PM Augmentation Procedures for the 1999 Point and Area Source NEI

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ABSTRACT

The 1999 National Emission Inventory (NEI) requires reporting of primary (PRI) PM10 and PM2.5 emissions for each emissions source of PM10 and PM2.5. In accordance with U.S. Environmental Protection Agency (EPA) guidance, State, Local, and Tribal (S/L/T) agencies may report either PRI or the filterable (FIL) and/or condensible (CON) fractions of either total PM, PM10, or PM2.5 emissions for Versions 2 and 3 of the NEI. As a result, most S/L/T inventories did not include both PM10-PRI and PM25-PRI emissions. PRI emissions are the sum of the FIL and CON fractions of PM10/PM2.5. Thus, EPA developed procedures to estimate FIL and CON emissions using the data supplied in S/L/T inventories. The FIL and CON emissions were then summed to estimate PM10-PRI and PM25-PRI emissions.

This paper explains the procedures developed to populate the NEI with PM10-PRI and PM25-PRI emissions using S/L/T data in conjunction with particle-size-specific emission factor data presented in AP-42 and the Factor Information REtrieval (FIRE) data system, the PM Calculator, and technology transfer.[1, 2, 3] This paper also explains the data bases developed to support the procedures and that S/L/T agencies may use in developing their 2002 base year inventories. In addition, the paper identifies the uncertainties in the emission estimation procedures that need improvement.

INTRODUCTION

Background

Final Version 2 of the 1999 NEI is the first national inventory where EPA carries both the FIL and the CON fractions of PM10 and PM2.5. In final Version 2 (and subsequent versions of the NEI), FIL and CON emissions are (will be) summed and reported as PRI emissions. In general, prior versions of the NEI include only FIL emissions (i.e., particles that are directly emitted as a solid or liquid at stack or release conditions and can be captured on the filter of a stack test train). PM-FIL may be PM2.5 or PM10 micrometers (μm). CON emissions include material that is vapor phase at stack conditions, but condenses and/or reacts upon cooling and dilution in the ambient air to form solid or liquid PM immediately after discharge from the stack. PM-CON is generally less than 1 μm in diameter and, therefore, included in the PM2.5 fraction of PM. Including CON emissions in the NEI provides more complete coverage of PM-related pollutants in the small size fractions that can better support air quality analyses for the fine PM National Ambient Air Quality Standard and the federal regional haze rule.

Purpose

This paper explains the methods EPA developed to populate Version 2 of the NEI with PM10-PRI, PM10-FIL, PM25-PRI, PM25-FIL, and PM-CON emissions missing from S/L/T inventories. The paper also presents the results, and identifies several limitations to the methods for which improvements are needed in future versions of the NEI. S/L/T agencies may use this information to develop their own methods for including the complete set of PM10 and PM2.5 emissions in their 2002 base year inventories.

METHODOLOGY

Point Sources

The NEI requires reporting of PM10-PRI and PM25-PRI emissions, which is the sum of the FIL and CON fractions of PM10/PM2.5, for each emissions source. However, S/L/T agencies generally did not report the CON fraction and the PM25-FIL fraction. This augmentation procedure uses the pollutant emissions in S/L/T inventories to estimate emissions for the pollutants missing in S/L/T inventories (i.e., PM10-PRI, PM10-FIL, PM25-PRI, PM25-FIL, or PM-CON).

Figure 1 provides a flow diagram of the procedures for calculating PM10/PM2.5. The procedures take advantage of the PM Calculator which calculates uncontrolled and controlled PM10-FIL and PM25-FIL emissions using either uncontrolled PM-FIL or PM10-FIL emissions as inputs. For controlled sources, up to two control devices can be used as input to the PM Calculator. The procedures start with S/L/T-agency supplied PM-PRI, PM-FIL, PM10-PRI, or PM10-FIL emissions by Source Classification Code (SCC) and control device which are prepared for input to the PM Calculator. The PM Calculator is run to estimate PM10-FIL and PM25-FIL emissions for the specified SCC and control device combinations provided in S/L/T inventories. Emission factor ratios, developed from AP-42 and FIRE particle-size-specific emission factors, are applied to PM10-FIL emissions to estimate PM-CON emissions. The PM-CON emissions are then summed with PM10-FIL and PM25-FIL to estimate PM10-PRI and PM25-PRI emissions. The procedures are broken down into the following steps:

Step 1. Identify and resolve QA issues with PM-related pollutants in S/L/T inventories;
Step 2. Prepare S/L/T PM and PM10 Emissions for Input to the PM Calculator;
Step 3. Develop and apply source-specific factors to convert S/L/T-supplied PM-PRI to PM-FIL or PM10-PRI to PM10-FIL based on uncontrolled data;
Step 4. Prepare factors from PM Calculator;
Step 5: Develop and apply algorithms to estimate emissions from S/L/T inventory data; and
Step 6: Review results and update the NEI with emission estimates and control information.

If a S/L/T inventory provided only PM25-FIL, PM25-PRI, or PM-CON emissions, ratios were developed from generic output of the PM Calculator (Step 4) to back-calculate PM10-FIL or PM10-PRI emissions.

Step 1: Identify and Resolve QA Issues with PM-related Pollutants in S/L/T Inventories

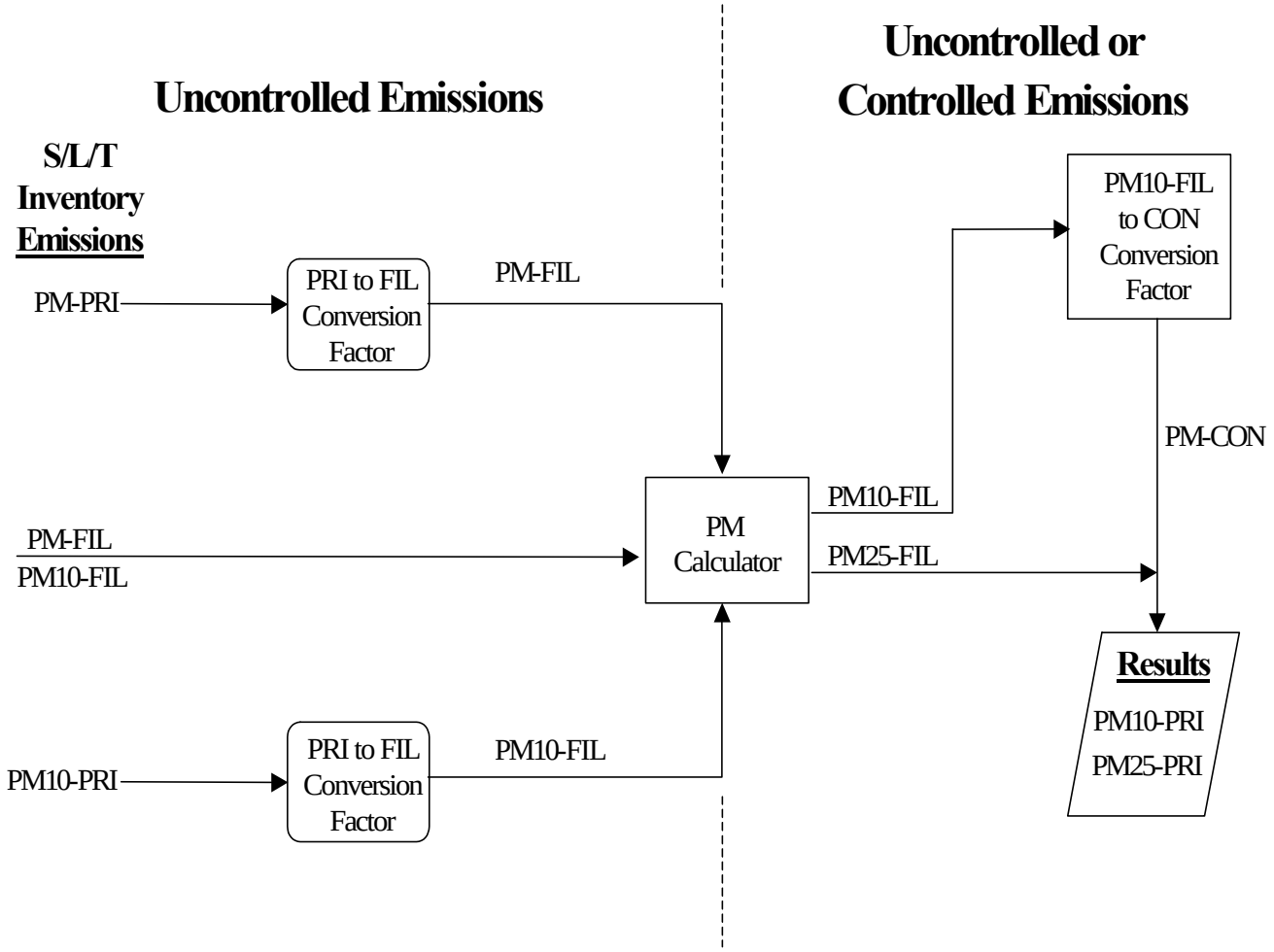
S/L/T inventories were reviewed to identify inconsistent reporting of PM-related pollutant emissions. If a S/L/T agency was unable to provide corrections, the following rules were applied to correct issues:

If PM25-FIL > PM10-FIL and PM10-FIL is not null or zero, set PM25-FIL = PM10-FIL.
If PM25-PRI > PM10-PRI and PM10-PRI is not null or zero, set PM25-PRI = PM10-PRI.

Control device codes in S/L/T inventories that did not comply with NEI Input Format (NIF) Version 2.0 codes were corrected to NIF 2.0 codes if possible, or replaced with the miscellaneous control device code 099.

SCCs in S/L/T inventories that did not appear in EPA's master list of SCCs were changed to a generic SCC code of 79900101 for point and 2999001001 for area sources. These SCCs were excluded from the PM augmentation procedures.

Figure 1. Procedures for calculating PM2.5 and PM10 emissions for the NEI.



Step 2: Prepare S/L/T PM-related Emissions for Input to the PM Calculator

The second step involved back-calculating uncontrolled emissions for controlled sources to prepare the emissions for input to the PM Calculator. Initially, the control efficiencies included in S/L/T inventories were used to back-calculate uncontrolled emissions. However, this approach resulted in inconsistent results for the following reasons:

1) The PM Calculator uses default, particle-size-specific control efficiencies from AP-42 for each SCC and control device type or combination of two control devices in series. The default control efficiencies are applied to the uncontrolled emissions to calculate controlled PM10-FIL and PM25-FIL emissions. Because the S/L/T control efficiency data typically did not match the default control efficiencies in the PM Calculator, the PM Calculator produced estimates for PM25-FIL in some cases that were higher than the PM10-FIL emissions included in S/L/T inventories.
2) Some S/L/T inventories contained control device codes but did not report control efficiency data for the control devices, or reported efficiencies of 100% for emission sources with emissions above zero.

Thus, the default control efficiencies in the PM Calculator were used to back-calculate uncontrolled emissions by SCC and control device code. Using the default control efficiencies in the PM Calculator ensured that the calculator produced the same PM10-FIL emission values reported in a S/L/T inventory, and provided a consistent basis for estimating PM25-FIL and PM-CON emissions from S/L/T PM10-FIL emissions.

The PM Calculator does not include particle-size profiles for several control devices for which S/L/T agencies reported PM or PM10 emissions. Therefore, records with control devices not in the PM Calculator were matched with similar control devices in the PM Calculator. The matching of control devices in S/L/T inventories to those in the PM Calculator is provided with the documentation for draft Version 3 of the criteria pollutant NEI.[4]

Step 3: Develop and Apply Source-specific Conversion Factors

Step 3 involved preparing SCC-specific factors to convert uncontrolled emissions from PM-PRI to PM-FIL or PM10-PRI to PM10-FIL for input to the PM Calculator. In addition, this step also involved developing factors to calculate PM-CON emissions from PM10-FIL emissions either supplied by S/L/T agencies or estimated by the PM Calculator.

The conversion factors were calculated with the following equations:

$\text{PM-PRI}_{\text{S/L/T}} \rightarrow \text{PM-FIL}$:

$$\text{PM-PRI}_{\text{S/L/T}} \times \left(\frac{\text{PM-FIL}_{\text{AP-42 or FIRE}}}{\text{PM-PRI}_{\text{AP-42 or FIRE}}} \right) = \text{PM-FIL}_{\text{S/L/T}}, \text{ conversion factor is } \left(\frac{\text{PM-FIL}_{\text{AP-42 or FIRE}}}{\text{PM-PRI}_{\text{AP-42 or FIRE}}} \right) \quad (1)$$

$\text{PM10-PRI}_{\text{S/L/T}} \rightarrow \text{PM10-FIL}$:

$$\text{PM10-PRI}_{\text{S/L/T}} \times \left(\frac{\text{PM10-FIL}_{\text{AP-42 or FIRE}}}{\text{PM10-PRI}_{\text{AP-42 or FIRE}}} \right) = \text{PM10-FIL}_{\text{S/L/T}}, \text{ conversion factor is } \left(\frac{\text{PM10-FIL}_{\text{AP-42 or FIRE}}}{\text{PM10-PRI}_{\text{AP-42 or FIRE}}} \right) \quad (2)$$

$\text{PM10-FIL}_{\text{S/L/T}} \rightarrow \text{PM-CON}$:

$$\text{PM10-FIL}_{\text{S/L/T}} \times \left(\frac{\text{PM-CON}_{\text{AP-42 or FIRE}}}{\text{PM10-FIL}_{\text{AP-42 or FIRE}}} \right) = \text{PM-CON}_{\text{S/L/T}}, \text{ conversion factor is } \left(\frac{\text{PM-CON}_{\text{AP-42 or FIRE}}}{\text{PM10-FIL}_{\text{AP-42 or FIRE}}} \right) \quad (3)$$

With these conversion factors and the PM Calculator, all of the needed emissions values can be produced from S/L/T agency-submitted inputs for each SCC and control device combination. The uncontrolled conversion factors are provided with the documentation for draft Version 3 of the criteria pollutant NEI.[4]

Conversion Factors for Stationary External and Internal Combustion Sources (SCCs Starting with 1 and 2)

The emission factors and supporting data available in Chapters 1 and 3 of AP-42 were used to prepare conversion factors for stationary external and internal combustion sources. All AP-42 emission factors that were not specified as being CON, FIL, or PRI were assumed to be FIL.

For each SCC for which uncontrolled emission factors were available, the emission factors were converted to common units to calculate ratios. For combustion sources, the common unit is pounds of pollutant per million British thermal units (lb/MMBtus). For coal emission factors, sulfur content was always assumed to be 1%, and ash content was always assumed to be 8%.

An example of calculating conversion factors from AP-42 for SCC 10100201 with no controls is as follows:

PM Category	Emission Factor (lb/MMBtu)	AP-42 Page No.
PM10-FIL	0.8	1.1-21
PM-FIL	2.1538	1.1-21
PM-CON[a]	0.07	1.1-24
PM-PRI	2.2238 (2.1538 + 0.07)	
PM10-PRI	0.87 (0.8 + 0.07)	

[a] Since the value applied to "All PM controls (without FGD controls)" this value was assumed to apply to uncontrolled emissions as well.

(PM-PRI$_{S/L/T}$ → PM - FIL) conversion factor:

$$\frac{\text{PM - FIL}_{AP-42}}{\text{PM - PRI}_{AP-42}} = \frac{2.1538 \frac{lb}{MMBtu}}{2.2238 \frac{lb}{MMBtu}} = 0.9685$$

(PM10 - PRI$_{S/L/T}$ → PM10-FIL) conversion factor:

$$\frac{\text{PM10-FIL}_{AP-42}}{\text{PM10 - PRI}_{AP-42}} = \frac{0.8 \frac{lb}{MMBtu}}{0.87 \frac{lb}{MMBtu}} = 0.9195$$

(PM10 - FIL$_{S/L/T}$ → PM-CON) conversion factor:

$$\frac{\text{PM - CON}_{AP-42}}{\text{PM10 - FIL}_{AP-42}} = \frac{0.07 \frac{lb}{MMBtu}}{0.8 \frac{lb}{MMBtu}} = 0.0875$$

AP-42 does not contain comprehensive data for each 8-digit SCC that is a source of PM10 and PM2.5 emissions. Thus, for 8-digit SCCs for which an emission factor for a specific PM form (e.g., PM10-FIL) was not available, average values were calculated for the first 6 digits of the SCC. For example, uncontrolled SCC 10100212 has no PM-CON emission factor in AP-42; therefore, its PM-CON value was assumed to be the average of the 11 SCCs in AP-42 that begin with "101002" and have a PM-CON emission factor. For this example, the PM-CON emission factors for the 11 SCCs were summed and divided by 11 to calculate an average PM-CON emission factor of 0.054545 lb/MMBtu. The average PM-CON emission factor was divided by the PM10-FIL emission factor of 0.7077 lb/MMBtu for SCC 10100212 to obtain the PM-CON to PM10-FIL ratio of 0.0771. If emission factors were not available at the 6-digit SCC level, then average emission factors were calculated based on the next level (i.e., 5, 4, 3, 2, and 1 digit levels) for which they were available.

Analysis of the factors presented in Chapters 1 and 3 of AP-42 revealed that Flue Gas Desulfurization (FGD), NEI control device code 039, was the only control that affected the PM-CON value. For all other control devices, the PM-CON conversion factor is the same for both uncontrolled and controlled PM emissions. For this control only, a separate controlled factor was prepared to estimate PM-CON from uncontrolled PM10-FIL. Analysis of the State data revealed that FGD controls occurred for SCCs 10100202, 10100222, and 10100501. The average emission factor value of 0.02 lb/MMBtu for SCCs that begin with "10100" was used to estimate controlled PM-CON from uncontrolled PM10-FIL emissions.

Once the necessary gaps had been filled, conversion factors were calculated by using Equations (1), (2), and (3). The conversion factors for uncontrolled PM10-FIL to controlled PM-CON for an FGD control were calculated by using Equation (3), but substituting in the controlled PM-CON value.

Conversion Factors for Industrial Processes (SCCs Starting with 3)

The procedures for preparing conversion factors for SCCs starting with 3 are similar to those for SCCs starting with 1 and 2. However, fewer particle-size-specific emission factors are available and the units of the emission factors vary considerably more for SCCs starting with 3. Thus, for example, factors developed for an SCC for natural gas burned in an industrial boiler cannot be applied to an industrial process burning natural gas because of the differences in the emission factor units. The procedures for SCCs relied on the use of particle-size-specific emission factors for specific source categories when available in FIRE and AP-42.

For SCCs that did not have enough information in FIRE or AP-42 to calculate conversion factors, the generic weight percent PM profiles in AP-42 were used to calculate conversion factors. The generic PM profile information is located in Appendix B.1, Appendix B.2, and the individual sections of AP-42. If the relative percent composition of PM emissions for a group of similar SCCs (i.e., processes) is known, then conversion factors were calculated for that group of SCCs based on the percentages.

Using the generic PM profiles, the following assumptions were applied:

- Emissions less than or equal to 1 μm are PM-CON emissions.
- Emissions less than or equal to 10 μm are PM10-PRI emissions (since they include emissions less than or equal to 1 μm as well).
- The weight percent for PM-PRI will always be 100%.
- PM-FIL and PM10-FIL weight percentages can be derived by subtracting the PM-CON from the PM-PRI and PM10-PRI weight percentage values, respectively.

The compilation of generic PM profiles resulted in two distinct types of profiles. Some of the PM profiles originated from specific sections of AP-42 and were SCC specific. Other PM profiles originated from the generic profiles found in Appendices B.1 and B.2 of AP-42. These profiles were applied at the more general, 6-digit SCC level. If AP-42 assigned a source category to more than one profile, the average weight percent values of all the profiles were used for the cumulative weight percent of PM that was less than 1 μm and less than 10 μm.

After compiling the generic PM profiles from AP-42, there was still a large number of SCCs beginning with 3 that did not have an attributed profile. To account for these SCCs, the first step was to further augment the 6-digit generic PM profiles. This was accomplished by using the average of the 8-digit generic PM profiles where they had the first 6 digits in common and those 6 digits were not already accounted for by a 6-digit generic PM profile.

The next step was averaging of the 6-digit PM generic profiles to produce more general PM profiles to account for even more SCCs. For example, the following 6-digit SCCs were used to produce a profile for the 5-digit SCC “30101" via averaging:

SCC	Cumulative % ≤10 μm	Cumulative % ≤1 μm
301012	51	4
301014	85	6
301015	85	6
301019	94	60
30101	**78.75**	**19**

Following this methodology, generic PM profiles at the 5, 4, 3, 2, and 1-digit level were derived from the 6-digit generic PM profiles.

Once completed, the generic profile information was then mapped to the appropriate SCCs beginning with 3. Those SCCs with complete PM information in FIRE and SCCs with 8-digit profiles

were excluded from the mapping process. The process started at the 6-digit SCC level and ended at the 1-digit SCC level. If an SCC had its first 6-digits matched to a 6-digit SCC PM generic profile, then it was considered to have the PM percentage composition of that generic profile. For instance, SCC 30101202, Chemical Manufacturing of Hydroflouric Acid (Rotary Kiln: Acid Reactor), was assumed to have the percentage composition of the generic "301012" PM profile from Appendix B.2: 51% is less than or equal to10 μm and 4% is less than or equal to1 μm. If the SCC did not match on the 6-digit level, then a match was attempted at the 5-digit level. The process was continued to the 4-digit, 3-digit, 2-digit, and even 1-digit level until a match was made.

Once all of the SCCs beginning with 3 had a PM profile in place, the conversion factors were calculated using the following equations:

Conversion Factor from PM-PRI to PM-FIL:

$$\frac{\text{PM-FIL}_{\text{AP-42}}}{\text{PM-PRI}_{\text{AP-42}}} = \frac{100\% - (\text{Cumulative \% } \le 1\ \textit{m}\text{m})}{100\%} \qquad (4)$$

Conversion Factor from PM10-PRI to PM10-FIL:

$$\frac{\text{PM10-FIL}_{\text{AP-42}}}{\text{PM10-PRI}_{\text{AP-42}}} = \frac{(\text{Cumulative \% } \le 10\ \textit{m}\text{m}) - (\text{Cumulative \% } \le 1\ \textit{m}\text{m})}{(\text{Cumulative \% } \le 10\ \textit{m}\text{m})} \qquad (5)$$

Conversion Factor from PM10-FIL to PM-CON:

$$\frac{\text{PM-CON}_{\text{AP-42}}}{\text{PM10-FIL}_{\text{AP-42}}} = \frac{(\text{Cumulative \% } \le 1\ \textit{m}\text{m})}{(\text{Cumulative \% } \le 10\ \textit{m}\text{m}) - (\text{Cumulative \% } \le 1\ \textit{m}\text{m})} \qquad (6)$$

Utilizing these equations, the conversion factors for SCC 30101202 is as follows:

Conversion Factor from PM-PRI to PM-FIL:

$$\frac{\text{PM-FIL}_{\text{AP-42}}}{\text{PM-PRI}_{\text{AP-42}}} = \frac{100\% - 4\%}{100\%} = 0.96$$

Conversion Factor from PM10-PRI to PM10-FIL:

$$\frac{\text{PM10-FIL}_{\text{AP-42}}}{\text{PM10-PRI}_{\text{AP-42}}} = \frac{51\% - 4\%}{51\%} = 0.92$$

Conversion Factor from PM10-FIL to PM-CON:

$$\frac{\text{PM-CON}_{\text{AP-42}}}{\text{PM10-FIL}_{\text{AP-42}}} = \frac{4\%}{51\% - 4\%} = 0.085$$

Conversion Factors for Petroleum and Solvent Evaporation (SCCs Starting with 4)

PM-CON emissions were estimated for coating oven heaters and fuel-fired equipment used in surface coating operations. Because of the lack of data for estimating PM-CON emissions for these sources, conversion factors for electric utility external combustion boilers were used as surrogate factors. Fuel type was used to match the conversion factors for external combustion boilers to the SCCs for coating oven heaters and fuel-fired equipment.

Conversion Factors for Solid Waste Disposal (SCCs Starting with 5)

For the Solid Waste Disposal category, PM-PRI, PM10-PRI, or PM-CON emissions factors were not available in AP-42. Because of the lack of particle-size-specific emission factors, average emission factors for External Combustion Sources and Stationary Internal Combustion Sources were used. The

average values used (displayed below in lbs/MMBtu) were those calculated directly from information presented in AP-42.

Average Values Used for Solid Waste Disposal Conversion Factor Calculations

PM Category	Average Emissions Factor (lb/MMBtu)
PM-FIL	1.0728
PM10-FIL	0.3383
PM-CON	0.0342

Conversion factors were calculated as follows:

($\text{PM-PRI}_{\text{STATE}} \rightarrow \text{PM-FIL}_{\text{STATE}}$) conversion factor:

$$\frac{\text{PM-FIL}_{\text{AP-42}}}{\text{PM-PRI}_{\text{AP-42}}} = \frac{1.0728 \ \frac{\text{lb}}{\text{MMBtu}}}{1.0728 \ \frac{\text{lb}}{\text{MMBtu}} + 0.0342 \ \frac{\text{lb}}{\text{MMBtu}}} = 0.9691$$

($\text{PM10-PRI}_{\text{STATE}} \rightarrow \text{PM10-FIL}_{\text{STATE}}$) conversion factor:

$$\frac{\text{PM10-FIL}_{\text{AP-42}}}{\text{PM10-PRI}_{\text{AP-42}}} = \frac{0.3383 \ \frac{\text{lb}}{\text{MMBtu}}}{0.3383 \ \frac{\text{lb}}{\text{MMBtu}} + 0.0342 \ \frac{\text{lb}}{\text{MMBtu}}} = 0.9082$$

($\text{PM10-FIL}_{\text{STATE}} \rightarrow \text{PM-CON}_{\text{STATE}}$) conversion factor:

$$\frac{\text{PM-CON}_{\text{AP-42}}}{\text{PM10-FIL}_{\text{AP-42}}} = \frac{0.0342 \ \frac{\text{lb}}{\text{MMBtu}}}{0.3383 \ \frac{\text{lb}}{\text{MMBtu}}} = 0.1011$$

Step 4: Prepare Factors from PM Calculator

S/L/T inventory data for PM/PM10/PM2.5 emissions include thousands of records. The NEI is prepared in a large Oracle data base in NIF 2.0. Consequently, because the PM Calculator is a computer desk-top tool, the PM Calculator could not be used to efficiently process the thousands of records of data in the NEI. Therefore, the PM Augmentation procedure was conducted in Oracle. Oracle scripts were written to use the underlying particle size data in the PM Calculator to produce uncontrolled and controlled emissions for every SCC and control device combination available in the PM Calculator. The scripts estimated PM10-FIL and PM25-FIL emissions using 100 tons of uncontrolled PM-FIL as input to the calculator. The emissions output was then used to prepare ratios to apply to S/L/T inventory data. The database containing the emissions output is provided with the documentation for draft Version 3 of the criteria pollutant NEI.[4]

Step 5: Develop and Apply Algorithms to Estimate Emissions from S/L/T Inventory Data

The S/L/T data were grouped to determine the different combinations of pollutants S/L/T submitted for individual process (SCC) and control device combinations. A total of 14 groups of data were identified, and some of the groups were further divided into uncontrolled and controlled scenarios. Table 1 identifies the 14 groups of data supplied by S/L/T agencies. For each group of data, the second column of Table 1 identifies the pollutant used as input to each algorithm; all of the pollutants supplied for a process are listed in parenthesis. The third column identifies the control status, and the fourth column identifies the algorithms applied to estimate emissions for missing pollutants. Note that,

Table 1. Algorithms applied to estimate PM10 and PM2.5 emissions missing from S/L/T inventories using data supplied by S/L/T agencies, conversion factors, and factors derived form the PM calculator.

Group Number	S/L/T Supplied Data for a Specific Emission Process[1]	Control Status	Algorithms for Calculating Missing Pollutants[2]
1	pm25pri (pmpri, pm25pri)	Uncontrolled	pm25fil = pm25pri * pm10pri_to_pm10fil, pm10fil = pm25fil * (pmcalc_pm10fil_uncontrolled / pmcalc_pm25fil_uncontrolled), pmcon = pm25pri - pm25fil
1	pm25pri (pmpri, pm25pri)	Controlled	pm25fil = pm25pri * pm10pri_to_pm10fil, pm10fil = pm25fil * (pmcalc_pm10fil_controlled / pmcalc_pm25fil_controlled), pmcon = pm25pri - pm25fil
2	pm25fil (pmfil, pm25fil)	Uncontrolled	pm10fil = pm25fil * (pmcalc_pm10fil_uncontrolled / pmcalc_pm25fil_uncontrolled), pmcon = pm10fil * pm10fil_to_pmcon
2	pm25fil (pmfil, pm25fil)	Controlled	pm10fil = pm25fil * (pmcalc_pm10fil_controlled / pmcalc_pm25fil_controlled), pmcon = pm10fil * pm10fil_to_pmcon
3	pm10pri (pmpri, pm10pri)	Uncontrolled	pm10fil = pm10pri * pm10pri_to_pm10fil, pmcon = pm10pri - pm10fil, pm25fil = pm10fil * (pmcalc_pm25fil_uncontrolled / pmcalc_pm10fil_uncontrolled)
3	pm10pri (pmpri, pm10pri)	Controlled	pm10fil = pm10pri * pm10pri_to_pm10fil, pmcon = pm10pri - pm10fil, pm25fil = pm10fil * (pmcalc_pm25fil_controlled / pmcalc_pm10fil_controlled)
4	pm10pri and pm25pri (pmpri, pm10pri, pm25pri)	Uncontrolled, Controlled	pm10fil = pm10pri * pm10pri_to_pm10fil, pmcon = pm10pri - pm10fil, pm25fil = pm25pri - (pm10pri - pm10fil)
5	pm10fil (pmfil, pm10fil)	Uncontrolled	pmcon = pm10fil * pm10fil_to_pmcon, pm25fil = pm10fil * (pmcalc_pm25fil_uncontrolled / pmcalc_pm10fil_uncontrolled)
5	pm10fil (pmfil, pm10fil)	Controlled	pmcon = pm10fil * pm10fil_to_pmcon, pm25fil = pm10fil * (pmcalc_pm25fil_controlled / pmcalc_pm10fil_controlled)
6	pm10fil and pm25fil (pmfil, pm10fil, pm25fil)	Uncontrolled, Controlled	pmcon = pm10fil * pm10fil_to_pmcon
7	pmpri	Uncontrolled	pm10fil = pmpri * pmpri_to_pmfil * (pmcalc_pm10fil_uncontrolled / pmcalc_pmfil_uncontrolled), pmcon = pmfil * pm10fil_to_pmcon, pm25fil = pmpri * pmpri_to_pmfil * (pmcalc_pm25fil_uncontrolled / pmcalc_pmfil_uncontrolled)
7	pmpri	Controlled	pm10fil = pmpri * pmpri_to_pmfil * (pmcalc_pm10fil_controlled / pmcalc_pm10fil_uncontrolled), pmcon = pm10fil * pm10fil_to_pmcon, pm25fil = pmpri * pmpri_to_pmfil * (pmcalc_pm25fil_controlled / pmcalc_pmfil_uncontrolled)
8	pmfil	Uncontrolled	pm10fil = pmfil * (pmcalc_pm10fil_uncontrolled / pmcalc_pmfil_uncontrolled), pmcon = pm10fil * pm10fil_to_pmcon, pm25fil = pmfil * (pmcalc_pm25fil_uncontrolled / pmcalc_pmfil_uncontrolled)
8	pmfil	Controlled	pm10fil = pmfil * (pmcalc_pm10fil_controlled / pmcalc_pm10fil_uncontrolled), pmcon = pm10fil * pm10fil_to_pmcon, pm25fil = pmfil * (pmcalc_pm25fil_controlled / pmcalc_pmfil_uncontrolled)
9	pmcon	Uncontrolled	pm10fil = pmcon * (1 / (pm10fil_to_pmcon)) , pm25fil = pm10fil * (pmcalc_pm25fil_uncontrolled / pmcalc_pm10fil_uncontrolled)
9	pmcon	Controlled	pm10fil = pmcon * (1 / (pm10fil_to_pmcon)) , pm25fil = pm10fil * (pmcalc_pm25fil_controlled / pmcalc_pm10fil_controlled)
10	pmcon and pm10fil (pmcon, pmfil, pm10fil)	Uncontrolled	pm25fil = pm10fil * (pmcalc_pm25fil_uncontrolled / pmcalc_pm10fil_uncontrolled)
10	pmcon and pm10fil (pmcon, pmfil, pm10fil)	Controlled	pm25fil = pm10fil * (pmcalc_pm25fil_controlled / pmcalc_pm10fil_controlled)
11	pmcon, pm10fil, and pm25fil (pmcon, pmfil, pm10fil, and pm25fil)	Controlled	Do nothing for group 11
12	pmcon, pmfil, and pm25fil	Uncontrolled	pm10fil = pm25fil * (pmcalc_pm10fil_uncontrolled / pmcalc_pm25fil_uncontrolled)
12	pmcon, pmfil, and pm25fil	Controlled	pm10fil = pm25fil * (pmcalc_pm10fil_controlled / pmcalc_pm25fil_controlled)
13	pm10fil and pm10pri	Uncontrolled	pm25fil = pm10fil * (pmcalc_pm25fil_uncontrolled / pmcalc_pm10fil_uncontrolled), pmcon = pm10pri - pm10fil

Table 1. (continued)

Group Number	S/L/T Supplied Data for a Specific Emission Process[1]	Control Status	Algorithms for Calculating Missing Pollutants[2]
13	pm10fil and pm10pri	Controlled	pm25fil = pm10fil * (pmcalc_pm25fil_controlled / pmcalc_pm10fil_controlled), pmcon = pm10pri - pm10fil
14	pm10fil, pm10pri, and pm25fil (pm10fil, pm10pri, pm25fil, and pm25pri)	Uncontrolled, Controlled	pmcon = pm10pri - pm10fil

[1] The pollutant used in the algorithm as the starting point for calculating emissions for missing pollutants is listed first. The pollutants in parenthesis identify the pollutants for which a S/L/T agency provided emissions and control information for an individual emissions process.

[2] The term "pmcalc_" identify factors developed by dividing emissions output data from the PM Calculator. The following terms identify the conversion factors discussed in Steps 2 and 4 of the text: pmpri_to_pmfil, pm10pri_to_pm10fil, and pm10fil_to_pmcon. Factors to convert pm25pri to pm25fil were not developed; therefore, S/L/T supplied pm25pri emissions were converted to pm25fil emissions using the conversion factors for pm10pri_to_pm10fil.

although not shown in the fourth column in Table 1, the procedure sums PM10-FIL and PM-CON to estimate PM10-PRI, and sums PM25-FIL and PM-CON to estimate PM25-PRI.

For example, Group 1 identifies emission processes for which S/L/T agencies supplied uncontrolled PM-PRI and PM25-PRI emissions. For this group, PM25-PRI emissions are used as the starting point in the algorithms to calculate uncontrolled PM25-FIL, PM10-FIL, and PM-CON emissions. The following equation was used to estimate PM25-FIL emissions from PM25-PRI emissions for a given SCC:

pm25fil = pm25pri * pm10pri_to_pm10fil

In this equation, PM25-PRI emissions are from the S/L/T inventory. The term “pm10pri_to_pm10fil” identifies where the conversion factor (SCC specific) was used to calculate PM25-FIL from PM25-PRI. Factors to convert PM25-PRI to PM25-FIL were not developed; therefore, S/L/T-supplied PM25-PRI emissions were converted to PM25-FIL emissions using the conversion factors for PM10-PRI to PM10-FIL.

The following equation was used to estimate PM10-FIL emissions:

pm10fil = pm25fil * (pmcalc_pm10fil_uncontrolled / pmcalc_pm25fil_uncontrolled)

In this equation, PM25-FIL calculated from the previous equation is multiplied by the term “pmcalc_pm10fil_uncontrolled / pmcalc_pm25fil_uncontrolled” which identifies the fields from the PM Calculator output file used to calculate a ratio to adjust uncontrolled PM25-FIL emissions to uncontrolled PM10-FIL emissions.

The following equation is then used to estimate PM-CON emissions by subtracting calculated PM25-FIL emissions from S/L/T-supplied PM25-PRI emissions.

pmcon = pm25pri - pm25fil

For the Group 1 controlled scenario, the equations are the same as those for the uncontrolled scenario except that the controlled emission fields in the PM Calculator output file are used to adjust controlled PM25-FIL emissions to controlled PM10-FIL emissions for each SCC and control device combination.

Step 6: Review results and Update the NEI with Emission Estimates and Control Information

After completing the emission estimates for pollutants missing from S/L/T inventories, the emission estimates are compared to the S/L/T inventory data to identify data issues. For example, the procedures resulted in negative PM2.5 emissions for a small number of emission units even though the algorithms key off of S/L/T-supplied emissions for other PM pollutants. For these records, negative values are set to zero.

The PM10-FIL to PM-CON conversion factors were developed using uncontrolled emission factors or particle-size data. However, when the factors were applied to uncontrolled PM10-FIL emissions that were back-calculated using control efficiencies, the PM-CON emissions and resulting PM10-PRI and PM25-PRI emissions were overestimated considerably for some processes. As a result, EPA applied the conversion factors to controlled PM10-FIL emissions even if an emission source was controlled.

S/L/T-supplied PM10-PRI, PM10-FIL, PM25-PRI, PM25-FIL, and PM-CON emissions are maintained in the NEI. Records generated for missing pollutants by the augmentation procedure are inserted into the Emission table and populated with the pollutant code and annual estimated emissions. Data Source flags are used to identify the source of the data. For example, if the data record is from a State submittal, the data flag is "S". If the data record is generated by the PM augmentation procedure, the data flag is "AUG-C". If an emission source is controlled, records for the missing pollutants were inserted into the Control Equipment table and populated with the pollutant code, overall control efficiency, and control device codes from the PM Calculator. Thus, for a given emission source, the control efficiencies and control device codes associated with S/L/T-supplied pollutants may be different from the pollutants generated by the augmentation procedure and added to the Control Equipment table. This decision was made in order to report the control efficiencies and control device codes upon which the augmented emission estimates are based. Note that control equipment records were not added for PM-CON emissions.

Area Sources

The methods for area sources are different for sources that have only FIL emissions versus sources that have CON and FIL or only CON emissions. After reviewing the AP-42 and FIRE emission factors for area sources of CON emissions, it was determined that emission factors were not available to develop ratios to calculate CON emissions from the various forms of PM emissions included in S/L/T inventories. Therefore, the SCCs were mapped to similar point source SCCs for which the PM Calculator was used to estimate FIL emissions, and for which a factor was available for estimating PM-CON from PM10-FIL emissions. For example, area source SCC 2103006000 (Commercial/ Institutional/Natural Gas/Total: Boilers and IC Engines) was mapped to point source SCC 10300602 (Commercial/ Institutional/Natural Gas/10-100 Million Btu/hr).[5] For area sources that have only FIL emissions, EPA developed ratios of emission factors from FIRE, AP-42, speciation profiles, and used the S/L/T emissions data to estimate emissions for the PM-related pollutants missing from S/L/T inventories. The mapping of the area source SCCs with FIL and CON emissions, and the ratios applied to other SCCs with only FIL emissions, is provided with the documentation report for draft Version 3 of the criteria pollutant NEI.[5]

RESULTS

Final Version 2 of the 1999 NEI is the first national inventory to which EPA added CON emissions. Figure 2 compares PM10-PRI, PM10-FIL, PM25-PRI, PM25-FIL, and PM-CON emissions in final Version 2 of the point source NEI. CON emissions account for 29% of total PM10-PRI emissions and 42% of total PM25-PRI emissions.

Figure 3 PM10-PRI, PM10-FIL, PM25-PRI, PM25-FIL, and PM-CON emissions in final Version 2 of the point source NEI. CON emissions account for 1% of total PM10-PRI emissions and

Figure 2. National annual emissions from point source NEI version 2.

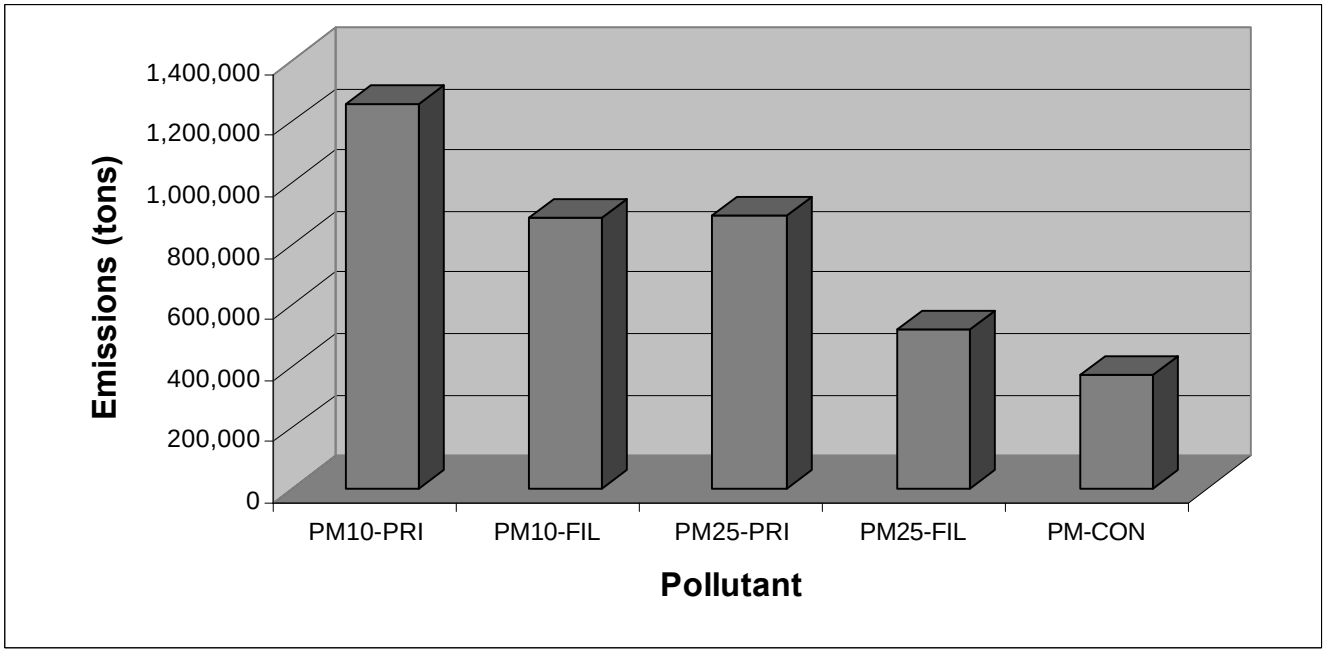
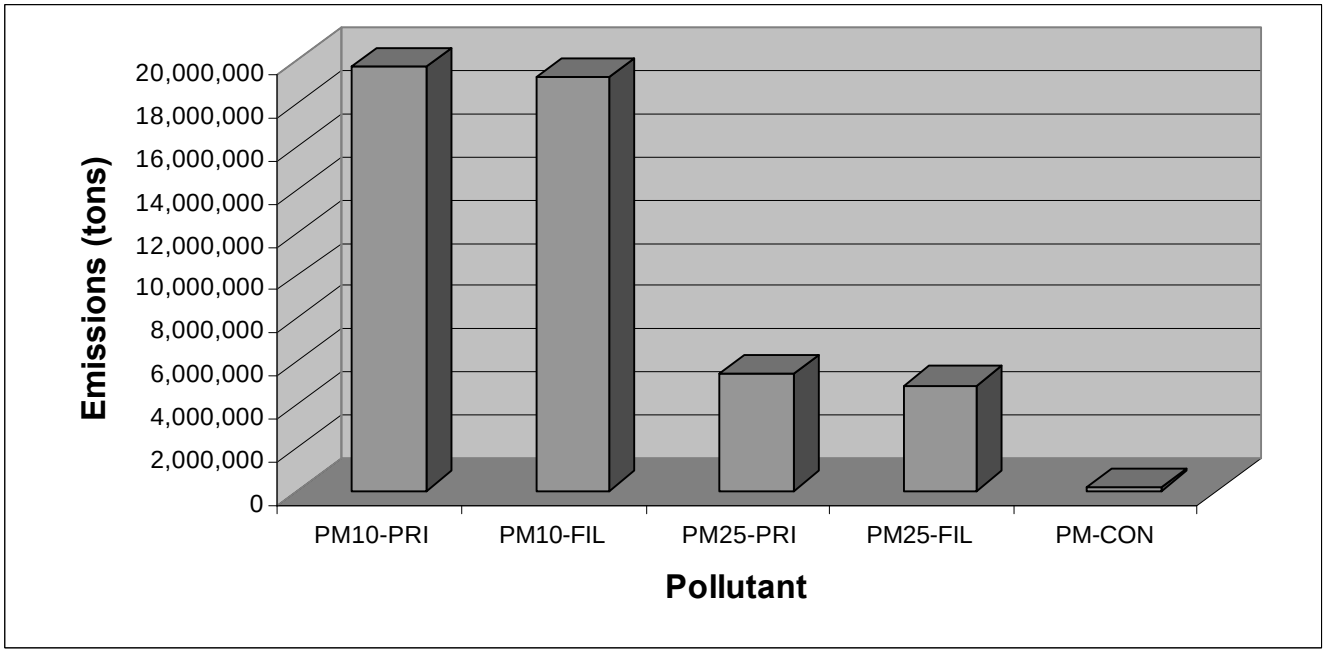


Figure 3. National annual emissions from area source NEI version 2.



2% of total PM25-PRI emissions. The area source PM inventory is dominated by sources of fugitive dust emissions which do not have a CON fraction.

STUDY LIMITATIONS/FUTURE RESEARCH

The most significant uncertainty associated with the PM augmentation procedures applied to populate the NEI with PM10-PRI, PM10-FIL, PM25-PRI, PM25-FIL, and PM-CON is the lack of particle-size-specific emission factors for uncontrolled sources and controlled sources for various types of control equipment combinations. The particle-size-specific emission factors for uncontrolled and controlled stationary external and internal fuel combustion sources in AP-42 are based on stack tests, but

the data is old and much of the stack tests may be flawed. Many of these source categories are on EPA's list to update. Good data for other SCCs are lacking. Thus, the emission inventory community should conduct research to prioritize source categories of fine PM emissions and focus on improving the data needed to estimate fine PM emissions for the highest priority categories.

For point sources, the procedures rely on S/L/T agency data for at least one form of PM to calculate emissions for the missing forms of PM. Thus, if a S/L/T agency did not provide any PM-related pollutants for a source of PM, PM emissions are missing in the NEI. This is also the case for area sources categories for which EPA has not prepared estimates.

The PM augmentation procedure relies on the use of the PM Calculator to estimate PM10-FIL and PM25-FIL emissions from S/L/T-supplied PM-PRI, PM-FIL, or PM10-PRI emissions. Although the PM Calculator uses particle size data available in AP-42 and FIRE, it will not provide estimates that will be as accurate as applying the emission factors to the activity, operating schedule, and control equipment data for individual sources. Thus, S/L/T agencies are encouraged to use emission factors in AP-42 or FIRE along with source-specific activity, operating schedule, and control equipment data to prepare their inventories in the future.

The PM Calculator does not contain particle size data for several SCCs and control devices for which S/L/T agencies reported PM, PM10, and/or PM2.5 emissions in their inventories. The augmentation procedures can be improved by updating the PM Calculator to include particle size data for SCCs and control equipment currently not included in the calculator.

S/L/T inventories contain several inaccuracies in the PM data. For example, for NEI Version 2, some agencies did not report the form of PM, PM10, and PM2.5 emissions. When an agency could not be reached to provide clarification, EPA made assumptions on the form of the emissions. In these cases, EPA assumed all PM emissions were FIL. For NEI Version 2 and draft Version 3, some agencies did not report control device codes that complied with NIF 2.0 codes which made it difficult to determine how to match the codes to control equipment codes in the PM Calculator. Mismatching of S/L/T codes to codes in the PM Calculator probably occurred resulting in increasing the inaccuracy of the emission estimates. Several agencies reported PM2.5 emissions as being significantly higher than PM10 emissions for a given process. For these cases, PM2.5 emissions were set equal to PM10 emissions if the agency did not provide corrections. However, this correction probably resulted in inaccurate emission estimates. Thus, S/L/T agencies need to compare PM2.5 and PM10 emission estimates to make sure that PM2.5 emissions are less than or equal to PM10 emissions.

The PM augmentation procedures need further refinement. For example, EPA is aware that the procedures calculate PM-CON for industrial SCCs (e.g., industrial paved and unpaved roads, material handling operations in the mineral products and primary and secondary metal production industries) that should not be sources of CON emissions. The EPA will review the Industrial Processes (SCCs starting with 3) and Petroleum and Solvent Evaporation (SCCs starting with 4) sectors for which PM-CON is estimated. For final Version 3, EPA will remove PM-CON emissions for any SCCs it decides are not sources of PM-CON. The EPA requests comments on this issue.

In addition, for most industrial SCCs, the procedures use generic profiles in Appendix B of AP-42 to calculate factors for estimating FIL and CON emissions. For the PM augmentation procedures, it was assumed that emissions less than or equal to 1 μm are CON emissions. However, these profiles are for FIL emissions only. The EPA knows this is not a good assumption; however, it was necessary to make the assumption given the lack of CON emissions data for industrial sources. This method should be regarded as a first attempt at estimating CON emissions for industrial sources that needs improvement. The EPA will evaluate this assumption in the future in an effort to improve the CON emission estimates for industrial sources.

The conversion factors for Solid Waste Disposal PM emissions were produced from the limited data provided in the External Combustion Sources and Stationary Internal Combustion Sources sections of AP-42. Further work is needed to identify alternative sources of data to develop PM-CON emission factors for Solid Waste Disposal SCCs.

CONCLUSIONS

This paper summarizes the methods EPA developed to add PM-CON to the NEI for the first time. The paper also summarizes the methods EPA developed to add PM10-PRI, PM10-FIL, PM25-PRI, and PM25-FIL emissions missing from S/L/T inventories included in the NEI. These methods provide a starting point for improving PM-related pollutant emissions in point and area source inventories. As previously discussed, the methods have many limitations and create uncertainties in the emissions estimates. S/L/T agencies are encouraged to provide comments on these methods or to develop their own methods to provide more accurate emissions estimates.

For the 2002 base year inventory, EPA recommends that S/L/T agencies keep the following in mind when preparing PM-related pollutant emissions:

1) Develop the list of point and area source SCCs for sources of PM-related pollutant emissions.
2) Use emission factors, actual throughput, and control efficiency data to estimate emissions. Emission factors developed from emission unit-specific source test data are best. In the absence of source test data, use emission factors in FIRE and AP-42. Check EPA's Chief web site for the latest versions of FIRE and AP-42. If continuous emissions monitoring data are available, use these data over the emission factor approach.
3) If throughput data are not available, you may use the PM Calculator to estimate PM10-FIL and PM25-FIL from PM-FIL, or PM25-FIL from PM10-FIL. QA your data prior to using it in the PM Calculator. For example, SCCs and control device codes should be NIF 2.0 compliant. If SCCs or control device codes are not in the PM Calculator, match your data with SCCs and control device codes in the PM Calculator that provide the best surrogate results.
4) QA the emissions you calculate using emission factors and controls, or the PM Calculator to ensure consistent results.
5) Apply ratios of pollutant emission factors to estimate PM-CON emissions.

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Key Words

National Emissions Inventory
Point Sources
Area Sources
Particulate Matter
Emission Factor
Augmentation