§ 1065.660  THC, NMHC, and CH₄ determination.

(a) THC determination and initial THC/CH₄ contamination corrections. (1) If you require you to determine THC emissions, calculate \( x_{THC\text{FID}}^{\text{cor}} \) for initial THC contamination using the initial THC contamination concentration \( x_{THC\text{FID}}^{\text{init}} \) from §1065.660 as follows:

\[
x_{THC\text{FID}}^{\text{cor}} = x_{THC\text{FID}}^{\text{uncor}} - x_{THC\text{FID}}^{\text{init}}
\]

Example:

\[
x_{THC\text{FID}}^{\text{uncor}} = 150.3 \text{ mmol/mol}
\]

\[
x_{THC\text{FID}}^{\text{init}} = 1.1 \text{ mmol/mol}
\]

(2) For the NMHC determination described in paragraph (b) of this section, correct \( x_{THC\text{FID}}^{\text{uncor}} \) for initial THC contamination using Equation 1065.660-1. You may correct \( x_{CH\text{FID}}\text{CH} \) for initial contamination of the CH₄ sample train using Equation 1065.660-1, substituting in CH₄ concentrations for THC.

(3) For the CH₄ determination described in paragraph (c) of this section, you may correct \( x_{CH\text{FID}}\text{CH} \) for initial THC contamination of the CH₄ sample train using Equation 1065.660-1, substituting in CH₄ concentrations for THC.

(b) NMHC determination. Use one of the following to determine NMHC concentration, \( x_{NMHC} \):

\[ x_{NMHC} = x_{NMHC}^{\text{cor}} \]

\[ x_{NMHC}^{\text{cor}} = x_{NMHC}^{\text{uncor}} - x_{THC\text{FID}}^{\text{init}} \]

Example:

\[
x_{THC\text{FID}}^{\text{uncor}} = 8.601 \text{ mmol/mol}
\]

\[
x_{THC\text{FID}}^{\text{init}} = 0.008601 \text{ mmol/mol}
\]
(1) If you do not measure CH₄, you may omit the calculation of NMHC concentrations and calculate the mass of NMHC as described in §1065.650(c)(5).

(2) For nonmethane cutters, calculate x_NMHC using the nonmethane cutter's penetration fraction (PF) of CH₄ and the response factor penetration fraction (RFPF) of C₂H₆ from §1065.365, the response factor (RF) of the THC FID to CH₄ from §1065.360, the initial THC contamination and dry-to-wet corrected THC concentration x_THC[THC–FID]cor as determined in paragraph (a) of this section, and the dry-to-wet corrected CH₄ concentration x_THC[NMC–FID]cor optionally corrected for initial THC contamination as determined in paragraph (a) of this section.

(i) Use the following equation for penetration fractions determined using an NMC configuration as outlined in §1065.365(d):

\[
x_{NMHC} = \frac{x_{THC}[THC-FID]cor - x_{THC}[NMC-FID]cor \cdot RF_{CH4[THC-FID]}}{1 - RFPF_{C2H6[NMC-FID]} \cdot RF_{CH4[THC-FID]}}
\]

Eq. 1065.660-2

Where:

- \( x_{NMHC} \) = concentration of NMHC.
- \( x_{THC}[THC-FID]cor \) = concentration of THC, initial THC contamination and dry-to-wet corrected, as measured by the THC FID during sampling while bypassing the NMC.
- \( x_{THC}[NMC-FID]cor \) = concentration of THC, initial THC contamination (optional) and dry-to-wet corrected, as measured by the NMC FID during sampling through the NMC.
- \( RF_{CH4[THC-FID]} \) = response factor of THC FID to CH₄ according to §1065.360(d).
- \( RFPF_{C2H6[NMC-FID]} \) = nonmethane cutter combined ethane response factor and penetration fraction, according to §1065.365(d).

Example:

\[
x_{NMHC} = \frac{150.3 - 20.5 \cdot 1.05}{1 - 0.019 \cdot 1.05}
\]

\[
x_{NMHC} = \frac{131.4 \cdot 1.05}{1 - 0.019 \cdot 1.05}
\]

(ii) For penetration fractions determined using an NMC configuration as outlined in section §1065.365(e), use the following equation:

\[
x_{NMHC} = \frac{x_{THC}[THC-FID]cor \cdot PF_{CH4[NMC-FID]} - x_{THC}[NMC-FID]cor}{PF_{CH4[NMC-FID]} - PF_{C2H6[NMC-FID]}}
\]

Eq. 1065.660-3

Where:

- \( x_{NMHC} \) = concentration of NMHC.
- \( x_{THC}[THC-FID]cor \) = concentration of THC, initial THC contamination and dry-to-wet corrected, as measured by the THC FID during sampling while bypassing the NMC.
\( x_{NMHC} = 132.3 \, \mu mol/mol \)

(iii) For penetration fractions determined using an NMC configuration as outlined in section §1065.365(f), use the following equation:

\[
x_{NMHC} = \frac{x_{THC[THC-FID]cor} \cdot PF_{CH4[NMC-FID]} - x_{THC[NMC-FID]cor} \cdot RF_{CH4[THC-FID]}}{PF_{CH4[NMC-FID]} - RFPF_{C2H6[NMC-FID]} \cdot RF_{CH4[THC-FID]}}
\]

Eq. 1065.660-4

Where:
\( x_{NMHC} = \) concentration of NMHC.
\( x_{THC[THC-FID]cor} = \) concentration of THC, initial THC contamination and dry-to-wet corrected, as measured by the THC FID during sampling while bypassing the NMC.
\( PF_{CH4[NMC-FID]} = \) nonmethane cutter CH\textsubscript{4} penetration fraction, according to §1065.365(f).
\( x_{THC[NMC-FID]cor} = \) concentration of THC, initial THC contamination (optional) and dry-to-wet corrected, as measured by the THC FID during sampling through the NMC.
\( RFPF_{C2H6[NMC-FID]} = \) nonmethane cutter CH\textsubscript{4} combined ethane response factor and penetration fraction, according to §1065.365(f).
\( RF_{CH4[THC-FID]} = \) response factor of THC FID to CH\textsubscript{4}, according to §1065.360(d).

\( RFPF_{C2H6[NMC-FID]} = 0.019 \)
\( RF_{CH4[THC-FID]} = 0.980 \)

\( x_{NMHC} = 132.5 \, \mu mol/mol \)

(3) For a GC–FID, calculate \( x_{NMHC} \) using the THC analyzer’s response factor (RF) for CH\textsubscript{4} from §1065.360, and the initial THC contamination and dry-to-wet corrected THC concentration \( x_{THC[THC-FID]cor} \) as determined in paragraph (a) of this section as follows:
\[ x_{NMHC} = x_{THC(THC-FID)\text{cor}} - RF_{CH4(THC-FID)} \cdot x_{CH4} \]

Eq. 1065.660-5

Where:

- \( x_{NMHC} \) = concentration of NMHC.
- \( x_{THC(THC-FID)\text{cor}} \) = concentration of THC, initial THC contamination and dry-to-wet corrected, as measured by the THC FID.
- \( x_{CH4} \) = concentration of CH\(_4\), dry-to-wet corrected, as measured by the GC–FID.
- \( RF_{CH4(THC-FID)} \) = response factor of THC–FID to CH\(_4\).

Example:

\[ x_{THC(THC-FID)\text{cor}} = 145.6 \, \mu\text{mol/mol} \]
\[ RF_{CH4(THC-FID)} = 0.970 \]
\[ x_{CH4} = 18.9 \, \mu\text{mol/mol} \]
\[ x_{NMHC} = 145.6 - 0.970 \cdot 18.9 \]
\[ x_{NMHC} = 127.3 \, \mu\text{mol/mol} \]

(c) CH\(_4\) determination. Use one of the following methods to determine CH\(_4\) concentration, \( x_{CH4} \):

(1) For nonmethane cutters, calculate \( x_{CH4} \) using the nonmethane cutter’s penetration fraction (PF) of CH\(_4\) and the response factor penetration fraction (RFPF) of C\(_2\)H\(_6\) from §1065.365, the response factor (RF) of the THC FID to CH\(_4\) from §1065.360, the initial THC contamination and dry-to-wet corrected THC concentration \( x_{THC(THC-FID)\text{cor}} \) as determined in paragraph (a) of this section, and the dry-to-wet corrected CH\(_4\) concentration \( x_{THC[NMC-FID]\text{cor}} \) optionally corrected for initial THC contamination as determined in paragraph (a) of this section.

\[ x_{CH4} = \frac{x_{THC[NMC-FID]\text{cor}} - x_{THC(THC-FID)\text{cor}} \cdot RFPF_{C2H6[NMC-FID]} \cdot RF_{CH4(THC-FID)}}{1 - RFPF_{C2H6[NMC-FID]} \cdot RF_{CH4(THC-FID)}} \]

Eq. 1065.660-6

Where:

- \( x_{CH4} \) = concentration of CH\(_4\).
- \( x_{THC[NMC-FID]\text{cor}} \) = concentration of THC, initial THC contamination (optional) and dry-to-wet corrected, as measured by the NMC FID during sampling through the NMC.
- \( x_{THC(THC-FID)\text{cor}} \) = concentration of THC, initial THC contamination and dry-to-wet corrected, as measured by the THC FID during sampling while bypassing the NMC.
- \( RFPF_{C2H6[NMC-FID]} \) = the combined ethane response factor and penetration fraction of the nonmethane cutter, according to §1065.365(d).
- \( RF_{CH4(THC-FID)} \) = response factor of THC FID to CH\(_4\), according to §1065.360(d).

Example:

\[ x_{THC[NMC-FID]\text{cor}} = 10.4 \, \mu\text{mol/mol} \]
\[ x_{THC(THC-FID)\text{cor}} = 150.3 \, \mu\text{mol/mol} \]
\[ RFPF_{C2H6[NMC-FID]} = 0.019 \]
\[ RF_{CH4(THC-FID)} = 1.05 \]

\[ x_{CH4} = \frac{10.4 - 150.3 \cdot 0.019}{1 - 0.019 \cdot 1.05} \]
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$x_{CH_4} = 7.69 \mu mol/mol$

(ii) For penetration fractions determined using an NMC configuration as outlined in §1065.365(e), use the following equation:

$$x_{CH_4} = \frac{x_{THC[NMC-FID]cor} - x_{THC[THC-FID]cor} \cdot PF_{C2H6[NMC-FID]}}{RF_{CH_4[THC-FID]} \cdot (PF_{CH_4[NMC-FID]} - PF_{C2H6[NMC-FID]})}$$

Eq. 1065.660-7

Where:
- $x_{CH_4} =$ concentration of CH$_4$
- $x_{THC[NMC-FID]cor} =$ concentration of THC, initial THC contamination (optional) and dry-to-wet corrected, as measured by the NMC FID during sampling through the NMC.
- $x_{THC[THC-FID]cor} =$ concentration of THC, initial THC contamination and dry-to-wet corrected, as measured by the THC FID during sampling while bypassing the NMC.
- $PF_{C2H6[NMC-FID]} =$ nonmethane cutter ethane penetration fraction, according to §1065.365(e).
- $RF_{CH_4[THC-FID]} =$ response factor of THC FID to CH$_4$, according to §1065.360(d).
- $PF_{CH_4[NMC-FID]} =$ nonmethane cutter CH$_4$ penetration fraction, according to §1065.365(e).
- $RF_{PF_{C2H6[NMC-FID]}} =$ the combined ethane response factor and penetration fraction of the nonmethane cutter, according to §1065.365(f).

Example:
- $x_{THC[NMC-FID]cor} = 10.4 \mu mol/mol$
- $x_{THC[THC-FID]cor} = 150.3 \mu mol/mol$
- $PF_{C2H6[NMC-FID]} = 0.020$
- $RF_{CH_4[THC-FID]} = 1.05$
- $PF_{CH_4[NMC-FID]} = 0.990$

$$x_{CH_4} = \frac{10.4 - 150.3 \cdot 0.020}{1.05 \cdot (0.990 - 0.020)}$$

$x_{CH_4} = 7.25 \mu mol/mol$

(iii) For penetration fractions determined using an NMC configuration as outlined in §1065.365(f), use the following equation:

$$x_{CH_4} = \frac{x_{THC[NMC-FID]cor} - x_{THC[THC-FID]cor} \cdot RFPF_{C2H6[NMC-FID]}}{PF_{CH_4[NMC-FID]} - RFPF_{C2H6[NMC-FID]} \cdot RF_{CH_4[THC-FID]}}$$

Eq. 1065.660-8

Where:
- $x_{CH_4} =$ concentration of CH$_4$
- $x_{THC[NMC-FID]cor} =$ concentration of THC, initial THC contamination (optional) and dry-to-wet corrected, as measured by the NMC FID during sampling through the NMC.
- $x_{THC[THC-FID]cor} =$ concentration of THC, initial THC contamination and dry-to-wet corrected, as measured by the THC FID during sampling while bypassing the NMC.
- $RFPF_{C2H6[NMC-FID]} =$ the combined ethane response factor and penetration fraction of the nonmethane cutter, according to §1065.365(f).
- $PF_{CH_4[NMC-FID]} =$ nonmethane cutter CH$_4$ penetration fraction, according to §1065.365(f).
- $RFPF_{CH_4[THC-FID]} =$ response factor of THC FID to CH$_4$, according to §1065.360(d).
Example:

\[ x_{\text{THC(NMC-FID)cor}} = 10.4 \, \mu\text{mol/mol} \]
\[ x_{\text{THC(THC-FID)cor}} = 150.3 \, \mu\text{mol/mol} \]

\[ x_{\text{CH}_4} = \frac{10.4 - 150.3 \cdot 0.019}{0.990 - 0.019 \cdot 1.05} \]

\[ x_{\text{CH}_4} = 7.78 \, \mu\text{mol/mol} \]

(2) For a GC-FID, \( x_{\text{CH}_4} \) is the actual dry-to-wet corrected \( \text{CH}_4 \) concentration as measured by the analyzer.

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§ 1065.665 THCE and NMHCE determination.

(a) If you measured an oxygenated hydrocarbon’s mass concentration, first calculate its molar concentration in the exhaust sample stream from which the sample was taken (raw or diluted exhaust), and convert this into a \( C_1 \)-equivalent molar concentration. Add these \( C_1 \)-equivalent molar concentrations to the molar concentration of NOTHC. The result is the molar concentration of THCE. Calculate THCE concentration using the following equations, noting that equation 1065.665-3 is only required if you need to convert your OHC concentration from mass to moles:

\[ x_{\text{THCE}} = x_{\text{NOTHC}} + \sum_{i=1}^{N} \left( x_{\text{OHC}_i} - x_{\text{OHC}_i\text{-init}} \right) \quad \text{Eq. 1065.665-1} \]

\[ x_{\text{NOTHC}} = x_{\text{THC(THC-FID)cor}} - \sum_{i=1}^{N} \left( x_{\text{OHC}_i} \cdot RF_{\text{OHC}_i(\text{THC-FID})} \right) \quad \text{Eq. 1065.665-2} \]

\[ x_{\text{OHC}_i} = \frac{m_{\text{OHC}_i}}{M_{\text{OHC}_i}} = \frac{n_{\text{OHC}_i}}{n_{\text{dash}}} \quad \text{Eq. 1065.665-3} \]

Where:

\( x_{\text{THCE}} \) = The \( C_1 \)-equivalent sum of the concentration of carbon mass contributions of non-oxygenated hydrocarbons, alcohols, and aldehydes.

\( x_{\text{NOTHC}} \) = The \( C_1 \)-equivalent sum of the concentration of nonoxygenated THC.

\( x_{\text{OHC}_i} \) = The \( C_1 \)-equivalent concentration of oxygenated species \( i \) in diluted exhaust, not corrected for initial contamination.

\( x_{\text{OHC}_i\text{-init}} \) = The \( C_1 \)-equivalent concentration of the initial system contamination (optional) of oxygenated species \( i \), dry-to-wet corrected.

\( x_{\text{THC(THC-FID)cor}} \) = The \( C_1 \)-equivalent response to NOTHC and all OHC in diluted exhaust, HC contamination and dry-to-wet corrected, as measured by the THC-FID.

\( RF_{\text{OHC}_i(\text{THC-FID})} \) = The response factor of the FID to species \( i \) relative to propane on a \( C_1 \)-equivalent basis.

\( C^\prime \) = The mean number of carbon atoms in the particular compound.

\( M_{\text{dash}} \) = The molar mass of diluted exhaust as determined in §1065.340.

\( m_{\text{OHC}_i} \) = The mass of oxygenated species \( i \) in diluted exhaust.

\( M_{\text{OHC}_i} \) = The \( C_1 \)-equivalent molecular weight of oxygenated species \( i \).

\( n_{\text{OHC}_i} \) = The number of moles of oxygenated species \( i \) in total diluted exhaust flow.