**Mining and Quarrying (2325000000)**

**a. *Source Category Description***

Mining and quarrying activities produce particulate emissions due to the variety of processes used to extract the ore and associated overburden, including drilling and blasting, loading and unloading, and overburden replacement. Fugitive dust emissions for mining and quarrying operations are the sum of emissions from the mining of metallic and nonmetallic ores and coal. Each of these mining operations has specific emission factors accounting for the different means by which the resources are extracted.

For this source category the following SCC was assigned:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Source Classification Code** | **SCC Level One** | **SCC Level Two** | **SCC Level Three** | **SCC Level Four** |
| 2325000000 | Industrial Processes | Mining and Quarrying: SIC 14 | All Processes | Total |

**b. *Emission Factors and Equations***

*Metallic Ore Mining*

The emissions factor for metallic ore mining includes overburden removal, drilling and blasting, and loading and unloading activities. The TSP emission factors developed for copper ore mining are applied to all three activities with PM10/TSP ratios of 0.35 for overburden removal, 0.81 for drilling and blasting, and 0.43 for loading and unloading operations.1 The emissions factor equation for metallic ore mining is:

EFmo = EFo + (B x EFb) + EFl + EFd

where, EFmo = metallic ore mining emissions factor (lbs/ton)

EFo = PM10 open pit overburden removal emission factor for copper ore (lbs/ton)

B = fraction of total ore production that is obtained by blasting at metallic ore mines

EFb = PM10 drilling/blasting emission factor for copper ore (lbs/ton)

EFl = PM10 loading emission factor for copper ore (lbs/ton)

EFd = PM10 truck dumping emission factor for copper ore (lbs/ton)

Applying the copper ore mining TSP emissions factors2 and PM10/TSP ratios yields the following metallic ore mining emissions factor:

EFmo = 0.0003 + (0.57625 x 0.0008) + 0.022 + 0.032 = 0.0548 lbs/ton

*Non-Metallic Ore Mining*

The emissions factor for non-metallic ore mining includes overburden removal, drilling and blasting, and loading and unloading activities. The emissions factor is based on western surface coal mining operations.

EFnmo = EFv + (D x EFr) + EFa + 0.5 (EFe + EFt)

where, EFnmo = non-metallic ore mining emissions factor (lbs/ton)

EFv = PM10 open pit overburden removal emission factor at western surface coal mining operations (lbs/ton)

D = fraction of total ore production that is obtained by blasting at non-metallic ore mines

EFr = PM10 drilling/blasting emission factor at western surface coal mining operations (lbs/ton)

EFa = PM10 loading emission factor at western surface coal mining operations (lbs/ton)

EFe = PM10 truck unloading: end dump-coal emission factor at western surface coal mining operations (lbs/ton)

EFt = PM10 truck unloading: bottom dump-coal emission factor at western surface coal

mining operations (lbs/ton)

Applying the TSP emissions factors developed for western surface coal mining operations from AP-423 and a PM10/TSP ratio of 0.44 yields the following non-metallic ore mining emissions factor:

EFnmo = 0.225 + (0.61542 x 0.00005) + 0.05 + 0.5 (0.0035 + 0.033) = 0.293 lbs/ton

*Coal Mining*

The emissions factor for coal mining includes overburden removal, drilling and blasting, loading and unloading and overburden replacement activities. The amount of overburden material handled is assumed to equal ten times the quantity of coal mined and coal unloading is assumed to split evenly between end-dump and bottom-dump operations. The emissions factor equation for coal mining is:

EFc = (10 × (EFto + EFor + EFdt)) + EFv + EFr +EFa + (0.5 × (EFe + EFt))

where, EFc = coal mining emissions factor (lbs/ton)

EFto = PM10 emission factor for truck loading overburden at western surface coal mining operations (lbs/ton of overburden)

EFor = PM10 emission factor for overburden replacement at western surface coal mining operations (lbs/ton of overburden)

EFdt = PM10 emission factors for truck unloading: bottom dump-overburden at western surface coal mining operations (lbs/ton of overburden)

EFv = PM10 open pit overburden removal emission factor at western surface coal mining operations (lbs/ton)

EFr = PM10 drilling/blasting emission factor at western surface coal mining operations (lbs/ton)

EFa = PM10 loading emission factor at western surface coal mining operations (lbs/ton)

EFe = PM10 truck unloading: end dump-coal emission factor at western surface coal mining operations (lbs/ton)

EFt = PM10 truck unloading: bottom dump-coal emission factor at western surface coal mining operations (lbs/ton)

Applying the PM10 emissions factors developed for western surface coal mining operations3 yields the following coal mining emissions factor:

EFc = (10 × (0.015 + 0.001 + 0.006)) + 0.225 + 0.00005 + 0.05 + (0.5 × (0.0035 + 0.033)) = 0.513 lbs/ton

PM-FIL emissions factors are assumed to be the same as PM-PRI emissions factors; however, in reality, there is a small amount of PM-CON emissions included in the PM-PRI emissions but insufficient data exists to tease out the PM-CON portion. In 2006, the EPA adopted new PM2.5/PM10 ratios for several fugitive dust categories and concluded that the PM2.5/PM10 ratios for fugitive dust categories should be in the range of 0.1 to 0.15.5 Consequently, a ratio of 0.125 was applied to the PM10 emissions factors to estimate PM2.5 emissions factors for mining and quarrying. A summary of emissions factors is presented in Table 1.

**Table 1. Summary of Emission Factors**

| **Mining Type** | **Pollutant Code** | **Factor Numeric Value** | **Factor Unit Numerator** | **Factor Unit Denominator** |
| --- | --- | --- | --- | --- |
| Coal | PM10-PRI | 0.513 | LB | TON |
| Coal | PM10-FIL | 0.513 | LB | TON |
| Coal | PM25-PRI | 0.064 | LB | TON |
| Coal | PM25-FIL | 0.064 | LB | TON |
| Metallic | PM10-PRI | 0.0548 | LB | TON |
| Metallic | PM10-FIL | 0.0548 | LB | TON |
| Metallic | PM25-PRI | 0.0068 | LB | TON |
| Metallic | PM25-FIL | 0.0068 | LB | TON |
| Non-Metallic | PM10-PRI | 0.293 | LB | TON |
| Non-Metallic | PM10-FIL | 0.293 | LB | TON |
| Non-Metallic | PM25-PRI | 0.037 | LB | TON |
| Non-Metallic | PM25-FIL | 0.037 | LB | TON |

**c. *Activity***

Emissions were estimated by obtaining state-level metallic and non-metallic crude ore handled at surface mines from the U.S. Geologic Survey (USGS) 6 and mine specific coal production data for surface mines from the Energy Information Administration (EIA) 7. Emissions were not estimated for underground mining given that emission factors are calculated exclusively for surface activity. Since some of the USGS metallic and non-metallic minerals waste data associated with ore production are withheld to avoid disclosing company proprietary data, an allocation procedure was developed to estimate the withheld data. For states with withheld waste data, the state fraction of national ore production was multiplied by the national undisclosed waste value to estimate the state withheld data. In addition, the USGS only reports metallic and non-metallic minerals production data separately at the national-level (e.g., the production data are combined at the state-level). To estimate metallic versus non-metallic ore production and associated waste at the state-level, the state-level total production and waste data were multiplied by the national metallic or non-metallic percentage of total production.

**d. *Activity Allocation Procedure***

State-level metallic and non-metallic crude ore and associated waste handled was allocated to the county-level using employment. Specifically, state-level activity data were multiplied by the ratio of county- to state-level number of employees in the metallic and non-metallic mining industries (see Table 2 for a list of NAICS codes).

**Table 2. NAICS Codes for Metallic and Non-Metallic Mining**

| **NAICS Code** | **Description** |
| --- | --- |
| 2122 | Metal Ore Mining |
| 212210 | Iron Ore Mining |
| 21222 | Gold Ore and Silver Ore Mining |
| 212221 | Gold Ore Mining |
| 212222 | Silver Ore Mining |
| 21223 | Copper, Nickel, Lead, and Zinc Mining |
| 212231 | Lead Ore and Zinc Ore Mining |
| 212234 | Copper Ore and Nickel Ore Mining |
| 21229 | Other Metal Ore Mining |
| 212291 | Uranium-Radium-Vanadium Ore Mining |
| 212299 | All Other Metal Ore Mining |
| 2123 | Nonmetallic Mineral Mining and Quarrying |
| 21231 | Stone Mining and Quarrying |
| 212311 | Dimension Stone Mining and Quarrying |
| 212312 | Crushed and Broken Limestone Mining and Quarrying |
| 212313 | Crushed and Broken Granite Mining and Quarrying |
| 212319 | Other Crushed and Broken Stone Mining and Quarrying |
| 21232 | Sand, Gravel, Clay, and Ceramic and Refractory Minerals Mining and Quarrying |
| 212321 | Construction Sand and Gravel Mining |
| 212322 | Industrial Sand Mining |
| 212324 | Kaolin and Ball Clay Mining |
| 212325 | Clay and Ceramic and Refractory Minerals Mining |
| 21239 | Other Nonmetallic Mineral Mining and Quarrying |
| 212391 | Potash, Soda, and Borate Mineral Mining |
| 212392 | Phosphate Rock Mining |
| 212393 | Other Chemical and Fertilizer Mineral Mining |
| 212399 | All Other Nonmetallic Mineral Mining |

Employment data were obtained from the U.S. Census Bureau’s 2012 County Business Patterns (*CBP*).8 Due to concerns with releasing confidential business information, the *CBP* does not release exact numbers for a given NAICS code if the data can be traced to an individual business. Instead, a series of range codes is used. To estimate employment in counties with withheld data, the following procedure is used for each NAICS code being computed.

1. County level data for counties with known employment are totaled by state.
2. #1 subtracted from the state total reported in state-level *CBP*.
3. Each of the withheld counties is assigned the midpoint of the range code (e.g., A:1-19 employees would be assigned 10).
4. These midpoints are then summed to the state level.
5. #2 is divided by #4 as an adjustment factor to the midpoints.
6. #5 is multiplied by #3 to get the adjusted county-level employment.

Note that step 5 adjusts all counties with withheld employment data by the same state-based proportion. It is unlikely that actual employment corresponds exactly with this smoothed adjustment method, but this method is the best option given the availability of the data.

For example, take the 2006 *CBP* data for NAICS 31-33 (Manufacturing) in Maine provided in Table 3.

**Table 3. 2006 County Business Pattern for NAICS 31-33 in Maine**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **fipsstate** | **fipscty** | **naics** | **empflag** | **emp** |
| 23 | 001 | 31---- |  | 6,774 |
| 23 | 003 | 31---- |  | 3,124 |
| 23 | 005 | 31---- |  | 10,333 |
| 23 | 007 | 31---- |  | 1,786 |
| 23 | 009 | 31---- |  | 1,954 |
| 23 | 011 | 31---- |  | 2,535 |
| 23 | 013 | 31---- |  | 1,418 |
| 23 | 015 | 31---- | F | 0 |
| 23 | 017 | 31---- |  | 2,888 |
| 23 | 019 | 31---- |  | 4,522 |
| 23 | 021 | 31---- |  | 948 |
| 23 | 023 | 31---- | I | 0 |
| 23 | 025 | 31---- |  | 4,322 |
| 23 | 027 | 31---- |  | 1,434 |
| 23 | 029 | 31---- |  | 1,014 |
| 23 | 031 | 31---- |  | 9,749 |

1. The total of employees not including counties 015 and 023 is 52801.
2. The state-level *CBP* reports 59,322 employees for NAICS 31----. The difference is 6,521.
3. County 015 is given a midpoint of 1,750 (since range code F is 1000-2499) and County 023 is given a midpoint of 17,500.
4. State total for these two counties is 19,250.
5. 6,521/19,250 = 0.33875.
6. The adjusted employment for county 015 is 1,750\*0.33875 = 593. County 023 has an adjusted employment of 17,500\*0.33875 = 5,928.

In the event that data at the state level are withheld, a similar procedure is first performed going from the U.S. level to the state level. For example, known state-level employees are subtracted from the U.S. total yielding the total withheld employees. Next the estimated midpoints of the withheld states are added together and compared (by developing a ratio) to the U.S. total withheld employees. The midpoints are then adjusted by the ratio to give an improved estimate of the state total.

**e. *Controls***

No controls were accounted for in the emissions estimation.

**f. *Emissions Equation and* *Sample Calculation***

Fugitive dust emissions for mining and quarrying operations are the sum of emissions from the mining of metallic and nonmetallic ores and coal:

E = Em + En + Ec

where, E = PM10 emissions from mining and quarrying operations

Em = PM10 emissions from metallic ore mining operations

En = PM10 emissions from non-metallic ore mining

Ec = PM10 emissions from coal mining operations

Four specific activities are included in the emissions estimate for mining and quarrying operations: overburden removal, drilling and blasting, loading and unloading, and overburden replacement. Not included are the transfer and conveyance operations, crushing and screening operations, and storage since the dust emissions from these activities are assumed to be well controlled. Emissions for each activity are calculated using the following equation:

E = EF × A

where, E = PM10 emissions from operation (e.g., metallic ore, non-metallic ore, or coal mining; lbs)

EF = emissions factor associated with operation (lbs/ton)

A = ore handled in mining operation (tons)

As an example, in 2012 Barbour County, Alabama handled 13,507,583 tons of metallic ore and associated waste, 113,501 tons of non-metallic ore and associated waste, and 0 tons of coal. Mining and quarrying PM10-PRI emissions for Barbour County are:

EPM10-PRI, Barbour County = [(13,507,583×0.0548) + (113,501×0.293) + (0×0.513)]/2000 = 386 tons

The division by 2000 is to convert from pounds to tons.

**g. *Changes from 2011 Methodology***

For the 2014 NEI, the activity data are updated to year 2012 using the most recent USGS and EIA data on metallic and non-metallic crude ore handled and coal production. The allocation procedure uses 2012 employment data from the U.S. Census Bureau. In addition, the allocation procedure in 2014 allocates state-level metallic and non-metallic activity to the county-level using the respective county fraction of metallic and non-metallic state employees that work in the county. In 2011, the allocation procedure combined the metallic and non-metallic employees to generate a single county allocation factor. The 2014 allocation methodology is an improvement because it more precisely assigns the mining emissions to counties where the mining is actually occurring.

**h. *Puerto Rico and US Virgin Islands Emissions Calculations***

Since insufficient data exists to calculate emissions for the counties in Puerto Rico and the US Virgin Islands, emissions are based on two proxy counties in Florida: 12011, Broward County for Puerto Rico and 12087, Monroe County for the US Virgin Islands. The total emissions in tons for these two Florida counties are divided by their respective populations creating a tons per capita emission factor. For each Puerto Rico and US Virgin Island county, the tons per capita emission factor is multiplied by the county population (from the same year as the inventory’s activity data) which served as the activity data. In these cases, the throughput (activity data) unit and the emissions denominator unit are “EACH”.

**i. *References***

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