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IN-LINE VISCOSITY MEASUREMENT SENSOR

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The disclosed invention allows the viscosity and pressure of the fluid passing through a single-patient disposable set (SPDS) to be measured. These measurements provide enough information to allow the system to estimate the fluid pressure at the catheter hub.

SPECIFICATION

Current injector systems control their injection pressures to 300 or 325 psi to prevent over pressurizing the catheter. Most catheters are rated at 300 psi. Because the pressure drop through a SPDS, disposed between the injector and catheter, can vary with flow rate, fluid viscosity, fluid temperature and fluid density, this control scheme tends to limit the pressure at the catheter to a very conservative value. This effectively reduces the achievable flow rate of the system in many situations.

Although a pressure sensor could be placed at the end of the single-patient disposable set (SPDS) to measure the fluid pressure near the catheter, this design option is usually not practical. Including such a pressure sensor at the end of the SPDS would require electrical wires to connect the sensor to the injector system. It would also potentially expose the sensor to the patient's blood and would most likely necessitate a disposable sensor.

A more practical approach would be to measure the fluid pressure in the SPDS (near the injector), then use theoretical considerations to calculate the fluid pressure at the far end of the SPDS (near the catheter).

In order to perform such calculations, the flow rate and viscosity of the fluid must be known. Although the flow rate is known precisely (because it is being delivered by the injector system), the fluid viscosity varies as a function of temperature. If the fluid has been heated to body temperature or has been cooled within the injector system, its viscosity may not be readily determined.

The disclosed invention provides a method to measure the fluid's viscosity as it enters the SPDS near the injector. The invention also allows the fluid pressure to be measured simultaneously. These measurements, along with the flow rate and other known parameters, will allow the pressure drop through the SPDS to be calculated and the pressure at the catheter to be found. This would allow the system to provide closed-loop servo control of the fluid pressure at the catheter, thereby maximizing performance.

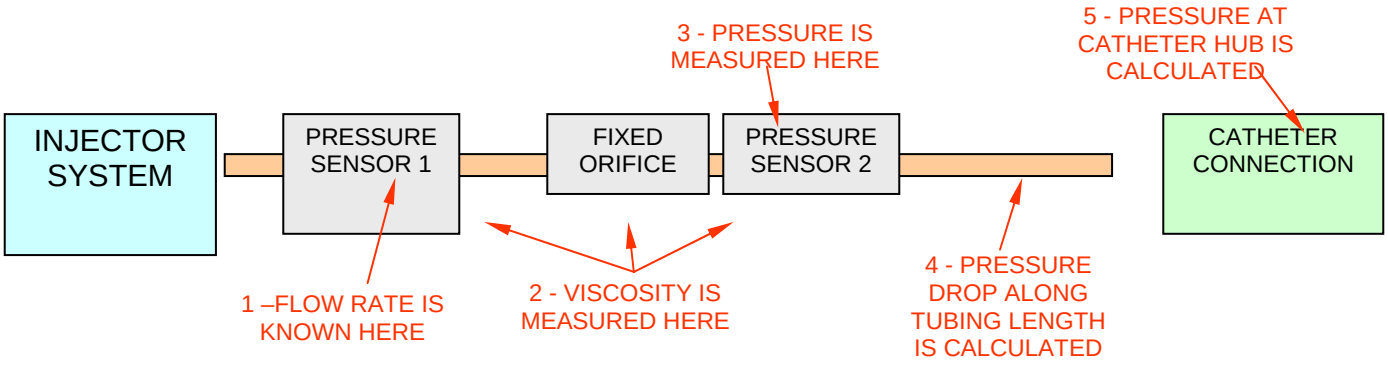
The disclosed invention allows the viscosity and pressure of the fluid passing through the single-patient disposable set (SPDS) to be measured. These measurements provide enough information to allow the system to estimate the fluid pressure at the catheter hub.

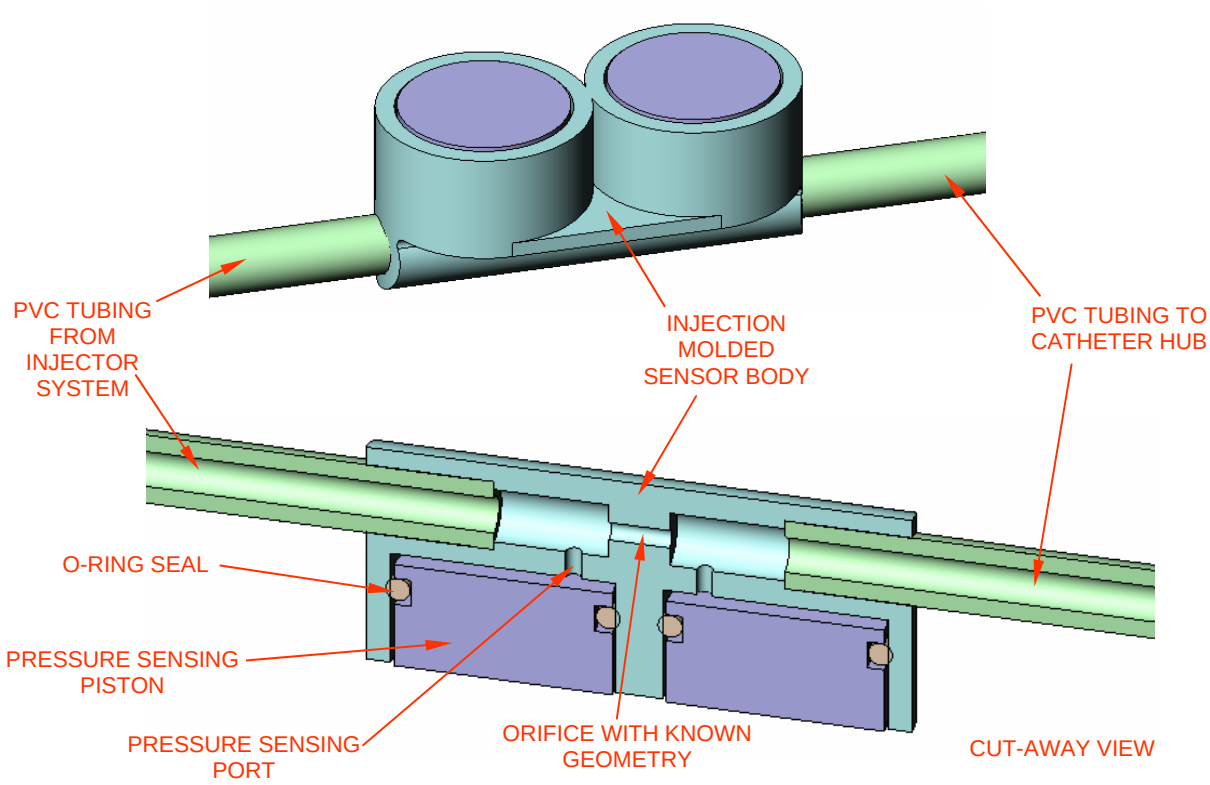
The in-line measurement device includes two adjacent pressure sensors separated by a small orifice. By measuring the pressure drop across the orifice, the viscosity of the fluid may be calculated if the orifice geometry and flow rate are known. The invention requires at least the following:

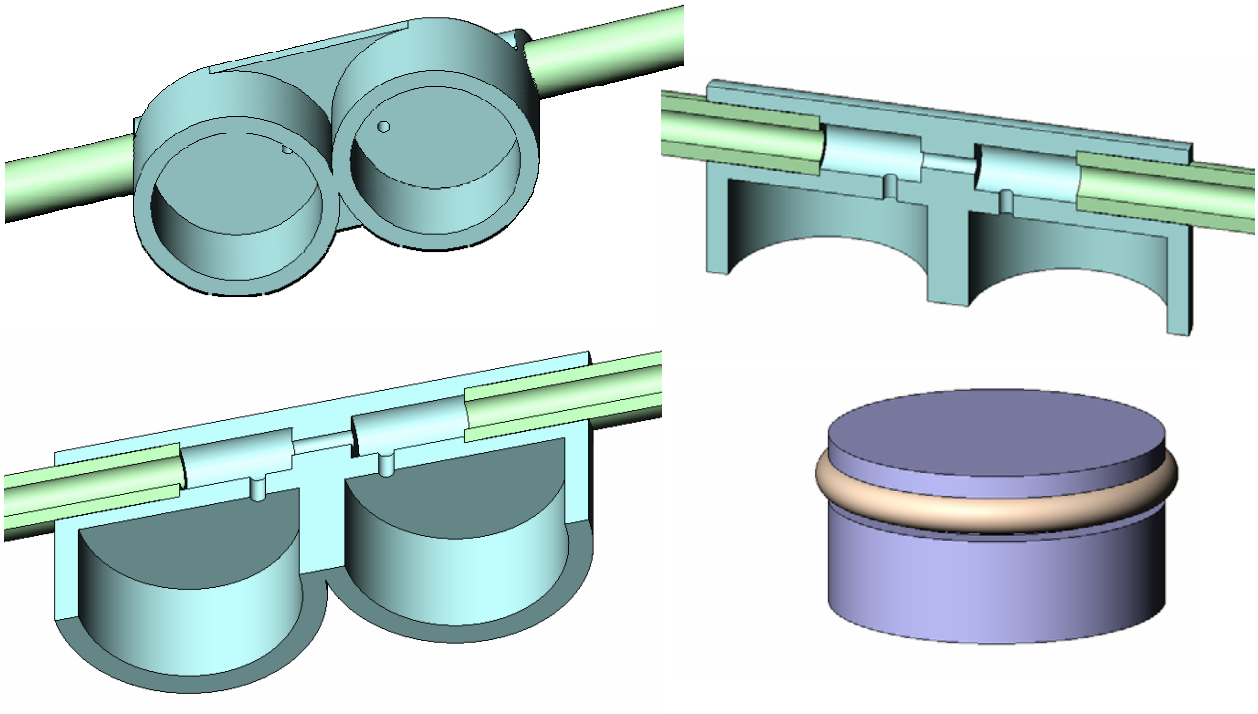
- An in-line sensor with a known fluid flow rate passing
- A fixed orifice or other fluid restriction with known geometry
- A means of measuring the differential pressure across the orifice
- A means of measuring the pressure on the far (catheter end) of the sensor assembly

Below are Figures illustrating one embodiment of the invention, including the pressure sensors. There are many different pressure sensors that may be used in the present invention, including:

- Small pistons (as shown)
- Flexible elastomeric diaphragms
- Convoluted bellows
- Deformable tube(s)




PVC TUBING FROM INJECTOR SYSTEM
INJECTION MOLDED SENSOR BODY
PVC TUBING TO CATHETER HUB
O-RING SEAL
PRESSURE SENSING PISTON
PRESSURE SENSING PORT
ORIFICE WITH KNOWN GEOMETRY
CUT-AWAY VIEW



There are several improvements that the present invention provides, including:

- **Accurate Pressure Measurement** – The system can accurately measure the pressure at the catheter hub and prevent the catheter from being over pressurized, instead of measuring the pressure at the injector and estimating the catheter conditions.
- **Maximized Performance** – Because the pressure at the catheter hub can be accurately measured, the injector's performance can be maximized. By keeping the fluid pressure at the catheter hub as high as possible (without exceeding the catheter's limit), the system will be able to maximize delivered flow rate regardless of contrast viscosity, density or temperature.
- **Improved Safety** – Measuring the fluid pressure at the most important location (the catheter hub) will increase patient safety.