

OVERVIEW

The Herriott cell can be implemented into optical setups in a wide variety of configurations, both from an optical point of view and a vacuum system point of view. Optically, there are two fundamentally different approaches when using the cell for analytical spectroscopic applications. These approaches differ in how the spectrum is resolved in the system. One of these approaches is to couple a tunable narrowband light source (most often a laser) into the cell and then use a photodetector on the other side of the cell for

analysis. By tuning the frequency of the light source over a spectral feature of the target analyte and by knowing the relevant experimental parameters, quantitative spectroscopy can be performed. The other approach incorporates a broadband source and a spectrally resolving device at the output of the cell; for instance, a Fourier-based optical spectrum analyzer, a grating, or a tunable optical filter. It is important in all cases that the system is capable of precisely selecting a target feature at a specific wavelength.

CONSIDERATIONS

A number of parameters must be determined in order to find a system design that meets the requirements imposed by the spectroscopic application:

- ◆ Can the experiment be run by evacuating the cell and subsequently filling it with the analyte under investigation (static pressure experiment) or is there a need of a continuous flow of the analyte through the cell for uninterrupted monitoring of the target feature (flow cell configuration)?
- ◆ What time resolution is needed? For static pressure measurements, this requires an answer to the questions of whether and how fast a background signal must be acquired; for flow cell experiments, one needs to decide what flow rate is required to ensure a gas exchange inside the cell fast enough to reach the time resolution needed for the experiment.
- ◆ What is the optimal pressure for the experiment? Can the cell be used at atmospheric pressure or does the experiment require sub-atmospheric pressures for optimal detection conditions, considering that absorption features are likely to interfere at atmospheric pressure conditions?
- ◆ Does the sample require preparation before being directed into the Herriott cell? This might for instance involve the removal of water, oil, or solid particles (e.g. dust or soot) from the sample to prevent interference with the target feature or contamination of the cell.

EXAMPLE APPLICATIONS

The three sample configurations below include either a pressure gauge, a mass flow controller, or both. Additional valves may be useful for improved control over the pressure or flow rate.

Example 1: Flow Cell Configuration at Atmospheric Pressure

This setup for a typical flow cell configuration at atmospheric pressure is illustrated in Figure 1. One or more samples are connected to a mass flow controller installed in-line between the cell and the sample (a gas cylinder, pipeline, etc.). The mass flow controller allows the mass flow rate through the cell to be set accurately. For less demanding experiments, the mass flow controller can be replaced by needle valves for less robust control of the flow rate.

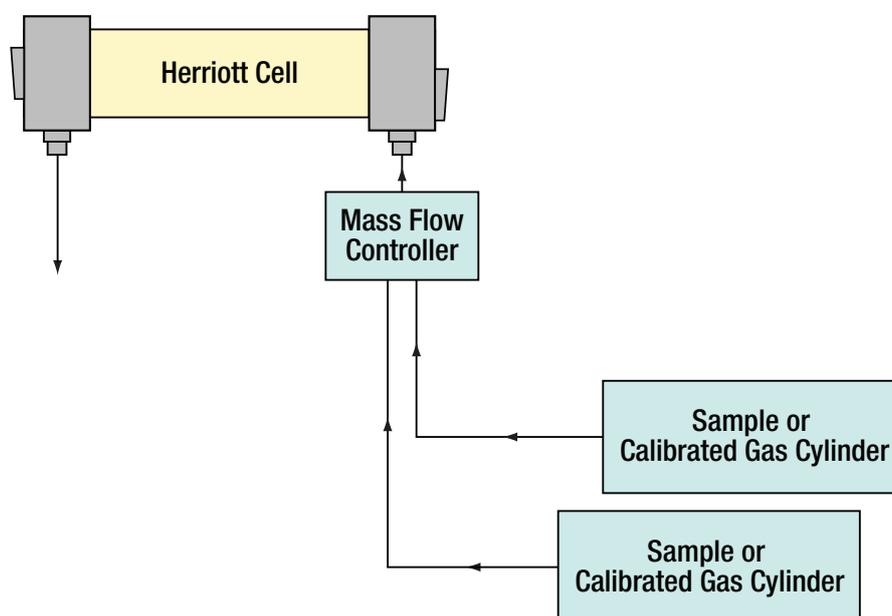


Figure 1: Flow Cell Configuration at Atmospheric Pressure

Example 2: Flow Cell Configuration at Sub-Atmospheric Pressure

In this example, a gas sample passes a needle valve before it enters the cell. The cell output is evacuated by a pump, where the pumping speed can be adjusted with another needle valve between the cell output and the pump. Balancing the two needle valves allows for adjustment of both pressure and mass flow rate through the cell. For a true reading of the pressure inside the cell it is important to install the pressure gauge between the two needle valves. An optional mass flow meter in-line with the gas flow (as illustrated in Figure 2) provides a reading of the mass flow through the cell.

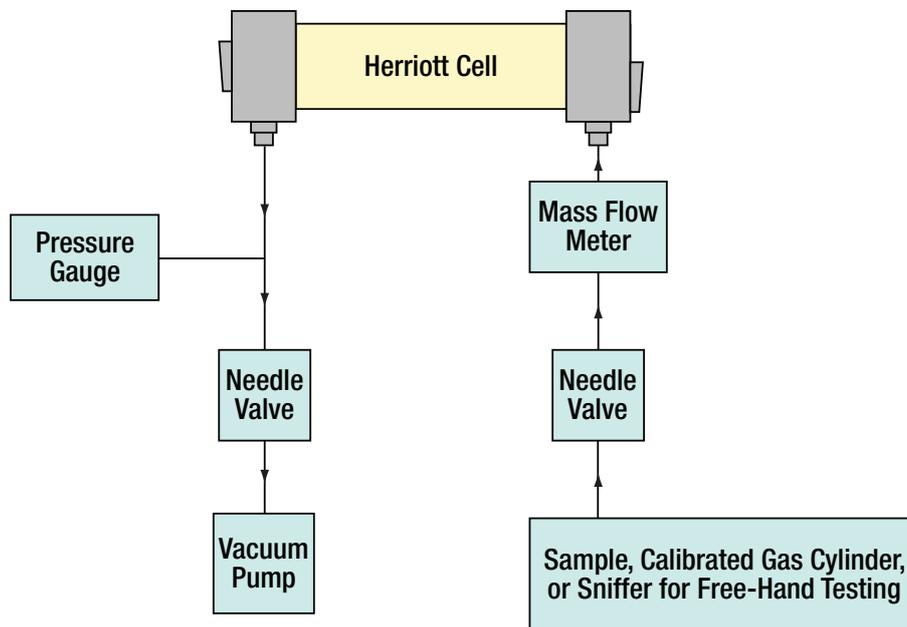


Figure 2: Flow Cell Configuration at Sub-Atmospheric Pressure

Example 3: Steady State Sub-Atmospheric Pressure Experiment

This setup for a typical steady state experiment at sub-atmospheric pressures is illustrated in Figure 3 below. Before a sample is directed into the Herriott cell, the cell is evacuated by a pump system, e.g. by a turbomolecular pump backed by a fore-vacuum (backing) pump. A pressure gauge connected to the cell allows the user to measure the pressure present inside the cell. Once the cell is evacuated, the pump is disconnected by closing the valve next to the pump system. Carefully opening the valve closest to the sample container (e.g. a gas cylinder or Tedlar bags containing either human breath or other gases collected at a remote test site) allows the cell to be filled with the sample; once the desired end pressure is reached, the inlet valve is closed and a measurement can be executed.

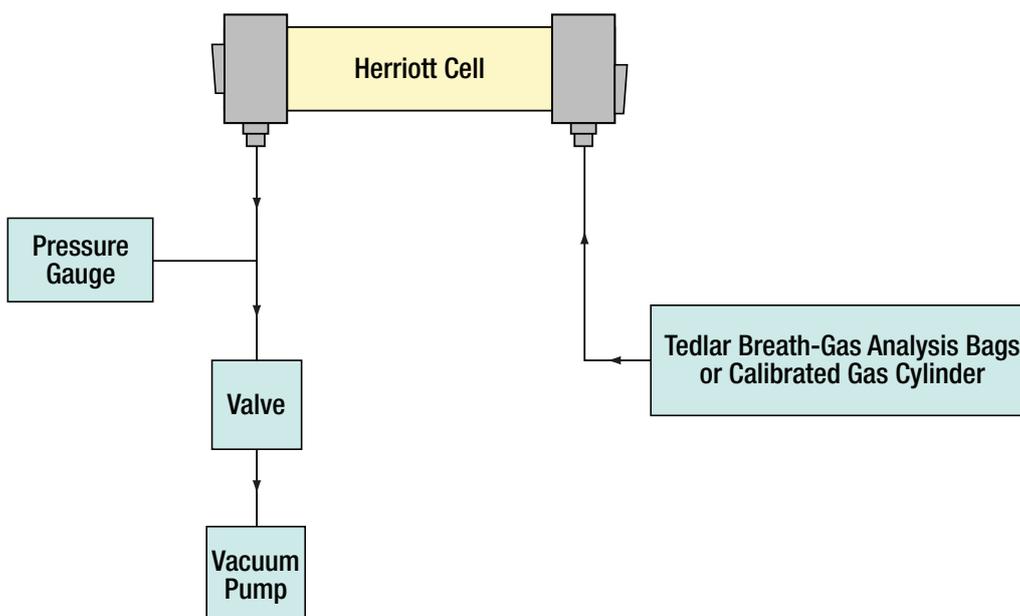


Figure 3: Steady State Sub-Atmospheric Pressure Experiment