

# J. Architectural Surface Coating

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## PREFERRED EMISSION CALCULATION METHODS

1. Survey  
EIIIP (Volume III - Area Sources) describes the ideal survey in detail.
2. Apply speciation profiles to the VOC emission estimate.  
Although the survey approach is the preferred method of emission estimation, it is costly and time consuming. Applying speciation profiles to a VOC emission estimate is the more feasible alternative. Architectural surface coating speciation profiles are obtained from the California Air Resource Board Speciation Manual (CARB, 1991, VOC Profile 196 and 717). The pollutants pertinent to RAPIDS for the solvent-based paint profile are Ethylbenzene, Isomers of Xylene and Toluene and for the water-based paint profile are Benzene and Methylene Chloride. All compounds are classified as VOC. The speciation profiles listed for the compounds are given in Table J-1.

Table J-1: Speciation Profile for Architectural Surface Coating (CARB, 1991)

| Air Toxin (TOX)      |                    | Speciation (TOX/VOC), % by wt |
|----------------------|--------------------|-------------------------------|
| Solvent based paints | Ethylbenzene       | 4.3                           |
|                      | Isomers of Xylene  | 2.6                           |
|                      | Toluene            | 5.2                           |
| Water based paints   | Benzene            | 0.3                           |
|                      | Methylene chloride | 5.5                           |

## EMISSION FACTOR

The emission factors used in calculating the VOC emissions were acquired from the STAPPA-ALAPCO-EPA EIIIP (Emission Inventory Improvement Program), Volume III, July 1997.

Since resources may be unavailable for accounting actual usage of architectural coatings in a given state, the 1996 population census can be used to determine the paint usage in each county. The paint usage is also acquired from EIIIP, July 1997 and this data is based upon the U.S. Bureau of Census MA28F - Paint and Allied Products - a compilation of national usage data.

Table J-2: VOC Emission Factors and Paint Usage Factors

| Paint Type          | VOC Emission Factor (lb./gal) | Usage Factors (gal/person) |
|---------------------|-------------------------------|----------------------------|
| Solvent-Based Paint | 3.87                          | 0.59                       |
| Water-Based Paint   | 0.74                          | 1.82                       |

## VOC EMISSION ESTIMATE

The following equations provide an estimation of VOC emissions using the population data, the paint usage factors and the appropriate emission factors.

$$\begin{aligned} \text{VOC}_{\text{wb}} &= \text{Population} * 1.82 \text{ gal/person} * (0.74 \text{ lb./gal}) \\ \text{VOC}_{\text{sb}} &= \text{Population} * 0.59 \text{ gal/person} * (3.87 \text{ lb./gal}) \end{aligned}$$

where,

$$\begin{aligned} \text{VOC}_{\text{wb}} &= \text{Total VOC emitted from water-based paint for a county} \\ \text{VOC}_{\text{sb}} &= \text{Total VOC emitted from solvent-based paint for a county} \end{aligned}$$

Using the estimated VOC emissions calculated above for each paint type, the TOX emissions from solvent-based and water-based paints were calculated by applying the appropriate speciation profiles from Table J-1 for the two paints in the following equation.

$$E = \text{VOC} * \text{TOX/VOC}$$

where,

$$\begin{aligned} E &= \text{Emissions of a pollutant, lb./yr.} \\ \text{VOC} &= \text{Total VOC for a county for each paint type, lb./yr.} \\ \text{TOX/VOC} &= \text{Ratio of TOX/VOC for each paint type, \% by weight} \end{aligned}$$

## REFERENCES

Environmental Protection Agency (EPA). *STAPPA-ALAPCO-EPA Emission Inventory Improvement Program (EIIP)*. Volume III - Area Sources Preferred and Alternative Methods. July 1997.

California Air Resources Board (CARB). 1991. *Air Resources Board Speciation Manual Identification of Volatile Organic Compound Species Profiles*. Emission Inventory Branch. Profile 783. 1991.

Environmental Protection Agency (EPA). 1991. *Procedures for the Preparation of Emission Inventories for Carbon Monoxide and Precursors of Ozone*. Volume 1. General Guidance for Stationary Sources. Research Triangle Park, NC. May 1991. 234P.

## K. Asphalt Paving Methodology

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### OVERVIEW

Based on available data and discussions with state and industry professionals in the field of asphalt paving, the State of Michigan has concluded that the area source category of asphalt paving is not a significant source of HAPS. Furthermore, the State of Michigan suggests that the Regional Inventory not spend any more time on this category. The basis for these conclusions is detailed below.

The Michigan Dept. of Transportation (MDOT) indicated that they used 4,595,000 gallons of emulsified asphalt in 1997. MDOT, and the county departments of transportation, only use cutback asphalt for filling potholes but the quantity is not tracked. Michigan DEQ, Air Quality Division (AQD) staff decided that they would apportion the state emulsified asphalt data to the county level via Vehicle Mile Traveled (VMT) estimates.

AQD staff contacted the Asphalt Institute, but opted not to use their data. They could provide a statewide total estimate for cutback and emulsified asphalts, but only if Michigan purchased their asphalt usage report (\$1,000.00 for a one year volume). Accordingly, AQD staff considered this source of information to be unfeasible.

One possible source of information is the Department of Energy, Energy Information Administration (EIA) at [www.eia.doe.gov/bookshelf/consumer.html](http://www.eia.doe.gov/bookshelf/consumer.html). One of their reports, the *State Energy Data Report*, has consumption data for each state. This includes asphalt and road oils. The report listed 7,777,000 barrels of asphalt and road oil in Michigan. AQD staff contacted the EIA to determine if a breakdown of the state number was available, but the data is only available as a combined number. Additionally, the data is based on U.S. refinery production totals, allocated to the state level based on state asphalt sales data from the Asphalt Institute.

The AQD considered the asphalt usage data provided by MDOT to be preferable, as it is data specific to the state of Michigan.

For information on VOCs and HAPs from emulsified asphalt, MDOT staff recommended that the AQD contact a chemical engineer from Bituminous Products, a company which supplies emulsified asphalt to MDOT.

Mark Homer, of Bituminous Products, informed AQD staff that there are no VOCs or HAPs in emulsified asphalt. The emulsion is an aqueous solution composed of water, asphalt, and an emulsifier (soap) which keeps the solution in suspension. The asphalt has no vapor pressure when emulsified. Water itself is the only volatile component in the emulsion.

Mr. Homer indicated that the asphalt industry as a whole has made a major transition to emulsified asphalt, but cutback solvents are still used in smaller quantities for specific instances, such as priming wet rock or winter application of asphalt. Based on his recommendation, and the available data, AQD staff feels that the area source category of asphalt paving is not a significant contributor to toxics in the State of Michigan.

Below, the AQD has provided an evaluation of EIIP alternative methods deemed most feasible, for any states or provinces that wish to continue with an inventory based on asphalt paving.

### Alternative Method One

This method requires the surveying of a representative set of DOTs, and was considered too time and labor intensive for this study.

### Alternative Method Two

This method involves the use of existing state asphalt usage data. This data may be obtained from the Asphalt Institute (<http://www.asphaltinstitute.org>) or other sources. First the state level data must be apportioned to the county level as in alternative method one, through the use of highway mileage, vehicle miles traveled, or other methods.

Because state usage data from the Asphalt Institute do not distinguish among the types of cutback asphalt or emulsified asphalt used, a minimum amount of information will still be needed from representative state and local DOTs. This information can be collected by telephone, and must determine: (1) the percent of each asphalt type used; (2) their typical diluent contents; and (3) when the types are used (for ozone inventories). Table 17.5-3, an example telephone survey is reproduced below.

Table K-1: EIIP Table: 17.5-3 - Example Telephone Survey Form

| Asphalt Type       | Cure/Set Rate | Estimated % of Total Usage | Approximate Diluent Content | Months of the Year Used <sup>a</sup> |
|--------------------|---------------|----------------------------|-----------------------------|--------------------------------------|
| Cutback Asphalt    | rapid         |                            |                             |                                      |
|                    | rapid         |                            |                             |                                      |
|                    | medium        |                            |                             |                                      |
|                    | medium        |                            |                             |                                      |
|                    | slow          |                            |                             |                                      |
|                    | slow          |                            |                             |                                      |
|                    |               |                            |                             |                                      |
| Emulsified Asphalt | rapid         |                            |                             |                                      |
|                    | rapid         |                            |                             |                                      |
|                    | medium        |                            |                             |                                      |
|                    | medium        |                            |                             |                                      |
|                    | slow          |                            |                             |                                      |
|                    | slow          |                            |                             |                                      |
|                    |               |                            |                             |                                      |

<sup>a</sup> Only needed for ozone inventories

Once this information has been obtained, equations from Alternative Method One can be used to estimate emissions.

### Alternative Method Three

This is the least preferred method. It involves the application of volume based emission factors to total asphalt usage. These emission factors are found in Table 17.5-4. The factors were prepared for EPA's document, *Procedures for the Preparation of Emission Inventories for Carbon Monoxide and Precursors of Ozone*, Volume 1. The EIIP guidance indicates assumptions made in this method may overestimate the emissions.

Data on asphalt use must either be requested from county DOTs, or state usage data from sources such as the Asphalt Institute must be apportioned to the county level as in Alternative Method Two.

Table K-2: EIIP Table 17.5-3 - Asphalt Paving Emission Factors

| <b>Asphalt Type</b> | <b>Volume-based <sup>a</sup> (lb VOC/Barrel Asphalt)</b> |
|---------------------|--|
| Cutback asphalt     | 88   |
| Emulsified asphalt  | 9.2  |

<sup>a</sup> Assuming that the density of asphalt is similar to that of water, 8.34 lbs/gal, one barrel (42 gal) of asphalt weighs 350 lbs.

Once the data have been collected, emissions are estimated as follows.

Equation 1:

$$\text{Mass Emissions} = \text{Volume Usage Emission Factor} * \text{Volume Used (Barrels of Asphalt)}$$

## Hazardous Air Pollutants

The simplest way to collect the necessary composition information to determine HAP emissions is for the inventory preparer to request material safety data sheets (MSDS) or manufacturer technical data sheets (TDSs) from the DOTs receiving the survey. The weight percent of each HAP is taken from the MSDS or TDS, then is multiplied by the weight of VOC emissions estimated by any of the alternative methods, to determine the speciated emissions (see Equations 17.4-8 and 17.4-9).

Equation 2:

$$\text{Mass Emissions for Each HAP} = \text{VOC Mass Emissions} * \text{Weight Fraction of Each HAP}$$

Equation 3:

$$\text{Weight Fraction of Each HAP} = \frac{\text{Weight of Each HAP}}{\text{Weight of VOC Emitted}}$$

As an alternative, the inventory preparer may solicit HAP information from local vendors or a few representative DOTs to establish typical compositions for the asphalt types used in the inventory area. This information will then be applied to the VOC estimate to determine the speciated HAP emissions.

## REFERENCES

- U.S. Environmental Protection Agency (U.S. EPA). 1996. *Compilation of Air Pollutant Emission Factors - Volume I: Stationary Point and Area Sources. Fifth Edition and Supplements, AP-42*. U.S. EPA, Office of Air Quality Planning and Standards. Research Triangle Park, NC.
- Homer, Mark. Chemical Engineer, Bituminous Products. Personal communication, March 30, and April 4, 2000.
- Mayes, Gary. Michigan Department of Transportation. Personal communication, March 1, 2000.
- Parker, Don. Michigan Department of Transportation. Personal communication, March 30, 2000.
- Environmental Protection Agency (EPA). *Procedures for the Preparation of Emission Inventories for Carbon Monoxide and Precursors of Ozone. Volume 1. General Guidance for Stationary Sources*. Research Triangle Park, NC. May 1991.
- Environmental Protection Agency (EPA). *STAPPA-ALAPCO-EPA Emission Inventory Improvement Program (EIIP). Volume III - Area Sources Preferred and Alternative Methods. Chapter 17, Asphalt Paving*. October 1998.

# L. Autobody Refinishing

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The following is a summary of preferred and alternative methodologies for estimating toxic emissions from the auto body refinishing area source category. All quotes and information contained within are from the source, Emission Inventory Improvement Program, Volume 3, Chapter 11, Auto Body Refinishing.

## OVERVIEW

“Auto body refinishing is the repairing of worn or damaged automobiles, light trucks, and other vehicles, and refers to any coating applications that occur subsequent to those at original equipment manufacture (OEM) assembly plants.” “This source category covers solvent emissions from the refinishing of automobiles, including paint solvents, thinning solvents, and solvents used for surface preparation and cleanup.” Auto body refinishing also, can be both an area and a point source (SIC 7532). Therefore, states will need to adjust their area source estimations by removing total point source emissions.

ASC: 2401005000

VOC emissions are influenced by

- 1) VOC content of the product used
- 2) Transfer efficiency of spraying equipment
- 3) Cleanup/housekeeping practices
- 4) Regulations

## METHODOLOGY

Table L-1: Descriptions of Different Methods for Calculating Emissions

| Methods                                      | Description  |
|--|--|
| Preferred Method – Survey                    | Gather detailed information from auto body refinishing operations. This may include information on activity (number of partial/complete refinishing jobs performed, temporal resolution of activity, etc.), number of employees, product use by product category, type of equipment used, pollution control measures used, business projections, etc. These data are then reviewed and compiled to develop an accurate description of the auto body refinishing activity in the survey area. Emission factors can be developed from specific product data such as Material Data Safety Sheets or can be based on typical VOC content ranges for product types. |
| Alternate Method 1 - Apportion National Data | Use national data on the number of refinishing jobs performed in year, apportion to inventory area by population to estimate activity. Use estimate of typical amount of surface preparation, coating, and cleaning products and typical VOC contents to estimate emissions.   |
| Alternate Method 2 - Per Employee Factor     | Use per employee emission factor and number of employees in inventory area to estimate emissions.  |
| Alternate Method 3 - Per Capita Factor       | Use per capita emission factor and population in inventory area to estimate emissions.   |

Table L-2: Data Elements Needed for Each Method

| Data Element   | Method                 |                    |                    |                    |
|--|------------------------|--------------------|--------------------|--------------------|
|  | Preferred <sup>a</sup> | Alt 1 <sup>b</sup> | Alt 2 <sup>c</sup> | Alt 3 <sup>d</sup> |
| Number of refinish jobs completed  | x                      | x                  |                    |                    |
| Type and amount of product used by product type or by specific product           | x                      | x                  |                    |                    |
| VOC content of product type or of specific product                               | x                      | x                  |                    |                    |
| Population (inventory area and/or U.S.)  |                        | x                  |                    | x                  |
| Amount of product type used by activity (surface preparation, coating, cleaning) | x                      | x                  |                    |                    |
| Employment in SIC 7532 in inventory area <sup>c</sup>                            |                        |                    | x                  |                    |
| Per capita emission factor   |                        |                    |                    | x                  |
| Per employee emission factor   |                        |                    | x                  |                    |

<sup>a</sup>Preferred method is the survey method.

<sup>b</sup>Alt 1 method is the apportion national data method.

<sup>c</sup>Alt 2 method is the per employee factor method.

<sup>d</sup>Alt 3 method is the per capita factor method.

## EMISSION CALCULATIONS

- 1) **Survey Method** - (Use EIIP for examples of surveys and additional ideas on how to implement this method)

Emissions = amount of product (gal) \* product VOC content (lbs./gal) ÷ 2000 lbs./ton  
 Sum emissions of all products

An alternative to this method is to assume that the number of jobs performed in an area is directly proportional to the area's population. Using the latest national figures on refinishing jobs performed:

# of jobs in the area of estimation is = US total jobs \* (area population/US population)

The next step is to calculate emissions by:

Emissions=# of jobs in area \* gal product per job \* VOC content in lbs./gal ÷ 2000 lbs./ton

- 2) **Per Employee**

Emissions=area employment in SIC 7532\*employee EF of lbs. VOC/yr. ÷ 2000 lbs./ton

Employee EF for VOC from EIIP document = 3,519 lbs./employee/yr.

- 3) **Per Capita**

Emissions = population \* lbs. VOC/person/yr. ÷ 2000 lbs./ton

\*\*\*Per capita EF for VOC in Rapids is 0.84 lbs./person/yr.

Per capita EF for VOC from EIIP document is 2.3 lbs./yr./person\*\*\*

The per capita emission factor of 2.3 lbs. per person is referenced from, Procedures for the Preparation of Emission Inventories for Carbon Monoxide and Precursors of Ozone, Volume I: General Guidance for Stationary Sources.

# SPECIATION

ASC: 2401005000

Profile Name Auto Body Repair

Profile Code: 1194

|             |                             |                      |
|-------------|-----------------------------|----------------------|
| 000071-43-2 | Benzene                     | 0.0151 lbs./lbs. VOC |
| 000084-74-2 | Dibutyl Phthalate           | 0.0001 lbs./lbs. VOC |
| 000091-20-3 | Naphthalene                 | 0.0146 lbs./lbs. VOC |
| 000108-88-3 | Toluene                     | 0.0865 lbs./lbs. VOC |
| 001330-20-7 | Xylene, (m, o, & p mixture) | 0.2067 lbs./lbs. VOC |

## Adjusting for regulations and control

|         |   |   |
|---------|---|---|
| $EF_A$  | = | emission factor for pollutant A                   |
| $Q$     | = | activity factor for category                      |
| $CE$    | = | control efficiency/100                            |
| $RP$    | = | rule penetration/100                              |
| $RE$    | = | rule effectiveness/100                            |
| $UAE_A$ | = | uncontrolled area source emissions of pollutant A |
| $CAE_A$ | = | controlled area source emissions of pollutant A   |

Adjustments to preferred survey method

$$CAE_{SUB A} = (UAE_{SUB A}) [1 - (CE)(RP)(RE)]$$

Adjustments to other methods using emission factors and activity data

$$CAE_{SUB A} = (EF_{SUB A})(Q) [1 - (CE)(RP)(RE)]$$

An example calculation to determine CE is included below and based on the following background information:

New York had a regulation in place affecting the NY Metropolitan Area (NYMA) nonattainment area before the inventory year being developed. This regulation established controlled VOC limits of:

Touch up/repair products = 6.2 lbs. VOC/gal (lacquers)

Full paint job products = 5.0 lbs./gal (enamels)

The average 1990 uncontrolled VOC content = 6.75 lbs. VOC/gal per "Meeting the 15-Percent Rate-of-Progress Requirement Under the Clean Air Act," dated September 1993 as provided by STAPPA/ALAPCO. Additional information provided by EPA document, Reduction of Volatile Organic Compound Emissions from Automobile Refinishing, indicates that:

53% of total usage is for full paint jobs

47% is for touch up/repair jobs

Because New York State's existing regulation (6NYCRR Part 228) limits VOC below this uncontrolled average VOC content value, the calculation below needs to be made to estimate control efficiency.

$$CE = (0.47[(6.75-6.2)/6.75] + (0.53[(6.75-5.0)/6.75]) * 100$$

$$CE = 17.6\%$$

RP=50% based on good engineering judgement

RE=80% EPA default based on good engineering judgement

Any federal regulations affecting the area source need to also, be considered. In the case of auto body refinishing, a federal regulation was promulgated in September, 1998. While it is arguable that VOC limits in auto body refinishing coatings have decreased in anticipation of this regulation, it is most likely that adjustments to actual emissions would be made beginning with the 1999 inventory year.

### **Spatial and temporal resolution**

Emissions would most appropriately be represented by county except where attainment designations require a further breakdown. While EPA reports no evidence of seasonal variation, there may be a correlation between number of accidents and seasons. Accident statistics may be an indicator for increases or decreases in refinishing. Daily resolution of refinishing activity has been reported as being typically five days of the week.

## **RECOMMENDATIONS**

Although the preferred method is to survey auto refinishing facilities including original coating facilities which may also refinish autos, each state and province needs to assess whether or not this is feasible. There are other alternatives such as employee and per capita based estimation techniques which enables states to estimate emissions for this source category when the preferred method is not feasible. When using other alternative methods, states should use the most recent emission factors available.

When estimating emissions using emission factors, each state and province will need to use the latest published emission factors available. It is important that point source estimates are subtracted out from the area source estimates. Additional work may need to be performed, as demonstrated within, in order to account for regulations and controls on the industry.

# **M. Consumer and Commercial Solvent Use**

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## **OVERVIEW**

All quotes and information contained within are from the source, Emission Inventory Improvement Program, Volume 3, Chapter 5, Consumer and Commercial Solvent Use. The consumer and commercial solvent source category includes a wide array of products including personal care products, household cleaning products and household pesticides. However, all VOC emitting products used by businesses, institutions and numerous industrial manufacturing operations are also included. Products included in this category are shown in Table M-1. The majority of VOC's introduced into the atmosphere from this category is a result of evaporation of the solvent contained in the product or from the propellant. There are two methods for estimating emissions for consumer and commercial solvent use recommended by the Emissions Inventory Improvement Program (EIIP). The choice as to which one is employed depends on the desired level of accuracy as well as available data and resources.

ASC: 2465000000

## **METHODOLOGY**

The two methodologies for estimating emissions of VOC's and HAP's from this source category are outlined below.

VOC's

- Use of national average per capita emission factors adjusted for state or local emission limits.
- Surveying consumer and commercial product use or sales in the inventory area.

The former population based method is preferred for emissions estimating. Surveying may be more accurate but will be quite expensive if done correctly. The procedure for the preferred method is outlined below:

- C Identify applicable state and local regulations;
- C Create a database or spreadsheet with per capita emission factors for the source categories of interest;
- C Obtain population data for the base year of interest and allocate it to geographic areas as needed;
- C Multiply per capita emission factors by population to obtain overall emissions estimates;
- C Adjust estimated emissions for applicable regulations as needed.

Example:

To estimate VOC emissions from personal care products:

Emissions = Population x Per Capita Emission Factor

Given a population of 1 million persons for a particular area, the VOC emissions from personal care products would be:

$$\begin{aligned} 1,000,000 \text{ persons} \times 2.32 \text{ lbs. VOC's/person/year} &= 2,320,000 \text{ lb. VOC/year} \\ &= 1,160 \text{ tons VOC/year} \end{aligned}$$

HAP's

- Use of national average per capita emission factors adjusted for state or local emission limits.
- Identify speciation profiles and apply them to the VOC emissions estimate developed using the alternative method.

The population based method is again the preferred method with adjustments made for state and local regulations on this industry.

An alternative procedure for estimating VOC and HAP emissions would include:

- C Perform a survey of distributors and retailers or consumers of consumer and commercial products in the inventory region;
- C Obtain data on the amounts of products sold or used in the inventory region;
- C Estimate the total amount of VOC's (or HAP's) emitted in the inventory region from consumer and commercial products.

## **DATA NEEDED**

Data needs for estimating the emissions of VOC's and HAP's from this source category are as follows:

Population-based method:

- Population in the inventory area.
- National average per capita emission factors.
- Information on state and local regulations.

Survey method:

- Product type.
- Product amount distributed or used by type (weight or volume).
- Product density.

## EMISSION FACTORS

Table M-1: Consumer and Commercial Solvent Product Categories and Emission Factors

| Product Category                               | Per Capita Emission Factor<br>(lb VOC/Person) |
|--|---|
| Personal Care Products                         | 2.32  |
| Household Products                             | 0.79  |
| Automotive Aftermarket Products                | 1.36  |
| Adhesives and Sealants                         | 0.57  |
| FIFRA-Regulated Products                       | 1.78  |
| Coatings and Related Products                  | 0.95  |
| Miscellaneous Products                         | 0.07  |
| Total for All Consumer and Commercial Products | 7.84  |

## SPECIATION

ASC: 2465000000

Profile code: 0197 - didn't use speciation factors associated with this profile code but those provide by EIIP below.

Table M-2: Per Capita Consumer and Commercial Solvent HAP Emission Factors (lb./yr./person)

| CAS code    | Chemical name         | Per Capita Emission Factor<br>(lbs./Person) |
|-------------|-----------------------|---|
| 000071-43-2 | Benzene               | 4.72e-06                                    |
| 000056-23-5 | Carbon tetrachloride  | 4.10e-10                                    |
| 000067-66-3 | Chloroform            | 9.91e-04                                    |
|             | Dibenzofuran          | 8.07e-06                                    |
| 000107-06-2 | Ethylene dichloride   | 4.65e-06                                    |
| 000100-41-4 | Ethyl benzene         | 2.07e-03                                    |
| 000075-21-8 | Ethylene oxide        | 1.51e-02                                    |
| 000050-00-0 | Formaldehyde          | 1.26e-03                                    |
|             | Glycol ethers         | 4.04e-02                                    |
| 000075-09-2 | Methylene Chloride    | 3.64e-02                                    |
| 000091-20-3 | Naphthalene           | 4.61e-02                                    |
| 000127-18-4 | Perchloroethylene     | 2.82e-02                                    |
| 000108-88-3 | Toluene               | 4.29e-01                                    |
| 000071-55-6 | 1,1,1-Trichloroethane | 3.87e-01                                    |
| 000079-01-6 | Trichloroethylene     | 4.86e-04                                    |
| 001330-20-7 | Xylenes, m, o, & p    | 2.03e-01                                    |

Table M-3: Per Capita Consumer and Commercial Solvent HAP Emission Factors by Category (lb./yr./person).

| Pollutant               | Personal Care Products | Household Products | Automotive Aftermarket Products | Adhesives & Sealants | FIFRA-Regulated Products <sup>b</sup> | Coatings & Related Products | Misc.    | Overall Emission Factor (lb./yr./person) |
|-------------------------|------------------------|--------------------|---------------------------------|----------------------|---------------------------------------|-----------------------------|----------|--|
| Acetamide               | 1.38E-07               |                    |                                 |                      |                                       |                             |          | 1.38E-07                                 |
| Acetophenone            |                        |                    |                                 |                      |                                       | 8.53E-06                    |          | 8.53E-06                                 |
| Acrylic acid            |                        |                    |                                 | 3.94E-09             |                                       |                             |          | 3.94E-09                                 |
| Benzene                 |                        |                    | 4.72E-06                        |                      |                                       |                             |          | 4.72E-06                                 |
| Carbon tetrachloride    |                        |                    |                                 |                      |                                       | 4.10E-10                    |          | 4.10E-10                                 |
| Chlorobenzene           |                        |                    |                                 |                      | 7.16E-02                              | 1.51E-05                    |          | 7.16E-02                                 |
| Chloroform              |                        |                    | 3.60E-05                        |                      |                                       | 9.55E-04                    |          | 9.91E-04                                 |
| Dibenzofurans           |                        |                    |                                 | 8.07E-06             |                                       |                             |          | 8.07E-06                                 |
| 1,4-Dichlorobenzene     |                        | 4.79E-02           |                                 |                      | 3.52E-02                              |                             |          | 8.31E-02                                 |
| 1,2-Dichloroethane      | 4.62E-06               | 3.52E-08           |                                 |                      |                                       |                             |          | 4.65E-06                                 |
| 1,3-Dichloropropene     |                        |                    |                                 |                      | 1.60E-01                              |                             |          | 1.60E-01                                 |
| Dimethyl formamide      | 2.71E-05               |                    | 2.78E-08                        | 2.29E-07             |                                       |                             | 7.43E-06 | 3.49E-05                                 |
| 1,4-Dioxane             |                        |                    |                                 | 1.09E-05             |                                       |                             |          | 1.09E-05                                 |
| Ethyl benzene           |                        | 2.56E-06           | 7.51E-05                        | 1.36E-05             | 1.30E-03                              | 6.86E-04                    |          | 2.07E-03                                 |
| Ethylene oxide          |                        |                    |                                 |                      | 1.51E-02                              |                             |          | 1.51E-02                                 |
| Formaldehyde            |                        | 6.74E-06           |                                 | 2.51E-05             | 3.81E-04                              | 8.55E-04                    |          | 1.26E-03                                 |
| Glycol ethers           | 1.52E-05               | 5.31E-03           | 2.69E-02                        | 1.28E-04             | 5.65E-03                              | 2.24E-03                    | 2.42E-04 | 4.04E-02                                 |
| Hexane                  |                        | 2.09E-03           | 3.53E-03                        | 7.83E-02             |                                       | 2.39E-03                    |          | 8.63E-02                                 |
| Hydrochloric acid       |                        | 1.75E-06           |                                 |                      |                                       |                             |          | 1.75E-06                                 |
| Hydrogen fluoride       |                        | 8.75E-08           | 1.41E-05                        |                      |                                       |                             |          | 1.41E-05                                 |
| Isophorone              |                        |                    |                                 |                      | 9.47E-04                              |                             |          | 9.47E-04                                 |
| Methanol                | 5.67E-07               | 6.66E-04           | 6.61E-01                        | 6.82E-04             | 9.48E-04                              | 1.60E-02                    | 1.84E-02 | 6.97E-01                                 |
| Methyl bromide          |                        |                    |                                 |                      | 2.22E-01                              |                             |          | 2.22E-01                                 |
| Methyl ethyl ketone     | 1.75E-05               | 4.49E-04           | 3.04E-03                        | 3.91E-02             | 2.01E-05                              | 7.94E-03                    | 1.01E-05 | 5.06E-02                                 |
| Methyl isobutyl ketone  |                        | 1.08E-04           | 8.73E-04                        | 1.24E-03             | 9.01E-05                              | 5.26E-03                    |          | 7.57E-03                                 |
| Methyl-tert-butyl ether |                        |                    | 2.36E-05                        |                      |                                       |                             |          | 2.36E-05                                 |
| Methylene chloride      |                        | 2.39E-03           | 4.83E-03                        | 8.78E-03             | 6.81E-04                              | 1.97E-02                    | 2.38E-05 | 3.64E-02                                 |
| Naphthalene             |                        | 5.52E-07           | 2.26E-06                        | 1.07E-04             | 4.60E-02                              | 5.75E-06                    |          | 4.61E-02                                 |
| 2-Nitropropane          |                        |                    |                                 | 2.12E-06             |                                       |                             |          | 2.12E-06                                 |
| Perchloroethylene       |                        | 2.96E-03           | 2.35E-02                        | 6.75E-04             | 1.92E-04                              | 1.48E-04                    | 7.53E-04 | 2.82E-02                                 |
| Toluene                 | 3.41E-03               | 5.82E-04           | 2.49E-02                        | 8.43E-02             |                                       | 3.16E-01                    | 2.46E-06 | 4.29E-01                                 |
| 1,1,1-TCE               | 7.45E-04               | 2.85E-02           | 7.63E-02                        | 2.14E-01             | 5.99E-02                              | 7.69E-03                    | 2.46E-04 | 3.87E-01                                 |
| Trichloroethylene       |                        | 4.34E-05           | 2.67E-04                        | 3.88E-05             |                                       | 1.37E-04                    |          | 4.86E-04                                 |
| Triethylamine           |                        |                    |                                 |                      | 3.13E-04                              | 5.26E-04                    |          | 8.39E-04                                 |
| Vinyl acetate           |                        |                    |                                 | 4.94E-08             |                                       |                             |          | 4.94E-08                                 |
| Xylenes                 |                        | 3.28E-03           | 1.20E-02                        | 9.76E-03             | 1.37E-01                              | 4.05E-02                    | 4.31E-04 | 2.03E-01                                 |

When estimating emissions using emission factors, each state and province will need to use the latest published emission factors available. It is important that point source estimates are subtracted out from the area source estimates. Additional work may need to be performed, as demonstrated below, in order to account for regulations and controls on the industry.

## Adjusting for regulations and control of VOC and HAP's

|         |   |   |
|---------|---|---|
| $EF_A$  | = | emission factor for pollutant A                   |
| $Q$     | = | activity factor for category                      |
| $CE$    | = | control efficiency/100                            |
| $RP$    | = | rule penetration/100                              |
| $RE$    | = | rule effectiveness/100                            |
| $UAE_A$ | = | uncontrolled area source emissions of pollutant A |
| $CAE_A$ | = | controlled area source emissions of pollutant A   |

Adjustments to preferred method using emissions factors and activity data

$$CAE_{SUB A} = (EF_{SUB A})(Q)[1 - (CE)(RP)(RE)]$$

Adjustments to survey method

$$CAE_{SUB A} = (UAE_{SUB A})[1 - (CE)(RP)(RE)]$$

Example:

New York has a regulation in place affecting various product subcategories of the categories listed in Table M-3. Hair spray, antiperspirants, deodorants, and all purpose cleaners had limits on the % VOC by weight of the products in these subcategories pursuant to 6NYCRR Part 235. The products regulated make up only parts of several categories listed in Table L-3. Therefore, when estimating emissions, CE and RP need to be calculated per affected category (see Table M-3) as follows:

$RP = \text{per capita emissions of regulated portion of category} / \text{per capita emissions of all products in category} * 100$

$RE = 80\% \text{ EPA default based on good engineering judgement (RE of 100 for federal regulation)}$

$CE = (\text{Uncontrolled VOC content} - \text{controlled VOC content}) / \text{uncontrolled VOC} * 100$

Calculate speciated contaminant and VOC emission estimates with CE, RE, & RP calculated for the relevant category using the formula for the preferred method above.

Refer to Appendix A of the Emission Inventory Improvement Program, Volume 3, Chapter 5, Consumer and Commercial Solvent Use for additional information on product types per category and associated per capita emissions estimates.

## Spatial and temporal resolution

Emissions would most appropriately be represented by county except where attainment designations require a further breakdown. Consumer and commercial product use is not influenced by season. While some exceptions can be noted as with pesticide use and with products like windshield washer (which typically has a higher VOC content in colder climates and seasons), there is no significant difference in the use between seasons. Daily resolution of product use is 7 days per week.

## **N. Chromium Electroplating**

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Chromium electroplating and anodizing operations include hard chromium, decorative chromium, decorative trivalent chromium, and chromic acid anodizing. Chromium electroplating and anodizing operations produce chromic acid mists. As these mists escape into the air, chromium emissions are released. As a result, these operations produce significant emissions of hexavalent chromium and chromium compounds. This section will focus on chromium emissions from chromic acid operations, hard and decorative hexavalent chromium electroplating operations. Decorative trivalent electroplating operations will not be included due to lack of information available for estimating emissions. Chromium electroplating and anodizing operations are regulated by the NESHAP for Hard and Decorative Chromium Electroplating and Chromium Anodizing Tanks, finalized on January 25, 1995.

### **Source Identification**

Chromium electroplating operations are classified under the Standard Industrial Classification Code (SIC) 3471 - Plating and Polishing.

The following codes were found for chromium electroplating operations in the Source Classification Code (SCC) list:

|          |  |
|----------|--|
| 3        | Industrial Processes   |
| 309      | Fabricated Metal Products                                      |
| 309010   | Electroplating Operations                                      |
| 30901018 | Hard Chromium Electroplating - Uncontrolled                    |
| 30901028 | Decorative Chromium Electroplating - Uncontrolled              |
| 30901038 | Chromic Acid Anodizing Tank - Uncontrolled and Packed Scrubber |

The following codes were found for electroplating and anodizing operations in the Area and Mobile Source Code (AMS) list:

|             |   |
|-------------|---|
| A23         | Industrial Processes                    |
| A2309       | Fabricated Metals                       |
| A2309100    | Coating, Engraving, and Allied Services |
| A2309100010 | Electroplating                          |
| A2309100050 | Anodizing                               |

### **Pollutants**

The targeted pollutant emissions of concern for chromium electroplating operations are Chromium and Chromium VI (hexavalent chromium).

## Emission Factors

There were no emission factors found for any of the applicable AMS codes in the FIRE database. The following emission factors were found in FIRE for the corresponding SCC codes.

Table N-1: Emission Factors from FIRE 5.1B

| Pollutant   | SCC Code | Description                                  | Factor Quality | Emission Factor (lb./1000 amp-hr)    |
|-------------|----------|--|----------------|--------------------------------------|
| Chromium VI | 30901018 | Hard Chrome - Electroplating                 | B              | 0.12                                 |
| Chromium VI | 30901028 | Decorative Chrome - Electroplating           | D              | 0.033                                |
| Chromium VI | 30901038 | Chromic Acid Anodizing (uncontrolled)        | D              | 2.0 (lb./1000hr-ft <sup>2</sup> )    |
| Chromium VI | 30901038 | Chromic Acid Anodizing (packed bed scrubber) | D              | 0.0096 (lb./1000hr-ft <sup>2</sup> ) |

All emission factors are from FIRE 5.1, Version B, but are referenced from EPA AP-42, Supplement B, October 1996.

Because emissions from chromium electroplating are considered area source emissions, the final emissions estimates will be included in the inventory with the appropriate AMS code, A2309100010 or A2309100050.

## Facility Identification

Applicable chromium electroplating facilities were identified by using the Initial Notification forms submitted to the PCA by electroplating facilities as required by the NESHAP for chromium electroplating facilities (subpart N). The initial notification forms provided information such as type of process, rectifier capacity (amperes), and location of the facility. Only those facilities with hexavalent chromium operations were included for the inventory. Trivalent chromium operations are significantly less toxic. In addition, emission factors and calculation methods for trivalent chromium were difficult to find.

Although some electroplating facilities do have fume suppressant equipment or incorporate some other type of emissions control method, the emission factors from FIRE are for uncontrolled systems. Therefore, these factors will be applied for all electroplating operations. One chromic anodizing facility in Minnesota has a packed bed scrubber for emissions control, but this facility is included in the point source inventory and therefore, the emissions from this facility were not included in the area source inventory. The emission factor for chromic anodizing with a packed bed scrubber is shown in Table N-1 for reference.

Data was gathered using the information contained in the NESHAP Initial Notification forms, the facilities' Compliance Certification reports for the NESHAP, facility performance test results, and by calling the facilities directly and requesting any additional information needed. Table N-2 shows a summary of the data collected.

## Emission Estimation

Total chromium emissions from hard and decorative chromium electroplating for each county are calculated by multiplying the total production ampere-hours per year by the appropriate emission factors in Table N-1. The following equation is an example calculation used to determine the chromium emissions at each facility.

$$E = EF \times PR$$

where:            E     = Chromium emissions (lb./yr.)  
                    EF     = Chromium emission factor from FIRE (lb./A-hr)  
                    PR     = total production rectifier ampere-hours per year (Amp-hr/yr.)

Emissions from chromic anodizing tanks were calculated using the operating hours of the unit and the surface area of the tank, then multiplying by the appropriate emission factor.

$$E = EF \times SA \times OP$$

where:            E     = Chromium emissions (lb./yr.)  
                    EF     = Chromium emission factor from FIRE (lb./ft<sup>2</sup>-hr)  
                    SA     = Surface area of the anodizing tank (ft<sup>2</sup>)  
                    OP     = Operating hours of the unit (hr/yr.)

The emission factors from FIRE are specific to hexavalent chromium emissions. Therefore, all emissions calculated using the emission factors in Table N-1 are hexavalent chromium emissions. It can be assumed that 75 percent of chromium emissions are hexavalent, therefore, total chromium emissions can be back-calculated from the hexavalent chromium emissions.

After each facility's emissions were calculated, process emissions were totaled by county. Those emissions are included in Table N-3.

Table N-2: Facility-Specific Information for 1997

| Facility Name                  | County    | Tank type | 1997 Activity | Units               | EIS? |
|--------------------------------|-----------|-----------|---------------|---------------------|------|
| United Defense                 | Anoka     | hard      | 1,440,000     | Amp-hr              | 0    |
| United Defense                 | Anoka     | anodizing | 28,800        | ft <sup>2</sup> -hr | 0    |
| Rapid Plating                  | Benton    | dec. hex  | 6,240,000     | Amp-hr              |      |
| North Star Plating             | Crow Wing | dec. hex  | 10,500,000    | Amp-hr              |      |
| Bo-Decor Metal Finishing       | Dakota    | dec. hex  | 1040          | Amp-hr              |      |
| D.S. Manufacturing             | Goodhue   | dec. hex  | 2,265,655     | Amp-hrs             |      |
| Douglas Corp. Plating Division | Hennepin  | dec. hex  | 50,000,000    | Amp-hr              | 0    |
| Hard Chrome                    | Hennepin  | hard      | 99,300,000    | Amp-hr              |      |
| Hard Chrome                    | Hennepin  | dec. hex  | 720,000       | Amp-hr              |      |
| Hiawatha Panel & Name Plate    | Hennepin  | anodizing | 49,275        | ft <sup>2</sup> -hr |      |
| J&R Chrome Plating             | Hennepin  | dec. hex  | 114,000       | Amp-hr              |      |
| Joyner's                       | Hennepin  | dec. hex  | 3,120,000     | Amp-hr              |      |
| Maxwell Aircraft Service       | Hennepin  | anodizing | 1,500         | ft <sup>2</sup> -hr |      |
| Minnesota Rubber Company       | Hennepin  | hard      | 3,600,000     | Amp-hr              |      |
| Nico Products, Inc.            | Hennepin  | dec. hex  | 0             |                     |      |
| Superior Plating               | Hennepin  | dec. hex  | 4.4           | lbs..               | 0    |
| Superior Plating               | Hennepin  | hard      | 2.2           | lbs..               | 0    |
| Twin City Plating              | Hennepin  | hard      | 3.99          | lbs..               |      |
| VisionEase Lens                | Hennepin  | hard      | 2800          | Amp-hrs             | 0    |
| New Dimension Plating          | McLeod    | dec. hex  | 300,000       | Amp-hr              |      |
| New Dimension Plating          | McLeod    | hard      | 3,400,000     | Amp-hr              |      |
| Prestige Plating               | McLeod    | dec. hex  | 500           | Amp-hr              |      |
| Northwest Airlines, MSP Maint. | Ramsey    | hard      | 42,666,667    | Amp-hr              | 0    |
| St. Paul Electroplating        | Ramsey    | dec. hex  | 73,810        | Amp-hr              |      |
| Wolkerstorfer Co, Inc.         | Ramsey    | hard      | 15,190        | Amp-hrs             | 0    |
| Plating Specialties, Inc.      | St. Louis | dec. hex  | 52,000        | Amp-hr              |      |
| SPX, Power Team Divisions      | Steele    | hard      | 618,076       | Amp-hr              |      |
| Olson Industries               | Watonwan  | hard      | 212,052       | Amp-hr              |      |
| St. James Automotive Products  | Watonwan  | dec. hex  | 3,129,619     | Amp-hr              |      |

Table N-3: Chromium Emissions (lbs.) by County

| County    | Dec. Hex Emissions | Hard Chrome Emissions | Anodizing | Hexavalent Chromium Emissions | Total Chromium Emissions |
|-----------|--------------------|-----------------------|-----------|-------------------------------|--------------------------|
| Benton    | 20.59              |                       |           | 20.59                         | 27.46                    |
| Crow Wing | 34.65              |                       |           | 34.65                         | 46.2                     |
| Dakota    | 0.003              |                       |           | 0.003                         | 0.004                    |
| Goodhue   | 7.48               |                       |           | 7.48                          | 9.97                     |
| Hennepin  | 178.05             | 1238.8                | 101.55    | 1518.4                        | 2024.5                   |
| McLeod    | 0.99               | 40.8                  |           | 41.79                         | 55.72                    |
| Ramsey    | 0.24               |                       |           | 0.24                          | 0.32                     |
| St. Louis | 0.17               |                       |           | 0.17                          | 0.23                     |
| Steele    | 7.42               |                       |           | 7.42                          | 9.89                     |
| Watonwan  | 10.33              |                       |           | 10.33                         | 13.77                    |

Total chromium emissions are calculated assuming that hexavalent chromium is 75% of total chromium emissions.

Those facilities which are included in the point source inventory (EIS) are not included in this summary.

## REFERENCES

Strong, Phyllis, 1995. Minnesota Small Business Assistance Program, Minnesota Pollution Control Agency. Conversation with Cathy Tran, October 2, 1995.

U.S. Environmental Protection Agency. AP-42, Supplement B, Compilation of Air Pollution Emission Factors, Section 12.20. Oct. 1996.

NESHAP Subpart N - 1997 Compliance Certification Reports

## **O. Drycleaners**

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### **General Hierarchy of Methods**

#### Coin operated

- local per facility emission factor (through survey/permits)
- local per machine factor from commercial dry cleaners
- national per employee emission factor

#### Commercial/Industrial

- local per facility solvent consumption (through survey/permits)
- local per employee factors (through surveys/permits)
- national employee factors
- national per capita factors

### **Data Requirements**

The data requirements for calculating emissions from dry cleaners depends upon the methods used. These elements are described perfectly in the EIIP document on dry cleaning (Volume III: Area Sources - Chapter 4: Dry Cleaning). The data items include:

- type of solvent used
- amount of solvent used
- number of employees
- number of employees by SIC
- machines per facility
- type of machines
- control methods
- number of facilities
- applicable emission factors (can be per facility, per machine, per employee or per capita and be a national value or a local (source specific) value)

### **Pollutants emitted by dry cleaners pertinent to RAPIDS**

- 1,1,1-trichloroethane (second most common)
- Ethylbenzene
- Naphthalene
- Perchloroethylene (most common)
- Toluene
- Xylenes

These pollutants came from the following speciation profiles in RAPIDS: 0085, 1193, 1196 and 9017. Profile 0085 is 100% perc while profile 1193 looks to be for petroleum solvent dry cleaning. The other two profiles are composites (sometimes with degreasers) and probably shouldn't be used.

Point source emission factors exist for dry cleaners in RAPIDS. No area source emission factors exist in RAPIDS for dry cleaners.

AP-42 has emission factors on a per capita basis and machine basis.

## **Reference Documents**

The following are good reference documents to read about calculating emissions from dry cleaners

- AP-42 Section 4.1 ([www.epa.gov/ttn/chief/ap42.html](http://www.epa.gov/ttn/chief/ap42.html))
- EIIP Document Volume III: Chapter 4 ([www.epa.gov/ttn/chief/eiip/techrep.htm](http://www.epa.gov/ttn/chief/eiip/techrep.htm))

## **Method to use for RAPIDS calculations**

For states that have the manpower, need, rules or capability, a survey is the way to go. This method should give accurate emissions that were based upon actual usage. Since emissions from the dry cleaners can be significant, some calculation methodology would need to be applied to the sources that do not submit the questionnaire to have a complete inventory.

Other states should be able to calculate emissions using per capita factors, at a minimum. Data available to the state will determine if the state uses employee based or population based emission factors. I would imagine that every state should have population by county. The Census Bureau ([www.census.gov](http://www.census.gov)) does have data on number of employees per county per SIC code called County Business Patterns. This data can be obtained at [www.census.gov/epcd/cbp/view/cbpview.html](http://www.census.gov/epcd/cbp/view/cbpview.html).

Another possible option is to use the data compiled for the 1993 inventory and convert that to a population based emission factor. For the Pilot Project Inventory compiled by Illinois, Indiana and Wisconsin, the calculated per capita emission factors for Illinois and Wisconsin were very close. Again, a state specific emission factor should probably override the national per capita factor.

## Emission Factors

From EIIP

Table O-1: Drycleaner Emission Factors

| <b>Subcategory</b>                             | <b>Reactive VOC<br/>(lb./year/employee)</b> | <b>Total Organics<br/>(lb./year/employee)</b> |
|--|---|---|
| All solvents (total)                           | 1,800                                       | 2,300   |
| Halogenated Solvents                           |   |   |
| PERC, TCA and CFC 113                          |   | 980   |
| Coin Operated                                  |   | 52  |
| Commercial/Industrial                          |   | 1,200   |
| Mineral Spirits and Other Unspecified Solvents | 1,800                                       | 1,800   |

On a per-unit basis: 0.8 tons/facility-year (assumes that average coin-op facility has two dry cleaning units and each emits 0.4 tons of PERC per year.

From AP-42

Commercial: 1.3 lb./year/person (all nonmethane VOC)  
Coin Operated: 0.4 lb./year/person (all nonmethane VOC)

## **P. Gasoline Marketing**

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### **DESCRIPTION OF EMISSION SOURCES**

Currently, there are essentially two types of fuel dispensed at gasoline service stations to consumers in the Great Lakes States and Ontario, unleaded gasoline and diesel. As a result of the low volatility of diesel fuel, the evaporative emissions from diesel fuel at service stations are very small and considered negligible. However, the evaporative emissions from gasoline fuel are significant and will be discussed in this section. The following emissions are covered:

- a) Delivery trucks in transit;
- b) Stage I (transfer of gasoline from tank trucks to storage tanks at service stations);
- c) Stage II (transfer of gasoline from storage tanks at service stations to the vehicle gasoline tank);
- d) Gasoline station storage tanks; and
- e) Spillage.

### **GASOLINE TRUCKS IN TRANSIT**

#### **Introduction**

Evaporative emissions of gasoline vapor occur (1) from loaded tank trucks during the transportation of gasoline from the bulk terminals/plants to the gasoline service stations, and (2) from empty tank trucks returning from service stations to bulk terminals/plants.

#### **Source Identification**

There is no uniquely defined SIC that categorizes the emissions resulting from the transportation of gasoline between bulk terminals/plants and service stations. This type of emission occurs neither at the bulk terminals/plants nor the service stations. Since the transportation of gasoline is part of the services provided by the bulk terminals/plants to their customers (service stations), the SIC of 5171 in the Standard Industrial Classification Code 1972 for bulk terminals/plants is used to identify this type of emission source, or under 42271 (petroleum bulk stations and terminals) in the North America Industry Classification System 1997 (NAICS).

There are also Source Classification Codes (SCC) and Area Mobile Source Codes (AMS) that describe the evaporative emissions from transportation of gasoline by trucks. Table P-1 shows the SCC relating to the transportation of gasoline.

Table P-1: SCC Codes for Transportation of Gasoline

| <b>FIRE SCC Code</b> | <b>Description</b>  |                       |
|----------------------|---|-----------------------|
| 406001               | Petroleum and Solvent Evaporation<br>Transportation and Marketing of Petroleum Products<br>Tank Cars and Trucks |                       |
| 40600162             | Gasoline: Loaded with Fuel (Transit Losses)   |                       |
| 40600163             | Gasoline: Return with Vapor (Transit Losses)  |                       |
| <b>FIRE AMS Code</b> | <b>Description</b>  | <b>Equivalent SCC</b> |
| A2505030             | Storage and Transport<br>Petroleum and Petroleum Product Transport<br>Truck                                     |                       |
| A2505030120          | Gasoline  | 40600162<br>40600163  |

## Identification of Emission Factors

There are four sources of information that contain the emission factors regarding gasoline service station operation, i) AP42-Chapter 5 Section 2<sup>1</sup>, ii) Emission Inventory Improvement Program, Volume III, Chapter 11<sup>2</sup>, iii) FIRE 6.1 (Factor Information Retrieval System Version 6.1)<sup>3</sup>, and iv) other technical documents<sup>5</sup>. A search of the first three sources revealed some emission factors on VOCs. Reference 5 provided a HAP profile on gasoline (Table P-2) and was used to generate a speciation profile for Benzene, Ethylbenzene, Naphthalene, Toluene, and Xylene. Only Ethylbenzene is included in the GLC 49 substance list.

Since the emissions from gasoline transportation are inventoried under area sources, new AMS codes are created for this GREAT LAKES COMMISSION (GLC) inventory and will be used to identify the sources. In FIRE 6, there are no associated emission factors for the AMS codes. The emission factors from the equivalent SCC codes will be applied as state-specific emission factors. A state-specific VOC speciation profile will be created for HAPs when there are no direct emission factors for the concerned HAPs in FIRE. Table P-3 presented a summary of the available emission factors from FIRE and the HAP profile.

Table P-2: HAP Profile in Gasoline Vapor

| <b>HAP</b>   | <b>Weight Percentage</b> |             |
|--------------|--------------------------|-------------|
| Benzene      | 0.9%                     | lb./lb. VOC |
| Ethylbenzene | 0.1%                     | lb./lb. VOC |
| Naphthalene  | 0.5%                     | lb./lb. VOC |
| Toluene      | 1.3%                     | lb./lb. VOC |
| Xylenes      | 0.5%                     | lb./lb. VOC |

Table P-3: Emission Factors for Gasoline Truck in Transit

| Pollutant   | Emission Factors                              | Remarks      | Reference    |
|---|---|--------------|--------------|
| SCC 40600162: Petroleum and Solvent Evaporation<br>Transportation and Marketing of Petroleum Products<br>Tank Cars and Trucks<br>Gasoline: Loaded with Fuel (Transit Losses)  |   |              |              |
| VOC   | 5.000E-3 [1] Lb. per 1000 Gallons Transferred | UNCONTROLLED | EIIP/FIRE    |
| Benzene   | 9.000E-3 Lb. per lb. of VOC                   | UNCONTROLLED | HAP SPECIATE |
| Ethylbenzene  | 1.000E-3 Lb. per lb. of VOC                   | UNCONTROLLED | HAP SPECIATE |
| Naphthalene   | 5.000E-3 Lb. per lb. of VOC                   | UNCONTROLLED | HAP SPECIATE |
| Toluene   | 1.300E-2 Lb. per lb. of VOC                   | UNCONTROLLED | HAP SPECIATE |
| Xylene, mixed isomers   | 5.000E-3 Lb. per lb. of VOC                   | UNCONTROLLED | HAP SPECIATE |
| SCC 40600163: Petroleum and Solvent Evaporation<br>Transportation and Marketing of Petroleum Products<br>Tank Cars and Trucks<br>Gasoline: Return with Vapor (Transit Losses) |   |              |              |
| VOC   | 5.500E-2 [2] Lb. per 1000 Gallons Transferred | UNCONTROLLED | EIIP/FIRE    |
| Benzene   | 9.000E-3 Lb. per lb. of VOC                   | UNCONTROLLED | HAP SPECIATE |
| Ethylbenzene  | 1.000E-3 Lb. per lb. of VOC                   | UNCONTROLLED | HAP SPECIATE |
| Naphthalene   | 5.000E-3 Lb. per lb. of VOC                   | UNCONTROLLED | HAP SPECIATE |
| Toluene   | 1.300E-2 Lb. per lb. of VOC                   | UNCONTROLLED | HAP SPECIATE |
| Xylene, mixed isomers   | 5.000E-3 Lb. per lb. of VOC                   | UNCONTROLLED | HAP SPECIATE |
| AMS A2505030132 Petroleum and Solvent Evaporation<br>Transportation and Marketing of Petroleum Products<br>Trucks<br>Gasoline: (Transit Losses)                               |   |              |              |
| VOC   | 6.000E-2 [3] Lb. per 1000 Gallons Transferred | UNCONTROLLED | EIIP/FIRE    |
| Benzene   | 9.000E-3 Lb. per lb. of VOC                   | UNCONTROLLED | HAP SPECIATE |
| Ethylbenzene  | 1.000E-3 Lb. per lb. of VOC                   | UNCONTROLLED | HAP SPECIATE |
| Naphthalene   | 5.000E-3 Lb. per lb. of VOC                   | UNCONTROLLED | HAP SPECIATE |
| Toluene   | 1.300E-2 Lb. per lb. of VOC                   | UNCONTROLLED | HAP SPECIATE |
| Xylene, mixed isomers   | 5.000E-3 Lb. per lb. of VOC                   | UNCONTROLLED | HAP SPECIATE |

Notes:

1. EIIP document recommends the midpoint value of the typical range, i.e. 5.000E-3 lb./1000 gallon throughput
2. EIIP document recommends the midpoint value of the typical range, i.e. 5.500E-2 lb./1000 gallon throughput
3. This factor is the sum of transit losses (loaded with fuel and return with vapor).

## Facility Identification

As recommended by the Emission Inventory Improvement Program, the county-level fuel sales statistics should be obtained by survey data or from other sources (e.g. tax department, statistics agencies). If county-level statistics are not readily available, the state/province total fuel sales should be obtained from the relevant department. This state/province total fuel sales data must be apportioned to the county level based on such factors as:

- a) gasoline service stations \$-sales in each county;
- b) previous county-level sales survey data;
- c) number of gasoline vehicle registrations in each county, travelling patterns and fuel economy.

## Emission Estimation

### *Gasoline Trucks in Transit*

The emissions from gasoline trucks in transit for each county can be estimated from the following equations.

$$GTA = \frac{TGD + TGT}{TGD}$$

Where GTA = Gasoline transportation adjustment factor  
TGD = Total gasoline dispensed in a county (1,000 gallons)  
TGT = Amount of gasoline transported twice within a county (1,000 gallons)

and

$$TTE = \frac{(TGD \times LEF \times GTA) + (TGD \times UEF \times GTA)}{2,000}$$

Where TTE = Annual emission of a pollutant from tank trucks in-transits (tons)  
LEF = Loaded tank truck in-transit emission factor (lb./1,000 gallons throughput)  
UEF = Unloaded tank truck in-transit emission factor (lb./1,000 gallons throughput)

## **GASOLINE SERVICE STATIONS**

### Introduction

There are two stages of fueling losses from gasoline fuel. Stage I fueling losses occur at the gas retail operations and result from truck delivery drop losses and underground tank breathing losses. Stage II fueling losses occur via the filling of vehicle gas tanks and include refueling losses from motor vehicle tanks and spillage.

## Source Identification

Gasoline service stations are categorized under SIC 5541 in the Standard Industrial Classification Code 1972, and under 44711 (gasoline service station with convenience store) and 44719 (other gasoline service station) in the North America Industry Classification System 1997 (NAICS).

There are also Source Classification Codes (SCC) and Area Mobile Source Codes (AMS) that describe the evaporative emissions from gasoline service station operations. Table P-4 shows the SCC regarding gasoline service station operations.

Table P-4: SCC Codes for Gasoline Service Stations (Stage I and II)

| <b>FIRE SCC Code</b> | <b>Description</b>  |                       |
|----------------------|---|-----------------------|
| 406003               | Petroleum and Solvent Evaporation<br>Transportation and Marketing of Petroleum Products<br>Gasoline Retail Operations - Stage I |                       |
| 40600301             | Splashing Filling   |                       |
| 40600302             | Submerged Filling w/o Controls  |                       |
| 40600305             | Unloading   |                       |
| 40600306             | Balanced Submerge Filling   |                       |
| 40600307             | Underground Tank Breathing & Emptying   |                       |
| 406004               | Petroleum and Solvent Evaporation<br>Transportation and Marketing of Petroleum Products<br>Filling Vehicle Gas Tanks - Stage II |                       |
| 40600401             | Vapor Loss w/o Control  |                       |
| 40600402             | Liquid Spill Loss w/o Control   |                       |
| 40600403             | Vapor Loss w/o Control  |                       |
| <b>FIRE AMS Code</b> | <b>Description</b>  | <b>Equivalent SCC</b> |
| A250106005           | Storage and Transport<br>Petroleum and Petroleum Product Storage<br>Gasoline Service Stations: Stage I                          |                       |
| A2501060050          | Total   | 40600300              |
| A2501060051          | Submerged Filling   | 40600302              |
| A2501060052          | Splash Filling  | 40600301              |
| A2501060053          | Balanced Submerged Filling  | 40600306              |
| A250106010           | Storage and Transport<br>Petroleum and Petroleum Product Storage<br>Gasoline Service Stations: Stage II                         |                       |
| A2501060100          | Total   |                       |
| A2501060101          | Displacement Loss/Uncontrolled  | 40600401              |

|             |   |          |
|-------------|---|----------|
| A2501060102 | Displacement Loss/Controlled  | 40600403 |
| A2501060103 | Spillage  | 40600402 |
| A250106020  | Storage and Transport<br>Petroleum and Petroleum Product Storage<br>Gasoline Service Stations: Underground Tank |          |
| A2501060200 | Total   |          |
| A2501060201 | Breathing and Emptying  | 40600307 |

## Emission Factors Identification

There are four sources of information that contain emission factors regarding gasoline service station operation, i) AP42-Chapter 5 Section 2<sup>1</sup>, ii) Emission Inventory Improvement Program, Volume III, Chapter 11<sup>2</sup>, iii) FIRE 6.1 (Factor Information Retrieval System Version 6.1)<sup>3</sup>, iv) MOBILE 5B Transportation model<sup>4</sup> and v) other technical documents<sup>5</sup>. A search of the first three sources revealed some emission factors for Benzene, 1,3-Butadiene, 1,2-Dibromoethane, 1,2-Dichloroethane, Ethylbenzene, Toluene, VOC, and Xylene. Only 1,2-Dichloroethane and Ethylbenzene are included in the GLC 49 substance list.

Since the emissions from gasoline service stations are inventoried under area sources, the AMS code will be used to identify the sources. In FIRE 6, there are no associated emission factors for the AMS code for gasoline service stations. The emission factors from the equivalent SCC codes will be applied as state-specific emission factors. A state-specific VOC speciation profile will be created for the HAPs shown in Table P-5 when there are no direct emission factors for the concerned HAPs in FIRE. The following table presented a summary of the available emission factors.

Table P-5: Emission Factors for Gasoline Service Stations (Stage I and II)

| Pollutant  | Emission Factors                             | Remarks      | Reference |
|--|--|--------------|-----------|
| SCC 40600301: Petroleum and Solvent Evaporation<br>Transportation and Marketing of Petroleum Products<br>AMS A2501060052 Gasoline Retail Operations - Stage I<br>Splashing Filling |  |              |           |
| Benzene  | 6.930E-2 Lb. per 1000 Gal Gas Stored         | UNCONTROLLED | FIRE      |
| 1,3-Butadiene  | 3.940E0 Lb. per 1000 Gal Gas Pumped          | UNCONTROLLED | FIRE      |
| 1,2-Dibromoethane  | 1.490E-4 Lb. per 1000 Gal Material Processed | UNCONTROLLED | FIRE      |
| 1,2-Dichloroethane   | 1.530E-3 Lb. per 1000 Gal Material Processed | UNCONTROLLED | FIRE      |
| Ethylbenzene   | 1.980E-2 Lb. per 1000 Gal Gas Pumped         | UNCONTROLLED | FIRE      |
| Toluene  | 1.760E-1 Lb. per 1000 Gal Gas Pumped         | UNCONTROLLED | FIRE      |
| Xylene, mixed isomers  | 8.800E0 mg per L Gas Stored                  | UNCONTROLLED | FIRE      |
| VOC  | 1.150E1 Lb. per 1000 Gallons Transferred     | UNCONTROLLED | FIRE      |

|   |          |  |                   |                 |
|---|----------|--|-------------------|-----------------|
| Naphthalene   | 5.000E-3 | Lb. per lb. of VOC                     | UNCONTROLLED      | HAP<br>SPECIATE |
| SCC 40600302: Petroleum and Solvent Evaporation<br>Transportation and Marketing of Petroleum Products<br>AMS A2501060051 Gasoline Retail Operations - Stage I<br>Submerged Filling w/o Controls         |          |  |                   |                 |
| Benzene   | 4.420E-2 | Lb. per 1000 Gal Gas<br>Stored         | SUBMERGED FILLING | FIRE            |
| 1,2-Dibromoethane   | 9.510E-5 | Lb. per 1000 Gal Material<br>Processed | UNCONTROLLED      | FIRE            |
| 1,2-Dichloroethane  | 9.760E-4 | Lb. per 1000 Gal Material<br>Processed | UNCONTROLLED      | FIRE            |
| Toluene   | 9.330E1  | mg per Liter Gas Stored                | UNCONTROLLED      | FIRE            |
| Xylene, mixed isomers   | 5.600E0  | mg per L Gas Stored                    | UNCONTROLLED      | FIRE            |
| VOC   | 7.300E0  | Lb. per 1000 Gallons<br>Transferred    | UNCONTROLLED      | FIRE            |
| Ethylbenzene  | 1.000E-3 | Lb. per lb. of VOC                     | UNCONTROLLED      | HAP<br>SPECIATE |
| Naphthalene   | 5.000E-3 | Lb. per lb. of VOC                     | UNCONTROLLED      | HAP<br>SPECIATE |
| SCC 40600306: Petroleum and Solvent Evaporation<br>Transportation and Marketing of Petroleum Products<br>AMS A2501060053 Gasoline Retail Operations - Stage I<br>Balanced Submerged Filling             |          |  |                   |                 |
| Benzene   | 1.670E-3 | Lb. per 1000 Gal Gas<br>Stored         | SUBMERGED FILLING | FIRE            |
| 1,2-Dibromoethane   | 3.840E-6 | Lb. per 1000 Gal Material<br>Processed | UNCONTROLLED      | FIRE            |
| 1,2-Dichloroethane  | 4.420E-5 | Lb. per 1000 Gal Material<br>Processed | UNCONTROLLED      | FIRE            |
| Toluene   | 4.200E0  | mg per Liter Gas Stored                | UNCONTROLLED      | FIRE            |
| Xylene, mixed isomers   | 7.500E-1 | mg per L Gas Stored                    | UNCONTROLLED      | FIRE            |
| VOC   | 3.000E-1 | Lb. per 1000 Gallons<br>Throughput     | UNCONTROLLED      | FIRE            |
| Ethylbenzene  | 1.000E-3 | Lb. per lb. of VOC                     | UNCONTROLLED      | HAP<br>SPECIATE |
| Naphthalene   | 5.000E-3 | Lb. per lb. of VOC                     | UNCONTROLLED      | HAP<br>SPECIATE |
| SCC 40600307: Petroleum and Solvent Evaporation<br>Transportation and Marketing of Petroleum Products<br>AMS 2501060201 Gasoline Retail Operations - Stage I<br>Underground Tank Breathing and Emptying |          |  |                   |                 |
| Benzene   | 5.840E-3 | Lb. per 1000 Gal Gas<br>Stored         | UNCONTROLLED      | FIRE            |
| Toluene   | 1.270E1  | mg per Liter Gas Stored                | UNCONTROLLED      | FIRE            |
| Xylene, mixed isomers   | 6.380E1  | mg per L Gas Stored                    | UNCONTROLLED      | FIRE            |
| VOC   | 1.000E0  | Lb. per 1000 Gallons<br>Throughput     | UNCONTROLLED      | FIRE            |

|  |          |                                     |                                  |                 |
|--|----------|-------------------------------------|----------------------------------|-----------------|
| Ethylbenzene   | 1.000E-3 | Lb. per lb. of VOC                  | UNCONTROLLED                     | HAP<br>SPECIATE |
| Naphthalene  | 5.000E-3 | Lb. per lb. of VOC                  | UNCONTROLLED                     | HAP<br>SPECIATE |
| SCC 40600401: Petroleum and Solvent Evaporation<br>Transportation and Marketing of Petroleum Products<br>AMS A2501060101 Filling Vehicle Gas Tanks - Stage II<br>Vapor Loss w/o Control        |          |                                     |                                  |                 |
| Benzene  | 6.590E-2 | Lb. per 1000 Gal Gas<br>Stored      | UNCONTROLLED                     | FIRE            |
| Toluene  | 9.940E-2 | Lb. per Ton Gas Stored              | UNCONTROLLED                     | FIRE            |
| Xylene, mixed isomers  | 4.050E0  | mg per L Gas Stored                 | UNCONTROLLED                     | FIRE            |
| Xylene, meta   | 1.710E-2 | Lb. per Ton Gas Stored              | UNCONTROLLED                     | FIRE            |
| Xylene, ortho  | 6.620E-3 | Lb. per Ton Gas Stored              | UNCONTROLLED                     | FIRE            |
| Xylene, para   | 6.620E-3 | Lb. per Ton Gas Stored              | UNCONTROLLED                     | FIRE            |
| VOC  | 1.100E1  | Lb. per 1000 Gallons<br>Pumped      | UNCONTROLLED                     | FIRE            |
| Ethylbenzene   | 1.000E-3 | Lb. per lb. of VOC                  | UNCONTROLLED                     | HAP<br>SPECIATE |
| Naphthalene  | 5.000E-3 | Lb. per lb. of VOC                  | UNCONTROLLED                     | HAP<br>SPECIATE |
| SCC 40600402: Petroleum and Solvent Evaporation<br>Transportation and Marketing of Petroleum Products<br>AMS A2501060103 Filling Vehicle Gas Tanks - Stage II<br>Liquid Spill Loss w/o Control |          |                                     |                                  |                 |
| 1,2-Dichloroethane   | 1.330E-4 | Lb. per 1000 Gal Gas<br>Transferred | UNCONTROLLED                     | FIRE            |
| Toluene  | 8.900E0  | mg per Liter Gas Stored             | UNCONTROLLED                     | FIRE            |
| Xylene, mixed isomers  | 3.000E-1 | mg per L Gas Stored                 | UNCONTROLLED                     | FIRE            |
| VOC  | 7.000E-1 | Lb. per 1000 Gallons<br>Pumped      | UNCONTROLLED                     | FIRE            |
| Benzene  | 9.000E-3 | Lb. per lb. of VOC                  | UNCONTROLLED                     | HAP<br>SPECIATE |
| Ethylbenzene   | 1.000E-3 | Lb. per lb. of VOC                  | UNCONTROLLED                     | HAP<br>SPECIATE |
| Naphthalene  | 5.000E-3 | Lb. per lb. of VOC                  | UNCONTROLLED                     | HAP<br>SPECIATE |
| SCC 40600403: Petroleum and Solvent Evaporation<br>Transportation and Marketing of Petroleum Products<br>Filling Vehicle Gas Tanks - Stage II<br>Vapor Loss w/o Control                        |          |                                     |                                  |                 |
| 1,2-Dichloroethane   | 1.750E-3 | Lb. per 1000 Gal Gas<br>Transferred | MISCELLANEOUS<br>CONTROL DEVICES | FIRE            |
| Toluene  | 1.390E1  | mg per L Gas Stored                 | MISCELLANEOUS<br>CONTROL DEVICES | FIRE            |
| Xylene, mixed isomers  | 4.500E-1 | mg per L Gas Stored                 | MISCELLANEOUS<br>CONTROL DEVICES | FIRE            |

|              |          |                             |                               |              |
|--------------|----------|-----------------------------|-------------------------------|--------------|
| VOC          | 1.100E0  | Lb. per 1000 Gallons Pumped | MISCELLANEOUS CONTROL DEVICES | AP42         |
| Benzene      | 9.000E-3 | Lb. per lb. of VOC          | MISCELLANEOUS CONTROL DEVICES | HAP SPECIATE |
| Ethylbenzene | 1.000E-3 | Lb. per lb. of VOC          | MISCELLANEOUS CONTROL DEVICES | HAP SPECIATE |
| Naphthalene  | 5.000E-3 | Lb. per lb. of VOC          | MISCELLANEOUS CONTROL DEVICES | HAP SPECIATE |

## Facility Identification

As recommended by the Emission Inventory Improvement Program, the county-level fuel sales statistics should be obtained by survey data or from other sources (e.g. tax department, statistics agencies). If the county-level statistics are not readily available, the state/province total fuel sales should be obtained from the relevant department. This state/province total fuel sales data must be apportioned to the county level based on such factors as:

- a) gasoline service stations \$-sales in each county;
- b) previous county-level sales survey data;
- c) number of gasoline vehicle registrations in each county, travelling pattern and fuel economy.

The control technology applied in the operation of the stations (e.g. filling underground tanks and dispensing fuel, etc) and the amount of fuel handled by each technology should also be obtained.

### *Emission Estimation*

#### **Stage I: Gas Retail Operations - Gasoline Filling**

The emissions from gasoline service stations include the evaporative emissions from the filling of underground gasoline storage tanks. Emissions are generated when gasoline vapors in the underground storage tanks are displaced to the atmosphere by the gasoline being loaded into the tank. Two methods are commonly used in filling the tanks, splash loading and submerged loading. With the splash loading method, the filling pipe dispensing the gasoline is lowered only part way into the tank. Significant turbulence and vapor/liquid contact occur during the splash loading operation, resulting in high levels of vapor generation and loss. In submerged loading, the fill pipe extends almost to the bottom of the storage tanks with the opening situated below the liquid surface level. Liquid turbulence is controlled significantly, resulting in much lower vapor generation than the splash loading method.

The Stage I emissions of a specific pollutant from gasoline filling operations in a county is estimated by the following formula:

$$EM_{\text{fill}} = [ (BQ * P_{\text{splash}} * EF_{\text{splash}}) + (BQ * P_{\text{submerged}} * EF_{\text{submerged}}) + (BQ * P_{\text{balsub}} * EF_{\text{balsub}}) ] / 100,000$$

|       |                         |   |  |
|-------|-------------------------|---|--|
| Where | $EM_{\text{fill}}$      | = | Annual emission of a pollutant in a county (lb./yr.)                       |
|       | BQ                      | = | Total annual consumption of gasoline in a county (gal)                     |
|       | $P_{\text{splash}}$     | = | Percentage of gasoline filling using splash method (%)                     |
|       | $EF_{\text{splash}}$    | = | Emission factor of pollutant for splash filling (lb./1000 gal)             |
|       | $P_{\text{submerged}}$  | = | Percentage of gasoline filling using submerged method (%)                  |
|       | $EF_{\text{submerged}}$ | = | Emission factor of pollutant for submerged filling (lb./1000 gal)          |
|       | $P_{\text{balsub}}$     | = | Percentage of gasoline filling using balanced submerged method (%)         |
|       | $EF_{\text{balsub}}$    | = | Emission factor of pollutant for balanced submerged filling (lb./1000 gal) |

### Stage I: Gas Retail Operations - Storage Tank Breathing and Emptying

Storage tank breathing losses occur daily and are attributed to gasoline evaporation that results from temperature and barometric pressure changes. As gasoline is withdrawn from the tank fresh air enters and enhances evaporation. This has a major effect on these emissions.

The Stage I emissions of a specific pollutant from storage tank breathing/emptying in a county is estimated by the following formula:

$$EM_{\text{breath}} = BQ * EF_{\text{breath}} / 1,000$$

|       |                      |   |   |
|-------|----------------------|---|---|
| Where | $EM_{\text{breath}}$ | = | Annual emission of a pollutant in a county (lb./yr.)              |
|       | BQ                   | = | Total annual consumption/throughput of gasoline in a county (gal) |
|       | $EF_{\text{breath}}$ | = | Emission factor of pollutant for splash filling (lb./1000 gal)    |

### Stage II: Motor Vehicle Refueling - refueling

Service station vehicle refueling also produces evaporate emissions. Vehicle refueling emissions result from vapors displaced from the automobile tank via dispensed gasoline and from spillage. The quantity of displaced vapors depends on gasoline temperature, auto tank temperature, gasoline RVP, and dispensing rate. The refueling emission rate (in lb./gal) can be obtained from the MOBILE model. Since variation in factors will affect the emission rate, it is preferable to obtain an individual emission rate for each county instead of a generic state/province rate.

The Stage II emissions of a specific pollutant from vehicle refueling in a county is estimated by the following formula:

$$EM_{\text{refuel}} = BQ * P_{\text{refuel}} * EF_{\text{refuel}} + BQ * P_{\text{refuel\_con}} * EF_{\text{refuel\_con}}$$

|       |                           |   |   |
|-------|---------------------------|---|---|
| Where | $EM_{\text{refuel}}$      | = | Annual emission of a pollutant in a county (lb./yr.)                                  |
|       | $BQ$                      | = | Total annual consumption/throughput of gasoline in a county (gal)                     |
|       | $P_{\text{refuel}}$       | = | Percentage of gasoline dispensed without Stage II control (%)                         |
|       | $EF_{\text{refuel}}$      | = | Emission factor of pollutant for vehicle refueling without Stage II control (lb./gal) |
|       | $P_{\text{refuel\_con}}$  | = | Percentage of gasoline dispensed with Stage II control (%)                            |
|       | $EF_{\text{refuel\_con}}$ | = | Emission factor of pollutant for vehicle refueling with Stage II control (lb./gal)    |

### Stage II: Motor Vehicle Refueling - Spill

Other evaporate emissions from vehicle refueling include spillage loss which is a result of prefill and postfill nozzle drip and from spit-back and overflow from the vehicle's tank filler pipe during filling.

The Stage II emissions of a specific pollutant from spillage loss in a county is estimated by the following formula:

$$EM_{\text{spill}} = BQ * EF_{\text{spill}} / 1,000$$

|       |                     |   |   |
|-------|---------------------|---|---|
| Where | $EM_{\text{spill}}$ | = | Annual emission of a pollutant in a county (lb./yr.)              |
|       | $BQ$                | = | Total annual consumption/throughput of gasoline in a county (gal) |
|       | $EF_{\text{spill}}$ | = | Emission factor of pollutant for spilling loss (lb./1,000 gal)    |

## REFERENCES

1. USEPA, "Compilation of Air Pollutant Emission Factors, 5th Edition, Volume I and Supplements, Section 5.2", AP-42, U.S. Environmental Protection Agency, January 1995
2. USEPA, "Emission Inventory Improvement Program documents, Volume III: Chapter 11>", U.S. Environmental Protection Agency, September 1997
3. USEPA, "User Guide to Mobile 5B", U.S. Environmental Protection Agency, September 1996
4. USEPA, "Factor Information Retrieval System Version 6.1", U.S. Environmental Protection Agency, November 1998
5. USEPA, "Technical Guidance - Stage II Vapor Recovery Systems for Control of Vehicle Refueling Emissions at Gasoline Dispensing Facilities, Volume I, EPA-450/3-91-022a, November 1991.

## **Q. Graphic Arts**

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### **POLLUTANTS OF CONCERN**

The following HAPs are associated with the this source category

\*Toluene  
\*Xylene  
\*Trichloroethylene  
Toluene Diisocyanate  
Dibutyl Phthalate

\* Obtained from those reported by establishments in SIC 27%% to the Wisconsin emissions inventory.

### **AMS CODES FOR THIS CATEGORY**

A2425000 All Processes  
A2425010 Lithography  
A2425020 Letterpress  
A2425030 Rotogravure  
A2425040 Flexography

### **EMISSION FACTORS**

No toxic emission factors were found in FIRE, EIIP or AP-42.  
The following speciation factors were found:

SCC: 2425040000, 2425040999  
Profile Code: 1086  
Process: Printing/Flexographic  
Pollutant: Toluene  
EF: 0.0648lb./lb. TOG

AMS: 242500000, 2425000999  
Profile Code: 1191

Pollutant: Dibutyl Phthalate  
EF: 0.09999lb./lb. TOG

Pollutant: Toluene Diisocyanate  
EF: 0.0003lb./lb. TOG

# EIIP'S EMISSION ESTIMATION METHODOLOGY REVIEW

## VOCs:

Release to the atmosphere are from evaporation of the VOC contained in the raw materials used in the process (inks, fountain solutions and cleaning agents).

The three main approaches to estimating VOC emissions:

Facility Survey

Ink sales emission factor method

Per capita emission factor method (NOT RECOMMENDED FOR HAPs)

The facility survey method provides the most accurate information. The Ink sales emission factor method is recommended over the per capita method for speciating HAPs.

## DATA NEEDS

For facility survey

Type of printing

Number of employees involved in the printing operation

Amount of VOC or HAPs contained in the raw materials and solvents (weigh %), and amount of material recycled

Controls used

For Ink Sales Emission Factor Method

- Ink sales for the state or data from the US Census Bureau
- Uncontrolled point source emissions from graphic arts operations
- Controls used in region (Note: controls may also include local state regulations)

Advantages of Method

- Inks are common to all printers and not used by any other sources
- VOC content of the inks is consistent
- Consistency of the printing process (same VOC content used in the same type of printing process)

Summary of Method:

- Obtain amount of ink produced in pounds, in the US (Ref. Census of Manufacturer's, Industry Series for SIC Code 289, Miscellaneous Chemical Products).

(Note: I checked with the National Association of Printing Ink Manufacturers about the availability of ink sales data per state. That information is not available. Also, the NAPIM does not agree with this method).

- Apportion nationwide ink amount to the state level by the ration between state and national employment in printing and publishing (SIC Code 27). This information can be

obtained from the Census Bureau's report Statistics for industry Groups and Industries. State information is also available from the state's departments of industry.

- Correct for point sources in the state.
- Apportion statewide ink sales data for each type of printing.
- Table 7.5-2, Chapter 3 EIIIP, offers VOC emission factors for VOC per pound of ink used.

## **REFERENCES**

Environmental Protection Agency (EPA). *STAPPA-ALAPCO-EPA Emission Inventory Improvement Program (EIIIP)*. Volume III - Area Sources Preferred and Alternative Methods. July 1997.

Personal communication, National Association of Printing Ink Manufacturer's

## **R. Hospital Sterilizers**

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### **SOURCE IDENTIFICATION**

Hospital sterilization is covered by Area and Mobile Source (AMS) code 2850000010: Hospitals – Sterilization Procedures. Standard Industrial Classification (SIC) code 8060 – Hospitals and North American Industrial Classification System (NAICS) code 622xx: Hospitals also describe the hospital sterilization category.

### **POLLUTANTS**

Ethylene oxide (EO) is the only pollutant identified.

### **AIR TOXIC EMISSION ESTIMATION**

Two methods are available to estimate emissions from ethylene oxide sterilizers. The first method assumes each hospital operates a sterilizer at given conditions. The second uses an EPA emission factor based on the number of beds in a hospital to estimate ethylene oxide emissions.

Hospital data for the first method can be obtained from state Health Departments. State NESHAP databases may also contain data on facilities with ethylene oxide sterilizers.

An ethylene oxide cartridge, assumed to be adequate for one sterilization cycle, contains 3.54 ounces of EO (0.22 lb).

If the sterilizer were assumed to operate continuously over the course of a year and complete one-quarter of a cycle per hour, the annual emissions of EO would be:

$$0.22 \text{ lb EO/cycle} * 0.25 \text{ cycle/hr} = 0.055 \text{ lb EO/hr}$$

$$0.055 \text{ lb EO/hr} * 8769 \text{ hr/yr} = 481.8 \text{ lb/yr}$$

$$481.8 \text{ lb/yr} * 2000 \text{ lb/ton} = 0.241 \text{ ton/yr.}$$

Each hospital would emit 0.241 tons of EO annually under the assumption of one sterilizer per hospital.

If facilities with hospital sterilizers were required to use Best Available Control Technology (BACT) with 99.9% control efficiency, the following emissions would result:

$$0.22 \text{ lb EO/cycle} * (1-0.999) = 0.00022 \text{ lb EO/cycle}$$

$$0.00022 \text{ lb EO/cycle} * 0.25 \text{ cycle/hr} = 0.000055 \text{ lb EO/hr}$$

$$0.000055 \text{ lb/hr} * 8760 \text{ hr/yr} = 0.4818 \text{ lb/yr}$$

$$0.4818 \text{ lb/yr} * 2000 \text{ lb/ton} = 0.000241 \text{ tons/yr.}$$

The second method uses emission factors based on hospital size. EPA developed EO emission factors for hospitals depending on the number of bed in the hospital:

Nationwide Emission Factors for EO from Hospital Sterilization

| Hospital Size | # Beds  | Emission Factors (kg EO/yr/bed) |
|---------------|---------|---------------------------------|
| Large         | >500    | 1.05                            |
| Medium        | 200-500 | 0.63                            |
| Small         | <200    | 0.82                            |

The number of hospitals and beds on a county basis for the Great Lakes states can be obtained from the American Hospital Association. As previously stated, hospital information may also be available from state Health Departments.

$$\text{EO Emissions} = \text{Number of Beds} * \text{Emission Factor (kg EO/bed)}$$

**REFERENCES**

Wisconsin Department of Natural Resources. Williams, Megan and Hanson, Jeffrey. *Analysis, Preliminary Determination and Draft Permit for the Category of Ethylene Oxide Sterilization Systems.* June 14, 2000.

United States Environmental Protection Agency (U.S. EPA). *Documentation for the 1996 Base Year National Toxics Inventory for Area Sources.* Appendix A, A-23. June 02, 2000.

# S. Human Cremation

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## METHODOLOGY

### Source Identification

Protocol Section 3.2.1-SIC codes  
SIC code 7261-Funeral Service and Crematories

Protocol Section 3.2.2-SCC/AMS codes  
SCC 2601020000-Waste Disposal, Treatment and Recovery-On-site Incineration

Protocol Section 3.2.3-New SCC/AMS codes  
The SCC code given above is the most appropriate one that could be found. A new SCC code may need to assign to this area source.

Protocol Section 3.3-Pollutants  
Pollutants identified include Arsenic, Beryllium, Cadmium, Chromium, Formaldehyde, Mercury and Nickel.

### Air Toxic Emission Estimation

Emissions were calculated using emission factors based on the weight cremated. The number of bodies cremated was obtained from Department of Health and Family Services, Wisconsin Bureau of Health Information. An average weight of 150 LB per body was assumed.

$$\text{Emissions} = \text{Bodies Cremated} * \text{Average Weight (LB)} * \text{Factor (LB/ton)} * \text{ton/2000LB}$$

### Nationwide Emissions Factors for Human Cremation

| Pollutant     | Emission Factors<br>(LB/ton cremated) |
|---------------|---------------------------------------|
| Arsenic       | 4.00e-04                              |
| Beryllium     | 1.84e-05                              |
| Cadmium       | 1.48e-04                              |
| Chromium      | 3.99e-04                              |
| Formaldehyde  | 2.89e-09                              |
| Mercury       | 4.39e-02                              |
| Nickel        | 5.09e-04                              |
| POM as 7-PAH  | 1.03e-09                              |
| POM as 16-PAH | 9.63e-04                              |

## **REFERENCES**

United States Environmental Protection Agency (U.S. EPA). *Documentation for the 1996 Base Year National Toxics Inventory for Area Sources*. Appendix A, A-24, A-25. March 27, 2000.

## T. Industrial Surface Coatings

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### ASSOCIATED TOXIC POLLUTANTS

The EPA's *Speciate* database contains fifteen different profiles associated with various surface coating operations. According to those profiles, eight of the 79 target compounds may be produced. These are Benzene, Ethylbenzene, Ethylene Oxide, Glycol Ether, Methyl Chloride, O-Xylene, P-Xylene, and Toluene. Although the profiles do not appear to include Lead, it is also possible that small amounts of Lead based coatings are still in use.

Table T-1: Profiles in the Speciate Database

| <b>By Solvent</b>               | <b>Profile</b> |
|---------------------------------|----------------|
| Naptha                          | 0282           |
| Butyl Acetate                   | 0288           |
| Butyl Alcohol                   | 0289           |
| Cellosolve                      | 0290           |
| Methyl Alcohol                  | 0291           |
| Dimethylformamide               | 0292           |
| <b>By Thinning Solvent</b>      |                |
| Hexylene Glycol                 | 1026           |
| Ethylene Oxide                  | 1031           |
| <b>By Coating type</b>          |                |
| Thinning                        | 1016           |
| Lacquer                         | 1017           |
| Enamel                          | 1018           |
| Primer                          | 1019           |
| Adhesives                       | 1020           |
| <b>Composite Profiles</b>       |                |
| Surface Coating (solvent based) | 1003           |
| Surface Coating (average)       | 9021           |

### TOXIC POLLUTANT EMISSION FACTORS

Emission factors for these pollutants have not yet been identified.

### OTHER AVAILABLE METHODS

Speciation of VOC emissions

The EIIP has consolidated a number of separate categories under the definition of "Industrial Surface Coating".

Pennsylvania has used the employee emission factors for these categories that were found in the EPA's May 1991 procedures document. Other per capita emission factors used were all EPA approved.

Table T-2: VOC emission factors for Industrial Surface Coating

| <b>Coating Type</b>            | <b>VOC emission Factor</b> | <b>Units</b> |
|--------------------------------|----------------------------|--------------|
| Furniture and Fixtures         | 1,597                      | lb./employee |
| Metal Containers               | 6,029                      | lb./employee |
| Automobiles (new)              | 793                        | lb./employee |
| Machinery and Equipment        | 77                         | lb./employee |
| Appliances                     | 463                        | lb./employee |
| Other Transportation Equipment | 35                         | lb./employee |
| Sheet, Strip and Coil          | 2877                       | lb./employee |
| Factory Finished Wood          | 131                        | lb./employee |
| Electrical insulation          | 290                        | lb./employee |
| Other Product Coatings         | 0.6                        | lb./capita   |
| High Performance Coatings      | 0.8                        | lb./capita   |
| Marine Coatings                | 308                        | lb./employee |
| Other Special Purpose Coatings | 0.8                        | lb./capita   |

## **RECOMMENDATIONS**

A survey of manufactures or trade associations may provide more information on this category. Speciation of the VOC inventory may also be possible; however, a method to validate the profiles used should be developed.

## **U. Marine Vessel Loading, Ballasting and Transit**

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### **AMS-SCC Code 2505020120**

#### **Method 1**

The first method was found in AP 42 Chapter 5: *Petroleum Refining*. The method involves applying VOC emission factors to the amount of fuel transferred. There are several VOC emission factors based on previous barge load and vessel tank condition. In RAPIDS, the speciation profile for barge loading is 1190. The speciation profile is based on Total Organics (TOG). It is assumed that a 1:1 ratio exists for VOC: TOG.

Table U-1: Speciation Profiles for Toxins Associated with Marine Vessel Loading:

| <b>Toxic</b>                               | <b>Speciation (tox/tog), % by weight</b> |
|--|--|
| Benzene                                    | 3.25                                     |
| Ethylbenzene                               | 4.07                                     |
| Naphthalene                                | 0.8                                      |
| Styrene                                    | 0.17                                     |
| Toluene                                    | 15.22                                    |
| Xylene, O                                  | 6.41                                     |
| Xylene, M, P                               | 15.28                                    |
| Xylene isomers (not in speciation profile) | 21.69 (O,M, and P added together)        |

Note: The Xylene isomers should be added together so that it will correspond w/ the RAPIDS pollutant list.

#### **Method 2**

The preferred method found is in *Technical Support Document for the Development of a VOC Rule for Marine Vessel Loading Operations*, U.S. EPA; May 1992.

Table U-2: Toxic emission factors based on gallons transferred.

| <b>Toxic</b> | <b>Emission Factor (lb./1000 gal) barges</b> |
|--------------|--|
| Benzene      | 0.029  |
| Toluene      | 0.048  |
| Xylene       | 0.015  |

The amount of fuel loaded and unloaded to barges by state can be found in *Waterborne Commerce of the United States*, 1996; US Army Corps of Engineers, December 1997.

Each states river system and/or city that has gasoline barge loading is available from this document.

## **V. Municipal Landfills**

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### **PREFERRED METHOD (landfill based)**

The preferred method requires the following information:

- landfill design capacity, amount of refuse in place or annual refuse acceptance rate
- methane generation rate
- potential methane generation capacity
- NMOC concentration in landfill gas
- Toxics concentration in landfill gas
- years the landfill has been in operation
- controls in place
- has the landfill been used for disposal of hazardous waste?

The calculation methodology is AP-42. The LAEEM program (Landfill Air Emissions Estimation Model) calculates emissions using AP-42 methodology

- provides defaults for methane generation rate, potential methane generation capacity and NMOC concentration. AP-42 also provides concentrations for HAPs.

The alternative methods are really variations on the preferred method. The difference is in the detail of data needed to calculate or the assumptions made. For all methods, the minimum information for using AP-42 or LAEEM is waste in place and the open and close dates for the landfills. Some examples of simplifying assumptions are:

- acreage of the landfills and landfill depth substituted for waste in place
- assumptions for open and close dates (opened 25 years before inventory year or if only the closed date is known, assume waste received for 10 years)
- estimate waste in place by using estimate of capacity and percent filled

### **ALTERNATIVE METHOD (population based)**

Information needed:

- population figures for the inventory year and the 24 years previous
- use the waste generation factor of 0.69 tons/person/year of waste generated
- convert to Mg by multiplying by 0.9072
- use the annual waste estimates in LAEEM or calculate average annual waste estimates and use that value in the equation

## **POLLUTANTS EMITTED PERTINENT TO RAPIDS**

- 1,1,1-trichloroethane
- 1,2-dichloroethane
- Acrylonitrile
- Benzene
- Carbon tetrachloride
- Chloroform
- Ethylbenzene
- Mercury
- Methylene chloride
- Perchloroethylene
- Toluene
- Trichloroethylene
- Xylenes

There is a speciation profile (0202) in RAPIDS which shows pollutants of perchloroethylene, toluene and xylene. These factors are probably out of date since the landfill section of AP-42 was updated recently.

There were no point source emission factors for landfills in FIRE or RAPIDS.

## **REFERENCES**

The following are good reference documents to read about calculating emissions from landfills

- AP-42 Section 2.4 ([www.epa.gov/ttn/chief/ap42.html](http://www.epa.gov/ttn/chief/ap42.html))
- EIIP Document Volume III: Chapter 15 ([www.epa.gov/ttn/chief/eiip/techrep.htm](http://www.epa.gov/ttn/chief/eiip/techrep.htm))
- LAEEM ([www.epa.gov/ttn/chief/software.html](http://www.epa.gov/ttn/chief/software.html))

## **METHOD TO USE FOR RAPIDS CALCULATIONS**

In my opinion, you are either going to have the data handy (for either method) or you're not. Through pure coincidence while I was writing this, there was a notification sent to me that a Landfill Capacity report for 1996 had been placed on our web site ([www.epa.state.il.us](http://www.epa.state.il.us)). This report gave me all the data I need. Using the population based method would be acceptable, but how many of the states can get population data for the last 25 years?

The EIIP document also makes mention of a method of calculation emissions by a regression model. In this case, you use data you've collected through a survey or permitting (or other states calculations) and relate that data to surrogate data (e.g., population, population density, rural/urban population mix, property values, land use, etc.). If states who calculate emissions in a detailed manner can relate those emissions (or landfill capacity, etc.) to a value that another state has that didn't have the data available to calculate landfill emissions, the second

state could then calculate emissions. Basically, this method is creating an emission factor in one or more states to be used by others.

Really the only method to calculate emissions is by using the LAEEM/AP-42 method. How you use this methodology depends upon your available data. Having states create emission factors for others to use remains to be seen. My recommendation is to use the preferred method.

# W. Open Burning Methodology

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## OVERVIEW

This area source category includes three categories.

- Municipal Solid Waste (MSW) burning
- Land clearing waste burning
- Yard waste burning

## METHODOLOGIES

MSW Burning (Table 16.3-1 of EIIP)

| <b>Method</b>  | <b>Activity Data Required</b>                                    |
|--|--|
| Preferred<br>local estimate of MSW open burned times<br>emission factor                                  | tons of waste burned   |
| Alternate 1<br>local estimate of MSW generated then<br>subtract the amount disposed of by other<br>means | tons of waste generated<br>tons of waste disposed by other means |
| Alternate 2<br>obtain data from an area that is similar to<br>your study area and extrapolate the data   | data from similar area<br>population ratio                       |

Land Clearing Waste Burning (Table 16.3-2 of EIIP)

| <b>Method</b>  | <b>Activity Data Required</b>                                    |
|--|--|
| Preferred<br>local estimate of MSW open burned times<br>emission factor                                  | tons of waste burned   |
| Alternate 1<br>local estimate of MSW generated then<br>subtract the amount disposed of by other<br>means | tons of waste generated<br>tons of waste disposed by other means |
| Alternate 2<br>obtain data from an area that is similar to<br>your study area and extrapolate the data   | data from similar area<br>population ratio                       |

Yard Waste Burning (Table 16.3-3 of EIIP)

| <b>Method</b>  | <b>Activity Data Required</b>  |
|--|--|
| Preferred<br>local estimate of MSW open burned times<br>emission factor  | tons of waste burned   |
| Alternate 1<br>study a subset of the inventory area using<br>permits to burn and violations of burning<br>to estimate extent of burning. scale to<br>larger area | permits to burn<br>violations<br>fuel loading for each burn<br>scaling factors |
| Alternate 2<br>obtain data from an area that is similar to<br>your study area and extrapolate the data   | data from similar area<br>scaling factors                                      |
| Alternate 3<br>develop a local per residence or per acre<br>waste generation rate  | tons of waste generated<br>scaling factor                                      |

## EMISSION FACTORS

Municipal Solid Waste (Table 16.4-1 of EIIP)

| <b>Pollutant</b>  | <b>Emission factor (lb/ton burned</b> |
|-------------------|---------------------------------------|
| PM10              | 38                                    |
| VOC               | 8.556                                 |
| Acenaphthylene    | 0.022                                 |
| Benzene           | 2.48                                  |
| Dichlorobenzenes  | 0.00032                               |
| HCL               | 0.568                                 |
| HCN               | 0.936                                 |
| Hexachlorobenzene | 0.000044                              |
| Naphthalene       | 0.036                                 |
| PCB               | 0.00572                               |
| PCDD              | 0.000076                              |
| PCDF              | 0.0000122                             |
| Phenanthrene      | 0.0146                                |
| Phenol            | 0.28                                  |
| Styrene           | 1.48                                  |

Land clearing emission factors depend upon what material is being burned and whether it is in a pile or spread out. Emission factors exist for the pollutants MEK, ethylbenzene, styrene, cumene, phenol and dibenzofuran. These factors depend upon whether or not a blower is used and are based upon a small number of tests. The table also does not have units associated with it so I'm assuming they are lb/ton burned. There are also factors available for other fuel models.

Yard waste factors also depend upon the type of material being burned (leaves, forest residues or weeds). The EIIP document only gives PM and TOC factors and no speciation profiles could be found.

## **DATA SOURCES**

- State or Local Air Quality Agencies
- Federal, state and local forest service and agricultural extension agents
- Local planning departments
- State or local transportation departments
- Local health and sanitation departments
- Local fire and public safety departments

## **CONCLUSION**

If it is readily available to you, calculating emissions by amount of waste burned is the appropriate method. In many places, the burning of municipal waste may be banned so that source may not be applicable. It will probably be difficult to get data for the yard waste burning. It may be possible to get data from open burning of landscape waste from any permitting programs your Agency may have.

But overall, I'd say with the time it would take to get good (any) data, this could be an area source category to skip.

## **REFERENCES**

United States Environmental Protection Agency (U.S. EPA). *EIIP document Volume III: Chapter 16: Open Burning*. May 08, 2000.

## X. Pesticides

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### AGRICULTURAL PESTICIDES

Emission factors for pesticides in FIRE are in Kg per hectare. The conversion to acres is 1 hectare equals 2.47 acres. The number of acres harvested for each crop by county can be found in the 1992 Census of agriculture.

[http://www.nass.usda.gov/census/census92/atlas92/datafile/\\*\\*st.txt](http://www.nass.usda.gov/census/census92/atlas92/datafile/**st.txt)

\*\* insert 2 letter state abbreviation

A list of active ingredients used on a given crop can be obtained from each state's Department of Agriculture. For example, in Ohio, atrazine is the ingredient used almost exclusively on corn. Most commonly used pesticides on crops can be found at:

<http://130.118.109.185/pnsp/crop/corn.html>.

Substitute wheat, soybean, etc. in the address for other crops.

Once you know the method of application (emission factors are broken down by application method) multiply the appropriate emission factor from FIRE by the number of hectares harvested per county for that crop to get each county's emissions.

#### Example

##### *Adams County*

15792 acres of corn harvested. Converting to hectares equals 39006 hectares. Atrazine applied by **spraying** has an emission factor of 1.800E-1 kg per hectare of pesticide applied.

Multiply 1.800E-1 \* 39006 to obtain atrazine emissions used in Adams County in 1992. Multiply by .0011023 to get tons used.

**7.7 tons atrazine used in**

### NON AGRICULTURAL PESTICIDES

Since non agriculture use of pesticides account for less than 25% of all pesticide use, the use of per capita emission factor is justified when compared with a survey approach of government agencies, commercial exterminators, lawn care companies, and consumers pesticide buying habits.

A per capita FIFRA (Federal Insecticide, Fungicide, and Rodenticide Act) emission factor is 1.78 E+00 RVOC (lbs./yr./person).

If active ingredient is known, the total tons of FIFRA used in 1992 in the US was 1411632.3.

## Y. Prescribed Burns and Forest Fires

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### METHODOLOGY

Michigan recommends that the Great Lakes states and provinces utilize the following method for calculating emissions from forest and wildfires.

For Michigan, the number of forest fires (tree, brush and grass wildfires) is available at the county level from the Michigan Department of State Police, Fire Marshall Division, Fire Incident Count database. The other states may be able to obtain similar information from their own local or state police and fire response agencies, or natural resources management agencies.

If county data is not available, a state total number for forest and wildfires may be available, which can be apportioned to the county level by acres forested, or some other basis which might correlate to the number of forest fires. This data may be available from the natural resources management agencies in each state.

Based on data supplied by the Michigan Department of Natural Resources, Forest Management Division, Michigan assumed that the fuel loading for each fire was 2.0 tons per acre. It was assumed, based on available data, that each fire burned one acre if in an urbanized county, and 4.54 acres if in a rural county.

If fire acreage data is not available, the other Great Lakes states may use Michigan's numbers for a default acreage per fire value.

The document *Documentation for the 1996 Base Year National Toxics Inventory for Area Sources* provided a different fuel loading value for forest and wildfires. A biomass consumption rate of 10.4 tons per acre was selected. 75% of the biomass was presumed to burn under flaming conditions, and 25% under smoldering conditions. In the absence of state specific data, Michigan recommends that these values be used.

The following calculation should be utilized to estimate emissions from forest and wildfires:

$$\text{Emissions} = \text{emission factor} * \frac{\text{number of acres}}{\text{burned}} * \frac{\text{fuel loading}}{\text{per acre}}$$

Or, if NTI fuel loading values are used:

$$\text{Emissions (flaming)} = \frac{\text{Number of acres burned}}{\text{acre}} * \frac{\text{biomass consumption}}{\text{acre}} * 75\% \text{ (flaming)} * \text{emission factor (flaming)}$$

$$\text{Emissions (smoldering)} = \frac{\text{Number of acres burned}}{\text{acre}} * \frac{\text{biomass consumption}}{\text{acre}} * 25\% \text{ (smoldering)} * \text{emission factor (smoldering)}$$

The range of available emission factors is presented below.

## NTI Emission Factors

Emission factors from the NTI document, for pollutants that are on the list of EPA toxics, are shown below.

| HAP               | Flaming Fuel Emission Factor | Smoldering Fuel Emission Factor |
|-------------------|------------------------------|---------------------------------|
| 1,3-butadiene     | 2.40E-01                     | 9.00E-01                        |
| 2,3,7,8-TCDD TEQ  | 2.00E-09                     | 2.00E-09                        |
| acetaldehyde      | 4.73E-01                     | 2.14E-01                        |
| acrolein          | 4.68E-01                     | 2.92E-01                        |
| benz(a)anthracene | 6.20E-03                     | 6.20E-03                        |
| benzene           | 6.60E-01                     | 2.52E+00                        |
| benzo(a)pyrene    | 1.48E-03                     | 1.48E-03                        |
| chrysene          | 6.20E-03                     | 6.20E-03                        |
| fluoranthene      | 6.73E-03                     | 6.73E-03                        |
| formaldehyde      | 1.50E+00                     | 5.80E+00                        |
| methyl chloride   | 1.01E-02                     | 4.83E-01                        |
| o,m,p-xylene      | 2.79E-01                     | 1.31E-01                        |
| toluene           | 6.55E-01                     | 3.08E-01                        |

## RAPIDS' SCC/AMS Code Lookup

2810001000: (Miscellaneous Area Sources, Other Combustion, Forest Wildfires)

| Emittant Material Code | Emittant Unit Code | Throughput Material Code | Throughput Unit Code | Amount   | Exponent | Quality | EPA Date |
|------------------------|--------------------|--------------------------|----------------------|----------|----------|---------|----------|
| BUTADIENE,13           | LB                 | VEGETATION               | TON                  | 9.0      | E -1     | U       | 08/08/94 |
| BUTADIENE,13           | LB                 | VEGETATION               | TON                  | 5.2      | E -1     | U       | 08/08/94 |
| BUTADIENE,13           | LB                 | VEGETATION               | TON                  | 2.4      | E -1     | U       | 08/08/94 |
| TOG                    | LB                 | VOC                      | LB                   | 1.108893 | E 0      |         | 03/15/88 |

Please note that these emission factors are identical to several emission factors presented in the SCC/AMS Lookup for 2810015000 (Miscellaneous Area Sources, Other Combustion, Managed Burning/Prescribed). These factors are reproduced below. This comparison will be used to support a request to use FIRE 6.22 emission factors for prescribed burning, in the absence of FIRE 6.22 emission factors for forest fires and wildfires.

2810015000:

(Miscellaneous Area Sources, Other Combustion, Managed Burning/Prescribed)

| Emittant Material Code | Emittant Unit Code | Throughput Material Code | Throughput Unit Code | Amount   | Exponent | Quality | EPA Date |
|------------------------|--------------------|--------------------------|----------------------|----------|----------|---------|----------|
| BUTADIENE,13           | LB                 | VEGETATION               | TON                  | 9.0      | E -1     | U       | 08/08/94 |
| BUTADIENE,13           | LB                 | VEGETATION               | TON                  | 5.2      | E -1     | U       | 08/08/94 |
| BUTADIENE,13           | LB                 | VEGETATION               | TON                  | 2.4      | E -1     | U       | 08/08/94 |
| VOC                    | LB                 | VEGETATION               | TON                  | 7.0      | E 0      | A       | 10/16/97 |
| TOG                    | LB                 | VOC                      | LB                   | 1.108893 | E 0      |         | 03/15/88 |

## Fire 6.22

Emission factors for SCC 2810001000 are not included in FIRE 6.22. However, various emission factors are available in FIRE 6.22 for SCC 2810015000 (Managed Burning, Prescribed). As indicated in the preceding paragraph, RAPIDS emission factors for prescribed burning and forest wildfires utilize several identical emission factors. Due to this correlation, and the absence of FIRE 6.22 emission factors, Michigan suggests that the Great Lakes states consider the prescribed burning emission factors for the category of forest fires. These factors are presented below.

SCC 2810015000: (Managed Burning, Prescribed), FIRE 6.22

| Pollutant     | Emission Factor                              | Quality | Reference | Reason for Duplicate factor            |
|---------------|--|---------|-----------|--|
| PM10, fltrble | 1.600E1 - 4.400 E1 lb. per tons waste burned | D       | EPA 1995  | line fire, conifer, palmetto/gallberry |
| PM10, fltrble | 1.800E1 lb. per tons waste burned            | C       | EPA 1995  | chaparral                              |
| PM10, fltrble | 2.000E1 lb. per tons waste burned            | B       | EPA 1995  | range fire, juniper slash              |
| PM10, fltrble | 2.000E1 lb. per tons waste burned            | D       | EPA 1995  | chaparral, grasslands                  |
| PM10, fltrble | 2.200E1 lb. per tons waste burned            | A       | EPA 1995  | range fire, chaparral shrub community  |
| PM10, fltrble | 2.400E1 lb. per tons waste burned            | C       | EPA 1995  | broadcast logging slash, hardwood      |
| PM10, fltrble | 2.600E1 lb. per tons waste burned            | D       | EPA 1995  | conifer, short needle                  |
| PM10, fltrble | 2.600E1 lb. per tons waste burned            | D       | EPA 1995  | conifer, long needle                   |
| PM10, fltrble | 3.000E1 lb. per tons waste burned            | B       | EPA 1995  | range fire, sagebrush                  |
| PM10, fltrble | 4.000E1 - 8.000E1 lb. per tons waste burned  | D       | EPA 1995  | line fire, conifer, long needle pine   |
| PM10,         | 8.000E0 lb. per tons waste                   | D       | EPA 1995  | logging slash debris, dozer            |

|           |   |   |          |  |
|-----------|---|---|----------|--|
| fltrble   | burned                                      |   |          | piled conifer, no mineral soil   |
| PM, total | 1.20 E1 lb. per tons waste burned           | B | EPA 1995 | Logging slash debris, dozer piled conifer, no mineral soil             |
| PM, total | 2.00 E1 lb. per tons waste burned           | D | EPA 1995 | Chaparral, grasslands  |
| PM, total | 2.80 E1 lb. per tons waste burned           | B | EPA 1995 | Range fire, juniper slash  |
| PM, total | 3.00 E1 lb. per tons waste burned           | C | EPA 1995 | Chaparral Emissions represent Heading phase                            |
| PM, total | 3.000E1 - 3.400E1 lb. per tons waste burned | D | EPA 1995 | Line fire, conifer, Palmetto/gallberry                                 |
| PM, total | 3.20 E1 lb. per tons waste burned           | A | EPA 1995 | Range fire, chaparral shrub communities                                |
| PM, total | 3.40 E1 lb. per tons waste burned           | A | EPA 1995 | Conifer, short needle  |
| PM, total | 3.60 E1 lb. per tons waste burned           | A | EPA 1995 | Broadcast logging slash, hardwood                                      |
| PM, total | 4.00 E1 lb. per tons waste burned           | B | EPA 1995 | Conifer, long needle   |
| PM, total | 4.000E1 - 1.000E2 lb. per tons waste burned | D | EPA 1995 | Line fire, conifer, long needle pine                                   |
| PM, total | 4.60 E1 lb. per tons waste burned           | B | EPA 1995 | Range fire, sagebrush  |
| PM, total | 5.00 E1 lb. per tons waste burned           | D | EPA 1995 | Logging slash debris, 10-30% mineral soil, smoldering emissions        |
| PM, total | 7.00 E1 lb. per tons waste burned           | D | EPA 1995 | Logging slash debris, 25% organic soil, smoldering emissions           |
| VOC       | 1.040E1 lb. per tons waste burned           | B | EPA 1995 | range fire, juniper slash  |
| VOC       | 1.120E1 lb. per tons waste burned           | A | EPA 1995 | conifer, short needle  |
| VOC       | 1.140E1 lb. per tons waste burned           | B | EPA 1995 | conifer, long needle   |
| VOC       | 1.200E1 lb. per tons waste burned           | B | EPA 1995 | range fire, juniper slash  |
| VOC       | 1.220E1 lb. per tons waste burned           | A | EPA 1995 | broadcast logging slash  |
| VOC       | 1.240E1 lb. per tons waste burned           | B | EPA 1995 | range fire, sagebrush  |
| VOC       | 1.280E1 lb. per tons waste burned           | A | EPA 1995 | broadcast logging slash  |
| VOC       | 1.380E1 lb. per tons waste burned           | B | EPA 1995 | range fire, sagebrush  |
| VOC       | 2.500E1 lb. per tons waste burned           | A | EPA 1995 | range fire, chaparral shrub communities                                |
| VOC       | 3.600E0 lb. per tons waste burned           | B | EPA 1995 | range fire, logging slash debris, dozer piled conifer, no mineral soil |
| VOC       | 5.600E0 lb. per tons waste burned           | C | EPA 1995 | chaparral  |
| VOC       | 7.000E0 lb. per tons waste burned           | A | EPA 1995 | conifer, short needle  |

|     |                                   |   |          |   |
|-----|-----------------------------------|---|----------|---|
| VOC | 7.000E0 lb. per tons waste burned | C | EPA 1995 | chaparral                               |
| VOC | 8.400E0 lb. per tons waste burned | B | EPA 1995 | conifer, long needle                    |
| VOC | 9.000E0 lb. per tons waste burned | A | EPA 1995 | range fire, chaparral shrub communities |

## Speciation

Speciation profile number 42321 was selected from RAPIDS. Pollutants that appeared in the list of EPA toxics are shown below.

| Profile Code | Emittant Material Code | Emittant Unit Code | Throughput Code | Throughput Unit Code | Amount  | Exponent | EPA Date |
|--------------|------------------------|--------------------|-----------------|----------------------|---------|----------|----------|
| 42321        | BENZO(A)PYRE           | LB                 | PM              | LB                   | 0.00001 | 0        | 03/15/88 |
| 42321        | BENZO(A)PY10           | LB                 | PM10            | LB                   | 0.00001 | 0        | 03/15/88 |
| 42321        | CADMIUM                | LB                 | PM              | LB                   | 0.00031 | 0        | 03/15/88 |
| 42321        | CADMIUM10              | LB                 | PM10            | LB                   | 0.00031 | 0        | 03/15/88 |
| 42321        | CHROMIUM               | LB                 | PM              | LB                   | 0.00002 | 0        | 03/15/88 |
| 42321        | CHROMIUM10             | LB                 | PM10            | LB                   | 0.00002 | 0        | 03/15/88 |
| 42321        | CHRYSENE               | LB                 | PM              | LB                   | 0.00001 | 0        | 03/15/88 |
| 42321        | CHRYSENE10             | LB                 | PM10            | LB                   | 0.00001 | 0        | 03/15/88 |
| 42321        | CHLORINE               | LB                 | PM              | LB                   | 0.00239 | 0        | 03/15/88 |
| 42321        | CHLORINE10             | LB                 | PM10            | LB                   | 0.00239 | 0        | 03/15/88 |
| 42321        | COPPER                 | LB                 | PM              | LB                   | 0.00002 | 0        | 03/15/88 |
| 42321        | COPPER10               | LB                 | PM10            | LB                   | 0.00002 | 0        | 03/15/88 |
| 42321        | FLUORANTHENE           | LB                 | PM              | LB                   | 0.00001 | 0        | 03/15/88 |
| 42321        | FLUORANTHE10           | LB                 | PM10            | LB                   | 0.00001 | 0        | 03/15/88 |
| 42321        | LEAD                   | LB                 | PM              | LB                   | 0.0001  | 0        | 03/15/88 |
| 42321        | LEAD10                 | LB                 | PM10            | LB                   | 0.0001  | 0        | 03/15/88 |
| 42321        | MANGANESE              | LB                 | PM              | LB                   | 0.00011 | 0        | 03/15/88 |
| 42321        | MANGANESE10            | LB                 | PM10            | LB                   | 0.00011 | 0        | 03/15/88 |
| 42321        | NICKEL                 | LB                 | PM              | LB                   | 0.00002 | 0        | 03/15/88 |
| 42321        | NICKEL10               | LB                 | PM10            | LB                   | 0.00002 | 0        | 03/15/88 |
| 42321        | PHOSPHORUS             | LB                 | PM              | LB                   | 0.0006  | 0        | 03/15/88 |
| 42321        | PHOSPHORUS10           | LB                 | PM10            | LB                   | 0.0006  | 0        | 03/15/88 |

## Additional EPA Toxics

Additional EPA toxic pollutants are emitted from wood combustion. Emission factors provided for woodburning stoves, in EHIP Volume III Chapter 2, *Residential Wood Combustion*, indicate other pollutants that would be expected, even though the quantities emitted will likely be different for forest and wildfires. Any suggestions on appropriate speciation profiles for these pollutants would be appreciated.

Acenaphthene  
 Acenaphthylene  
 Benz(a)anthracene  
 Benzo(b)fluoranthene  
 Benzo(ghi)perylene  
 Benzo(k)fluoranthene  
 Dibenz(ah)anthracene

Fluorene  
Indeno(123-cd)pyrene  
Naphthalene  
Phenanthrene  
Pyrene  
Xylene, ortho

## **REFERENCES**

Michigan Department of Environmental Quality, Air Quality Division. 1996 State Implementation Plan Submittal. 1999.

Eastern Research Group, Inc. *Documentation for the 1996 Base Year National Toxics Inventory for Area Sources*. April 27, 1999.

Environmental Protection Agency (EPA). *STAPPA-ALAPCO-EPA Emission Inventory Improvement Program (EIIP)*. Volume III - Area Sources Preferred and Alternative Methods. Chapter 2, Residential Woodburning. September 1997.

## **Z. Public Owned Treatment Works (POTW)**

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### **OVERVIEW**

POTWs are municipal treatment facilities where wastewater from different industrial, commercial, and residential sources is directed for treatment. Hence, POTW wastewater may have large concentrations of many toxic compounds. Specific industrial and commercial activities are the largest source of organic compounds entering the municipal collection systems. However, other residential sources of organic compounds such as home maintenance and cleaning products contribute to the total organic compounds that enter the POTWs. These organic compounds produce emissions through volatilization at the surface of the wastewater during treatment processes. Nationwide estimates indicate that POTWs are significant sources of volatile organic compounds (VOC) in the United States (Water Environment Federation, 1995). Thus, this section considers toxic air emissions (VOCs) from POTWs.

### **SOURCE IDENTIFICATION**

POTWs are associated with the Standard Industrial Code (SIC) 4952: Sewerage Systems. Searching through the Factor Information Retrieval System Version 6.01 (FIRE) provides all the Source Classification Codes (SCC) for POTW. The following SCCs were found:

50100700: Solid Waste Disposal - Government - Sewerage Treatment

50100707: POTW: Headworks Screening  
50100715: POTW: Aerated Grit Chamber  
50100719: POTW: Lift Stations  
50100720: POTW: Primary Settling Tank  
50100731: POTW: Diffused Air Activated Sludge  
50100732: POTW: Mechanical Mix Air Activated Sludge  
50100733: POTW: Pure Oxygen Activated Sludge  
50100734: POTW: Trickling Filters  
50100740: POTW: Secondary Clarifier  
50100750: POTW: Tertiary Filters  
50100760: POTW: Chlorine Contact Tank  
50100761: POTW: Dechlorination  
50100771: POTW: Gravity Sludge Thickener  
50100772: POTW: DAF Sludge Thickener  
50100781: POTW: Anaerobic Digester  
50100789: POTW: Sludge Digester Gas Flare  
50100791: POTW: Belt Filter Press  
50100792: POTW: Sludge Centrifuge  
50100793: POTW: Sludge Drying Bed

Because the emissions from POTWs will be classified as area source emissions, the AMS code A2630020000, wastewater treatment-publicly owned-total processed, will be used to classify emissions in the inventory system.

## POLLUTANTS

The FIRE database contained emission factors for the pollutants and processes listed in below.

Table Z-1: Processes with Available Emission Factors for Pollutants of Concern

| Pollutant             | Processes with Available Emission Factors  |
|-----------------------|--|
| 1,1,1-Trichloroethane | 50100707, 50100715, 50100720, 50100731, 50100734, 50100760, 50100761, 50100771, 50100791, 50100792, 50100793                     |
| 1,2-Dichloroethane    | 50100707, 50100734, 50100760   |
| Acetaldehyde          | 50100793   |
| Benzene               | 50100707, 50100715, 50700720, 50100731, 50100734, 50100740, 50100760, 50100771, 50100781, 50100791, 50100792, 50100793           |
| Carbon tetrachloride  | 50100707, 50100720, 50100731, 50100740, 50100760, 50100792   |
| Chloroform            | 50100707, 50100715, 50700720, 50100731, 50100734, 50100740, 50100760, 50100771, 50100781, 50100791, 50100792                     |
| Ethylbenzene          | 50100707, 50100760   |
| Ethylene dibromide    | 50100760   |
| Formaldehyde          | 50100715, 50700720, 50100731, 50100734, 50100740, 50100760, 50100771, 50100781, 50100791, 50100792, 50100793                     |
| Methylene chloride    | 50100707, 50100715, 50700720, 50100731, 50100734, 50100740, 50100760, 50100771, 50100781, 50100791, 50100792, 50100793           |
| Perchloroethylene     | 50100707, 50100715, 50700720, 50100731, 50100734, 50100740, 50100760, 50100761, 50100771, 50100781, 50100792, 50100793           |
| Styrene               | 50100715, 50100720, 50100734, 50100771, 50100781, 50100792   |
| Toluene               | 50100707, 50100715, 50700720, 50100731, 50100734, 50100740, 50100760, 50100761, 50100771, 50100781, 50100791, 50100792, 50100793 |
| Trichloroethylene     | 50100707, 50100715, 50700720, 50100731, 50100734, 50100760, 50100761, 50100771, 50100781, 50100791, 50100792                     |
| Vinyl chloride        | 50100760, 50100781, 50100792   |
| Vinylidene chloride   | 50100720, 50100734, 50100761, 50100771, 50100781, 50100792   |
| Xylenes               | 50100707, 50100715, 50700720, 50100731, 50100734, 50100740, 50100760, 50100761, 50100771, 50100781, 50100791, 50100792, 50100793 |

## **EMISSION FACTORS**

The compounds and their concentrations in wastewater vary with time for each facility. There are no practical or feasible methods to accurately estimate emissions based on this time variation without continuous monitoring (Water Environment Federation, 1995). Therefore, emission factors are developed based on the estimation of the volatilization of the compounds from the discharge influent of the individual processes and operations. Emission factors for the various treatment processes were available from FIRE for all the SCCs listed in the “Source Identification” section except for SCC 50100789 and SCC 50100719, which are sludge digester gas flares and lift stations, respectively. Minnesota does not have any sludge digester gas flaring systems (WWTFIR, 1995). No information was available for SCC 50100719.

Since a variety of treatment processes and equipment are used in POTWs, it would be very difficult and would require a great deal of effort, to estimate individual emissions for all of the POTWs in Minnesota. To simplify the emission estimation, AP-42 was used as a reference to establish the standard processes at a typical POTW. Per AP-42, a typical POTW usually consists of a grit chamber for storage, a lift station for collection, a primary clarifier for settling solids, a biotreatment process for biological waste treatment, a secondary clarifier for settling, a sludge digester, and a chlorine contact tank for disinfecting. In addition, the vast majority of the POTWs in Minnesota have additional equipment and processes such as a dechlorination process, a screening process, and a trickling filter (WWTFIR, 1995).

Although, most POTWs do have a dechlorination process, this process was not included for toxics emissions estimations. Conversation with Tod Ekberg of Minnesota Pollution Control Agency Water Quality Division (11/21/95) indicated that the vast majority of POTWs use sulfur dioxide as a dechlorination agent which is not one of the targeted compounds.

Hence, based on the collected information, a typical Minnesota POTW is characterized to have the following equipment: a screening device, a grit chamber, a primary clarifier (includes a primary settling tank, or a primary sedimentation tank), a diffused activated sludge treatment device for biotreatment (Dunnett, Randy, 1996), a trickling filter, a secondary clarifier, a sludge digester, and a chlorine contact tank.

Table 2 shows the emission factors and corresponding SCC codes for the processes included in the inventory. The individual emission factors are added together to arrive at one general emission factor for the entire wastewater treatment process. This factor will be applied as the total process factor with the appropriate AMS code.

## **FACILITY IDENTIFICATION**

Specific facility identification was collected from Wastewater Treatment Facilities Inventory Report (WWTIR) in the Water Quality Division. This report identified all the treatment facilities and inventoried all the treatment processes within each facility in Minnesota for 1995. Per conversation with Randy Dunnett (MPCA, WQD), equipment has not changed significantly at the facilities since 1995, so that equipment inventory was used for 1996 also.

Emissions will not be considered for many of the small treatment facilities. Most of these facilities have stabilization ponds, surface water discharges, and spray irrigations. This means that these smaller treatment facilities virtually do not have any treatment processes. With a stabilization pond and a surface water discharge or spray irrigation, the wastewater flowrate is small enough that the wastewater has time to biodegrade. In addition, not much emissions information is available for these types of treatment processes.

In summary, there are a total of 204 POTW facilities with treatment processes in Minnesota for 1996. This **excludes** the POTWs with stabilization ponds, surface water discharges, and spray irrigation systems.

The 1996 volumetric flowrates of annual discharge and chlorine consumption for the POTWs were available from the Water Quality Division. Chlorine consumption rates were obtained from the Water Quality Division in average pounds per day for each month chlorine was used at the facility. Those rates were converted to monthly rates by multiplying by the number of days in each month, then added to arrive at an annual total.

Table 3 includes total volumetric flowrates and/or chlorine consumption data for all counties in Minnesota. If all the facilities in a county have stabilization ponds, surface discharges, or spray irrigations and no influent flowrate data available, the county is not included in Table 3.

Three facilities have sludge incinerators. The emissions from these incinerators were included in the point source inventory because they are included as part of the EIS. Therefore, incinerator emissions will not be included in this portion of the inventory. However, toxic emissions from all other processes at these facilities will be included in the area source inventory.

## **EMISSION ESTIMATION**

As mentioned in the "Emission Factor" section, estimating air emissions from wastewater collection, treatment, and storage systems for each POTW is very complex due to the variation of treatment processes from one POTW to the next. Hence, AP-42 was used as a reference to characterize the standard equipment in each POTW facility to provide statewide emission estimations.

Total emissions of a county is estimated by summing the emissions emitted by the annual flow from each treatment plant and the emissions from the chlorine for disinfecting. The following equation provides an example:

$$E_{\text{total}} = (EF_{\text{flow}} \times PR_{\text{flow}}) + (EF_{\text{chlorine}} \times PR_{\text{chlorine}})$$

where,

|                        |   |   |
|------------------------|---|---|
| $E_{\text{total}}$     | = | Total emissions of a pollutant (lb./yr.)                      |
| $EF_{\text{flow}}$     | = | Generic emission factor based on treated flow (lb./MG)        |
| $EF_{\text{chlorine}}$ | = | Emission factor based on chlorine (lb./lb. chlorine consumed) |
| $PR_{\text{flow}}$     | = | Total annual volumetric flowrate (MG/yr.)                     |
| $PR_{\text{chlorine}}$ | = | Total annual chlorine consumption (lb./yr.)                   |

To provide the most accurate results, the emissions from a total of the 6 largest POTW facilities (those POTWs with greater than 10 MGD average flows) in Minnesota were calculated based on facility specific equipment inventory as obtained from the WWTIR Report. To estimate the amount of emissions for each process, the amount of wastewater treated by each process is multiplied by the emission factor for each pollutant. The total emissions from all the processes in each facility were then summed and added on to the appropriate county total. These emissions are shown in Table 4.

Total emissions in lb./year from POTWs for each county in Minnesota are listed in Table 3.

## REFERENCE

- Dunnett, Randall, 1995. Water Quality Division, Minnesota Pollution Control Agency. October 20, 1995.
- Eckberg, Tod, 1995. Water Quality Division, Minnesota Pollution Control Agency. November 21, 1995.
- Minnesota Pollution Control Agency. (1995) *Wastewater Treatment Facilities Inventory*. Water Quality Division Point Source Compliance Section. August 1995.
- U.S. Environmental Protection Agency. (1995) *Waste Water Collection, Treatment and Storage*. AP-42, Compilation of Air Pollution Emission Factors, Section 4.3. 1995.
- Water Environment Federation and the American Society of Civil Engineers. (1995) *Toxic Air Emissions from Wastewater Treatment Facilities*. 1995.

# AA. Residential Fuel Combustion

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## INTRODUCTION

Residential fuel combustion is energy consumed by private households and includes the burning of coal, fuel oil, natural gas, and liquid petroleum gas.

## Source Identification

### AMS-SCC CODES

| AMS CODE    | LEVEL 1                           | LEVEL 2     | LEVEL 3                         | LEVEL 4                    |
|-------------|-----------------------------------|-------------|---------------------------------|----------------------------|
| A2104002000 | Stationary Source Fuel combustion | Residential | Bituminous / Subbituminous Coal | Total: All Combustor Types |
| A2104004000 | Stationary Source Fuel combustion | Residential | Distillate Oil                  | Total: All Combustor Types |
| A2104006000 | Stationary Source Fuel combustion | Residential | Natural Gas                     | Total: All Combustor Types |
| A2104006010 | Stationary Source Fuel combustion | Residential | Natural Gas                     | Residential Furnaces       |

| AMS CODE | LEVEL 1                     | LEVEL 2                    | LEVEL 3                        | LEVEL 4                |
|----------|-----------------------------|----------------------------|--------------------------------|------------------------|
| 10300206 | External Combustion Boilers | Commercial/ Institutional  | Bituminous/ Subbituminous Coal | Pulverized: Dry Bottom |
| 10100401 | External Combustion Boilers | Electric Generation        | Residual Oil                   | Grade 6 Normal Firing  |
| 10100501 | External Combustion Boilers | Electric Generation        | Distillate Oil                 | Grade 1 and 2          |
| 10300401 | External Combustion Boilers | Commercial / Institutional | Residual Oil                   | Grade 6 oil            |
| 10300501 | External Combustion Boilers | Commercial / Institutional | Distillate Oil                 | Grade 1 and 2          |
| 10300603 | External Combustion Boilers | Commercial / Institutional | Natural Gas                    | < 10 mmbtu/hr          |
| 10301001 | External Combustion Boilers | Commercial / Institutional | Liquid Petroleum Gas (LPG)     | Butane                 |
| 10301002 | External Combustion Boilers | Commercial / Institutional | Liquid Petroleum Gas (LPG)     | Propane                |

## Pollutants and Emission Factors

The targeted pollutants with their corresponding emission factors were inventoried for each type of fuel:

Table AA-1: Pollutants and Emission Factors for Coal Combustion Sources

Bituminous coal is by far the largest group of coal being burned in residential furnaces. AP42 was updated in 1998 and included a study on emission factors from ten facilities burning bituminous coal, eight facilities burning subbituminous coal and one facility burning lignite. NTI adopted those factors in their 1996 estimate of area sources. The NTI published factors with those listed in this methodology differs on metal emission factors. The 1998 study applied to boilers utilizing both wet limestone scrubbers or spray dryers with an ESP or fabric filters. Those control devices are targeting particulate matter and not organic compounds. For this reason, metal uncontrolled emission factors are used when available. The table presents emission factors on both weight basis (Lb./ton) and an energy basis (Lb./MMbtu). To convert from Lb./ton to Lb./MMbtu divide by a heating value of 26 MMbtu/ton.

| Pollutant                | Emission Factors (Lbs./ton of coal) | Emission Factor (Lbs./MMbtu) | Emission Factor Source       |
|--------------------------|-------------------------------------|------------------------------|------------------------------|
| Acetaldehyde             | 5.7E-4                              | 2.2E-5                       | 10300206 Controlled Factor   |
| Acrolein                 | 2.9E-4                              | 1.2E-5                       | 10300206 Controlled Factor   |
| Acenaphthene             | 5.1E-7                              | 2.0E-8                       | 10300206 Controlled Factor   |
| Acenaphththylene         | 2.5E-7                              | 9.6E-9                       | 10300206 Controlled Factor   |
| Anthracene               | 2.1E-7                              | 8.1E-9                       | 10300206 Controlled Factor   |
| Antimony                 | 1.8E-5                              | 6.9E-7                       | 10300206 Controlled Factor   |
| Arsenic                  | 1.8E-2                              | 6.84E-4                      | 10300206 Uncontrolled Factor |
| Benzene                  | 1.3E-3                              | 5E-5                         | 10300206 Controlled Factor   |
| Benz(a)anthracene        | 8E-8                                | 3E-9                         | 10300206 Controlled Factor   |
| Benzo(a)pyrene           | 3.8E-8                              | 1.5E-9                       | 10300206 Controlled Factor   |
| Benzo(g,h,i)perylene     | 2.7E-8                              | 1.1E-9                       | 10300206 Controlled Factor   |
| Beryllium                | 2.1E-3                              | 8.1E-5                       | 10300206 Uncontrolled Factor |
| Cadmium                  | 7.3E-4                              | 2.8E-5                       | 10300206 Uncontrolled Factor |
| Carbon Monoxide          | 5E-1                                | 2E-2                         | 10300206 Uncontrolled Factor |
| Chloroform               | 5.9E-5                              | 2.3E-6                       | 10300206 Controlled Factor   |
| Chromium                 | 5.5E-3                              | 2.12E-4                      | 10300206 Uncontrolled Factor |
| Chrysene                 | 1.0E-7                              |                              | 10300206 Controlled Factor   |
| Cobalt                   | 1.1E-4                              | 4.23E-6                      | 10300206 Controlled Factor   |
| Diocetyl phthalate       | 7.3E-5                              | 2.8E-7                       | 10300206 Controlled Factor   |
| Ethylene dichloride      | 4.2E-5                              | 1.6E-6                       | 10300206 Controlled Factor   |
| Ethylbenzene             | 9.4E-5                              | 3.6E-6                       | 10300206 Controlled Factor   |
| Ethylene dibromide       | 1.2E-6                              | 4.9E-8                       | 10300206 Controlled Factor   |
| Fluoranthene             | 7.1E-7                              | 2.7E-8                       | 10300206 Controlled Factor   |
| Fluorene                 | 9.1E-7                              | 3.5E-8                       | 10300206 Controlled Factor   |
| Formaldehyde             | 2.4E-4                              | 9.2E-6                       | 10300206 Controlled Factor   |
| Indeno(1,2,3-c,d) pyrene | 6.1E-8                              | 2.34E-9                      | 10300206 Controlled Factor   |
| Lead                     | 1.4E-2                              | 5.7E-4                       | 10300206 Uncontrolled Factor |
| Manganese                | 6.0E-3                              | 2.28E-4                      | 10300206 Uncontrolled Factor |

|                     |        |         |                              |
|---------------------|--------|---------|------------------------------|
| Mercury             | 4.2E-4 | 1.6E-5  | 10300206 Uncontrolled Factor |
| Methylene chloride  | 2.9E-4 | 1.1E-6  | 10300206 Controlled Factor   |
| Nickel              | 3.4E-2 | 1.03E-3 | 10300206 Uncontrolled Factor |
| Naphthalene         | 1.3E-5 | 5.0E-7  | 10300206 Controlled Factor   |
| Phenanthrene        | 2.7E-6 | 1.E-7   | 10300206 Controlled Factor   |
| Phenol              | 1.6E-5 | 6.2E-7  | 10300206 Controlled Factor   |
| Pyrene              | 3.3E-7 | 1.3E-8  | 10300206 Controlled Factor   |
| Styrene             | 2.5E-5 | 9.6E-7  | 10300206 Controlled Factor   |
| Tetrachloroethylene | 4.3E-5 | 1.7E-6  | 10300206 Controlled Factor   |
| Toluene             | 2.4E-4 | 9.2E-6  | 10300206 Controlled Factor   |

Table AA-2: Pollutants and Emission Factors for Distillate Fuel

The PAH emission factors are for residual oil and for uncontrolled processes. Those factors were derived in 1998 with a C quality rating. Residual oils are more viscous with higher PAH content than distillate oils and provide a conservative estimate of PAHs for distillate oils. The metal emission factors are for distillate oils and for uncontrolled processes. Factors are given in two set of units (lb./MMbtu or in Lb./1000gal of coal.) To convert volume basis units (Lb./1000 gal) to an energy basis (lb./MMBTU), divide by a heating value of 140 MMbtu/1000 gal of oil.

| Pollutant               | Emission Factor (lb./mmbtu) | Emission Factor (Lb./1000gal) | Emission Factor Source  |
|-------------------------|-----------------------------|-------------------------------|-------------------------|
| Acenaphthene            | 1.5E-07                     | 2.11E-5                       | 10100401 AP-42          |
| Acenaphthylene          | 1.8E-09                     | 2.53E-7                       | 10100401 AP-42          |
| Acetaldehyde            | 3.5E-05                     | 4.9E-3                        | From 1996 NTI Inventory |
| Anthracene              | 8.7E-09                     | 1.22E-6                       | 10100401 AP-42          |
| Arsenic                 | 4.0E-06                     | 5.6E-4                        | 10300501 AP-42          |
| Benz(a)anthracene       | 2.9E-08                     | 4.01E-6                       | 10100401 AP-42          |
| Benzene                 | 1.5E-06                     | 2.16E-4                       | 10100401 AP-42          |
| Benzo(b,k)fluoranthene  | 1.1E-08                     | 1.48E-6                       | 10100401 AP-42          |
| Benzo(g,h,i)perylene    | 1.6E-08                     | 2.26E-6                       | 10100401 AP-42          |
| Beryllium               | 3.0E-06                     | 4.2E-4                        | 10300501 AP-42          |
| Cadmium                 | 3.0E-06                     | 4.2E-4                        | 10300501 AP-42          |
| Chromium                | 3.0E-06                     | 4.2E-4                        | 10300501 AP-42          |
| Chrysene                | 1.7E-08                     | 2.4E-6                        | 10300501 AP-42          |
| Dibenz(a,h)anthracene   | 1.2E-08                     | 1.67E-6                       | 10100401 AP-42          |
| Fluoranthene            | 3.5E-08                     | 4.84E-6                       | 10100401 AP-42          |
| Fluorene                | 3.2E-08                     | 4.47E-6                       | 10100401 AP-42          |
| Formaldehyde            | 2.4E-04                     | 3.3E-2                        | 10100401 AP-42          |
| Indeno(1,2,3-c,d)pyrene | 1.5E-08                     | 2.14E-6                       | 10100401 AP-42          |
| Lead                    | 9.0E-06                     | 1.26E-3                       | 10300501 AP-42          |
| Manganese               | 6.0E-06                     | 8.4E-4                        | 10300501 AP-42          |
| Mercury                 | 3.0E-06                     | 4.2E-4                        | 10300501 AP-42          |
| Naphthalene             | 8.1E-06                     | 1.13E-3                       | 10100401 AP-42          |
| Nickel                  | 3.0E-06                     | 4.2E-4                        | 10300501 AP-42          |
| POM                     | 2.4E-5                      | 3.3E-3                        | 10300501 AP-42          |
| Phenanthrene            | 7.5E-08                     | 1.05E-5                       | 10100401 AP-42          |
| Pyrene                  | 3.0E-08                     | 4.25E-6                       | 10100401 AP-42          |
| Selenium                | 1.5E-05                     | 2.1E-3                        | 10300501 AP-42          |

Table AA-3: Pollutants and Emission Factors for Natural Gas

Pollutants and emission factors from natural gas combustion were taken from AP 42 (which are same as in Fire 6.22) and are presented below. Emission factors units are provided on a volume basis (Lb./MM SCF) and energy basis (Lb./MM Btu). To convert to an energy basis, divide the volume basis by a heating value of 1,020 MMBTU/MMSCF.

| Pollutant             | Emission Factor (Lb./MMSCF) | Emission Factor (Lb./MMbtu) | Emission Factor Source       |
|-----------------------|-----------------------------|-----------------------------|------------------------------|
| Acenaphthene          | 1.8E-6                      | 1.8E-9                      | 10300603 Uncontrolled Factor |
| Acenaphthylene        | 1.8E-6                      | 1.8E-9                      | 10300603 Uncontrolled Factor |
| Anthracene            | 2.4E-6                      | 2.4E-9                      | 10300603 Uncontrolled Factor |
| Benz(a)anthracene     | 1.8E-6                      | 1.8E-9                      | 10300603 Uncontrolled Factor |
| Benzo(a)pyrene        | 1.2E-6                      | 1.2E-9                      | 10300603 Uncontrolled Factor |
| Benzo(b)fluoranthene  | 1.8E-6                      | 1.8E-9                      | 10300603 Uncontrolled Factor |
| Benzene               | 2.1E-3                      | 2.1E-6                      | 10300603 Uncontrolled Factor |
| Benzo(g,h,i)perylene  | 1.2E-6                      | 1.2E-9                      | 10300603 Uncontrolled Factor |
| Benzo(k)fluoranthene  | 1.8E-6                      | 1.8E-9                      | 10300603 Uncontrolled Factor |
| Dibenz(a,h)anthracene | 8.5E-4                      | 4.5E-7                      | 10300603 Uncontrolled Factor |
| Fluoranthene          | 3E-6                        | 3E-9                        | 10300603 Uncontrolled Factor |
| Fluorene              | 2.8E-6                      | 2.8E-9                      | 10300603 Uncontrolled Factor |
| Formaldehyde          | 7.5E-2                      | 7.5E-5                      | 10300603 Uncontrolled Factor |
| Naphthalene           | 6.1E-4                      | 6.1E-7                      | 10300603 Uncontrolled Factor |
| Phenanthrene          | 1.7E-5                      | 1.7E-8                      | 10300603 Uncontrolled Factor |
| Pyrene                | 5E-6                        | 5E-9                        | 10300603 Uncontrolled Factor |
| Toluene               | 3.4E-3                      | 3.4E-6                      | 10300603 Uncontrolled Factor |
| Arsenic               | 2E-4                        | 2E-7                        | 10300603 Uncontrolled Factor |
| Beryllium             | 1.2E-5                      | 1.2E-8                      | 10300603 Uncontrolled Factor |
| Cadmium               | 1.1E-3                      | 1.1E-6                      | 10300603 Uncontrolled Factor |
| Chromium              | 1.4E-3                      | 1.4E-6                      | 10300603 Uncontrolled Factor |
| Cobalt                | 8.4E-5                      | 8.4E-8                      | 10300603 Uncontrolled Factor |
| Copper                | 8.5E-4                      | 8.5E-7                      | 10300603 Uncontrolled Factor |
| Lead                  | 5E-4                        | 5E-7                        | 10300603 Uncontrolled Factor |
| Manganese             | 3.8E-4                      | 3.8E-7                      | 10300603 Uncontrolled Factor |
| Mercury               | 2.6E-4                      | 2.6E-7                      | 10300603 Uncontrolled Factor |

Table AA-4: Pollutants and Emission Factors for Liquid Petroleum Gas

The AP 42 and Fire database provide only emission factors for criteria pollutants and the speciation profile in the speciate database is in question because of the high emission factors that result from it. The speciate profile for LPG and natural gas was used in the 1996 methodology and resulted to an overestimate of metals. However, emission factors for speciated organic and metal compounds for natural gas combustion were published in 1998 in AP42 but not for liquefied petroleum gases. In most cases, natural gas emission factors dropped by a factor of 100 or 1000 times. The speciation profile for LPG and natural gas is expected to be similar. The combustion processes that use LPG are very similar to those that use natural gas. For the above reasons, the decision is to use the natural gas emission factors and adjust them by the PM and TOC ratios of LPG to natural gas as shown in the table below:

| Pollutant     | Natural Gas<br>Lb./MMSCF | Natural Gas <sup>1</sup><br>Lb./MMbtu | LPG<br>Lb./1000 gal | LPG <sup>2</sup><br>Lb./MMbtu | ratio <sup>3</sup> |
|---------------|--------------------------|---------------------------------------|---------------------|-------------------------------|--------------------|
| PM Filterable | 1.9E+0                   | 1.08 E-4                              | 4E-1                | 4.27E-3                       | 39.5               |
| TOC           | 11                       | 1.08E-2                               | 5E-1                | 5.46E-3                       | 0.5                |

<sup>1</sup> PM filterable and VOC emission factors for natural gas were converted to an energy basis by dividing the Lb./MMSCF by a heating value of 1,020 MMBTU/MMSCF

<sup>2</sup> PM filterable and VOC emission factor for LPG were converted to an energy basis by dividing the Lb./1000 gal factor by a heating value of 91.5 Lb./MMBTU.

<sup>3</sup> Ratios are calculated by dividing LPG (Lb./MMBTU) by Natural Gas (Lb./MMBtu)

Table AA-5: The ratios calculated above are used to adjust the emission factors of the natural gas pollutant table. The natural gas emission factors (expressed in Lb./MMBTU) are multiplied by either, 39.5 for organics or 0.5 for metals, to calculate propane emission factors in Lb./MMBTU. Since activity data for LPG are given in Barrels (42gallons/barrel), LPG units are better expressed on a volume basis (Lb./1000 gal). To convert to a volume basis, multiply the Lb./MMBTU emission factor by a heating value of 91.5 MMBTU/1000 gal for propane.

| Pollutant             | Emission Factor (Lb./100 Gal) | Emission Factor (Lb./MMBtu) | Emission Factor Source         |
|-----------------------|-------------------------------|-----------------------------|--------------------------------|
| Acentaphthene         | 6.5E-6                        | 7.1E-8                      | 10300603 Uncontrolled Adjusted |
| Acenaphthylene        | 6.5E-6                        | 7.1E-8                      | 10300603 Uncontrolled Adjusted |
| Anthracene            | 8.7E-6                        | 9.5E-8                      | 10300603 Uncontrolled Adjusted |
| Benz(a)anthracene     | 6.5E-6                        | 7.1E-8                      | 10300603 Uncontrolled Adjusted |
| Benzo(a)pyrene        | 4.3E-6                        | 4.7E-8                      | 10300603 Uncontrolled Adjusted |
| Benzo(b)fluoranthene  | 6.5E-6                        | 7.1E-8                      | 10300603 Uncontrolled Adjusted |
| Benzene               | 7.6E-3                        | 8.3E-5                      | 10300603 Uncontrolled Adjusted |
| Benzo(g,h,i)perylene  | 4.3E-6                        | 4.7E-8                      | 10300603 Uncontrolled Adjusted |
| Benzo(k)fluoranthene  | 6.5E-6                        | 7.1E-8                      | 10300603 Uncontrolled Adjusted |
| Dibenz(a,h)anthracene | 1.6E-3                        | 1.8E-5                      | 10300603 Uncontrolled Adjusted |
| Fluoranthene          | 1.1E-5                        | 1.2E-7                      | 10300603 Uncontrolled Adjusted |
| Fluorene              | 1.08E-5                       | 1.1E-7                      | 10300603 Uncontrolled Adjusted |
| Formaldehyde          | 1.6E-1                        | 1.8E-3                      | 10300603 Uncontrolled Adjusted |
| Napthalene            | 2.2E-3                        | 2.4E-5                      | 10300603 Uncontrolled Adjusted |
| Phenanthrene          | 6.1E-5                        | 6.7E-7                      | 10300603 Uncontrolled Adjusted |
| Pyrene                | 2.1E-5                        | 2.3E-7                      | 10300603 Uncontrolled Adjusted |
| Toluene               | 1.2E-2                        | 1.3E-4                      | 10300603 Uncontrolled Adjusted |
| Arsenic               | 9.2E-6                        | 1E-7                        | 10300603 Uncontrolled Adjusted |
| Beryllium             | 5.5E-7                        | 6E-9                        | 10300603 Uncontrolled Adjusted |
| Cadmium               | 5.0E-5                        | 5.5E-7                      | 10300603 Uncontrolled Adjusted |
| Chromium              | 6.4E-5                        | 7E-7                        | 10300603 Uncontrolled Adjusted |
| Cobalt                | 7.7E-6                        | 8.4E-8                      | 10300603 Uncontrolled Adjusted |
| Copper                | 3.9E-5                        | 4.3E-7                      | 10300603 Uncontrolled Adjusted |
| Lead                  | 2.3E-5                        | 2.5E-7                      | 10300603 Uncontrolled Adjusted |
| Manganese             | 1.7E-5                        | 1.9E-7                      | 10300603 Uncontrolled Adjusted |
| Mercury               | 1.2E-5                        | 1.3E-7                      | 10300603 Uncontrolled Adjusted |

## METHODOLOGY

### Step 1. State Residential Consumption Estimate

The activity data for all forms of residential fuels come from the State Energy Data Report of the U.S. Department of Energy. Information can be downloaded via their Web site, <http://www.eia.doe.gov/emeu/states/states.html>. For each inventory, activity data are provided for bituminous coal in thousand tons, natural gas in billion cubic feet, distillate fuel in thousand barrels (42 gallons per barrel) and LPG in thousand barrels.

### Step 2. County Apportionment of Statewide Consumption Data

The Bureau of Census compiles housing information every ten years. The 1990 census for the entire country is on <http://govinfo.library.orst.edu/index.html> web site. Click on the 1990 Census of Population and Housing Section icon and it will take you to <http://govinfo.library.orst.edu/stateis.html>. Choose the state of your choice, click on the 1990 State of ..... Summaries, select housing and view your state's summary information. Search for detailed county information and you can obtain number of households on each county that use LPG, Natural Gas, Oil or Coal and calculate the county's fuel consumption.

#### *Example Calculation*

In 1996, there were 2,787,946 households in Ohio and 1533 households in Adams County that used natural gas. The state's natural gas consumption in 1996 was 375 Billion Cubic Feet. Assuming that all houses across state consume an equal amount of natural gas, consumption in Adams County can calculate to be:

$$(1,533 / 2,787,946 \text{ Households}) \times 375,000 \text{ MMSCF} = 206 \text{ MMSCF}$$

### Step 3. Emission Estimate

After having apportioned the house heating fuel to the county level, apply the appropriate toxic emission factor to the county's fuel consumption.

#### *Example Calculation*

Benzene Emissions in Adams County from Natural Gas calculate to be:  
 $2.1\text{E-}3 \text{ Lb./MMSCF} \times 206\text{MMSCF} = .43 \text{ lbs. of Benzene.}$

## REFERENCES

AP42 and Fire 6.22 database

Detailed Housing Characteristics, 1990 Census of Housing

State Energy Data Report 1996, Energy Information Administration, Office of Energy Markets and End Use, U.S. Department of Energy

## **BB. RESIDENTIAL WOOD-BURNING**

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### **BACKGROUND**

Residential woodburning is done in three major types of equipment: woodstoves, furnaces, and fireplaces. Woodstoves and furnaces are commonly used in residences for primary and supplemental heating, and fireplaces are commonly used for pleasure burning. Minnesota does not currently have any regulations put into place for residential wood burning, but most of the woodstoves, furnaces, and fireplaces are equipped with some emission reducing technology or features. This section will focus on the emissions from residential wood burning throughout Minnesota.

### **SOURCE IDENTIFICATION**

Searching through the Standard Industrial Classification Code List (SIC), residential wood burning is not categorized under any SIC Code since residential wood burning is not an industrial activity. Therefore, it is classified as SIC 9999: Non Classifiable Establishments.

Searching through the FIRE6.01 (Factor Information Retrieval System Version 6.01) and Source Summary Database (SSD), the following Area Mobile Source Codes (AMS) were found:

- A2104008000: Total woodstoves and fireplaces
- A2104008001 (lb./ton dry wood burned): Fireplaces - general
- A2104008010 (mg/Mg dry wood burned): Woodstoves - general
- A2104008030 (lb./ton dry wood burned): Catalytic woodstoves - general
- A2104008050 (lb./ton dry wood burned): Non-catalytic woodstoves - general
- A2104008051 (lb./ton dry wood burned): Non-catalytic woodstoves - conventional
- A2104008052 (lb./ton dry wood burned): Non-catalytic woodstoves - low emitting
- A2104008053 (lb./ton dry wood burned): Non-catalytic woodstoves - pellet fired

### **POLLUTANTS**

All the AMS codes listed above were considered when locating all the possible targeted emission pollutants. Using the FIRE 6.01 database and the information found in the STAPPA-ALAPCO Emission Inventory Improvement Program (EIIP), emission factors were found for 31 pollutants, shown in Table BB-1. In order to create a more complete emission inventory for Minnesota, emission estimates for some greenhouse gases and criteria pollutants were also calculated. They are methane (CH<sub>4</sub>), carbon dioxide (CO<sub>2</sub>), particulate matter smaller than 10 microns (PM<sub>10</sub>), carbon monoxide (CO), sulfur oxides (SO<sub>x</sub>), nitrogen oxides (NO<sub>x</sub>), and total volatile organic compounds (VOC).

## **EMISSION FACTORS**

Since there was not any information found in the FIRE database for furnaces, the emission factors for furnaces are assumed to be grouped with wood burning stoves.

There are many variations in device design and operation characteristics of fireplace, furnace and woodstove burning. Hence, assumptions were made in order to provide the most accurate emission estimates. When considering emission factors for emission estimation, factors for non-catalytic conventional stoves were used, as they were the most conservative factors available. There were five pollutants for which there were no emission factors listed under non-catalytic conventional stoves in FIRE 6.22. For those pollutants, the emission factors listed under non-catalytic general stoves were used instead. Also, there were four instances where no emission factors were available for either non-catalytic conventional or non-catalytic general stoves. General woodstove emission factors were used in those cases. Emission factors for the criteria pollutants were available for residential fireplaces. Thus, emission factors from A2104008050, A2104008051, A2104008001, and A2104008010 were chosen for the emission estimate calculations. They are listed in Table BB-1.

Table BB-1: Emission Factors for Residential Wood Burning

| Pollutant                  | Emission Factor<br>(lb./ton) | AMS Code    | Reference |
|----------------------------|------------------------------|-------------|-----------|
| Acenaphthene               | 0.010                        | A2104008050 | FIRE 6.22 |
| Acenaphthylene             | 0.212                        | A2104008051 | FIRE 6.22 |
| Anthracene                 | 0.014                        | A2104008051 | FIRE 6.22 |
| Benzene                    | 1.938                        | A2104008051 | FIRE 6.22 |
| Benz(a)anthracene          | 0.020                        | A2104008051 | FIRE 6.22 |
| Benzo(a)pyrene             | 0.004                        | A2104008051 | FIRE 6.22 |
| Benzo(b)fluoranthene       | 0.006                        | A2104008051 | FIRE 6.22 |
| Benzo(g,h,i)perylene       | 0.004                        | A2104008051 | FIRE 6.22 |
| Benzo(k)fluoranthene       | 0.002                        | A2104008051 | FIRE 6.22 |
| Cadmium                    | $2.2 \times 10^{-5}$         | A2104008051 | FIRE 6.22 |
| Chromium                   | $1.0 \times 10^{-6}$         | A2104008051 | FIRE 6.22 |
| Chrysene                   | 0.012                        | A2104008051 | FIRE 6.22 |
| Copper                     | $3.4 \times 10^{-4}$         | A2104008050 | FIRE 6.22 |
| Dibenz(a,h)anthracene      | 0.004                        | A2104008050 | FIRE 6.22 |
| Fluoranthene               | 0.020                        | A2104008051 | FIRE 6.22 |
| Fluorene                   | 0.024                        | A2104008051 | FIRE 6.22 |
| Indeno(1,2,3-cd)pyrene     | 0.02                         | A2104008050 | FIRE 6.22 |
| Manganese                  | $1.7 \times 10^{-4}$         | A2104008051 | FIRE 6.22 |
| Naphthalene                | 0.288                        | A2104008051 | FIRE 6.22 |
| Nickel                     | $1.40 \times 10^{-5}$        | A2104008051 | FIRE 6.22 |
| Phenanthrene               | 0.078                        | A2104008051 | FIRE 6.22 |
| Phenol                     | 0.001                        | A2104008050 | FIRE 6.22 |
| Pyrene                     | 0.024                        | A2104008051 | FIRE 6.22 |
| 2,3,7,8-TCDD               | $7.4 \times 10^{-9}$         | A2104008010 | FIRE 6.22 |
| 2,3,7,8-TCDF               | $4.4 \times 10^{-7}$         | A2104008010 | FIRE 6.22 |
| PCDD                       | $2.88 \times 10^{-6}$        | A2104008010 | FIRE 6.22 |
| PCDF                       | $1.59 \times 10^{-5}$        | A2104008010 | FIRE 6.22 |
| Toluene                    | 0.73                         | A2104008051 | FIRE 6.22 |
| o-Xylene                   | 0.202                        | A2104008051 | FIRE 6.22 |
| Carbon Monoxide            | 252.6                        | A2104008001 | FIRE 6.22 |
| Particulate Matter < 10 µg | 34.6                         | A2104008001 | FIRE 6.22 |
| Sulfur Oxides              | 0.4                          | A2104008001 | FIRE 6.22 |
| Nitrogen Oxides            | 2.6                          | A2104008001 | FIRE 6.22 |
| Volatile Organic Compounds | 229.0                        | A2104008001 | FIRE 6.22 |
| Carbon Dioxide             | 3400                         | A2104008001 | FIRE 6.22 |
| Methane                    | 4.800                        | A2104008051 | FIRE 6.22 |

## FACILITY IDENTIFICATION

Residential wood burning data were obtained from the 1995-1996 Minnesota Residential Fuelwood Survey (DNR, 1996). The survey provides information based on the Minnesota Forest Service Survey Units classified by location. There were a total of 5 units (Table BB-2). Each

county was placed in one of 5 survey units (Refer to Table BB-3 for all the counties listed under the 5 survey units). The survey supplied information relative to total volume of wood consumed for pleasure, supplemental and primary heating, average number of cords burned per survey unit, geographic data, and percent of wood burned in fireplaces, woodstoves, and furnaces.

A summary of the required parameters to estimate emissions are listed in Table BB-2 below.

Table BB-2: Estimated Average Annual Wood Consumption and Percent of Households that Burn Wood (Data from DNR, 1996)

| Unit | % of Households Burning Wood | Avg. # Cord Burned per Household for heating (cords/house/year) | Avg. # Cords Burned per Household for pleasure (cords/house/year) |
|------|------------------------------|---|---|
| 1    | 21%                          | 1.74  | 0.64  |
| 2    | 25%                          | 2.90  | 0.29  |
| 3    | 17%                          | 2.90  | 0.70  |
| 4    | 31%                          | 3.89  | 0.70  |
| 5    | 36%                          | 4.9   | 0.94  |

- Where Unit #1: Metro (Metropolitan)
- #2: Central Hardwoods (Central MN)
- #3: Prairie (South-West MN)
- #4: Aspen-Birch (East MN)
- #5: Northern Pine (North MN)

Standard Cord: 4ft x 4ft x 8ft or 128 standard cubic ft

To simplify the calculations, two categories of wood burning were developed. They are pleasure and primary/supplemental heat burning (Table BB-2). The average numbers of cords burned in Table BB-2 were calculated based on the data taken from the appendix in the survey. This was calculated based upon the estimated number of cords burned for each heating purpose in each unit and dividing by the number of households burning wood for that heating purpose.

Note from Table BB-2 that the percent of the households that burn wood and the average number of cords of wood burned per household by pleasure and primary/supplemental heating vary from one unit to the other. This variation is dependent on what part of the state a survey unit is located. Therefore, to obtain the most accurate data and to provide the most accurate emission estimates, the emission estimates for each county were calculated using the appropriate data from the survey unit where the county is located (assuming the same averages over the entire survey unit).

## EMISSION ESTIMATION

The total estimated residential consumption of wood burned for each county was determined by taking the average number of cords of wood burned per household in the survey unit (Table BB-3) and multiplying by the number of households that burn wood for pleasure and the number of households that burn wood for supplemental and primary heating, respectively. Combine cords burned for pleasure and heating to arrive at a county-wide total. See Table BB-3 for the total number of cords of wood burned per county for all the counties in Minnesota. The 1997 Household data for the state and all the counties were obtained from the Minnesota Planning.<sup>2</sup> Calculation example:

$$T = (HP * PA) + (HH * WA)$$

Where

- T = Total number of cords burned in a county
- HP = # of Households in county that burn wood for pleasure
- HH = # of Households in county that burn wood for heating
- PA = Average cords burned/household-yr. for pleasure
- HA = Average cords burned/household-yr. for heating.

Total emissions of a pollutant from residential wood burning for each county are achieved by multiplying the total number of cords burned in each county by the density of wood, 2 tons of dry wood per cord<sup>3</sup> and the appropriate emission factor.

Calculation example:

$$TE = T * D * EF$$

Where

- TE = Total emissions of a pollutant (lb./yr.)
- T = Total cords burned in county
- D = Density of wood (2 Tons dry wood/Cord)
- EF = Emission factor for the pollutant (lb./ton)

All calculations were verified by spreadsheets and RAPIDS.

## REFERENCES

Minnesota Department of Natural Resources (DNR), 1996. 1995-1996 Minnesota residential Fuelwood Survey.

Minnesota Planning, Population and Household Estimates: County Estimates.  
<http://www.mnplan.state.mn.us/demography/demogpop.html>. Accessed 5/19/00.

Dahlman, Rick, 1995. Minnesota Department of Natural Resources. August 07, 1995.

EPA, STAPPA, ALAPCO, Emission Inventory Improvement Program (EIIP), Volume III, July 1997, Chapter 2.

## CC. Industrial Solvent Cleaning

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### METHODOLOGY

In this category, the use of solvents is broken into two broad classifications. The classifications are solvent cleaning (which is composed of cold cleaning and vapor/in-line cleaning), and solvent cleanup (predominantly wipe cleaning of external surfaces). Michigan recommends that the main emphasis be on solvent cleaning, as that will be the primary source of emissions.

#### EIIP Preferred Method

##### *Solvent Cleaning Equipment*

###### Cold Cleaners

Conduct survey of suppliers, until cold cleaner NSPS is promulgated.

###### Vapor/In-line Cleaners

Facility specific data submitted per the halogenated solvent cleaning NESHAP; or data from facilities permitted as VOC and/or HAP sources.

#### EIIP Alternative Method

##### *Solvent Cleaning Equipment (both Cold Cleaners and Vapor/In-line Cleaners)*

###### Surveys

Useable only if data available for reasonable subset of facilities.

###### Emission factors

EIIP Table 6.5-2 provides per capita and per employee emission factors, as reproduced below. Throughput for per capita emission factors may be found with the U.S. Department of Commerce, Bureau of the Census (<http://www.census.gov/population/www/estimates/countypop.html>), in the form of *County Population Estimates for July 1, 1998 and Population Change for July 1, 1997 to July 1, 1998* for individual states. County population estimates for 1997 are provided here.

## Recommended Method for Solvent Cleaning Equipment

Michigan opted to utilize the per capita emission factor from Table 6.5-2 of EIIP for calculating solvent cleaning equipment emissions. The document, *Procedures for the Preparation of Emission Inventories for Carbon Monoxide and Precursors of Ozone: Volume I: General Guidance for Stationary Sources* (EPA, 1991), states “Using per capita factors assumes that emissions in a given area can be reasonably associated with population. This assumption is valid over broad areas for certain activities such as dry cleaning, architectural surface coating, small degreasing operations and solvent evaporation from household and commercial products”.

Cold cleaning and vapor/in-line cleaning can be calculated together by the use of the total solvent cleaning emission factor. After total solvent cleaning emissions are calculated with the per capita emission factor, point source emissions must be accounted for. Point source emissions by SIC code, from Michigan’s 1997 Emission Inventory System, were subtracted from the total solvent cleaning emissions to generate area source emission estimates for each county.

Per Capita and Per Employee Solvent Cleaning Emission Factors (EIIP Table 6.5-2)

| Subcategory                       | SIC Codes                                   | Per Capita Factor<br>(lb/yr/person) |          | Per Employee Factor<br>(lb/yr/person) |          |
|-----------------------------------|---|-------------------------------------|----------|---------------------------------------|----------|
|                                   |   | VOCs                                | Organics | VOCs                                  | Organics |
| <b>Solvent cleaning (total)</b>   | 25, 33-39, 417, 423, 551, 552, 554-556, 753 | 4.3                                 | 7.2      | 87                                    | 144      |
| <b>Cold Cleaning</b>              |   |                                     |          |                                       |          |
| Automobile Repair                 | 417, 423, 551, 552, 554-556, 753            | 2.5                                 | 2.5      | 270                                   | 270      |
| Manufacturing                     | 25, 33-39                                   | 1.1                                 | 1.1      | 24                                    | 24       |
| <b>Vapor and In-Line Cleaning</b> |   |                                     |          |                                       |          |
| Electronics and Electrical        | 36  | 0.21                                | 1.1      | 29                                    | 150      |
| Other                             | 25, 33-39, 417, 423, 551, 552, 554-556, 753 | 0.49                                | 25       | 9.8                                   | 49       |

## Great Lakes Toxics

AMS codes were found for the following SIC groups.

| <b>SIC</b> | <b>AMS CODE</b> | <b>DESCRIPTION</b>  | <b>INDUSTRY DESCRIPTION</b>           |
|------------|-----------------|---------------------|---------------------------------------|
| 25         | 2415005000      | TOTAL: ALL SOLVENTS | FURNITURE & FIXTURES                  |
| 33         | 2415010000      | TOTAL: ALL SOLVENTS | PRIMARY METAL INDUSTRY                |
| 33         | 2415015000      | TOTAL: ALL SOLVENTS | SECONDARY METAL INDUSTRY              |
| 34         | 2415020000      | TOTAL: ALL SOLVENTS | FABRICATED METAL                      |
| 35         | 2415025000      | TOTAL: ALL SOLVENTS | INDUSTRIAL MACHINERY & EQUIPMENT      |
| 36         | 2415030000      | TOTAL: ALL SOLVENTS | ELECTRONIC AND OTHER ELEC.            |
| 37         | 2415035000      | TOTAL: ALL SOLVENTS | TRANSPORTATION EQUIPMENT              |
| 38         | 2415040000      | TOTAL: ALL SOLVENTS | INSTRUMENTS AND RELATED PRODUCTS      |
| 39         | 2415045000      | TOTAL: ALL SOLVENTS | MISC MANUFACTURING                    |
| 40-45      | 2415050000      | TOTAL: ALL SOLVENTS | TRANSPORTATION MAINTENANCE FACILITIES |
| 55         | 2415055000      | TOTAL: ALL SOLVENTS | AUTOMOTIVE DEALERS                    |
| 75         | 2415060000      | TOTAL: ALL SOLVENTS | AUTO REPAIR SERVICES                  |

These SIC codes each matched Profile Number 1195 in RAPIDS. Under Profile Number 1195, the following pollutants from the GLC Toxics material group are speciated. Next to the pollutants, emission factors from the RAPIDS Generic Speciation Factor table are provided, in lb. of emittants per lb. of throughput. The throughput is TOG. One lb. of TOG is emitted for every lb. of VOC throughput. This relationship came from the RAPIDS emission factor table.

|                       |                    |
|-----------------------|--------------------|
| benzene               | 0.010000 LB/LB TOG |
| cumene                | 0.000300 LB/LB TOG |
| hexane                | 0.000400 LB/LB TOG |
| methyl ethyl ketone   | 0.011000 LB/LB TOG |
| methylene chloride    | 0.041000 LB/LB TOG |
| naphthalene           | 0.000300 LB/LB TOG |
| perchloroethylene     | 0.074000 LB/LB TOG |
| 1,1,1 trichloroethane | 0.222900 LB/LB TOG |
| toluene               | 0.082900 LB/LB TOG |

|                   |                    |
|-------------------|--------------------|
| trichloroethylene | 0.210900 LB/LB TOG |
| xylene, m         | 0.002300 LB/LB TOG |
| xylene, o         | 0.001700 LB/LB TOG |
| xylene, p         | 0.002300 LB/LB TOG |
| xylenes iso       | 0.034000 LB/LB TOG |

## REFERENCES

U.S. Environmental Protection Agency (U.S. EPA). *Procedures for the Preparation of Emission Inventories for Carbon Monoxide and Precursors of Ozone: Volume I: General Guidance for Stationary Sources* (May 1991).

U.S. EPA. *STAPPA-ALAPCO-EPA Emission Inventory Improvement Program (EIIP)*. Volume III - Area Sources Preferred and Alternative Methods. Chapter 6, Solvent Cleaning. September 1997.

US Department of Commerce, Bureau of the Census. *County Business Patterns 1997*. September 1999 (<http://www.census.gov/prod/www/abs/cbptotal.html>).

US Department of Commerce, Bureau of the Census. *County Population Estimates for July 1, 1998 and Population Change for July 1, 1997 to July 1, 1998*. September 1999. (<http://www.census.gov/population/www/estimates/countypop.html>).

## **DD. Traffic Markings**

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### **PREFERRED METHOD: Survey of Traffic Marking Usage**

Data requirements of the preferred method as per EIIP Document Volume III: Chapter 14 - Traffic Markings.

- product type, including thinning and cleanup solvents
- product amount used by type (gallon)
- product density (lb./gallon)
- estimates of the proportion of products used during the inventory season
- VOC/solvent content or air toxic/solvent content of each product type (lb./gallon or weight percent), depending on the inventory type

### **ALTERNATIVE METHODS**

Data requirement of each alternative approach

1. Alternative Method One: National traffic paint sales and National Paint & Coating Association (NPCA) emission factor
  - National traffic paint usage
  - National and state spending for highway maintenance
  - State and county paved lane miles (preferred approach) or state and county population
  - Proportion of solvent- versus water-based coatings for the state or county to develop a local emission factor from the NPCA solvent and water-based coating factors, or the NPCA national average emission factor
2. Alternative Method Two: Lane miles emission factor
  - Traffic lane miles painted (preferred approach) or total lane miles
  - Proportion of solvent- versus water-based coatings for the state or county to develop a local emission factor (preferred approach), or the solvent-based emission factor
3. Alternative Method Three: Per capita emission factor
  - National traffic paint sales data, in gallons
  - National population and inventory area population figures for the inventory year
  - NPCA per-gallon emission factor

### **CHOOSING A METHOD & CALCULATING EMISSIONS**

All of the alternative methods, even the preferred method to an extent, are based on an assumed proportional relationship between traffic marking usage and some acceptable and accessible surrogate measurement for county/state/national level, i.e. highway maintenance spending, population, traffic lane miles, etc. While the survey method may be a necessity in some states, others need to consider issues of cost and complexity before undertaking this method. A state may have some but not all of the necessary information to do a thorough survey method, i.e. you know the solvent usage from the paint but not the solvent usage from

the thinning and cleanup activities, the paint usage provided by the state highway department is categorized by districts or subdivision of the state that cuts across county boundaries, etc. You may start out trying to do a survey method only to combine it with one of the alternative methods when you have insufficient information. Once a baseline survey method has been established, using a smaller sample size or updating traffic marking coating usage maybe sufficient in following years. Using the Preferred Method, Alternative Method One or Three will give the county-based pain usage. Alternative Method Two assumes 16 gallons of traffic paint of either solvent- or water-based paint are used for every mile counted (EPA, 1988). The air toxic emission factors are available from EIIP Document Volume III: Chapter 14 - Traffic Markings. The equation for calculating air toxic emissions is the following:

$$\text{Air Toxic Emissions} = \text{County Traffic Paint Usage} * \text{Air Toxic Volume \%} * \text{Air Toxic Density}$$

Table DD-1: Pollutants emitted of interest to RAPIDS and Species Profile

| AIR Toxic               | Volume Percent (%) | Density (lb./gal) |
|-------------------------|--------------------|-------------------|
| Carbon tetrachloride    | 0.009              | 12.19             |
| Ethylbenzene            | 0.009              | 7.24              |
| Glycol ethers           | 0.040              | 7.01              |
| Naphthalene             | 0.002              | 9.55              |
| Styrene                 | 0.277              | 7.55              |
| Toluene                 | 6.914              | 7.23              |
| Xylenes (mixed isomers) | 0.499              | 7.18              |

The FIRE 6.01 is also checked. The SCC A2401008xxx (traffic markings) has no air toxic emission factors and the SCC 402001-01 (paint: solvent based) is too generic and its Air Toxic emission factors may differ substantially from traffic marking paint formulations.

## REFERENCES

Environmental Protection Agency (EPA). *STAPPA-ALAPCO-EPA Emission Inventory Improvement Program (EIIP)*. Volume III - Area Sources Preferred and Alternative Methods. Chapter 14 - Traffic Markings. July 1997.