Every modern gas chromatograph is equipped with a flow control and/or a pressure regulator to assure a constant flow through the column and detector independent of the type of gas, the temperature and the column dimensions.

The flow of the carrier gas is dependent on density and viscosity of the gas and the resistance of the column (Poiseuille' law).

\[ F = \frac{\pi r^4 p_c}{8 \eta L} \]

\( p_{\text{column}} \) = inlet pressure

\( L \) = column length

In order to maintain a constant flow within the GC system, the pressure varies. In a pressure regulated system, the pressure is kept constant and the flow will vary.

Both systems can be used in isothermal analyses. Since temperature does not change, the flow will remain constant.

However, in temperature-programmed analyses a flow-regulated system is preferred, because the decrease in flow at higher temperatures can be dramatic (50% from 50 to 300°C). A 1% change of the gas flow affects the retention time by 1%. Moreover, detectors which are concentration sensitive are strongly affected by flow. Irregular and drifting baselines are the result.

Flow-regulated systems are used with packed columns (gas flows 20 - 120 ml/min).

Pressure-regulated systems are used with capillary columns. The gas flow through capillary columns is so small (0.1 - 10 ml/min) that flow controllers are not necessary. An exception to this is the wide-bore capillary column, which may be compared to a packed column with regard to the gas flow.

\[ F_c = \frac{\pi}{4 j} d_c^2 \frac{L}{t_0} \frac{T_0}{T_c} \] in which \( j = \frac{3}{2} \frac{p_c^2-1}{p_c^3-1} \)

\( d_c \) = column diameter [mm]
\( L \) = column length [m]
\( t_0 \) = dead time [min]
\( p_{\text{column}} \) = inlet pressure
\( p_{\text{ambient}} \) = pressure at end of column (mostly 1 bar)

---

**The Pressure Regulator**

Pressure regulators, which are mounted in most modern GC units, can supply constant gas pressures, independent of the ambient temperature and pre-pressure.

**Pressure Regulator**
Basic operation is as follows: The pressure regulator has an inlet and an outlet chamber that are connected by a flexible needle valve. The pressure to the column is maintained at a constant level by the pressure in the outlet chamber according to the movement of a poppet valve. This valve is connected to a diaphragm or a membrane to which a spring is attached with an adjusting screw. The tension in the spring can be adjusted by means of this screw and consequently the pressure on the diaphragm.

A decrease of pressure in the outlet chamber causes the needle valve to open, as a result of which the pressure increases up to the desired level.

**The Flow Controller**

A flow controller in general contains the same components as the pressure regulator. The only difference is that the tension of the spring is not variable and the amount of flowing from the gas outlet can be controlled.

The flow-adjusting knob in the pressure regulator now functions as a fixed needle valve, which controls the gas outlet orifice.

Some caution is required with needle valves. The needle valve should never be tightened too vigorously as this could damage the fragile needle. The needle valve should never be used as an off valve. Hand-tight will suffice.
Modern GC electronic pneumatic systems deliver carrier and detector gases with unparalleled precision and accuracy compared with more traditional manual pneumatic controls.

Electronic pneumatic systems can be controlled to maintain constant inlet pressure, constant column mass flow, or constant average carrier-gas linear velocity as the oven temperature changes. Keyboard control of split flow and ratio plus detector gas flow rates are standard electronic pneumatic features. Electronic pneumatic systems facilitate new sampling modes, and they compensate for the effects of drifting ambient temperatures and atmospheric and column-outlet pressure changes.

**Features and advantages Electronic Flow Control (EFC):**

- Controls flow and pressure
- Injector and detector compatible
- Valve system compatible
- Compatible electronic control
- Automated method development (split ratio)
- Auto control flow and pressure
- Electronically documented (GLP): method parameters saved with data file
- Accurate column flow calculations (e.g. plot column)

One of electronic pneumatic systems' strengths is their design flexibility.