance sampling at 10 LPM and higher requires the Gilian Aircon stationary type pumps.

When using a filter type that is not covered in the chart, we can determine the backpressure using the Gilian Diagnostics panel, which incorporates a manometer. With the Gilian diagnostics panel we can also test the pump's ability to compensate for changes in back pressure. Gilian pumps utilize a flow control circuit that compensates for increases in back pressure, such as would happen in dust sampling as the filter becomes loaded with dust. By simulating high and low backpressures, the panel can be used to demonstrate that the pump will hold its flow rate within the +/- 5% flow control specification.

Conclusion & Review

Personal monitoring pumps must always work against some level of resistance we know as backpressure. By measuring and understanding backpressure we can quantify the pump's ability to operate. Remember the following points.

1. The higher the backpressure, the harder the pump has to work.
2. High backpressures can shorten the pump's run time by increasing the battery draw.
3. Backpressure can increase during dust sampling as filters become loaded with dust.
4. Backpressure increases as the flow rate increases. A slower flow rate can increase pump run time in high backpressure situations.
5. Backpressure is read with a manometer like the one included in the Gilian diagnostics panel.
6. Excessive backpressure can cause a pump to go into its fault mode and shut off prematurely.

For information on backpressure specifications for individual Gilian pump models see the Gilian Air Sampling Catalog.