Estimates of the Uncertainty of Velocity Measurements

The (incompressible) velocity measured by a Pitot tube is calculated from the recorded differential pressure, Δp, and density, ρ, of the fluid. The velocity is given by

$$v = \sqrt{\frac{2\Delta p}{\rho}}$$

Assuming negligible uncertainty in the measured density (or using standard temperature and pressure), the uncertainty in the velocity may be expressed as:

$$Wv = \sqrt{\left(\frac{dv}{\Delta p}\right)^2 w_{\Delta p}{}^2}$$

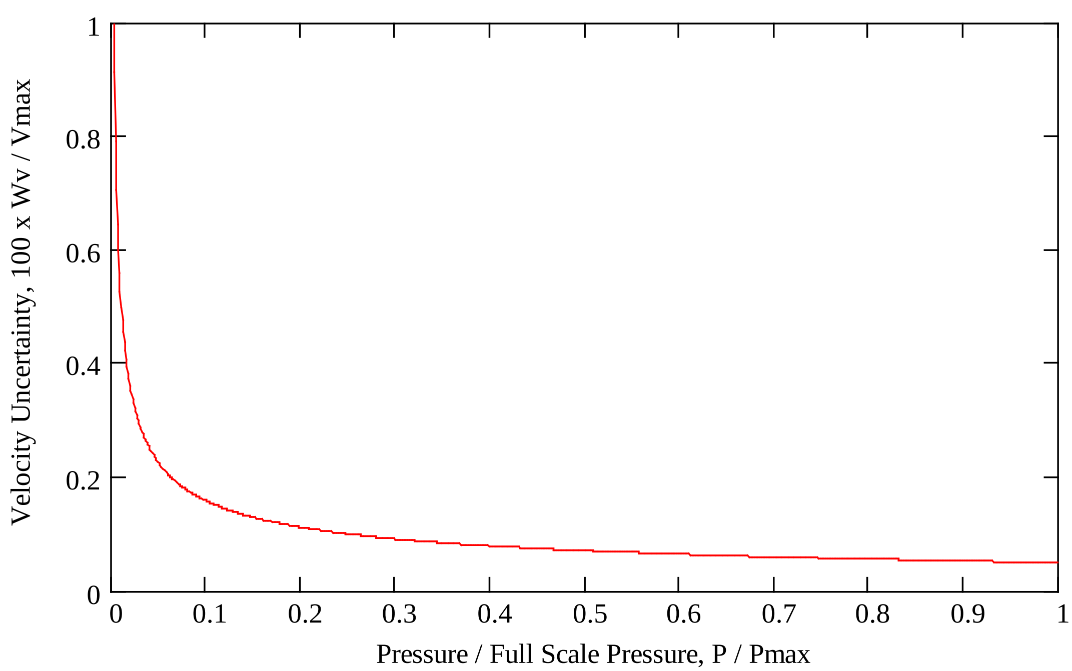
and noting that the uncertainty in the pressure is given by:

$w_{\Delta p} = k \times Pmax$ where k is typically 0.1% and Pmax is the full scale range of the transducer

Upon substitution of the first equation and simplification yields:

$$Wv = \frac{kP\max}{\rho v}$$

A plot of this equation divided by the velocity as a function of the pressure and velocity is shown below:



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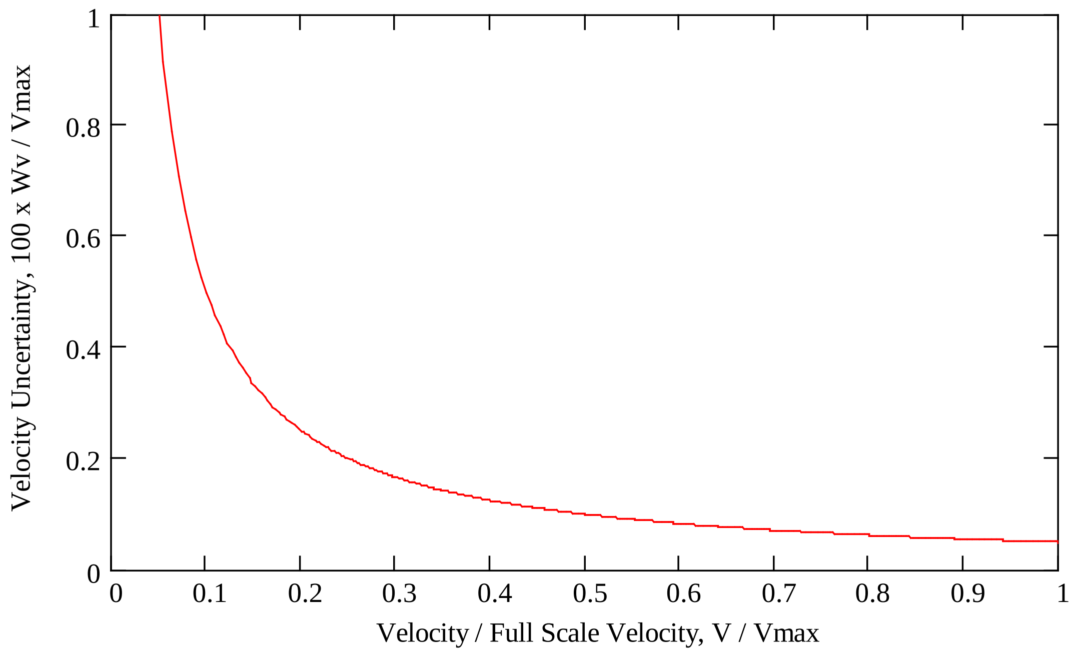

The plots show, that as with any Pitot based system, the uncertainty in the velocity is larger than that in the differential pressure. However, as long as measurements are not taken at the low end of the transducer's range, accuracy is still maintained.

Example:

For a pressure transducer with 1inH_2O range and 0.1% accuracy what is the velocity uncertainty at the lowest and highest pressure reading?

Pmax = 1 inH_2O = 248.8 Pa, ρ = 0.0749 lb/ft^3 = 1.2 kg/m^3, k = 0.001

At the lowest pressure reading:

Pressure: Δp = 1 inH_2O × k = 0.001 inH_2O = 0.25 Pa (lowest representative pressure)

Velocity: v = 0.64 m/sec = 127 ft/min

Velocity uncertainty: Wv = 0.32 m/sec = 63.4 ft/min

At the highest pressure reading:

Pressure: Δp = 1 inH_2O = 248.84 Pa

Velocity: v = 20.4 m/sec = 4009 ft/min

Velocity uncertainty: Wv = 0.01 m/sec = 2 ft/min