EASTERN INSTRUMENTS

Technical Application Bulletin
For All VAP's

TAB-VAP-101

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Objective:

To determine if Static Pressure or Temperature correction is needed in pitot flow measurement

Calculations:

95% of processes are dependent on **mass flow**, and the rest will be **volume flow** dependent. There is a notable exception to this, however. Airplanes perform by uncorrected pitot readout. Some fluidized bed systems fludization may also be dependent on uncorrected pitot readings.

Pitot calculations are made from a given set of conditions of temperature and static pressure. Error occurs when these conditions change from the given values. These given conditions are called "given" in the below calculations and "new" the changed set form the given values.

MASS FLOW:

$m_{flow} := 1097 \cdot A_e \cdot \sqrt{\rho \cdot \Delta h}$

where: m_{flow} = mass flow rate, lbs/min
A_e = duct effective area, ft^2
ρ = density, lb/ft^3

Then:

$m_{flow\_given} := 1097 \cdot A_e \cdot \sqrt{\rho_{given} \cdot \Delta h}$

$m_{flow\_new} := 1097 \cdot A_e \cdot \sqrt{\rho_{new} \cdot \Delta h}$

ratioing "new to "given", and arranging for "new"

$$m_{flow\_new} := m_{flow\_given} \cdot \sqrt{\frac{\rho_{new}}{\rho_{given}}}$$

In other words, the new mass flow is equal to the given mass flow times the ratio of the square root of the densities at the same Δh.

Also, from the equation of state

$$\rho := \frac{M_{wt} \cdot P}{R \cdot T}$$

used to calculate the density when absolute temperature and pressue are known

where: M_{wt} = Molecular wt
P = absolute pressure
T = absolute temperature

Subsituting and rearranging

$$m_{flow\_new} := m_{flow\_given} \cdot \sqrt{\frac{P_{new} \cdot T_{given}}{P_{given} \cdot T_{new}}}$$

Try some actual numbers

The NWS says normal variation in barometric pressure is approximately 1.2 in Hg

$P_{given} := 29.92 \quad P_{new} := 30.52 \quad mass\_ratio\_new\_to\_given := \sqrt{\frac{P_{new}}{P_{given}}} \quad mass\_ratio\_new\_to\_given = 1.01$

In other words, if the pressure goes up by 0.6 in_Hg, (8.1 in_wc), there will be an error of 1% introduced. This assumes that the pitot is set at the middle since the change would be +/- 1.0%

If the pressure goes up by 8.1 in_wc, the actual uncorrected reading will go down by 1%

For temperature, assume that it goes up by 10°F from 70°F to 80°F

$T_{given} := 532 \quad T_{new} := 542$

$mass\_ratio\_new\_to\_given := \sqrt{\frac{T_{given}}{T_{new}}} \quad mass\_ratio\_new\_to\_given = 0.991$

If the temperature goes up by 10°F, the actual uncorrected reading will go up by 1%

VOLUME FLOW:

$$Q_{flow} := 1097 \cdot A_e \cdot \sqrt{\frac{\Delta h}{\rho}}$$

where: Q_{flow} = volume flow rate in ft^3/min

Note that the only difference between mass and volume flow calculation is the density is now located in the denominator. The uncorrected error would be the same as in the mass calculation, only the direction of the error would be opposite.

RECOMMENDATIONS: If the variation exceeds the above amount or accuracies (repeats) greater than +/-2.0% are required, the the **DPS** receiver must be chosen to compensate for temperature and/or pressure variations.

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