

The density measured with an instrument ([such as our FKT series meter](#)) is a direct relation to temperature and ambient pressure sensor readings. Density is given by the ideal gas law:

$$\rho = \frac{P}{R \cdot T}$$

Where ρ is density, P is the ambient (static) pressure, T is the temperature of the flow and R is the gas constant. The temperature should be in absolute units (Kelvin or Rankine). Each sensor reading (P , and T) has an uncertainty (U) associated with it, so the full density uncertainty is expressed below: (see <http://www.flowkinetics.com/uncertainty-analysis.htm>)

$$U_{\rho} = \sqrt{\left(\frac{\partial \rho}{\partial P}\right)^2 U_P^2 + \left(\frac{\partial \rho}{\partial T}\right)^2 U_T^2}$$

The differentials, based on the ideal gas law above, are:

$$\frac{\partial \rho}{\partial P} = \frac{1}{R \cdot T}$$

$$\frac{\partial \rho}{\partial T} = \frac{-P}{R \cdot T^2}$$

The uncertainty for each reading depends on the characteristics of each sensor and should be determined from the manufacture's specifications.

As an example, assume an instrument with the following uncertainties:

$$U_T = \pm 1^{\circ}\text{C} \text{ or } \pm 1\text{K}$$

$$U_P = \pm 0.5\% \text{ of full scale}$$

Also the following flow conditions are used:

$$P = 15 \text{ to } 115 \text{ kPa}$$

$$T = 73 \text{ to } 1050 \text{ K } (-200 \text{ to } 777^{\circ}\text{C})$$

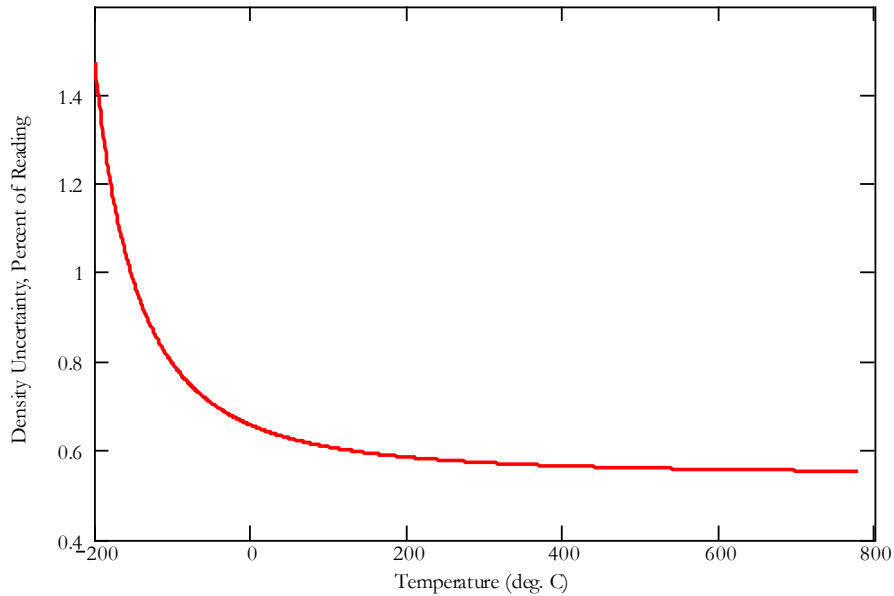
$$R = 287.026 \frac{\text{Joule}}{\text{kg} \cdot \text{K}}$$

For this example assume the full scale for the ambient (or absolute) pressure sensor is 115 kPa. So the uncertainty values are:

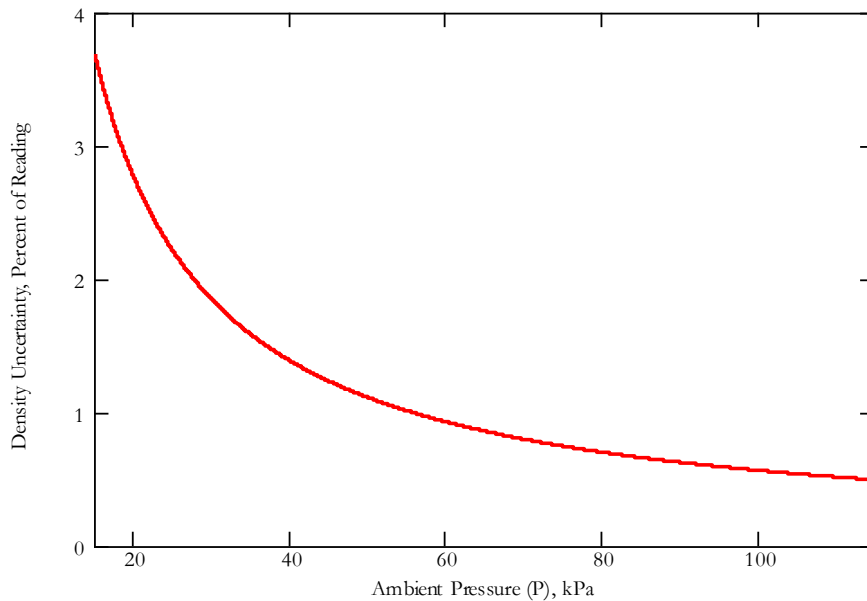
$$U_T = \pm 1^\circ\text{C} \text{ or } \pm 1\text{K}$$

$$U_P = \pm 552 \text{ Pa}$$

Using the above values the plot of density uncertainty as a fraction of reading for different temperatures is shown below. The ambient pressure is 101325 Pa.



If the temperature is kept at 20°C the density uncertainty variation with ambient pressure is shown below:



The plots show the uncertainty in the density increases significantly for low temperature and ambient pressure. For this example, at standard ambient conditions, the density uncertainty is about 0.6% of reading.