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40 C.F.R. § 1065.640

Flow meter calibration calculations.

This section describes the calculations for calibrating various flow meters. After you calibrate a flow meter using these calculations, use the calculations described in § 1065.642 to calculate flow during an emission test. Paragraph (a) of this section first describes how to convert reference flow meter outputs for use in the calibration equations, which are presented on a molar basis. The remaining paragraphs describe the calibration calculations that are specific to certain types of flow meters.

(a) *Reference meter conversions.* The calibration equations in this section use molar flow rate, n_{ref}, as a reference quantity. If your reference meter outputs a flow rate in a different quantity, such as standard volume rate, V_{stdref}, actual volume rate, V_{actref}, or mass rate, m_{ref}, convert your reference meter output to a molar flow rate using the following equations, noting that while values for volume rate, mass rate, pressure, temperature, and molar mass may change during an emission test, you should ensure that they are as constant as practical for each individual set point during a flow meter calibration:

$$\dot{n}_{ref} = \frac{\dot{V}_{stdref} \cdot p_{std}}{T_{std} \cdot R} = \frac{\dot{V}_{actref} \cdot p_{act}}{T_{act} \cdot R} = \frac{\dot{m}_{ref}}{M_{mix}}$$

Eq. 1065.640-1

Where: n_{ref} = reference molar flow rate. V_{stdref} = reference volume flow rate corrected to a standard pressure and a standard temperature. V_{actref} = reference volume flow rate at the actual pressure and temperature of the flow rate. m_{ref} = reference mass flow. p_{std} = standard pressure. p_{act} = actual pressure of the flow rate. T_{std} = standard temperature. T_{act} = actual temperature of the flow rate. R = molar gas constant. M_{mix} = molar mass of the flow rate.

Example 1:

V_{stdref} = 1000.00 ft 3/min = 0.471948 m 3/s p_{std} = 29.9213 in Hg @ 32 °F = 101.325 kPa = 101325 Pa = 101325 kg/(m·s) T_{std} = 68.0 °F = 293.15 K R = 8.314472 J/(mol·K) = 8.314472 (m ·kg)/(s ·mol·K)

$$\dot{n}_{ref} = \frac{0.471948 \cdot 101325}{293.15 \cdot 8.314472}$$

n_{ref} = 19.619 mol/s

Example 2:

m_{ref} = 17.2683 kg/min = 287.805 g/s M_{mix} = 28.7805 g/mol

$$\dot{n}_{ref} = \frac{287.805}{28.7805}$$

n_{ref} = 10.0000 mol/s

(b) *PDP calibration calculations.* Perform the following steps to calibrate a PDP flow meter:

(1) Calculate PDP volume pumped per revolution, $V_{rev,}$ for each restrictor position from the mean values determined in § 1065.340 as follows:

$$V_{rev} = \frac{\bar{n}_{ref} \cdot R \cdot \bar{T}_{in}}{\bar{p}_{in} \cdot \bar{f}_{nPDP}}$$

Eq. 1065.640-2

Where:

n_{ref} = mean reference molar flow rate. R = molar gas constant. $T\,\tilde{}_{in}$ = mean temperature at the PDP inlet. $P\,\tilde{}_{in}$ = mean static absolute pressure at the PDP inlet. $f\,\tilde{}_{nPDP}$ = mean PDP speed.

Example:

n_{ref} = 25.096 mol/s R = 8.314472 J/(mol·K) = 8.314472 (m ·kg)/(s ·mol·K) $T\,\tilde{}_{in}$ = 299.5 K $P\,\tilde{}_{in}$ = 98.290 kPa = 98290 Pa = 98290 kg/(m·s) $f\,\tilde{}_{nPDP}$ = 1205.1 r/min = 20.085 r/s

$$V_{rev} = \frac{25.096 \cdot 8.314472 \cdot 299.5}{98290 \cdot 20.085}$$

V_{rev} = 0.03166 m /r

(2) Calculate a PDP slip correction factor, K_s, for each restrictor position from the mean values determined in § 1065.340 as follows:

$$K_s = \frac{1}{\bar{f}_{nPDP}} \cdot \sqrt{\frac{\bar{p}_{out} - \bar{p}_{in}}{\bar{p}_{out}}}$$

Eq. 1065.640-3

Where:

$f\,\tilde{}_{nPDP}$ = mean PDP speed. $P\,\tilde{}_{out}$ = mean static absolute pressure at the PDP outlet. $P\,\tilde{}_{in}$ = mean static absolute pressure at the PDP inlet.

Example:

$f\,\tilde{}_{nPDP}$ = 1205.1 r/min = 20.085 r/s $P\,\tilde{}_{out}$ = 100.103 kPa $P\,\tilde{}_{in}$ = 98.290 kPa

$$K_s = \frac{1}{20.085} \cdot \sqrt{\frac{100.103 - 98.290}{100.103}}$$

K_s = 0.006700 s/r

(3) Perform a least-squares regression of V_{rev}, versus K_s, by calculating slope, a_1, and intercept, a_0, as described for a floating intercept in § 1065.602.

(4) Repeat the procedure in paragraphs (b)(1) through (3) of this section for every speed that you run your PDP.