AN015: How to Choose a Pump for CO_2 Sampling Applications

ABSTRACT

This application note reviews the important considerations for choosing a pump as part of a gas sampling system. Some Gas Sensing sensors are designed for or can be configured with flow port adaptors, designed for gas to be pumped into the optical measurement chamber, particularly for high speed or rapid response CO_2 applications.

The aim of this application note is to highlight how to specify a pump to sample gas for use with a sealed flow-through sensor. The topics discussed here are common with almost all gas sensors irrespective of sensing technology or manufacturer. Applications are varied and each will have a separate set of issues to address, so this note should only be used as a guide.

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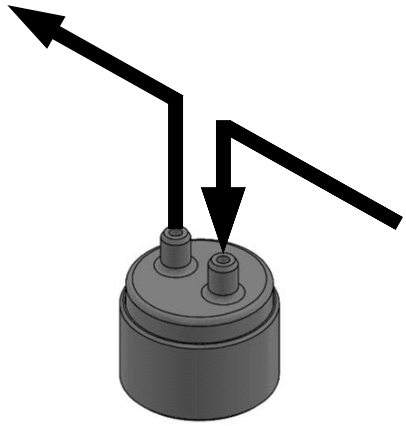
GAS SAMPLING

Some Gas Sensing sensors such as the SpintIR®-R, shown below are designed to sample gas via a flow port adaptor.



The gas flow can be derived from a sample bleed from a high pressure system, or from a pump that is used to induce flow. Ideally, there should be a match between the required gas sampling speed and the gas flow rate.

GAS FLOW RATE

The gas flow rate and sensor sampling speed have a major influence on the fidelity of the gas measurements and the response time of the sensor. As a rule of thumb, 5 x the volume of gas in the system is required to be fully exchanged in order to ensure 'fresh' gas is being sampled by the sensor.

For example, if the gas sample volume is 20ml, you will need to flow 100ml of sample gas into the sensor measurement chamber to flush the chamber with the new gas. In practice the amount of gas needing to be replaced is the volume of the complete sample system, including tubing, filters, pump, and sensor. The response time will be improved by minimising the volume of the complete system.

The simplified calculation for flow rate is as follows.

$$Flow\ Rate\ Required = \frac{System\ volume * 5}{Response\ time\ required}$$

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PUMP SELECTION

There will be many criteria for pump selection including the required flow rate, but also air tightness, size, cost, reliability, noise, weight, power consumption, material composition and lifetime. The priorities will be specific to the application but should start with pump flow rate.

CONTAMINANTS

Gas Sensing sensors, like almost all NDIR sensors, rely on the sample gas being in direct contact with optical surfaces. Whether that surface is a window, lens or reflective, all are susceptible to contamination by dry or wet contents that are contained in the sample gas. In the case of Gas Sensing, the flow path contains a reflective optic and the sample gas supplied to the sensor is required to be clean. If the source gas not already clean, some type of filter and/or water trap will be required.

The two main types of pump used in gas sampling applications are oil-sealed and oil-free pumps.

Pump	Type
Rotary Vane	Oil-Sealed
Rotary Piston	Oil-Sealed
Diaphragm or membrane	Oil-Free
Blowers	Oil-Free
Piston	Oil-Free
Scroll	Oil-Free
Screw	Oil-Free
Hook and Claw	Oil-Free

The most common type of pump used with Gas Sensing gas sensors is the diaphragm pump. Diaphragm pumps are typically gas tight, low noise and don't inject oil contamination into the sample gas.

PUMP POSITION

The position of the pump in the system is important and depends on how the gas is sampled. Ideally, the pressure in the sensor should be at atmospheric ambient levels. Gas measurements are affected if the sample gas is pressurised, although sensor readings can be compensated for barometric pressure differences.

When a fast sensor response is required, the volume between the sample point and sensor should be minimized. Drawing the sample through the sensor instead of pumping the sample gas through the system minimises the volume. Placing the pump placed after the sensor in the direction of flow removes the pump volume from the system volume used to determine the required flow rate.

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However, if filtering or humidity removal is required, this can lead to low pressure in the sensor. In this scenario, the pump position may need to be altered to give better results.

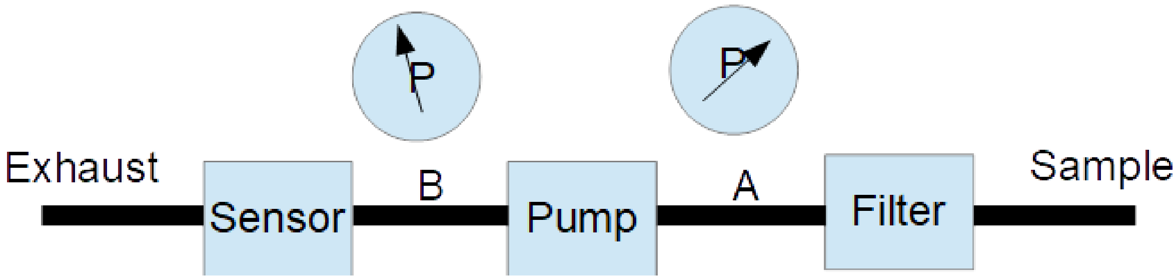

Fig. 1: Simplified sampling example

Figure 1 shows a simplified pump system. The pump is configured to draw a sample through the filter and push it out through the sensor. The filter is likely to be to be a restriction in the flow, with the pressure in the sample line at position **A** below ambient pressure, while the pressure at position **B** will be at ambient or above. As the pump speed increases, the pressure difference from ambient will increase. With this arrangement of components, the sample tube diameter can be minimised to reduce system volume between sample point and sensor, and ideally the exhaust should be of a larger diameter to avoid restricting the exhaust gas and causing an increase in barometric pressure inside the sensor.

PUMP SPEED

Small diaphragm pumps tend to be driven by DC motors, which allows for variable speed. The pump should be run as close to design speed as possible. As the motor speed is reduced the pump efficiency reduces causing the flow to be lower than expected, due to the slower operational speed of the valves. It is important to define the required flow rate early in the pump selection decision to ensure the pump operational speed is optimised.

PRESSURE COMPENSATION

Gas Sensing sensors are calibrated at an ambient barometric pressure of 1013mbar. Measurement accuracy will be compromised if the barometric pressure deviates from the calibration point. The measurement errors can be considerable, especially at high gas concentrations.

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If it is not possible to have the gas at a nominal ambient pressure when the pump is sampling, gas measurements may need to be compensated. Accurate compensation can only be done if the barometric pressure inside the sampling system is known. This may necessitate adding a barometric pressure transducer inside the sampling system and using this information to compensate the sensor readings based on this pressure. For further information on pressure compensation please refer to **AN001 Pressure Compensation of a CO2 Sensor,** on the Gas Sensing website.

OPTIONS TO AVOID PRESSURE COMPENSATION

If pressure compensation is not practical or economical for the application, it is sometimes possible to turn off the pump, and allowing the pressure to return to ambient levels before taking a reading. This is only possible if the application does not require continuous sampling. In many applications, the actual concentration is not critical as it is a change in concentration that is being measured. E.g., when monitoring for a leak, it is the presence of an elevated level that indicates the leak, rather than an actual value.

BACK DIFFUSION

To reduce pressure changes in a pumped system, reducing the gas flow speed by using larger tubing is advisable. In some setups, particularly where the flow rate is low, the gas pressure is low or the sampling tubes entering and exiting the sensor are short and large, the exhaust gas can diffuse back into the sample flow, especially where the exhaust is vented directly to ambient. This can allow ambient air or exhaust gas to dilute the sample within the sensor, compromising measurement accuracy. The simplest way to reduce back diffusion is to increase the length of tubing in the exhaust.

CONCLUSION

Selecting the most appropriate pump to supply gas to the sensor involves some compromises. The key step is to determine the system flow rate required to support the desired measurement speed. Once the pump flow rate has been specified, other criteria will be application specific but particular care should be taken to avoid injecting gas into the sensor at gas pressures that deviate significantly from ambient barometric levels.

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IMPORTANT NOTICE

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