

Precision Inlet Systems

Sample introduction is a critical step in developing a successful MS based analytical method. Any error in gas sampling directly affects the quantitative precision and accuracy of the measurement. Therefore, an inlet system must minimize sample discrimination while also meeting other objectives such as analysis speed, and ease of operation. Monitor Instruments provides application specific inlet systems which deliver representative gas samples. These inlets fall into three general categories: batch, flow-by molecular leak, and direct connection. Each can be supplied with heating, pressure measurement, corrosive gas, and connection hardware options.

Batch Inlet

A batch inlet system is used to analyze gases trapped in a fixed volume quickly and accurately. The Monitor Instruments automated high pressure batch inlet, shown schematically in Figure 1, can accurately analyze a gas stream at pressures in excess of 3,000 psig. .

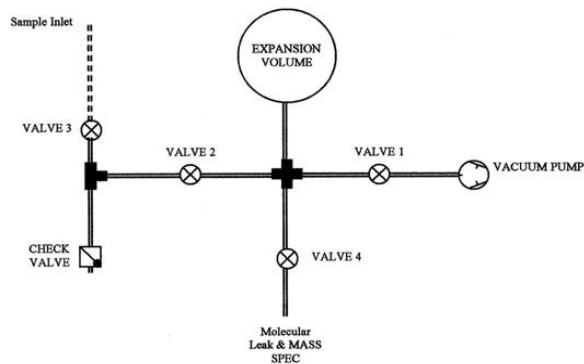


Figure 1: The Dynabarc High Pressure Batch Inlet system features computer controlled valves to assure precise and accurate measurements. The expansion volume (normally 50 to 500 ml), the check valve set point, and the molecular leak are designed to provide fast sample cycles, and enough sample for the longer analysis time needed to measure low level components.

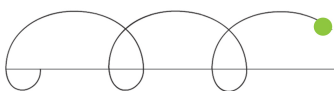
The following sequence is conducted under computer control:

- With the sample line connected to the sample inlet port, valves 1 and 3 are opened while valves 2 and 4 are closed. This is to purges the volume between the sample port and the check valve with the sample gas, while the expansion volume and connection lines are evacuated.
- After a short period of time, valve 3 is closed, and the sample gas pressure drops to that set by the check valve.
- After a short equilibration period (application dependent, but generally seconds), valve 1 is closed and valve 2 opened so the trapped sample can enter the evacuated expansion volume. The expansion volume is sized relative to the sample inlet “T” (between valves 2, 3 and the check valve) to drop the sample pressure to a value appropriate for the molecular leak inlet to the mass spectrometer.
- This cycle is repeated once or twice to purge any previous sample, after which valve 2 is closed and, after a few seconds equilibration time, valve 4 is opened to allow the gas sample to enter the mass spectrometer through a molecular leak.

Flow-by Molecular Leak Inlet

This versatile inlet can be easily configured to work in a broad range of sample gas pressures, typically from 500 to 1500 torr. It uses two flow divided stages with an intermediate pressure flow-by region in order to insure both fast response and compositional accuracy. The diagram shown in Figure 2 will help simplify an explanation of how each stage works.

- The gas sample is drawn from a sample stream “flowing by” a capillary and then into an intermediate chamber by the auxiliary port of the compound turbo pump. This part of the system is carefully



designed to make sure that the sample gas is in laminar or viscous flowⁱ up to the molecular leak, while the sample flow is fast to assure rapid response.

- The sample is admitted to the mass spectrometer via the “molecular leak.” The gas flow at the leak is in the molecular flowⁱⁱ regime. Since the turbomolecular pump removes the sample from the mass spectrometer chamber in molecular flow, the mass spectrometer is presented with an accurate sample of the process stream. Hence, there is no mass discrimination in the inlet and the mass spectrometer measures gas composition accurately.

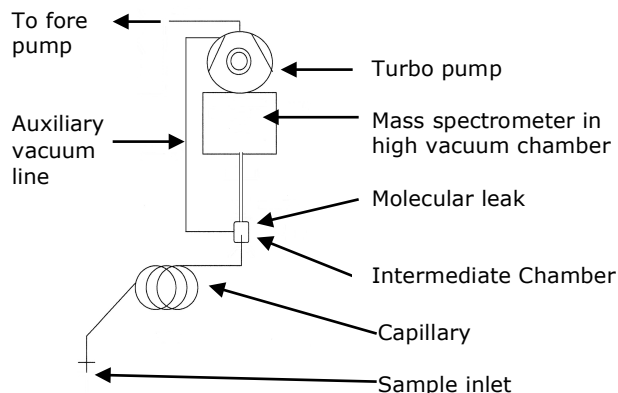


Figure 2: The Monitor flow-by molecular leak inlet. A sample of the gases to be measured is drawn through a capillary tube by the turbomolecular pump auxiliary port (as shown), or by an independent diaphragm pump (optional). The pressure is reduced at the region containing the molecular leak to about 1 mbar. The molecular leak is usually a thin laser drilled aperture. A thin orifice has the advantage of a length approaching zero, so a larger aperture size can be used to avoid problems with clogging. A heating option is available if stream components are condensible.

Direct Connection Inlets

In some applications, particularly those where the gas sample is at a reduced pressure, a direct inlet system may be an appropriate solution. The sample line length, internal diameter and temperature are determined by the gas composition and pressure.

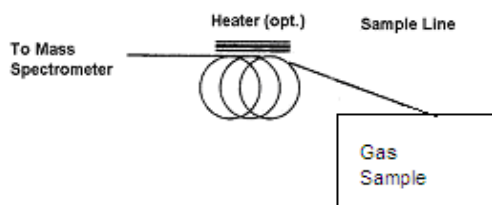


Figure 3. Monitor instruments can design custom direct inlets to deliver small samples to the mass spectrometer

Monitor Instruments’ Series 3000 cycloidal mass spectrometers provide process analysis in a wide variety of industries. Our application specific inlet systems, versatile Gas-Wizard™ software, and stable analyzers assure cost effective, high quality process control information. We invite you to visit our website (www.monitorinstruments.com), to request information via e-mail at info@monitorinstruments.com, or post at 290 East Union Rd., Cheswick, PA 15024, USA, or to contact us by telephone at +1.724.265.1212 or fax at +1.274.265.1199. We will give your application the careful, confidential consideration it deserves.

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ⁱ Viscous flow occurs when the linear dimension of the flow channel (d = diameter of the capillary) is greater than the mean free path of a gas molecule (λ). This ratio, the Knudsen number (Kn) is less than 0.01 in viscous flow. The gas flow is described by the Poiseuille equation: flow rate is a function of the length and diameter of the tube, the pressure drop, and gas viscosity. This creates a radial dependence of flow velocity (slower near the walls, faster in the center) due to frictional forces. Since these frictional forces depend upon gas composition, changes in gas composition will not be quickly or accurately detected by mass spectrometer. Therefore the transition to molecular flow is needed.

ⁱⁱ Molecular flow occurs when Kn is equal to or greater than one. The flow rate depends on upon the length, diameter, and perimeter of the tube, the pressure drop across the tube, and the velocity or mean molecular speed of the gas molecules. Gas viscosity does not enter into this relationship and therefore the gas flow rate is not limited by collisions between molecules as is the case for viscous flow, but rather by collisions of molecules with the walls.

