EMIT Emissions Statement Guidance Document:
Stack Test Emission Factor Origins and Particulate Matter (PM) Pollutants

Emission factors derived from the results of EPA methodology stack tests are deemed the best among all factors and should always be used in EMIT to calculate emissions. The only exception is when a unit is equipped with a Continuous Emissions Monitoring System (CEMS). Stack test results must either be approved by CT DEEP or be submitted to through the EPA's Compliance and Emissions Data Reporting Interface (CEDRI). Stack test derived emission factors reported in EMIT should be based solely on stack tests conducted during steady-state operations.

Stack Test Emission Factor Origins:

When reporting an emission factor derived from a stack test in EMIT, it should be accompanied with a "STACK TEST…" emission factor origin. There are two stack test emission factor origins in EMIT:

1. "STACK TEST – PRIOR CONTROL" is defined as when a stack test is performed upstream of the relevant control equipment for the pollutant <u>OR</u> if the control equipment was not operational during the test.
2. "STACK TEST – AFTER CONTROL", on the other hand, should be listed as the emission factor origin when the stack test was performed downstream of the relevant control equipment for the pollutant <u>AND</u> the control equipment was operational during the test.

If there is no control equipment for the given pollutant on the tested stack, DEEP requests for the "STACK TEST – AFTER CONTROL" emission factor origin to be used.

"STACK TEST – AFTER CONTROL" is the only controlled emission factor origin in EMIT, meaning that the control efficiency for the pollutant is incorporated within the emission factor. All other EMIT emission factor origins, including "STACK TEST – PRIOR CONTROL", are uncontrolled emission factors.

EMIT uses the following formula to calculate uncontrolled emissions for a pollutant:

$$E\left[\frac{mass}{time}\right] = A\left[\frac{volume}{time}\right] * EF|_{Uncontrolled}\left[\frac{mass}{volume}\right] * \left(1 - \frac{CE|_{overall}\,[\%]}{100}\right) \qquad \textit{Eq. I}$$

where A is the actual fuel activity, $EF|_{Uncontrolled}$ is the uncontrolled emission factor for the pollutant, $CE|_{overall}$ is the Overall Control Efficiency of the control equipment for the pollutant, and E is the actual emissions of the pollutant. Note: Activity and emission factor units are generalized and could be in units of mass or volume depending on the material being combusted.

Emissions calculated for a pollutant with a controlled emission factor origin (STACK TEST – AFTER CONTROL) use a controlled emission factor ($EF|_{Controlled}$) instead of an uncontrolled one as in Eq. I above. A controlled emission factor is simply the product of the uncontrolled emission factor and the overall efficiency of the control equipment as seen in the equation below:

$$EF|_{Controlled}\left[\frac{mass}{volume}\right] = EF|_{Uncontrolled}\left[\frac{mass}{volume}\right] * \left(1 - \frac{CE|_{overall}\,[\%]}{100}\right) \qquad \textit{Eq. II}$$

The previous two equations can be combined to calculate the controlled emissions for a pollutant as seen below:

$$E\left[\frac{mass}{time}\right] = A\left[\frac{volume}{time}\right] * EF|_{Controlled}\left[\frac{mass}{volume}\right] \qquad \textit{Eq. III}$$

Note: If the results of a stack test are used as a mathematical basis for the reported emission factor instead of reporting the actual results, then a stack test emission factor origin should still be used in lieu of other emission factor origins, such as "ENGINEERING JUDGMENT".

EMIT Emissions Statement Guidance Document:
Stack Test Emission Factor Origins and Particulate Matter (PM) Pollutants

Background of Particulate Matter:

Particulate matter (PM) is reported in EMIT as condensable (PM CON), filterable (PM FIL), and primary (PM PRI) particulate matter, where PM PRI is the sum of PM CON and PM FIL as seen in the following equation:

$$PM_{xx} \, PRI = PM_{xx} \, FIL + PM \, CON \qquad \text{Eq. IV}$$

Where xx is either 10 or 2.5 because PM FIL and PM PRI are reported in two sizes: particles with aerodynamic diameters less than or equal to 10 μm (PM_{10}) and 2.5 μm ($PM_{2.5}$). $PM_{2.5}$ is a subset of PM_{10} and EMIT requires that $PM_{2.5}$ be equal to or less than the value of PM_{10}.

Particulate matter pollutants in EMIT should have emission factors of either "STACK TEST – PRIOR CONTROL" or "STACK TEST – AFTER CONTROL" if the following DEEP approved stack tests have been conducted:

Pollutant	EPA Air Emission Measurement Center (EMC) Test Method(s) Needed to Properly Assign Emission Factor Origin as "STACK TEST…" in EMIT
PM_{10} Primary (PM_{10}-PRI)	Test Methods 5 and 202
PM_{10} Filterable (PM_{10}-FIL)	Test Method 5
$PM_{2.5}$ Primary ($PM_{2.5}$-PRI)	Test Methods 5, 201a, and 202
$PM_{2.5}$ Filterable ($PM_{2.5}$-FIL)	Test Methods 5 and 201a
PM Condensable (PM-CON)	Test Method 202

Calculation of Primary Particulate Matter Control Efficiency:

Because primary particulate matter is the combination of filterable and condensable particulate matter, it does not have a direct control efficiency. However, EMIT requires a control efficiency of primary particulate matter be included in emission calculations. This value must be derived to account for the actual control efficiencies of filterable and condensable particulate matter as seen below:

$$(CE \, of \, PM_{xx} \, PRI)|_{overall} \, [\%] = \left(1 - \frac{EF|_{PM_{xx} \, PRI \, Controlled} \left[\frac{mass}{volume} \right]}{EF|_{PM_{xx} \, PRI \, Uncontrolled} \left[\frac{mass}{volume} \right]} \right) * 100\% \qquad \text{Eq. V}$$

$EF|_{PM_{xx} \, PRI \, Controlled}$ and $EF|_{PM_{xx} \, PRI \, Uncontrolled}$ can both be determined by combining Equations II and IV, where $EF|_{PM_{xx} \, PRI \, Controlled}$ for a single process (SCC) takes the following form:

$$EF|_{PM_{xx} \, PRI \, Controlled} \left[\frac{mass}{volume} \right] = \begin{aligned} & EF|_{PM_{xx} \, FIL \, Uncontrolled} * \left(1 - \frac{CE|_{PM_{xx} \, FIL \, overall} \, [\%]}{100} \right) \\ & + EF|_{PM \, CON \, Uncontrolled} * \left(1 - \frac{CE|_{PM \, CON \, overall} \, [\%]}{100} \right) \end{aligned} \qquad \text{Eq. VI}$$

Emissions estimates must be entered into EMIT for each individual process, but control efficiencies are entered for an entire unit, which can be comprised of multiple processes. As such, the control efficiency for a unit should be calculated based on the emissions of all processes which use the control. Certain operational modes, such as startup, shutdown, and other non-normal operations, typically do not utilize controls and therefore should not be considered in the calculation of primary particulate matter control efficiency. While these processes should not be used to calculate the control efficiency, the emission factors for these processes will be affected by the control

efficiency due to the design of EMIT. To compensate for this, emissions associated with processes that do not use the control should have the emission factors adjusted to yield the correct final emission value.

Notes on Control Efficiency:

Control efficiencies should always be provided, even if reporting using the "STACK TEST – AFTER CONTROL" emission factor origin. The EPA requests this data because it is used to improve emission estimates.

Filterable particulate matter controls are applied to processes where significant benefit can be derived from the application of a control. For example, a filterable particulate matter control would be considered for a dirtier burning process such as waste, wood, etc., where a cleaner process such as the burning of natural gas would not be something that would warrant a control.

Condensable particulate matter is often not controlled and typically has a zero percent control efficiency.

Derivation of Control Efficiency for PM_{xx} Primary:

1) Begin with Equation V:

$$(\text{CE of PM}_{xx} \text{ PRI})|_{\text{overall}} = 1 - \frac{\text{EF}|_{PM_{xx} \text{ PRI Controlled}}}{\text{EF}|_{PM_{xx} \text{ PRI Uncontrolled}}}$$

2) Substitute in Equation IV:

$$(\text{CE of PM}_{xx} \text{ PRI})|_{\text{overall}} = 1 - \frac{\text{EF}|_{PM_{xx} \text{ FIL Controlled}} + \text{EF}|_{\text{PM CON Controlled}}}{\text{EF}|_{PM_{xx} \text{ FIL Uncontrolled}} + \text{EF}|_{\text{PM CON Uncontrolled}}}$$

3) Because the control efficiency of PM CON should be zero, Equation II states that $\text{EF}|_{\text{PM CON Controlled}}$ and $\text{EF}|_{\text{PM CON Uncontrolled}}$ are equivalent:

$$\text{EF}|_{\text{PM CON Controlled}} = \text{EF}|_{\text{PM CON Uncontrolled}} * [1 - (\text{CE of PM CON})|_{\text{overall}}]$$

$$\text{EF}|_{\text{PM CON Controlled}} = \text{EF}|_{\text{PM CON Uncontrolled}} * [1 - 0]$$

$$\text{EF}|_{\text{PM CON Controlled}} = \text{EF}|_{\text{PM CON Uncontrolled}}$$

4) Substitute in Equation II for $\text{EF}|_{PM_{xx} \text{ FIL Uncontrolled}}$ if using a PM Filterable emission factor with a "STACK TEST – AFTER CONTROL" origin:

$$(\text{CE of PM}_{xx} \text{ PRI})|_{\text{overall}} = 1 - \frac{\text{EF}|_{PM_{xx} \text{ FIL Controlled}} + \text{EF}|_{\text{PM CON}}}{\text{EF}|_{PM_{xx} \text{ FIL Controlled}} * [1 - (\text{CE of PM}_{xx} \text{ FIL})|_{\text{overall}}]^{-1} + \text{EF}|_{\text{PM CON}}}$$

5) In all other cases, substitute in Equation II for $\text{EF}|_{PM_{xx} \text{ FIL Controlled}}$:

$$(\text{CE of PM}_{xx} \text{ PRI})|_{\text{overall}} = 1 - \frac{\text{EF}|_{PM_{xx} \text{ FIL Uncontrolled}} * [1 - (\text{CE of PM}_{xx} \text{ FIL})|_{\text{overall}}] + \text{EF}|_{\text{PM CON}}}{\text{EF}|_{PM_{xx} \text{ FIL Uncontrolled}} + \text{EF}|_{\text{PM CON}}}$$

NOTE: EMIT only allows for two decimal places of precision in the control efficiency field.

How to Enter a Formula into EMIT as an Emission Factor for Uncontrolled PM$_{XX}$ PRI Instead of a Numeric Value:

Typically, Equation IV is true for both controlled and uncontrolled emission factors. In the event that the PM$_{XX}$ Primary control efficiency needed to be rounded to two decimal places to satisfy the EMIT input constraint, Equation IV for uncontrolled emission factors will no longer be true. Instead, the uncontrolled emission factors must be substituted in using Equation II. The following derivation is correct for any primary control efficiency, rounded or not:

1) Begin with Equation IV for controlled emission factors:

$$\text{EF}|_{\text{PM}_{xx}\text{ PRI Controlled}} = \text{EF}|_{\text{PM}_{xx}\text{ FIL Controlled}} + \text{EF}|_{\text{PM CON Controlled}}$$

2) Substitute in Equation II for PM$_{XX}$ Primary. Remember that $\text{EF}|_{\text{PM CON Controlled}} = \text{EF}|_{\text{PM CON Uncontrolled}}$ because the control efficiency of condensable particulate matter should be zero.

$$\text{EF}|_{\text{PM}_{xx}\text{ PRI Uncontrolled}} * \left(1 - \text{CE}|_{\text{PM}_{xx}\text{ PRI overall}}\right) = \text{EF}|_{\text{PM}_{xx}\text{ FIL Controlled}} + \text{EF}|_{\text{PM CON}}$$

   a. Also substitute for PM$_{XX}$ FIL using Equation II if the emission factor origin for PM$_{XX}$ FIL is not "STACK TEST – AFTER CONTROL".

3) Solve for $EF|_{PM_{xx}\ PRI\ Uncontrolled}$ and enter in the appropriate formula into EMIT:

$$\text{EF}|_{\text{PM}_{xx}\text{ PRI Uncontrolled}} = \frac{\text{EF}|_{\text{PM}_{xx}\text{ FIL Controlled}} + \text{EF}|_{\text{PM CON}}}{\left(1 - \text{CE}|_{\text{PM}_{xx}\text{ PRI overall}}\right)}$$

OR

$$\text{EF}|_{\text{PM}_{xx}\text{ PRI Uncontrolled}} = \frac{\text{EF}|_{\text{PM}_{xx}\text{ FIL Uncontrolled}} * \left(1 - \text{CE}|_{\text{PM}_{xx}\text{ FIL overall}}\right) + \text{EF}|_{\text{PM CON}}}{\left(1 - \text{CE}|_{\text{PM}_{xx}\text{ PRI overall}}\right)}$$

<u>Example</u>:

$\text{EF}|_{\text{PM}_{2.5}\text{ FIL Controlled}} = 0.0059 \frac{\text{lb PM}_{2.5}\text{ FIL}}{\text{ton Waste}}$ (Emission Factor Origin is "STACK TEST – AFTER CONTROL")

$\text{CE}|_{\text{PM}_{2.5}\text{ FIL overall}} = 99.9\%$

$\text{EF}|_{\text{PM CON}} = 0.0455 \frac{\text{lb PM CON}}{\text{ton Waste}}$

Solve for $\text{CE}|_{\text{PM}_{2.5}\text{ PRI overall}}$ using above derivation: $\text{CE}|_{\text{PM}_{xx}\text{ PRI overall}} = 99.13548\% \sim 99.14\%$

$\text{EF}|_{\text{PM}_{2.5}\text{ PRI Uncontrolled}}$ can be entered directly into EMIT as: $\frac{(0.0059+0.0455)}{(1-0.9914)}$

EMIT will perform the math for the user. Entering in an emission factor as a formula can be advantageous because it allows the viewer to see how emission factors were derived. In some instances, the math may not work correctly due to rounding errors in the programming. This can be resolved by adding a small value to the control efficiency in the denominator as such: 0.99140000001. DEEP encourages the user to add as many zeros before the one to as necessary to relieve the rounding issue.