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 coef-
ficient, $C_d$, for each venturi, or cali-
brate each combination of venturis as
one venturi. In the case where you cali-
brate a combination of venturis, use
the sum of the active venturi throat
areas as $A_t$, the square root of the sum
of the squares of the active venturi
throat diameters as $d_t$, and the ratio of
the venturi throat to inlet diameters
as the ratio of the square root of the
sum of the active venturi throat diam-
eters ($d_t$) to the diameter of the com-
mon entrance to all of the venturis ($D$).

To determine the $C_d$ for a single ven-
turi or a single combination of
venturis, perform the following steps:
(1) Use the data collected at each
calibration set point to calculate an in-
dividual $C_d$ for each point using Eq.
(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 $C_d$ use the mean $C_d$ in Eq
1065.642–6, and use the CFV only up to
the highest $r$ measured during calibra-
tion using the following equation:

$$r = 1 - \frac{\Delta p_{\text{CFV}}}{p_m}$$

Where:

$\Delta p_{\text{CFV}}$ = Differential static pressure; ven-
turi inlet minus venturi outlet.

(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 highest $r$
measured during calibration.

(5) If the number of remaining data
points is less than seven, take correc-
tive action by checking your calibra-
tion 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 re-
mainning $C_d$ values.

(7) If the standard deviation of the re-
mainning $C_d$ 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 up to the
highest $r$ associated with the remain-
ing $C_d$.

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

(70 FR 40516, July 13, 2005, as amended at 73
FR 37326, June 30, 2008; 73 FR 59331, Oct. 8,
2008; 75 FR 23045, Apr. 30, 2010; 75 FR 68464,
Nov. 8, 2010; 76 FR 57455, Sept. 15, 2011)

§ 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 cali-
brate 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 cor-
responding slope, $a_t$, and intercept, $a_0$,
as calculated in §1065.640, to calculate
molar flow rate, $\dot{n}$ as follows:
\[ \dot{n} = f_\text{ave} \cdot \frac{P_\text{in} \cdot V_\text{rev}}{R \cdot T_\text{in}} \]

Eq. 1065.642-1

Where:

\[ V_\text{rev} = \frac{a_1}{f_\text{ave}} \sqrt{\frac{P_\text{out} - P_\text{in}}{P_\text{out}}} + a_0 \]

Eq. 1065.642-2

Example:
\[ a_1 = 50.43 \text{ (m}^3\text{/min)} = 0.8405 \text{ (m}^3\text{/s)} \]
\[ f_\text{ave} = 755.0 \text{ r/min} = 12.58 \text{ r/s} \]
\[ P_\text{in} = 99950 \text{ Pa} \]
\[ p = 98575 \text{ Pa} \]
\[ a_0 = 0.056 \text{ (m}^3\text{/r)} \]
\[ R = 8.314472 \text{ J/(mol·K)} \]
\[ T_\text{in} = 323.5 \text{ K} \]
\[ C_\text{p} = 1000 \text{ (J/m}^3\text{/kPa)} \]
\[ C_\text{t} = 60 \text{ s/min} \]

\[ V_\text{rev} = \frac{0.8405}{12.58} \sqrt{\frac{99950 - 98575}{99950}} + 0.056 \]

\[ V_\text{rev} = 0.06383 \text{ m}^3\text{/r} \]

\[ \dot{n} = 12.58 \cdot \frac{98575 \cdot 0.06383}{8.314472 \cdot 323.5} \]

\( \bar{n} = 29.428 \text{ mol/s} \)

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

\[ \dot{n} = C_d \cdot C_t \cdot \frac{A_1 \cdot p_\text{in}}{\sqrt{Z \cdot M_{\text{max}} \cdot R \cdot T_\text{in}}} \]

Eq. 1065.642-3

Example:
\[ A_1 = 0.014824 \text{ m}^2 \]
\[ p_\text{in} = 99132 \text{ Pa} \]
\[ Z = 1 \]
\[ M_{\text{max}} = 28.7805 \text{ g/mol} = 0.0297805 \text{ kg/mol} \]
\[ R = 8.314472 \text{ J/(mol·K)} \]
\[ T_\text{in} = 296.15 \text{ K} \]
\[ Re^\theta = 7.232 \times 10^{3} \]
\[ \gamma = 1.399 \]
\[ \beta = 0.8 \]
\[ \Delta p = 2.312 \text{ kPa} \]
Using Eq. 1065.640–7, \( r_{\text{ave}} = 0.987 \)
Using Eq. 1065.640–6,
\[ C_f = 0.274 \]
Using Eq. 1065.640–5,
\[ C_d = 0.990 \]
\[
\dot{n} = 0.990 \cdot 0.274 \cdot \frac{0.01824 \cdot 99132}{\sqrt{1 \cdot 0.0287805 \cdot 8.314472 \cdot 298.15}} \]
\[ \dot{n} = 58.173 \text{ mol/s} \]

(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, 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:

\[
\dot{n} = C_d \cdot C_f \cdot \frac{A_t \cdot p_{in}}{\sqrt{Z} \cdot M_{mix} \cdot R \cdot T_{in}} \quad \text{Eq. 1065.642-4} \]

Example:
\[ C_d = 0.985 \]
\[ C_f = 0.7219 \]
\[ A_t = 0.00456 \text{ m}^2 \]
\[ p_{in} = 98836 \text{ Pa} \]
\[
\dot{n} = 0.985 \cdot 0.7219 \cdot \frac{0.00456 \cdot 98836}{\sqrt{1 \cdot 0.0287805 \cdot 8.314472 \cdot 378.15}} \]
\[ \dot{n} = 33.690 \text{ mol/s} \]

\[ n = 33.690 \text{ mol/s} \]

§ 1065.644 Vacuum-decay leak rate.
This section describes how to calculate the leak rate of a vacuum-decay leak verification, which is described in §1065.345(e). Use Eq. 1065.644-1 to calculate the leak rate, \( \dot{n}_{\text{leak}} \), and compare it to the criterion specified in §1065.345(e).

\[
\dot{n}_{\text{leak}} = \frac{V_{\text{vac}}}{R} \cdot \left( \frac{P_2 - P_1}{T_2 - T_1} \right) \quad \text{Eq. 1065.644-1} \]

Where:
\( V_{\text{vac}} = \) geometric volume of the vacuum-side of the sampling system.
\( R = \) molar gas constant.