VOLUME III: CHAPTER 17

ASPHALT PAVING

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DISCLAIMER

As the Environmental Protection Agency has indicated in Emission Inventory Improvement Program (EIIP) documents, the choice of methods to be used to estimate emissions depends on how the estimates will be used and the degree of accuracy required. Methods using site-specific data are preferred over other methods. These documents are non-binding guidance and not rules. EPA, the States, and others retain the discretion to employ or to require other approaches that meet the requirements of the applicable statutory or regulatory requirements in individual circumstances.

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CONTENTS

Section **Page**

1 Introduction 17.1-1

2 Source Category Description 17.2-1

2.1 Process Description 17.2-1
2.1.1 Asphalt Mixtures 17.2-1

2.2 Emission Sources 17.2-3
2.2.1 Asphalt Mixtures 17.2-3

2.3 Factors Influencing Emissions 17.2-5
2.3.1 Process Operating Factors 17.2-5
2.3.2 Control Techniques 17.2-5

3 Overview of Available Methods 17.3-1

3.1 Estimation Methods 17.3-1

3.2 Available Methodologies 17.3-1
3.2.1 Volatile Organic Compounds 17.3-2
3.2.2 Hazardous Air Pollutants 17.3-4

3.3 Data Needs 17.3-4
3.3.1 Data Elements 17.3-4
3.3.2 Application of Controls 17.3-5
3.3.3 Spatial Allocation 17.3-5
3.3.4 Temporal Resolution 17.3-6
3.3.5 Projecting Emissions 17.3-8

4 Preferred Method for Estimating Emissions 17.4-1

4.1 Survey Planning 17.4-2

4.2 Survey Preparation 17.4-3

4.3 Survey Distribution 17.4-4

CONTENTS (CONTINUED)

Section **Page**

4.4 Survey Compilation and Scaling 17.4-4

4.5 Emission Estimation 17.4-8
4.5.1 Volatile Organic Compounds 17.4-8
4.5.2 Hazardous Air Pollutants 17.4-9

5 Alternative Methods for Estimating Emissions 17.5-1

5.1 Volatile Organic Compounds 17.5-1
5.1.1 Alternative Method 1: Limited Survey of Selected DOTs 17.5-1
5.1.2 Alternative Method 2: State Usage Data, Minimum Data Collection From DOTs 17.5-5
5.1.3 Alternative Method 3: Volume Usage Emission Factors 17.5-6

5.2 Hazardous Air Pollutants 17.5-9

6 Quality Assurance/Quality Control 17.6-1

6.1 Emission Estimate Quality Indicators 17.6-1
6.1.1 Data Attribute Rating System (DARS) Scores 17.6-2

6.2 Sources of Uncertainty 17.6-2

7 Data Coding Procedures 17.7-1

7.1 Necessary Data Elements 17.7-1

8 References 17.8-1

FIGURES AND TABLES

Figure **Page**

17.4-1 Survey Request Form for Asphalt Cement Use - Instructions 17.4-5

17.4-2 Cutback Asphalt Data Request Form 17.4-6

17.4-3 Emulsified Asphalt Data Request Form 17.4-7

17.5-1 Simplified Data Request Form 17.5-2

17.5-2 Example Telephone Survey Form 17.5-7

Table

17.5-1 Evaporative VOC Emissions From Cutback Asphalts as a Function of Diluent Content and Cutback Asphalt Type 17.5-3

17.5-2 Asphalt Paving Emission Factors 17.5-8

17.5-3 HAP Speciation Profiles for Asphalt Paving: Cutback Asphalt 17.5-8

17.6-1 DARS Scores for Asphalt Paving Preferred Method: Comprehensive Survey 17.6-3

17.6-2 DARS Scores for Asphalt Paving Alternative Method 1: Simplified Survey 17.6-3

17.6-3 DARS Scores for Asphalt Paving Alternative Method 2: State-Level Usage Data 17.6-3

17.6-4 DARS Scores for Asphalt Paving Alternative Method 3: Emission Factors 17.6-4

17.7-1 Area and Mobile Source Category Codes for Asphalt Paving 17.7-2

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1

INTRODUCTION

This chapter is one of a series of documents developed to provide cost-effective, reliable and consistent approaches to estimating emissions for area source inventories. Multiple methods are provided in the chapters to accommodate needs of state agencies with different levels of available resources and skills; and different levels of needs for accuracy and reliability of their estimates. More information about the EIIP program can be found in Volume 1 of the EIIP series, *Introduction and Use of EIIP Guidance for Emissions Inventory Development.*

This chapter describes the procedures and recommended approaches for estimating emissions from asphalt paving. Section 2 of this chapter contains a general description of the asphalt paving category, the emission sources, and an overview of available control technologies. Section 3 of this chapter provides an overview of available emission estimation methods. Section 4 presents the preferred emission estimation method for asphalt paving, and Section 5 presents alternative emission estimation techniques. Quality assurance and quality control (QA/QC) procedures are described in Section 6. Coding procedures used for data input and storage are discussed in Section 7, and Section 8 is the reference section.

Throughout this chapter and other EIIP area source methods chapters, we stress that area source categories should be prioritized by the inventory planners so that resources can be spent on the source categories that are the largest emitters, most likely to be subject to regulations or are already subject to regulations, or require special effort because of some policy reason. Prioritization is particularly important for area source inventories, because in some cases, a difficult to characterize source category may contribute very little to overall emissions and attempting a high quality estimate for that source category may not be cost effective.

EIIP chapters are written for the state and local air pollution agencies, with their input and review. EIIP is a response to EPA's understanding that state and local agency personnel have more knowledge about their inventory area's activities, processes, emissions, and availability of information; and require flexible inventory methods to best use their sometimes limited resources. These EIIP area source chapters are written as a set of options presented to inventory professionals capable of using their own experience and judgement to apply the method that best fits their overall needs and constraints.

This source category does not include emissions from asphalt plants, or emissions from other related products such as roofing asphalts and sealers. It also does not include emissions that may occur during the road preparation prior to paving.

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2

SOURCE CATEGORY DESCRIPTION

2.1 PROCESS DESCRIPTION

Asphalt paving is used to pave, seal, and repair surfaces such as roads, parking lots, drives, walkways, and airport runways. Asphalt concrete used in paving is a mixture of asphalt cement, which is a binder, and an aggregate. Asphalt cement is the semi-solid residual material left from petroleum refining after the lighter and more volatile fractions have been distilled out. Hot-mix asphalt is a mixture of heated asphalt cement and aggregate. Asphalt cutbacks are asphalt cements thinned with petroleum distillates (diluents). Asphalt emulsions are mixtures of asphalt cement with water and emulsifiers. Aggregates used in asphalt cements are typically rock gravel or recycled asphalt pavement, but can also be byproducts from metal ore refining processes. Aggregate may constitute up to 95 percent by weight of the total mixture.[1] Mixture characteristics for asphalt concrete are determined by the amount and grade of asphalt cement used, the addition of solvent- or soap-based liquefying agents, and the relative amount and types of aggregate used.

Recycled asphalt pavement (RAP) is being used more frequently, partly as a means to reduce solid waste. One source estimates that 90 percent of asphalt processed is RAP.[1] To reuse the asphalt, the RAP is typically pulverized; sorted; mixed with recycling agents such as lime or calcium chloride, or additional aggregate; then applied. The five methods of recycling are: cold planing, hot recycling, hot in-place recycling, cold in-place recycling, and full depth reclamation. All except hot recycling occur at the location where paving is to be done, although material removed during cold planing may be processed at an asphalt plant.

2.1.1 ASPHALT CONCRETE

Asphalt concrete is grouped into three general categories: hot-mix, cutback, and emulsified. Each is discussed below. Emissions from the application of hot-mix, cutback and emulsified asphalt are discussed in Section 2.2.

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[1] Personal communication between Gary Fore, of the National Asphalt Pavement Association and L. Adams, Eastern Research Group, Inc., February 1997.

Hot-Mix Asphalt

Hot-mix asphalt is the most commonly used paving asphalt for surfaces of 2 to 6 inches thick. Hot-mix asphalt is prepared at a hot-mix asphalt plant by heating asphalt cement before adding the aggregate. To maintain a liquid mixture, these plants must be near to the paving site. In some cases, mobile facilities are used. An estimated 22 million tons of hot-mix asphalt cement concrete were sold in 1994 (Moulthrop, et al. 1997).

Cutback Asphalt

Cutback asphalt is used in tack and seal operations, in priming roadbeds for hot-mix application, and for paving operations for pavements up to several inches thick. In preparing cutback asphalt, asphalt cement is blended or "cut back" with a diluent, typically from 25 to 45 percent by volume of petroleum distillates, depending on the desired viscosity. Cutback asphalt is prepared at an asphalt plant. There are three types of cutback asphalt cement:

- Rapid Cure (RC) which uses gasoline or naphthas as diluents;
- Medium Cure (MC) which uses kerosene as a diluent; and
- Slow Cure (SC) which uses low volatility fuel solvents as diluents.

An estimated 0.75 million tons of cutback asphalt were sold in 1994 (Moulthrop, et al. 1997). This represents about three percent of sales of all asphalt cement types.

A number of states recognize the emission potential from the use of cutback asphalts and have established regulations limiting the amounts used and the time of year when they are used. The inventory preparer should determine whether such regulations are in place for the area to be inventoried before beginning data collection.

Emulsified Asphalt

Emulsified asphalt is used in most of the same applications as cutback asphalts but is a lower-emitting, energy saving, and safer alternative to the cutback asphalts (Moulthrop, et al. 1997). Instead of blending asphalt cement with petroleum distillates, emulsified asphalts use a blend of asphalt cement, water and an emulsifying agent, such as soap. Such blends typically contain one-third water, two-thirds asphalt cement and minor amounts of an emulsifier.[2] Some

[2] Telephone conversation between R. Benson of the Asphalt Institute and S. K. Buchanan, Eastern Research Group, Inc., September 1997.

emulsified asphalts may contain up to 12 percent organic solvents by volume (California SCAQMD Rule 1108.1).[1] Emulsification is done at an asphalt plant. Emulsified asphalts cure by two methods: water evaporation and, in the case of cationic and anionic emulsions, ionic bonding. For purposes of this document, the three types of concern are determined by the proportions of the emulsifier and water in the blend:[2]

- Rapid Set (RS);
- Medium Set (MS); and
- Slow Set (SS).

Approximately 1.76 million tons of emulsified asphalt were used in 1994 (Moulthrop, et al. 1997). This represents about seven percent of overall use of all asphalt types that year.

2.2 EMISSION SOURCES

Emissions from asphalt paving operations occur when asphalt mixtures are applied and as they cure. The pollutants emitted depend on the diluents used and may include volatile organic compounds (VOCs) and hazardous air pollutants (HAPs). Emission estimation methods are available for calculating VOC emissions. To estimate HAP emissions, inventory preparers will need to develop their own HAP content profiles from local data.

2.2.1 ASPHALT MIXTURES

Emissions from the application of the different asphalt mixtures are discussed below.

Hot-Mix Asphalt

For hot-mix asphalt, the organic components have high molecular weights and low vapor pressures. Therefore, hot-mix asphalt use produces minimal emissions of VOCs and HAPs. Estimates for national hot-mix asphalt paving emissions are about one order of magnitude lower than national estimates of cutback asphalt paving. More information about hot-mix asphalt paving emissions can be found in the EPA publication, *Final Report - Evaluation of Emissions*

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[1] Telephone conversation between R. Ryan of the U.S. Environmental Protection Agency and L. Adams, Eastern Research Group, Inc., February 1997.

[2] Additional information on emulsions may be obtained from the Asphalt Emulsion Manufacturers Association, phone: (410) 267-0023

from Paving Asphalts (EPA, 1994a). Because emissions from hot-mix asphalt are low, estimation methods will not be included in this chapter.

Cutback Asphalt

For cutback asphalt, emissions are due to the use of diluents that contain VOCs and, in some cases, HAPs. Cutback asphalt has the highest diluent content of the three asphalt categories and, as a result, emits the highest levels of VOCs per ton used. Estimating emissions from the use of cutback asphalt should be given a high priority in this source category. The two major variables affecting both the quantity of VOCs and HAPs emitted and the time over which emissions occur are the type and the quantity of organic solvent used as a diluent. As the rapid cure cutback asphalt has the highest diluent content, use of this type of cutback asphalt produces the highest emissions; evaporative losses are estimated at 95 percent by weight of diluent. Medium cure evaporative losses are estimated at 70 percent by weight of diluent, and slow cure at 25 percent by weight of diluent (EPA, 1996).

Emulsified Asphalt

In general, emulsified asphalts have a lower emission potential than cutback asphalts as they contain less or no diluents. However, some may contain up to 12 percent by volume solvents (California SCAQMD Rule 1108.1).[5] Therefore, the inventory preparer should consider evaluating the diluent content and composition of emulsified asphalts used in the inventory area, before deciding whether to collect data to estimate emissions. Because cutback asphalt use is regulated by a number of states to reduce VOC emissions, use of emulsified asphalts has gained popularity. Thus, although emulsified asphalt diluent contents are typically lower than the cutback asphalt, the amount used may be twice that of the cutbacks. If the emulsified asphalts in use contain any VOC or HAP diluents, they may be worth including in the inventory.

Recycled Asphalt Pavement

Emissions from the use of recycled asphalt pavement (RAP) are expected to be no higher than from hot-mix use. Heat is used to soften the asphalt coating the aggregate, thus no additional source of VOCs or HAPs is introduced.[6]

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[5] Telephone conversation between R. Ryan of the U.S. Environmental Protection Agency and L. Adams, Eastern Research Group, Inc., February 1997.

[6] Telephone conversation between R. Benson of the Asphalt Institute and S. K. Buchanan, Eastern Research Group, Inc., September 1997.

2.3 FACTORS INFLUENCING EMISSIONS

2.3.1 PROCESS OPERATING FACTORS

Emissions from asphalt paving depend on the type of asphalt used (hot-mix, cutback, or emulsified). Emissions are also a function of the VOC/HAP content. Because emissions result from diluent evaporation, factors such as temperature will affect the rate of evaporation. Hot-mix asphalt results in the lowest emissions per ton used, followed by emulsified asphalts. Cutback asphalts result in the highest emissions.

2.3.2 CONTROL TECHNIQUES

The primary control option for emissions from asphalt paving is to reduce the amount of any VOC/HAP-containing diluent in the asphalt. However, in some situations, asphalt with a lower diluent content may not meet the performance requirements of the paving job and a higher emitting asphalt must be used. Some reductions are also realized where the slower cure asphalts are used. An estimated 95 percent of the diluent in rapid cure cutback asphalt evaporates, whereas only 25 percent of diluent evaporates from the slow cure cutback asphalts (EPA, 1996). States have also either prohibited the use of diluent-containing asphalts or established seasonal schedules for the higher VOC asphalt cements such that these are not used during the peak ozone formation season.

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3

OVERVIEW OF AVAILABLE METHODS

3.1 ESTIMATION METHODS

Two methods are available for estimating emissions from asphalt paving operations:

- Estimates based on surveys of the state and local Departments of Transportation (DOTs) and paving companies; and
- Estimates using emission factors.

Selection of the appropriate estimation method depends on the relative significance of emissions from this source in the inventory area and the data quality objectives (DQOs) of the inventory plan. Refer to EIIP Volume VI, *Quality Assurance Procedures,* Sections 2.1 and 2.4 for discussions of inventory categories and DQOs.

Before selecting an estimation method, the inventory preparer should research state and local rules for asphalt paving operations in the inventory area. Many state and local air agencies limit or ban the use of cutback asphalts, particularly during the ozone season. If this is the case for the area to be inventoried and the timeframe of interest for the inventory is the ozone season, then the priorities for inventorying asphalt paving operations will change and the estimation method chosen may differ.

3.2 AVAILABLE METHODOLOGIES

Methods for estimating emissions for this source category differ primarily in the amount of data to be collected and the manner in which the data are collected. Surveys are used in the preferred method and the first and second alternative methods. Collecting more locally-specific information will provide more accurate estimates. Surveys are a more intensive data collection effort than gathering activity data to use with emission factors. With surveys, information on the specific HAPs can be requested and the speciated emissions calculated from the outset. Emission factors are only available for VOC estimates; therefore, speciation can be done only after the VOC emissions are estimated using diluent composition information.

3.2.1 VOLATILE ORGANIC COMPOUNDS

VOC emissions depend on the amount of VOCs in the diluent used in asphalt (term used generically to include cutback and emulsified asphalts). For the purposes of the chapter, diluents are assumed to contain 100 percent VOCs. Thus, the amount of each asphalt type and the diluent content must also be determined. Regardless of the estimation method used, assumptions about the amount of VOC that evaporates must be made. Approximations for the amount of diluent that evaporates from cutback asphalt are provided in *AP-42*:

- Rapid cure: 95 percent by weight of the diluent evaporates;
- Medium cure: 70 percent by weight of the diluent evaporates; and
- Slow cure: 25 percent by weight of the diluent evaporates.

Note that evaporation to these levels occurs over a period of about four months. Evaporation curves are provided in *AP-42*. About 75 percent by weight of diluent evaporates in the first day following application of rapid cure cutback asphalts, whereas, it takes about one week for 50 percent by weight of the diluent to evaporate from medium cure cutback asphalts.

Such estimates of evaporation are not available for emulsified asphalts. In the absence of this information, the inventory preparer may elect to apply the estimates for the cutback asphalt evaporation rates or may conservatively assume all the diluent evaporates.

A majority of asphalt paving work is done by the state and local DOTs, either by their own staff or by contractors. Thus information on practices is generally centralized and should be available to the state agency preparing the inventory. In addition, private companies may also pave such surfaces as private roads and parking lots with asphalt materials. They may also pave under contract to other governmental agencies like the military, the Bureau of Land Management, forest service, or entities such as tribal governments. Information on this asphalt use is more difficult to collect. Before undertaking a data gathering effort for these private paving operations, the inventory preparer should assess the potential for these private activities to be a significant emission source. One way would be to determine how much construction and private road maintenance and repair is occurring in the inventory area, perhaps through the cognizant construction permitting agency or a trade association for developers. Another way to assess activity might be to contact a few private paving companies to develop an understanding of how their asphalt uses compare to those by the DOTs. If the activity level is low, the inventory preparer may opt to exclude the private paving operations from the inventory. Because the emissions contribution from private paving operations is often much less than from DOT paving activities, methods to estimate emissions from private paving operations have not been

specifically addressed. These methods would be the same as for paving activities done for or by the state and local DOTs.

For emissions from asphalt paving, the ranking of the estimation methods is as follows:

1. **Preferred Method:** Comprehensive survey of all state and local DOTs for data on asphalts;

2. **Alternative Method 1:** Survey representative state and local DOTs, shorten the survey by making assumptions about asphalt specific gravity, use *AP-42* cutback asphalt emission factors;

3. **Alternative Method 2:** Survey representative state and local DOTs, shorten the survey further by making assumptions about asphalt specific gravity and collecting usage data from other resources (e.g., trade associations), use *AP-42* cutback asphalt emission factors; and

4. **Alternative Method 3:** A per capita or usage emission factor from EPA guidance for preparing carbon monoxide and ozone inventories (EPA, 1991), collect activity data (census data or usage data from trade associations or DOTs).

With the exception of Alternative Method 3, all require assumptions about evaporation of the diluent. As mentioned earlier, *AP-42* is one source for information.

The Preferred Method results in the most accurate estimate because data are collected on actual paving practices. Alternative Method 1 is less accurate as it relies on EPA emission factors rather than actual data. The estimate is improved by the use of activity data that are specific to the inventory area. Alternative Method 2 is less accurate than the Preferred Method and Alternative Method 1 because the usage data are not specific to the inventory area. Published state data needs to be allocated to the local inventory level. Alternative Method 3 is the least accurate, even though local per capita or usage data would be used. The emission factors are based on the assumption that the diluent content is 35 percent solvent (special petroleum naphthas), which is the midpoint of the range of contents according to *AP-42*, and that five percent of diluent remains in the pavement, which is the evaporation rate for rapid cure cutback asphalts. Thus, the resulting emissions may be overestimated.

To date, emission factors have not been developed by industry. However, if these are available at the time the inventory is prepared, the inventory preparer should determine if these would be an improvement over the EPA emission factors before using them. To assess this, the methods used by industry and for *AP-42* for deriving the emission factors need to be compared and a

determination made of which is more accurate, based on a technical evaluation. Also, how well the underlying data represent paving practices in the inventory area should be considered.

3.2.2 HAZARDOUS AIR POLLUTANTS

Surveys can be used to collect HAP data from state and local DOTs. In general, this will involve requesting material safety data sheets (MSDSs) or manufacturer technical data sheets (TDSs) for each of the asphalt types the state and local DOTs apply to identify diluent composition. Resulting estimates are HAP-specific. Emission factors for HAPs are not available; therefore, the inventory preparer must again rely on MSDSs and TDSs. The VOC emission estimates can then be adjusted to determine speciated emissions. Although local data on the HAP content of diluents used in the inventory area are preferred, a secondary source for speciation information may be other state agencies.

3.3 DATA NEEDS

3.3.1 DATA ELEMENTS

The data elements used to calculate emission estimates for this category will depend on the methodology used for data collection. The data elements necessary for an emission calculation that should be requested in a comprehensive survey of state and local DOTs, the preferred method, include:

- types of cutback asphalts (rapid, medium, slow cure);
- types of emulsified asphalts (rapid, medium, slow set);
- amount of each asphalt type used for the inventory year, before aggregate is added;
- diluent content of each type;
- HAP content by weight for each diluent (*for HAP inventories only*); and
- seasonal practices for each asphalt type (*for ozone inventories*).

Also needed for the estimation are the specific gravities (density) of the diluted asphalt and the diluents, where VOC and HAP contents are reported in percents by volume. Default values for the density of cutback asphalt diluents are provided in *AP-42* (0.7kg/L for rapid cure, 0.8kg/L for medium cure, and 0.9kg/L for slow cure). According to the Asphalt Institute, emulsified asphalt

densities are similar to that of water (1.0 kg/L; the *AP-42* default is 1.1 kg/L). Emulsified asphalts with diluents have densities somewhat higher or lower than that of water, depending on the types and amounts of solvents.[1] Solvent densities are available from MSDSs and other standard chemistry references.

Fewer elements are needed if emission factors are to be used. It is still preferable to collect the data from the state and local DOTs, but some may be available from other sources. For example, local paving companies may be able to supply the typical diluent contents and trade associations may be able to provide data on state usage that can be apportioned to the local inventory area. Additionally, an estimate based on surveying representative DOTs may be sufficiently accurate for inventory purposes.

3.3.2 APPLICATION OF CONTROLS

The most effective way to control emissions from asphalt paving is to reduce the VOC and HAP contents in the asphalts. Because the asphalt types have different characteristics and meet specific paving needs, use of the low VOC/HAP asphalts is not always feasible. As the data collected will represent the actual VOC and HAP contents for asphalts in use, no additional adjustment for controls will be needed.

Another control strategy to reduce ozone formation is to prohibit or limit the use of the VOC-containing asphalts during the ozone season, as some states have done. Any adjustments to incorporate state regulatory requirements will need to be made as a part of the temporal allocation of emissions.

3.3.3 SPATIAL ALLOCATION

Spatial allocation is used in two cases in the preparation of an area source inventory: (1) to allocate emissions or activity to the county level, and (2) to allocate county-level emission estimates or activity to a modeling grid cell. For all but one method, the resulting estimate will be at the county level because county level data are used in the estimate. To allocate emissions or activity from the state level to the county level for Alternative Method 2, a number of parameters may be used to determine county level activity. These include highway spending data published by the Federal Highway Administration, population data published by the U.S. Census Bureau, data on miles paved or lane miles from the state DOT, and data on vehicle miles traveled (VMT) from the mobile source emissions group at the agency.

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[1] Telephone conversation between R. Benson of the Asphalt Institute and S. K. Buchanan, Eastern Research Group, Inc., September 1997.

Allocation of the emission estimates or activity to a modeling grid can be done using one of four potential spatial surrogates, shown below in order of preference:

1. Detailed information about the miles of highway paved or the vehicle miles traveled (VMT) within each grid cell, or a group of grid cells. This will typically be done by the inventory personnel involved in estimating mobile source emissions.

2. Highway spending data.

3. Lane miles.

4. Population data.

3.3.4 TEMPORAL RESOLUTION

Because asphalt paving activities depend somewhat on the weather, the level of activity over the course of the year will vary from state to state. State and local regulations may also limit activities during the ozone season. For the best information to temporally allocate emissions, the inventory preparer should talk with the state DOT to establish any seasonal patterns. Daily allocation of emissions for asphalt paving operations differ from other source categories in that emissions occur over a period of time after the paving is done (EPA, 1996). Therefore, a seven day week should be used to allocate daily emissions from this source category. However, if the number of days worked per week are being used to estimate the relative amount of asphalt used during a time period, then information about actual work schedules will need to be collected. Application of asphalt paving materials will generally occur 5 days per week during typical business hours; however, some large projects and maintenance operations may involve overtime. Activity is dependant of the weather; more activity will take place during warmer and dryer months. Refer to Chapter 1 of this volume for more information about temporal resolution. Example 17.3-1 shows a typical calculation of daily emissions during the ozone season from annual emissions.

Example 17.3.1

Cutback asphalt use in County A is banned by state regulation. Weather conditions limit the use of emulsified asphalt to the warmer months, from May through September, which is about 21 weeks. Paving work is done 5 days a week during the months of May and September (8 weeks) and 6 days a week from June through August (13 weeks). Asphalt use is expected to be proportionate to the number of days worked. Evaporation of the asphalt diluents are assumed to take place over a period of time after paving. Emissions are expected to occur over 7 days a week.

Because cutback asphalt use is banned, emissions for cutback asphalt are not included in County A's ozone season inventory. Daily emissions from emulsified asphalt paving are calculated from annual emissions by following these steps:

1) Calculate the ozone season emissions from the proportion of days worked:

Number of Days Asphalt is Applied = (8 weeks * 5 days/week) + (13 weeks * 6 days/week)

= 40 + 78

= 118 days asphalt is applied

Activity Percentage During Ozone Season = (78 days/118 days) * 100

= 66%

Ozone Season Emissions = Annual Emissions * 66%

2) Calculate daily emissions from ozone season emissions:

Daily Emissions = Ozone Season Emissions/(7 days/week) (13 weeks/year)

3.3.5 PROJECTING EMISSIONS

A discussion about developing growth factors and projecting emission estimates can be found in Section 4 of Chapter 1 of this volume, Introduction to Area Source Emission Inventory Development. Projecting emissions for this source category will require that two variables be taken into account, the change in paving activity and any change in emission controls. Paving activity may be projected using the same factors used to project changes in local lane miles, VMT, or highway spending.

The EIIP Projections Committee has developed a series of guidance documents containing information on options for forecasting future emissions. You can refer to these documents at http://www.epa.gov/ttn/chief/eiip/project.htm.

4

PREFERRED METHOD FOR ESTIMATING EMISSIONS

The preferred method for estimating emissions from asphalt paving is to conduct a comprehensive survey of asphalt use by state and local departments of transportation (DOTs). These highway and road maintenance departments are responsible for much of the total asphalt paving activity. Furthermore, records should be accessible and information should be sufficiently detailed to calculate VOC and HAP emissions. This section provides an outline for preparing and using an asphalt paving survey and calculating emission estimates from the information collected.

Use of the survey method depends on DOTs keeping records of asphalt usage. If DOTs do not keep these records, this method is not practical. Also, a survey of DOTs will not include private asphalt paving activities done by private contractors unless the contractors are also surveyed. However, it is unlikely that a survey of contractors would be as reliable as that of DOTs for a number of reasons. First, the response rate will likely be lower; second, they may not keep as complete or as detailed records; and third, a contractor will do work over county or state boundaries and may not be able to estimate asphalt use for just the inventory area.

Another drawback to this method is that a well-planned, well-implemented survey requires more resources than other methods. Inventory preparers must judge whether the costs of this approach are outweighed by the benefit of having an estimate that is more accurate and specific to the inventory area and time period. Costs and labor efforts are highest the first time that a regional or local survey is performed. Subsequent updates to the survey may be done using fewer surveys at a much lower cost. In the years following the baseline survey, updates on asphalt usage may be all that are needed. Periodically, information on changes in the percentages of different types of asphalt used and the VOC/HAP content will be needed to accurately estimate emissions.

Surveys for area sources are specifically discussed in Volume I of the Emission Inventory Improvement Program (EIIP) series and in Chapter 1 of this volume. A survey of state and county DOTs will consist of: (1) survey planning, (2) survey preparation, (3) survey distribution, (4) survey compilation and scaling, and (5) emission estimation. Discussion of these steps follows.

4.1 SURVEY PLANNING

During the planning phase, the following issues should be addressed:

- Survey data quality objectives (DQOs) should be identified, and procedures for realistically reaching these objectives specified.

- The survey recipients and data needs must be identified.

    - For counties where paving responsibilities are shared to a significant degree by others (e.g., private developers, military installations, state or National Parks), the survey may need to be sent to others besides local DOTs.
    - Where private contractors are used by DOTs, the DOTs may not maintain all the records. Inventory preparers should consider having the DOTs take responsibility for having their contractors complete the survey. However, in the interest of time or due to resource constraints, the inventory preparer may need to survey contractors directly.
    - The use of diluents in emulsified asphalts should be preliminarily assessed. If this is rare or only limited to certain counties or times of the year, then the survey may be able to be shortened.
    - Where the characteristics of the types of asphalts used (i.e., percent diluent and types of solvents) are similar across the state or for a region within the state, a representative profile can be developed and applied to the others. This would greatly reduce the survey effort.
    - The assumptions for diluent evaporation and asphalt densities should be determined.
    - Paving projects may cross county boundaries, thus usage data must be allocated to each county. Alternatively, the inventory area may include only parts of some counties, thus only some of its paving activities need be included. The basis for apportioning these activities is best determined by the cognizant county agencies; however, some surrogates like the ratio of miles paved or population may suffice. A choice of surrogate should be made before the survey design is complete so that the data can be collected.

- Data handling needs specific to this survey must be identified.

- Survey QA/QC methods must be delineated and implemented.

The survey package should include a cover letter explaining the program, the survey form, a list of definitions and a postage-paid return envelope. Both state and local DOTs may need to be surveyed to collect necessary information.

4.2 SURVEY PREPARATION

A survey may be either comprehensive or collect the minimum amount needed to estimate emissions. The more detailed survey necessary for the preferred method would request:

- the types of cutback asphalts used (rapid, medium and slow cure);
- the types of emulsified asphalts used (rapid, medium and slow set);
- the amounts of each type of asphalt used in the inventory year;
- the diluent content of each type of asphalt; and
- seasonal usage patterns *(for an ozone inventory).*

Additional elements to consider requesting include:

- HAP content for each diluent *(for HAP inventories only)*;
- specific gravities for each asphalt type *(only if diluent or HAP contents are in percents by volume)*; and
- Factors to use for spatial or temporal allocation.

For a HAP inventory, the diluent composition would also be needed (types and percents of each solvent) to determine the HAP content of the diluents. This may be available from material safety data sheets (MSDSs) and manufacturer technical data sheets (TDSs) so the survey respondent should send the relevant MSDSs and TDSs.

Where volume percents are provided, the inventory preparer will also need specific gravities for the diluents or HAPs. These can be determined from standard chemistry references.

Survey preparers should clearly define the time period for which the survey information is being collected. A request for annual data, for instance, should specify the range of months to avoid confusion between fiscal and calendar years. It is preferable to collect data specific to the inventory period, but for periods less than 12 months, usage will probably have to be apportioned by the inventory preparer.

If the survey results need to be adjusted to a different spatial scale for future inventories, factors that may be used to adjust the survey information may also be collected. For example, the miles paved within the county for which the department is responsible could be requested from that

department. Alternatively, VMT as a surrogate may be available from mobile emissions inventory preparers.

The advantages of the more detailed approach are that the inventory developed is specific to the locality, and the information collected can be more readily projected to inventories for subsequent years.

Instructions for using the example survey form are provided on the survey cover page, shown in Figure 17.4-1. Example data request forms are presented in Figures 17.4-2 and 17.4-3. For HAP inventories, MSDSs for each asphalt type should be requested. The HAP weight-percent information on the MSDSs is then used to determine HAP-specific emissions. An alternative survey-based method for a HAP inventory would use a representative sample of the HAP contents for each asphalt type, applied to a more complete VOC inventory of asphalt types and usages.

4.3 SURVEY DISTRIBUTION

The preferred method requires the inventory preparer to contact every DOT in the inventory area. Surveys are best distributed by mail, with an initial call to ensure receipt and to answer any questions, and a follow-up call when the inventory preparer has any questions. Survey distribution issues are discussed in Chapter 1 of this volume.

4.4 SURVEY COMPILATION AND SCALING

Survey compilation and scaling issues are discussed in Volume I of this series. Completed surveys will result in information for many asphalt types and, in the case of HAP inventories, multiple pollutants, so accurate and efficient data compilation will require planning for data transfer and data management.

QC checks should be performed during this phase of the work (see Volume VI for QA/QC methods). Incoming surveys should be checked for errors such as potential unit conversion errors or omissions. Survey information should be checked for reasonableness. Survey recipients may need to be contacted to clarify responses or to correct any errors. Once compiled, survey information should also be subject to similar checks to ensure complete and accurate data entry, prior to analysis. Preliminary sorting of the data by county to compare responses can be used to identify outliers.

Depending on who responds to the survey, results may need to be either scaled up to account for all counties in the inventory area, or scaled down to the inventory area where some counties need only be partially included. In either case, a scaling factor should have been identified in the

Department of Transportation for: _____ county

Street Address: _____

City: _____

Contact Person/Phone Number: _____

The purpose of this survey is to collect information about the amounts and types of asphalts used for paving so that estimates of air pollution from paving operations can be made. Please enter the following information on the attached forms.

1. List the asphalt types used in calendar year____. Note that Table 17.4-1 is for cutback asphalt; Table 17.4-2 is for emulsified asphalts. Information about hot-mix asphalt is not needed.

2. Provide the cure or set rate for each asphalt type (include units of measure).

3.* Provide the amount, in tons, of each asphalt type used.

4.* Provide the specific gravity for each asphalt type.

5.* Provide the volume percent of diluents in each asphalt type.

6. List the months during the year that each asphalt type is used *(for ozone inventories)*.

7. Attach copies of the material safety data sheets and manufacturer technical data sheets for all of the asphalt types listed *(for HAP inventories)*.

* For the asphalt mixed with aggregate (less the aggregate) and is not "as applied" during actual paving operations.

FIGURE 17.4-1. SURVEY REQUEST FORM FOR ASPHALT CEMENT USE - INSTRUCTIONS

1 Identification # or Name	2 Cure Rate[a]	3 Amount Used, Tons	4 Specific Gravity	5 Diluent Content, Volume %	6 Amount Used in Each Calendar Month

[a] Rapid, medium, slow

FIGURE 17.4-2. CUTBACK ASPHALT DATA REQUEST FORM

1 Identification # or Name	2 Set Rate[a]	3 Amount Used, Tons	4 Specific Gravity	5 Diluent Content, Volume %	6 Amount Used in Each Calendar Month

[a] Rapid, medium, slow

FIGURE 17.4-3. EMULSIFIED ASPHALT DATA REQUEST FORM

planning phase, and any necessary requests for information from the survey respondents included on the survey form. Refer to Sections 3.3.3 Spatial Allocation and 3.3.4 Temporal Resolution for more information about allocation and scaling factors for this source category.

4.5 EMISSION ESTIMATION

4.5.1 VOLATILE ORGANIC COMPOUNDS

Emission estimate calculations involve determining emissions of the pollutant(s) of interest, then the application of any necessary spatial or temporal adjustments. Because asphalt paving is defined as an area source, there should be no need to subtract the contribution from point sources from the total. Emission estimate calculations from the information collected by survey require the following steps. The diluent content may be assumed to be 100 percent VOCs.

When the weight of cutback (or emulsified) asphalt used and the volume percent of diluent are provided:

$$\text{Volume of Cutback Used} = \text{Weight of Cutback Used} \div \text{Density of Cutback} \quad (17.4\text{-}1)$$

$$\text{Volume of Diluent Used} = \text{Volume of Cutback Used} * \text{Volume \% Diluent in the Cutback} \quad (17.4\text{-}2)$$

$$\text{Weight of Diluent Used} = \text{Volume of Diluent Used} * \text{Density of Diluent} \quad (17.4\text{-}3)$$

$$\text{Mass Emissions} = \text{Weight of Diluent Used} * \text{Weight \% of Diluent Evaporated} \quad (17.4\text{-}4)$$

If the weight percent of diluent is provided, Equation 17.4-5 is used instead of Equations 17.4-1, 17.4-2, and 17.4-3 to determine the weight of diluent used. Equation 17.4-4 is still used as the last step to calculate mass emissions.

$$\text{Weight of Diluent Used} = \text{Weight of Cutback Used} * \text{Weight \% of Diluent in the Cutback} \quad (17.4\text{-}5)$$

Diluent evaporation rates depend on the type of asphalt used and were discussed earlier. The best information to use is product-specific; however, this kind of information is not expected to be available. In the absence of product-specific data, *AP-42* provides some guidance for cutback asphalts. Note that the diluent densities assumed may differ from those in the inventory area and this will be a source of error.

- Rapid cure cutback asphalts: 95% by weight of diluent evaporates;
- Medium cure cutback asphalts: 75% by weight of diluent evaporates; and
- Slow cure cutback asphalts: 25% by weight of diluent evaporates.

For emulsified asphalts, a conservative estimate can be derived by assuming all the diluent evaporates. Alternatively, values similar to those from *AP-42* for the cutback asphalts might be used.

To convert specific gravity to density for use in Equations 17.4-1 and 17.4-3:

$$\text{Density (lb/gal)} = \text{Specific Gravity} * \frac{8.34 \text{ lb}}{\text{gal}} \quad (17.4\text{-}6)$$

or

$$\text{Density (kg/L)} = \text{Specific Gravity} * \frac{1 \text{ kg}}{\text{liter}} \quad (17.4\text{-}7)$$

4.5.2 HAZARDOUS AIR POLLUTANTS

To determine HAP emissions, first estimate the VOC emissions from Equations 17.4-1 through 17.4-4, then multiply by the ratio of the HAP of interest to the total VOC emitted (the weight fraction).

$$\text{Mass Emissions for Each HAP} = \text{VOC Mass Emissions} * \text{Weight Fraction of Each HAP} \quad (17.4\text{-}8)$$

Where:

$$\text{Weight Fraction of Each HAP} = \frac{\text{Weight of Each HAP}}{\text{Weight of VOC Emitted}} \quad (17.4\text{-}9)$$

Example 17.4-1 illustrates how both VOC and HAP emissions are estimated.

Example 17.4-1

Data provided by one county for use in this example are summarized in the table:

Asphalt Type	Amount Used (tons)	Density (lb/gal)	Diluent Content (vol%)
Medium cure cutback asphalt	250	7.8	28
Rapid set emulsified asphalt	190	8.5	7

The MSDSs state the diluent in the medium cure cutback asphalt was naphtha and the diluent in the rapid set emulsified asphalt was xylene. Additional data used in the calculations are:

- density of naphtha = 7.5 lb/gal
- density of xylene = 7.2 lb/gal
- evaporation of diluent from the medium cure cutback asphalt = 75% by weight (from *AP-42*)
- evaporation of diluent from the rapid set emulsified asphalt = 95% by weight (assumed same as for rapid cure cutback asphalt, in *AP-42*)

Example 17.4-1 (Continued)

Combining Equations 17.4-1 through 17.4-4, emissions from the medium cure cutback asphalt use:

$$= \frac{\text{Weight of Cutback Used}}{\text{Density of Cutback}} * \text{Vol \% Diluent in Cutback} * \text{Density of Diluent} * \text{Weight \% Diluent Evaporated} * \text{Unit Conversion}$$

$$= \frac{250 \text{ tons}}{7.8 \text{ lbs/gal}} * 0.28 * \frac{7.5 \text{ lbs}}{\text{gal}} * 0.75 * \frac{2{,}000 \text{ lbs}}{\text{ton}}$$

$$= 100{,}961 \text{ lbs naphtha}$$

Similarly, emissions from the rapid set emulsified asphalt use:

$$= \frac{\text{Weight of Emulsified Used}}{\text{Density of Emulsified}} * \text{Vol \% Diluent in Emulsified} * \text{Density of Diluent} * \text{Weight \% Diluent Evaporated} * \text{Unit Conversion}$$

$$= \frac{190 \text{ tons}}{8.5 \text{ lbs/gal}} * 0.07 * \frac{7.2 \text{ lbs}}{\text{gal}} * 0.95 * \frac{2{,}000 \text{ lbs}}{\text{ton}}$$

$$= 21{,}405 \text{ lbs xylene}$$

Total VOC emissions are the sum of the emissions for each type of asphalt used:

$$\text{Total VOC Emissions for the One County} = 100{,}961 \text{ lbs naphtha} + 21{,}405 \text{ lbs xylene}$$

$$= 122{,}366 \text{ lbs}$$

Total HAP emissions in this example are the same as total VOC emissions, 122,366 pounds. Speciated HAP emissions are calculated as the sum of each HAP emitted from each type of asphalt used. As each asphalt type contained a single, different HAP, the speciated HAP emissions from each asphalt type are the same as the VOC calculated for each asphalt type, 100,961 lbs naphtha and 21,405 lbs xylene.

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5

ALTERNATIVE METHODS FOR ESTIMATING EMISSIONS

This section provides alternatives to the comprehensive survey approach that is the preferred method. Alternative Methods 1 and 2 require some information collection from state and local DOTs, but some of the information needed is collected from other sources. Alternative Method 3 requires the least amount of data collection, however, the resultant emission estimate is the least accurate.

5.1 VOLATILE ORGANIC COMPOUNDS

5.1.1 ALTERNATIVE METHOD 1: LIMITED SURVEY OF SELECTED DOTS

Alternative Method 1 is a simplified version of the preferred method. Instead of sending surveys to all DOTs, a representative set are selected for surveying. Additionally, assumptions about specific gravities are made by the inventory preparer which reduces the information requested in the survey. The example survey form shown in Figure 17.5-1 differs from Figures 17.4-1 and 17.4-2 only in that specific gravity is no longer requested. For cutback asphalts, densities are assumed to be the same as those used in developing the *AP-42* emission factors in Table 17.5-1, thus *AP-42* emission factors can be used to estimate emissions. For emulsified asphalts, the density is assumed to be the same as that of water.[1]

Once the data have been compiled, estimates of use by the rest of the counties must be calculated. To do this, the inventory preparer will apply a ratio of activities for the counties, determined during the survey planning phase. Some possible ratios are miles of highway (state transportation data), VMT (mobile emission inventory preparers), government highway spending (U.S. Office of Highway Information Management), and population (U.S. census data).

[1] Telephone conversation between R. Benson of the Asphalt Institute and S. K. Buchanan, Eastern Research Group, Inc., September 1997.

1 Asphalt Type[a,b]	2 Cure or Set Rate[c]	3 Amount Used, Tons	5 Diluent Content, Volume %	6 Months of the Year Used

[a] Numbers in each column match the instructions provided in Section 4.4. Item 4, Specific Gravity, is not needed for this alternative.

[b] Cutback Asphalt = CA
Emulsified Asphalt = EA

[c] Rapid , medium , slow

FIGURE 17.5-1. SIMPLIFIED DATA REQUEST FORM[a]

Cutback Asphalt

To estimate emissions from cutback asphalt paving, the data collected on the cure type and diluent content are used to determine the weight percent of cutback asphalt evaporated from Table 17.5-1.

TABLE 17.5-1

EVAPORATIVE VOC EMISSIONS FROM CUTBACK ASPHALTS AS A FUNCTION OF DILUENT CONTENT AND CUTBACK ASPHALT TYPE[a]

Type of Cutback[b]	Percent, by Volume, of Diluent In Cutback[c]		
	25%	35%	45%
Rapid cure (RC)	17	24	32
Medium cure (MC)	14	20	26
Slow cure (SC)	5	8	10

[a] These numbers represent the percent, by weight, of cutback asphalt evaporated. *AP-42* Emission Factor Rating: C

[b] Typical densities assumed for diluents used in RC, MC, and SC cutback asphalts are 0.7, 0.8, and 0.9 kg/liter, respectively.

[c] Diluent contents typically range between 25 - 45%, by volume. Emissions may be linearly interpolated for any given type of cutback asphalt between these values.

The weight percent is then multiplied by the weight of cutback asphalt used, also determined from the surveys, to estimate emissions.

$$\text{Mass Emissions} = \text{Weight of Cutback Used} * \text{Weight \% of Cutback that Evaporates} \quad (17.5\text{-}1)$$

Emulsified Asphalt

As discussed earlier, data on diluent evaporation are not available for emulsified asphalt. As a conservative estimate, the inventory preparer can choose to assume all the diluent evaporates. Alternatively, some adjustment can be made based on the set rate; data in *AP-42* suggests that the slower the cure, the lower the evaporative emissions. The *AP-42* emission factors in

Table 17.5-1 do not apply, thus emissions must be calculated using Equations 17.4-1 through 17.4-4 in Section 4.5.

Combining these equations, emissions from emulsified asphalts are calculated as:

$$\text{Mass Emissions} = \text{Weight of Emulsified Asphalt Used} \div \text{Density of Emulsified Asphalt} * \text{Volume \% of Diluent in the Emulsified Asphalt} * \text{Density of Diluent} * \text{Weight \% of Diluent Evaporated} \quad (17.5\text{-}2)$$

The equation is further simplified by assuming that emulsified asphalt is the same density as water, regardless of the diluent content.[2] The density parameters cancel and emissions are calculated as:

$$\text{Mass Emissions} = \text{Weight of Emulsified Asphalt Used} * \text{Volume \% of Diluent in the Emulsified Asphalt} * \text{Weight \% of Diluent Evaporated} \quad (17.5\text{-}3)$$

When all the diluent is assumed to evaporate, the value in Equation 17.5-3 for percent diluent that evaporates is 100. When less than complete evaporation is assumed, the value of the percent diluent represents the adjustment.

An example is provided to illustrate use of Alternative Method 1.

Example 17.5-1:

Data provided by one county for use in this example are summarized in the table:

Asphalt Type	Amount Used (tons)	Diluent Content (vol%)
Medium cure cutback asphalt	250	28
Rapid set emulsified asphalt	50	7

[2] Telephone conversation between R. Benson of the Asphalt Institute and S. K. Buchanan, Eastern Research Group, Inc., September 1997.

Example 17.5-1 (Continued)

Interpolating from Table 17.5-2, about 16 percent of the weight of the cutback asphalt would evaporate from a medium cure cutback asphalt with 28 percent by volume of diluent.

$$\text{Mass Emissions, Cutback Asphalt} = 250 \text{ tons} * \frac{2{,}000 \text{ lbs}}{\text{ton}} * 0.16$$

$$= 80{,}000 \text{ lbs}$$

To determine emissions from the use of emulsified asphalt, densities for the diluent and the emulsified asphalt are needed. Assuming the density for emulsified asphalt including diluent is the same as for water, 8.34 lbs/gal, and assuming 100% of the diluent evaporates:

$$\text{Mass Emissions, Emulsified Asphalt} = 50 \text{ tons} * \frac{2{,}000 \text{ lbs}}{\text{tons}} * 7\% * 100\%$$

$$= 7{,}000 \text{ lbs}$$

Total VOC emissions are the sum of the emissions for each type of asphalt used:

$$\text{Total VOC Emissions for the One County} = 80{,}000 \text{ lbs} + 7{,}000 \text{ lbs}$$

$$= 87{,}000 \text{ lbs}$$

5.1.2 ALTERNATIVE METHOD 2: STATE USAGE DATA, MINIMUM DATA COLLECTION FROM DOTS

Alternative Method 2 involves the use of state asphalt usage data from other sources like the Asphalt Institute, rather than requesting this from DOTs, as is done with the preferred method

and Alternative Method 1.[3] First the state level data must be apportioned to the county level. As discussed earlier, the basis for this should be determined in the planning phase. Like extrapolating representative county data to counties for which data have not been collected as done in Alternative Method 1, some options to use as a basis for this allocation include miles of highway, VMT, government highway spending budgets, and population.

State usage data from the Asphalt Institute may not distinguish between the cutback and emulsified asphalt types. The information needed to proportion the total into emulsified and cutback categories can be collected from state and local DOTs. As with Alternative Method 1, a representative group of DOTs should be identified, then information on practices and usage can be collected by telephone. The goal is to (1) determine the percents of each asphalt type that are used, (2) their typical diluent contents, and (3) when the types are used (for ozone inventories). An example telephone survey is shown in Figure 17.5-2.

Once the usage by county has been assigned and the data on asphalt types are available, the equations under Alternative Method 1 can be used to estimate emissions (Equations 17.5-1 and 17.5-3).

5.1.3 ALTERNATIVE METHOD 3: VOLUME USAGE EMISSION FACTORS

The least preferred alternative, Alternative Method 3, is to use volume-based emission factors applied to total asphalt usage data (Table 17.5-2).

These emission factors were prepared for EPA's 1991 guidance for preparing CO and ozone inventories (EPA, 1991) and are discussed in that document. Data on asphalt use must be requested from county DOTs, or state usage data from sources like the Asphalt Institute can be apportioned to the county level as described for Alternative Method 2.

Per capita factors based on national average asphalt use are **not** recommended for this source category, because population is not a reliable indicator of local activity when scaling down from a national level, and usage can vary from year to year, making a factor developed from one year's data inappropriate for another year. A per capita factor developed from state specific data may be an inexpensive way to estimate emissions when the source category is not a high priority.

[3] The Asphalt Institute can be contacted by telephone: (606) 288-4960, or through their internet web page: http://www.asphaltinstitute.org.

Asphalt Type	Cure/Set Rate	Estimated % of Total Usage	Approximate Diluent Content	Months of the Year Used[a]
Cutback Asphalt	rapid			
	rapid			
	medium			
	medium			
	slow			
	slow			
Emulsified Asphalt	rapid			
	rapid			
	medium			
	medium			
	slow			
	slow			

[a] Only needed for ozone inventories.

FIGURE 17.5-2. EXAMPLE TELEPHONE SURVEY FORM

TABLE 17.5-2

ASPHALT PAVING EMISSION FACTORS

Asphalt Type	Volume-based[a] (lb VOC/Barrel Asphalt)
Cutback asphalt	88
Emulsified asphalt	9.2

[a] 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.

Asphalt Paving

The EIIP Asphalt Paving chapter was compared to the NTI source category, Asphalt Paving: Cutback Asphalt. The EIIP chapter states that no generic emission factors for HAPs were available. We can supplement the EIIP asphalt paving chapter by using the speciation profiles used in the NTI for cutback asphalt. The speciation profile used in the NTI is shown in Table 17.5-3.

TABLE 17.5-3

HAP SPECIATION PROFILES FOR ASPHALT PAVING: CUTBACK ASPHALT

HAP	Percent Weight of VOC
Ethylbenzene	2.3
Toluene	6.4
Xylene (mixed isomers)	12.2

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

$$\text{Mass Emissions} = \begin{matrix}\text{Volume Usage} \\ \text{Emission Factor}\end{matrix} * \begin{matrix}\text{Volume Used} \\ \text{(Barrels of Asphalt)}\end{matrix} \qquad (17.5\text{-}4)$$

5.2 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 (MSDSs) 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). Alternatively, 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. Again, this information is applied to the VOC estimate to determine the speciated HAP emissions.

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6

QUALITY ASSURANCE/QUALITY CONTROL

Data collection and data handling for all estimation methods for this source category should be planned and documented in the Quality Assurance Plan. Quality assurance (QA) and quality control (QC) methods may vary based on the data quality objectives for the inventory.

When using survey based estimation methods, the QA Plan should address the survey method and sample design, in addition to data collection, and data handling steps. Refer to the discussion of survey planning and survey QA/QC in Chapter 1, *Introduction to Area Source Emission Inventory Development*, of this volume, and Volume VI, *Quality Assurance Procedures*, of the Emission Inventory Improvement Program (EIIP) series. When using other methods, data collection, data handling, apportioning of activity data to the inventory area and by asphalt type (for the second alternative method) should be laid out in the QA Plan.

6.1 EMISSION ESTIMATE QUALITY INDICATORS

The highest quality results will come from collecting the most detailed, locality- and time-specific data possible. The preferred approach, if there is good survey coverage, should yield such high quality data. When there are too many asphalt users in the inventory area to survey completely, or when not all of the survey forms are returned, the first alternative method can still provide information about asphalt types, diluent contents, and usage that can be used to develop a high quality area source emission estimate. However, the work involved in collecting the required information through surveys is significantly higher than the work required for the second and third alternative methods. The greater amount of work involved in the preferred and first alternative methods is rewarded in estimates that are more specific to the inventory area and time period. Because asphalt types used and amounts of asphalt used can vary substantially by locale and time period, this more detailed information could be useful, especially where rules have been put in place since the previous inventory period, or new rules are being considered.

The Data Attribute Rating System (DARS) has been developed as a tool to rate emission inventories. A description of the system and the EIIP recommendations for its use can be found in Appendix F of EIIP Volume VI, *Quality Assurance Procedures.* The following discussion uses the DARS rating system as a way to compare the estimation approaches presented in this chapter and analyze their strengths and weaknesses.

6.1.1 DATA ATTRIBUTE RATING SYSTEM (DARS) SCORES

The DARS scores for asphalt paving emission estimate methods are shown in Tables 17.6-1 through 17.6-4. The preferred method should provide very good results, so long as most of the asphalt use is included in the survey. The first alternative method, a simplified survey, will also provide good results, but will be less specific because of the scaling of the sample data and the use of average emission factors in some of the equations. Both of these two methods reflect use of specific types of asphalt during the inventory period. Scoring for these two methods scores the asphalt type and diluent content information collection under the emission factor attribute, and scores the usage of each type of asphalt as the activity factor.

The second and third alternative methods, in contrast, are less representative of the inventory area and time period. The second alternative method provides results that reflect state asphalt type usage, but not necessarily local asphalt type usage. The proportions of the asphalt types and the diluent type and content are used to determine the emission factor. Scores for the emission factor attributes are lower than those for the survey methods since this method uses a less specific approach for identifying asphalt types. The third alternative method uses emission factors that were developed through a 1989 top-down, material balance approach. The emission factor attribute scores for this method reflect the overestimation that is introduced by taking this more general approach.

6.2 SOURCES OF UNCERTAINTY

Actual emissions from this source category are affected by variables such as diluent contents of asphalts, climate, road types, and repair frequencies. Emission estimates are affected by the collection of information about the types and amounts of asphalt, diluent contents, scaling factors and the use of average or default diluent contents and densities. Because of these variables, local, inventory time specific data is the best way to reduce uncertainty in emission estimates.

It is important, however, to look at the uncertainty of estimates for asphalt paving in the context of emissions from all area sources. For example, in an area where cutback asphalt use is banned during the inventory season, emissions from emulsified asphalt may be so low that a high degree of uncertainty in the estimate may not significantly impact the overall quality of the inventory.

TABLE 17.6-1

DARS SCORES FOR ASPHALT PAVING
PREFERRED METHOD: COMPREHENSIVE SURVEY

Attribute	Factor	Activity	Emissions
Measurement	0.8	0.9	0.72
Source specificity	0.9	0.9	0.81
Spatial congruity	0.9	0.9	0.81
Temporal congruity	1	0.9	0.90
Composite	0.90	0.90	0.81

TABLE 17.6-2

DARS SCORES FOR ASPHALT PAVING
ALTERNATIVE METHOD 1: SIMPLIFIED SURVEY

Attribute	Factor	Activity	Emissions
Measurement	0.7	0.8	0.56
Source specificity	0.8	0.9	0.72
Spatial congruity	0.8	0.8	0.64
Temporal congruity	1	0.9	0.90
Composite	0.83	0.85	0.71

TABLE 17.6-3

DARS SCORES FOR ASPHALT PAVING
ALTERNATIVE METHOD 2: STATE-LEVEL USAGE DATA

Attribute	Factor	Activity	Emissions
Measurement	0.4	0.7	0.28
Source specificity	0.6 - 0.7	0.8	0.48 - 0.56
Spatial congruity	0.6	0.7	0.42
Temporal congruity	0.8	0.8	0.64
Composite	0.60 - 0.63	0.75	0.46 - 0.48

TABLE 17.6-4

DARS SCORES FOR ASPHALT PAVING
ALTERNATIVE METHOD 3: EMISSION FACTORS

Attribute	Factor	Activity	Emissions
Measurement	0.3	1	0.30
Source specificity	0.5	0.5	0.25
Spatial congruity	0.5	1	0.50
Temporal congruity	0.5	1	0.50
Composite	0.45	0.88	0.39

7

DATA CODING PROCEDURES

The inventory preparer should check the EPA website (http://www.epa.gov/ttn/chief/) for the latest information (codes) available to characterize emission estimates from asphalt paving. A complete list of Source Classification Codes (SCC) can be retrieved at http://www.epa.gov/ttn/chief/codes/. Table 17.7-1 lists the applicable SCCs for asphalt paving.

Available codes and process definitions influence and help guide the preparation of emission estimates for this category. Data transfer formats should be taken into account when an inventory preparer plans for data collection, calculation, and inventory presentation. Consistent categorization and coding will result in greater continuity between emission inventories for use in regional and national scale analyses.

7.1 NECESSARY DATA ELEMENTS

If the category emissions data will be transferred to EPA for incorporation into the national criteria and toxics air pollutant inventory, specific data transfer formats are acceptable. The acceptable data transfer format(s) are described and available for download at http://www.epa.gov/ttn/chief/net/. The acceptable data transfer formats contain the data elements necessary to complete the data set for use in regional or national air quality and human exposure modeling. The inventory preparer should review the area source portion of the acceptable file format(s) to understand the necessary data elements. The EPA describes its use and processing of the data for purposes of completing the national inventory, in its Data Incorporation Plan, also located at http://www.epa.gov/ttn/chief/net/.

TABLE 17.7-1

AREA AND MOBILE SOURCE CATEGORY CODES FOR ASPHALT PAVING

Process Description	Source Category Code
Cutback Asphalt - Total: All Solvent Types	24-61-021-000
Cutback Asphalt - Special Naphthas	24-61-021-370
Cutback Asphalt - Solvents: NEC[a]	24-61-021-999
Emulsified Asphalt - Total: All Solvent Types	24-61-022-000
Emulsified Asphalt - Special Naphthas	24-61-022-370
Emulsified Asphalt - Solvents: NEC	24-61-022-999

[a] NEC = Not elsewhere classified.

8

REFERENCES

EPA. 1995. *Compilation of Air Pollution Emission Factors - Volume I: Stationary Point and Area Sources, Fifth Edition and Supplements, AP-42*. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. (GPO-055-000-00251-7). Research Triangle Park, North Carolina.

EPA. 1994a. *Final Report - Evaluation of Emissions from Paving Asphalts*. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, EPA-600/R-94-135. Research Triangle Park, North Carolina

EPA. 1994b. *AIRS Database*. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. Research Triangle Park, North Carolina.

EPA. 1993. *Guidance for Growth Factors, Projections, and Control Strategies for the 15 Percent Rate-of-Progress Plans.* U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, EPA-453/R-93-002. Research Triangle Park, North Carolina.

EPA. 1991. *Procedures for the Preparation of Emission Inventories for Carbon Monoxide and Precursors of Ozone, Vol. I: General Guidance for Stationary Sources.* U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, EPA-450/4-91-016. Research Triangle Park, North Carolina.

Moulthrop, J.S., R.G. Hicks, W.R. Ballou. *Emulsion: The Future of Pavement Maintenance? Emulsified Asphalt seeks its niche in the paving industry.* The Asphalt Contractor. February 1997. p. 49.

State of California South Coast Air Quality Management District Rule 1108.1. Emulsified Asphalt. Adopted August 3, 1979, amended December 4, 1981, November 4, 1983. Paragraph (b) Requirements.

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