the equation, you may use any mathematical expression, including a polynomial or a power series. The following equation is an example of a commonly used mathematical expression for relating C_d and $Re^{\#}$:

$$C_d = a_0 - a_1 \cdot \sqrt{\frac{10^6}{Re^{\#}}} \quad \text{Eq. 1065.640-12}$$

(3) Perform a least-squares regression analysis to determine the best-fit coefficients to the equation and calculate the equation's regression statistics, *SEE* and r^2, according to § 1065.602.

(4) If the equation meets the criteria of $SEE \leq 0.5\% \cdot \dot{n}_{refmax}$ and $r^2 \geq 0.995$, you may use the equation to determine C_d for emission tests, as described in § 1065.642.

(5) If the *SEE* and r^2 criteria are not met, you may use good engineering judgment to omit calibration data points to meet the regression statistics. You must use at least seven calibration data points to meet the criteria.

(6) If omitting points does not resolve outliers, take corrective action. For example, select another mathematical expression for the C_d versus $Re^{\#}$ equation, check for leaks, or repeat the calibration process. If you must repeat the process, we recommend applying tighter tolerances to measurements and allowing more time for flows to stabilize.

(7) Once you have an equation that meets the regression criteria, you may use the equation only to determine flow rates that are within the range of the reference flow rates used to meet the C_d versus $Re^{\#}$ equation's regression criteria.

(e) *CFV calibration*. Some CFV flow meters consist of a single venturi and some consist of multiple venturis, where different combinations of venturis are used to meter different flow rates. For CFV flow meters that consist of multiple venturis, either calibrate each venturi independently to determine a separate discharge coefficient, C_d, for each venturi, or calibrate each combination of venturis as one venturi. In the case where you calibrate a combination of venturis, use the sum of the active venturi throat areas as A_t, the sum of the active venturi throat diameters as d_t, and the ratio of venturi throat to inlet diameters as the ratio of the sum of the active venturi throat diameters to the diameter of the common entrance to all of the venturis. To determine the C_d for a single venturi or a single combination of venturis, perform the following steps:

(1) Use the data collected at each calibration set point to calculate an individual C_d for each point using Eq. 1065.640–4.

(2) Calculate the mean and standard deviation of all the C_d values according to Eqs. 1065.602–1 and 1065.602–2.

(3) If the standard deviation of all the C_d values is less than or equal to 0.3% of the mean C_d, then use the mean C_d in Eq 1065.642–6, and use the CFV only down to the lowest Δp_{CFV} measured during calibration.

(4) If the standard deviation of all the C_d values exceeds 0.3% of the mean C_d, omit the C_d values corresponding to the data point collected at the lowest Δp_{CFV} measured during calibration.

(5) If the number of remaining data points is less than seven, take corrective action by checking your calibration data or repeating the calibration process. If you repeat the calibration process, we recommend checking for leaks, applying tighter tolerances to measurements and allowing more time for flows to stabilize.

(6) If the number of remaining C_d values is seven or greater, recalculate the mean and standard deviation of the remaining C_d values.

(7) If the standard deviation of the remaining C_d values is less than or equal to 0.3 % of the mean of the remaining C_d, use that mean C_d in Eq 1065.642–6, and use the CFV values only down to the lowest Δp_{CFV} associated with the remaining C_d.

(8) If the standard deviation of the remaining C_d still exceeds 0.3% of the mean of the remaining C_d values, repeat the steps in paragraph (e) (4) through (8) of this section.

§ 1065.642 SSV, CFV, and PDP molar flow rate calculations.

This section describes the equations for calculating molar flow rates from various flow meters. After you calibrate a flow meter according to

§ 1065.640, use the calculations described in this section to calculate flow during an emission test.

(a) *PDP molar flow rate.* Based upon the speed at which you operate the PDP for a test interval, select the corresponding slope, a_1, and intercept, a_0, as calculated in § 1065.640, to calculate molar flow rate, $\dot{n}$, as follows:

$$\dot{n} = f_{nPDP} \cdot \frac{p_{in} \cdot V_{rev}}{R \cdot T_{in}} \qquad \text{Eq. 1065.642-1}$$

Where:

$$V_{rev} = \frac{a_1}{f_{nPDP}} \cdot \sqrt{\frac{p_{out} - p_{in}}{p_{in}}} + a_0 \qquad \text{Eq. 1065.642-2}$$

Example:

a_1 = 50.43
f_{nPDP} = 755.0 rev/min = 12.58 rev/s
p_{out} = 99950 Pa
p_{in} = 98575 Pa
a_0 = 0.056
R = 8.314472 J/(mol·K)
T_{in} = 323.5 K
C_p = 1000 (J/m³)/kPa
C_t = 60 s/min

$$V_{rev} = \frac{50.43}{755} \cdot \sqrt{\frac{99950 - 98575}{98575}} + 0.056$$

V_{rev} = 0.06389 m³/rev

$$\dot{n} = 12.58 \cdot \frac{98575 \cdot 0.06389}{8.314472 \cdot 323.5}$$

$\dot{n}$ = 29.464 mol/s

(b) *SSV molar flow rate.* Based on the C_d versus $Re^{\#}$ equation you determined according to § 1065.640, calculate SSV molar flow rate, $\dot{n}$ during an emission test as follows:

$$\dot{n} = C_d \cdot C_f \cdot \frac{A_t \cdot p_{in}}{\sqrt{Z \cdot M_{mix} \cdot R \cdot T_{in}}} \qquad \text{Eq. 1065.642-3}$$

Example:

A_t = 0.01824 m²
p_{in} = 99132 Pa
Z = 1
M_{mix} = 28.7805 g/mol = 0.0287805 kg/mol
R = 8.314472 J/(mol·K)
T_{in} = 298.15 K
$Re^{\#}$ = $7.232 \cdot 10^5$
γ = 1.399
β = 0.8
Δp = 2.312 kPa
Using Eq. 1065.640–6,
r_{ssv} = 0.997
Using Eq. 1065.640–5,
C_f = 0.274
Using Eq. 1065.640–4,
C_d = 0.990

$$\dot{n} = 0.990 \cdot 0.274 \cdot \frac{0.01824 \cdot 99132}{\sqrt{1 \cdot 0.0287805 \cdot 8.314472 \cdot 298.15}}$$

$\dot{n}$ = 58.173 mol/s

(c) *CFV molar flow rate.* Some CFV flow meters consist of a single venturi and some consist of multiple venturis, where different combinations of venturis are used to meter different flow rates. If you use multiple venturis and you calibrated each venturi independently to determine a separate discharge coefficient, C_d, for each venturi, calculate the individual molar flow rates through each venturi and sum all their flow rates to determine $\dot{n}$. If you use multiple venturis and you calibrated each combination of venturis, calculate $\dot{n}$ using the sum of the active venturi throat areas as A_t, the sum of the active venturi throat diameters as d_t, and the ratio of venturi throat to inlet diameters as the ratio of the sum of the active venturi throat diameters to the diameter of the common entrance to all of the venturis. To calculate the molar flow rate through one venturi or one combination of venturis, use its respective mean C_d and other constants you determined according to §1065.640 and calculate its molar flow rate $\dot{n}$ during an emission test, as follows:

$$\dot{n} = C_d \cdot C_f \cdot \frac{A_t \cdot p_{in}}{\sqrt{Z \cdot M_{mix} \cdot R \cdot T_{in}}} \qquad \text{Eq. 1065.642-6}$$

Example:

C_d = 0.985
C_f = 0.7219
A_t = 0.00456 m²
p_{in} = 98836 Pa
Z = 1
M_{mix} = 28.7805 g/mol = 0.0287805 kg/mol
R = 8.314472 J/(mol·K)
T_{in} = 378.15 K
$\dot{n}$ = 0.985·0.712

$$\frac{0.00456 \cdot 98836}{\sqrt{1 \cdot 0.0287805 \cdot 8.314472 \cdot 378.15}}$$

$\dot{n}$ = 33.690 mol/s

§ 1065.645 Amount of water in an ideal gas.

This section describes how to determine the amount of water in an ideal gas, which you need for various performance verifications and emission calculations. Use the equation for the vapor pressure of water in paragraph (a) of this section or another appropriate equation and, depending on whether you measure dewpoint or relative humidity, perform one of the calculations in paragraph (b) or (c) of this section.

(a) *Vapor pressure of water*. Calculate the vapor pressure of water for a given saturation temperature condition, T_{sat}, as follows, or use good engineering judgment to use a different relationship of the vapor pressure of water to a given saturation temperature condition:

(1) For humidity measurements made at ambient temperatures from (0 to 100) °C, or for humidity measurements made over super-cooled water at ambient temperatures from (−50 to 0) °C, use the following equation:

$$-\log_{10}(p_{H20}) =$$
$$10.79574 \cdot \left(\frac{273.16}{T_{sat}} - 1\right) +$$
$$5.02800 \cdot \log_{10}\left(\frac{T_{sat}}{273.16}\right) +$$
$$1.50475 \cdot 10^{-4} \cdot \left(10^{-8.2969 \cdot \left(\frac{T_{sat}}{273.16}\right)} - 1\right) +$$
$$0.42873 \cdot 10^{-3} \cdot \left(1 - 10^{4.76955 \cdot \left(1 - \frac{273.16}{T_{sat}}\right)}\right) +$$
$$0.21386 \qquad \text{Eq. 1065.645-1}$$

Where:

p_{H20} = vapor pressure of water at saturation temperature condition, kPa.
T_{sat} = saturation temperature of water at measured conditions, K.

Example:

T_{sat} = 9.5 °C
T_{dsat}= 9.5 + 273.15 = 282.65 K