Technical Note

Using Force Sensors in Applications that Measure Flow

BACKGROUND
Certain applications (i.e., medical applications) require the measurement of fluid flow without having the measurement system in direct contact with the fluid.

One solution to this problem is to use force sensors to measure the pressure in compliant tubing. If the pressure can be measured in two locations with a restriction between them, Bernoulli's equation may be used to measure the fluid flow.

SOLUTION
This approach requires that the density of the fluid and the cross sectional area of the restriction be known. Once known, the flow can be measured in real time (see Figure 1).

Figure 1. Bernoulli's Equation

$$Q = k \times \text{area} \times \sqrt{\frac{2}{\rho}(P_2 - P_1)}$$

Where:

Q = flow
k = orifice coefficient (depends on shape of the flow restriction)[1]
area = cross section of the restriction that the fluid "sees"
ρ = fluid density
$\mathbf{P_2}$ = upstream pressure
$\mathbf{P_1}$ = downstream pressure relative to the restriction

Note: This concept is extensively covered in the book ***Hydraulic Control Systems***, Chapter 3 by Herbert Merritt.

This simple equation is used extensively to measure flow in applications where the pressure drop can be measured (e.g., in automobiles to measure the exhaust gas recirculation flow, in home water meters to measure flow into the home, and in infusion pumps to interface with the fluid tubing).

This equation may be modified in one of two ways when using force sensors.

- The simplest way is to develop the relationship between the pressure in the tubing and the force readings on the outside of the tubing. Because the two pressure readings are subtracted, the two force readings may also be subtracted. This makes the process much simpler, as the offset or null force when installed will vary with each installation. Because the two values are subtracted, this offset, or null force is the same for both sensors and cancels out. All that is left is the difference between the two force sensor readings.
- The accuracy can further be improved if the system flow can be stopped. With no flow in the system, the system may be "zeroed out" or adjusted to recognize whatever output value is "zero flow", enabling the system to be calibrated for zero. Once zero is established, a known flow value may be pushed through the system and calibrated for span.

Figure 2 shows the Honeywell force sensors that may be used in these types of potential applications.

Figure 2. Honeywell Force Sensor Series

1865 Series	FS01/FS03 Series
	
FSG Series	**FSS Series**
	

BENEFITS
Using force sensors to measure flow provides the following benefits:

- Fluid flow measurement.
- Occlusion detection with flow.
- Sensors don't contaminate the system and don't need cleaning after use, helping to reduce customer costs.
- Sensors may be permanently mounted and wired into system, reducing connections and failure modes.

Figure 3 shows the location of the force sensors in a potential infusion pump application.

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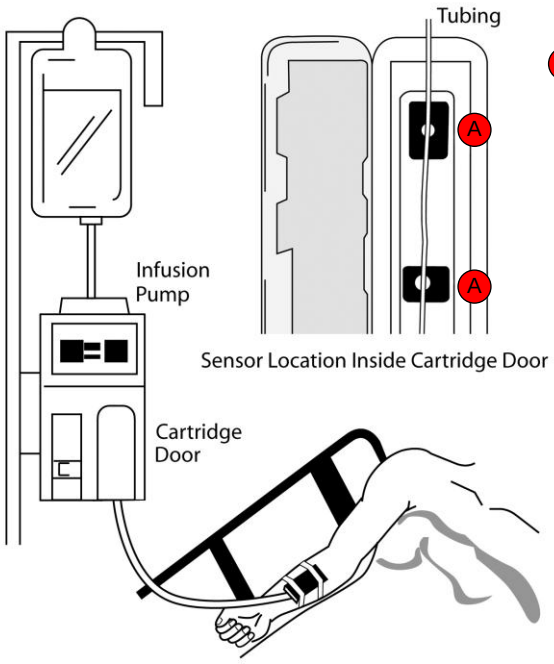
Figure 3. Force Sensors in Infusion Pump Application



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