

PREFERRED AND ALTERNATIVE METHODS FOR ESTIMATING AIR EMISSIONS FROM HOT-MIX ASPHALT PLANTS

Final Report

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DISCLAIMER

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INTRODUCTION

The purposes of the preferred methods guidelines are to describe emission estimation techniques for stationary point sources in a clear and unambiguous manner and to provide concise example calculations to aid in the preparation of emission inventories. While emissions estimates are not provided, this information may be used to select an emission estimation technique best suited to a particular application. This chapter describes the procedures and recommends approaches for estimating emissions from hot-mix asphalt (HMA) plants.

Section 2 of this chapter contains a general description of the HMA plant source category, common emission sources, and an overview of the available control technologies used at HMA plants. Section 3 of this chapter provides an overview of available emission estimation methods.

Section 4 presents the preferred methods for estimating emissions from HMA plants, while Section 5 presents the alternative emission estimation techniques. It should be noted that the use of site-specific emission data is preferred over the use of industry-averaged data such as AP-42 emission factors (EPA, 1995a). Depending upon available resources, site-specific data may not be cost effective to obtain. However, this site-specific data may be a requirement of the state implementation plan (SIP) and may preclude the use of other data. Quality assurance and control procedures are described in Section 6. Coding procedures used for data input and storage are discussed in Section 7. Some states use their own unique identification codes, so individual state agencies should be contacted to determine the appropriate coding scheme to use. References are cited in Section 8. Appendix A provides an example data collection form to assist in information gathering prior to emissions calculations.

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2

GENERAL SOURCE CATEGORY DESCRIPTION

This section provides a brief overview of HMA plants. The reader is referred to the *Air Pollution Engineering Manual* (referred to as AP-40) and AP-42, 5th Edition, January 1995, for a more detailed discussion on these facilities (AWMA, 1992; EPA, 1995a).

2.1 PROCESS DESCRIPTION

HMA paving materials are a mixture of well graded, high quality aggregate (which can include reclaimed or recycled asphalt pavement [RAP]) and liquid asphalt cement, which is heated and mixed in measured quantities to produce HMA. Aggregate and RAP (if used) constitute over 92 percent by weight of the total HMA mixture. Aside from the relative amounts and types of aggregate and RAP used, mix characteristics are determined by the amount and grade of asphalt cement used. Additionally, the asphalt cement may be blended with petroleum distillates or emulsifiers to produce "cold mix" asphalt, sometimes referred to as cutback or emulsified asphalt, respectively (EPA, 1995a; Gunkel, 1992; TNRCC, 1994).

The process of producing HMA involves drying and heating the aggregate to prepare them for the asphalt cement coating. In the drying process, the aggregate are dried in a rotating, slightly inclined, direct-fired drum dryer. The aggregate is introduced into the higher end of the dryer. The interior of the dryer is equipped with flights that veil the aggregate through the hot exhaust as the dryer rotates. After drying, the aggregate is typically heated to temperatures ranging from 275 to 325°F and then coated with asphalt cement in one of two ways. In most drum mix plants, the asphalt is introduced directly into the dryer chamber to coat the aggregate. In batch mix plants, the mixing of aggregate and asphalt takes place in a separate mixing chamber called a pug mill.

The variations in the HMA manufacturing process are primarily defined by the following types of plants:

- Batch mix plants;
- Parallel flow drum mix plants; and
- Counterflow drum mix plants.

(Continuous mix plants, which represent a very small fraction of the plants presently operating, are not discussed here [EPA, 1995a]. The estimation techniques described for the batch mixing process should be followed when estimating emissions from continuous mix plant operations.).

2.1.1 BATCH MIXING PROCESS

In the batch mixing process, the aggregate is transported from storage piles and is placed in the appropriate hoppers of a cold feed unit. The material is metered from the hoppers onto a conveyor belt and is transported into a rotary dryer (typically gas- or oil-fired) (Gunkel, 1992; NAPA, 1995).

As hot aggregate leave the dryer, it drops into a bucket elevator and is transferred to a set of vibrating screens, that drop the aggregate into individual "hot" bins according to size. To control aggregate size distribution in the final batch mix, the operator opens various hot bins over a weigh hopper until the desired mix and weight for individual components are obtained. RAP may also be added at this point. Concurrent with the aggregate being weighed, liquid asphalt cement is pumped from a heated storage tank to an asphalt bucket, where it is weighed to achieve the desired mix.

Aggregate from the weigh hopper is dropped into the mixer (pug mill) and dry-mixed for 6 to 10 seconds. The liquid asphalt is then dropped into the pug mill where it is wet-mixed until homogeneous. The hot-mix is conveyed to a hot storage silo or dropped directly into a truck and hauled to a job site.

2.1.2 PARALLEL FLOW DRUM MIXING PROCESS

The parallel flow drum mixing process is a continuous mixing type process that uses proportioning cold feed controls for the process materials. The major difference between this process and the batch process is that the dryer is used not only to dry aggregate but also to mix the heated and dried aggregate with the liquid asphalt cement. Aggregate, which has been proportioned by size gradations, is introduced to the drum at the burner end. As the drum rotates, the aggregate, as well as the combustion products, move toward the other end of the drum in parallel (EPA, 1995). The asphalt cement is introduced into approximately the lower third of the drum. The aggregate are is coated with asphalt cement as it veils to the end of the drum. The RAP is introduced at some point along the length of the drum, as far away from the combustion zone as possible (about the midpoint of the drum), but with enough drum length remaining to dry and heat the material adequately before it reaches the coating zone (Gunkel, 1992). The flow of liquid asphalt cement is controlled by a variable flow pump electronically linked to the aggregate and RAP weigh scales (EPA, 1995a).

2.1.3 COUNTERFLOW DRUM MIXING PROCESS

In the counterflow drum mixing process, the aggregate is proportioned through a cold feed system prior to introduction to the drying process. As opposed to the parallel flow drum mixing process though, the aggregate moves opposite to the flow of the exhaust gases. After drying and heating take place, the aggregate is transferred to a part of the drum that is not exposed to the exhaust gas and coated with asphalt cement. This process prevents stripping of the asphalt cement by the hot exhaust gas. If RAP is used, it is usually introduced into the coating chamber.

2.2 EMISSION SOURCES

Emissions from HMA plants derive from both controlled (i.e., ducted) and uncontrolled sources. Section 7 lists the source classification codes (SCCs) for these emission points.

2.2.1 MATERIAL HANDLING (FUGITIVE EMISSIONS)

Material handling includes the receipt, movement, and processing of fuel and materials used at the HMA facility. Fugitive particulate matter (PM) emissions from aggregate storage piles are typically caused by front-end loader operations that transport the aggregate to the cold feed unit hoppers. The amount of fugitive PM emissions from aggregate piles will be greater in strong winds (Gunkel, 1992). Piles of RAP, because RAP is coated with asphalt cement, are not likely to cause significant fugitive dust problems. Other pre-dryer fugitive emission sources include the transfer of aggregate from the cold feed unit hoppers to the dryer feed conveyor and, subsequently, to the dryer entrance. Aggregate moisture content prior to entry into the dryer is typically 3 percent to 7 percent. This moisture content, along with aggregate size classification, tend to minimize emissions from these sources, which contribute little to total facility PM emissions. PM less than or equal to 10 μm in diameter (PM_{10}) emissions from these sources are reported to account for about 19 percent of their total PM emissions (NAPA, 1995).

If crushing, breaking, or grinding operations occur at the plant, these may result in fugitive PM emissions (TNRCC, 1994). Also, fine particulate collected from the baghouses can be a source of fugitive emissions as the overflow PM is transported by truck (enclosed or tarped) for on-site disposal. At all HMA plants there may be PM and slight process fugitive volatile organic compound (VOC) emissions from the transport and handling of the hot-mix from the mixer to the storage silo and also from the load-out operations to the delivery trucks (EPA, 1994a). Small amounts of VOC emissions can also result from the transfer of liquid and gaseous fuels, although natural gas is normally transported in a pipeline (Gunkel, 1992, Wiese, 1995).

2.2.2 GENERATORS

Diesel generators may be used at portable HMA plants to provide electricity. Maximum electricity generation during process operations is typically less than 500 kilowatts per hour (kW/hr) with rates of 20-50 kW/hr at other times (Fore, 1995). (Note that 1 kW equals 1.34 horsepower.) Emissions from these generators are likely uncontrolled and are correlated with fuel usage, as determined by engine size, load factor, and hours of operation. Emissions primarily include criteria pollutants—particularly NO_x and CO (EPA, 1995b).

2.2.3 STORAGE TANKS

Storage tanks are used to store fuel oils, heated liquid asphalts, and asphalt cement at HMA plants, and may be a source of VOC emissions. Storage tanks at HMA plants are usually fixed roof (closed or enclosed) due to the smaller size of the tanks, usually less than 30,000 gallons (Fore, 1995; Patterson, 1995). Emissions from fixed-roof tanks (closed or enclosed) are typically divided into two categories: working losses and breathing losses. Working losses refer to the combined loss from filling and emptying the tank. Filling losses occur when the VOC contained in the saturated air are displaced from a fixed-roof vessel during loading. Emptying losses occur when air drawn into the tank becomes saturated and expands, exceeding the capacity of the vapor space. Breathing losses are the expulsion of vapor from a tank through vapor expansion caused by changes in temperature and pressure. Because of the small tank sizes and fuel usage, total VOC emissions would typically be less than 1 ton per year. Emissions from tanks used for No. 5 or 6 oils or for asphalt cement may be increased when they are heated to control oil viscosity. Emissions from asphalt cement tanks are particularly low, due to its low vapor pressure.

The TANKS computer program, available from the EPA, is commonly used to quantify emissions; however, its use should be carefully evaluated since it is a complicated program with a great number of input parameters. Check with your local or state authority as to whether TANKS is required for your facility. The use of the TANKS program for calculating emissions from storage tanks is discussed in Chapter 1 of this volume, *Introduction to Stationary Point Source Emissions Inventory Development*.

2.2.4 PROCESS EMISSIONS

The most significant source of emissions from HMA plants is the dryer (EPA, 1995a; Gunkel, 1992; NAPA, 1995). Dryer burners capacities are usually less than 100 million British thermal units per hour (100 MMBtu/hr), but may be as large as 200 MMBtu/hr (NAPA, 1995; Wiese, 1995). Combustion emissions from the dryer include products of complete combustion and products of incomplete combustion. Products of complete combustion include carbon dioxide (CO_2), water, oxides of nitrogen (NO_x), and, if sulfur is present in the fuel, oxides of sulfur (SO_x), for example sulfur dioxide (SO_2). Products of

incomplete combustion include carbon monoxide (CO), VOC, including smaller quantities of hazardous air pollutants (HAP) (e.g., benzene, toluene, and xylene), and other organic particulate matter. These incomplete combustion emissions result from improper air and fuel mixtures (e.g., poor mixing of fuel and air), inadequate fuel air residence time and temperature, and quenching of the burner flame. Depending on the fuel, small amounts of ash may also be emitted. In addition to combustion emissions, emissions from a dryer include water and PM from the aggregate. Non-combustion emissions from rotary drum dryers may include small amounts of VOC, polynuclear aromatic hydrocarbons (PAH), aldehydes, and HAP from the volatile fraction of the asphalt cement and organic residues that are commonly found in recycled asphalt (i.e., gasoline and engine oils) (EPA, 1995a; Gunkel, 1992; TNRCC, 1994; EPA, 1991a; NAPA, 1995).

For drum mix processes, the dryer contributes most of the facility's total PM emissions (NAPA, 1995). At these plants, PM emissions from post-dryer processes are minimal due to the mixing with asphalt cement.

In batch mix plants, post-dryer PM emission sources include hot aggregate screens, hot bins, weigh hoppers, and pug mill mixers (NAPA, 1995, TNRCC, 1994). Uncontrolled PM emissions from these sources will be greater than emissions from pre-dryer sources primarily due to the lower aggregate moisture content in addition to the greater number of transfer points (NAPA, 1995). Post-dryer emission sources at batch plants are usually controlled by venting to the primary dust collector (along with the dryer gas) or sometimes to a separate dust collection system. Captured emissions are mostly aggregate dust, but they may also contain gaseous VOC and a fine aerosol of condensed liquid particles. This liquid aerosol is created by the condensation of gas into particles during the cooling of organic vapors volatilized from the asphalt cement and RAP in the pug mill. The aerosol emissions are primarily dependent upon the temperatures of the materials entering the mixing process. This problem appears to be more acute when the RAP has not been preheated prior to entering the pug mill or boot of the hot elevator. This results in a sudden, rapid release of steam resulting from evaporation of the moisture in the RAP upon mixing it into the superheated (often above 400°F) aggregate (EPA, 1995a; Gunkel, 1992).

Recycled tires, which are sometimes used in the production of asphalt concrete, may be a source of VOC and PM emissions. When heated, ground up tire pieces (referred to as crumb rubber) have been shown to emit VOC. These emissions are a function of the quantity of crumb rubber used in the liquid asphalt and the temperature of the mix (TNRCC, 1994).

If cutback or emulsions are used to make cold mix asphalt concrete, VOC emissions can be significant. These emissions can occur as stack emissions from mixing of asphalt batches and as fugitives from handling areas. Emission levels depend on the type and quantity of the cold mix produced. VOC emissions associated with cutback asphalt production may include naphtha, kerosene, or diesel vapors.

In some states (e.g., Wisconsin) asphalt drum dryers are used for soil remediation. In this practice, the contaminated soil may be run through the dryer as an aggregate, cut with virgin aggregate at ratios ranging from 1:1 to 1:10 (contaminated soil to virgin aggregate) depending on the clay content of the material. The dried material is coated with asphalt and "RAP" is produced. The manufactured RAP can then be fed into the hot mix asphalt process normally, as any RAP would be, and incorporated into the final mix. This practice can result in HAP emissions, which are a function of the HAP content and quantity of the soil as well as the dryer temperature and residence time. There is significant control of VOC/HAPs in the dryer drum. Based on testing performed by the asphalt industry, a control on the average of 75 percent with numbers ranging from 45 to 98 percent control depending on the plant type (parallel flow versus counterflow drum designs) have been recorded. (Wiese, 1995).

2.3 PROCESS DESIGN AND OPERATING FACTORS INFLUENCING EMISSIONS

There are two methods of introducing combustion air to the dryer burners and two types of combustion chambers, with the combination resulting in four types of burner systems that can be found at HMA plants. The type of burner system employed has a direct effect on gaseous combustion emissions, including VOC, HAP, CO, and NO_x. The two types of burners related to the introduction of combustion air include the induced draft burner and the forced draft burner. Forced draft burners are usually more fuel efficient under proper operating and maintenance conditions and, consequently, have lower emissions (Gunkel, 1992). The two types of burners related to the use of combustion chambers include those with refractory-lined combustion chambers and those without combustion chambers. While most older burners had combustion chambers, today's burners generally do not (Gunkel, 1992).

Incomplete combustion in the dryer burner increases emissions of CO and organics (e.g., VOC). This may be caused by: (1) improper air and fuel mixtures (e.g., poor mixing prior to combustion); (2) inadequate residence time (i.e., too short) and temperature (i.e., too low); and (3) flame quenching. The primary cause of CO and organic emissions in chamberless burners is quenching of the flame caused by improper flighting. This occurs when the flame temperature is reduced by contact with cold surfaces or cold material dropping through the flame (NAPA, 1995). In addition, the moisture content of the aggregate in the dryer may contribute to the formation of CO and unburned fuel emissions by reducing the temperature (Gunkel, 1992). A secondary cause of these gaseous pollutants may be excess air entering the combustion process, particularly in the case of an induced draft burner. The use of a precombustion chamber to promote better fuel air mixing may reduce VOC and CO emissions.

NO_x is primarily formed from nitrogen in the combustion air, thermal NO_x, and from nitrogen in the fuel, fuel NO_x. Thermal NO_x is negligible below 1300°C and increases with combustion temperature (Nevers, 1995). Fuel NO_x, which is likely lower than thermal NO_x from dryer burners, is formed by conversion of some of the nitrogen in the burner fuel. While No. 4, 5 and 6 fuel oils may contain significant amounts of nitrogen, No. 1 and 2 oils and natural gas contain very little (Nevers, 1995).

Dryer burners can be designed to operate on almost any type of fuel; natural gas, liquefied petroleum gas (LPG), light fuel oils, heavy fuel oils, and waste fuel oils (Gunkel, 1992). The type of fuel and its sulfur content will affect SO_x, VOC, and HAP emissions and, to a lesser extent, NO_x and CO emissions. Sulfur in the burner fuel will convert to SO_x during combustion; burner operation will have little effect on the percent of this conversion (TNRCC, 1994; EIIP, 1995). VOC emissions from natural gas combustion are less than emissions from LPG or fuel oil combustion, which are lower than emissions from waste-blended fuel combustion (TNRCC, 1994). Ash levels and concentrations of most of the trace elements in waste oils are normally much higher than those in virgin oils, producing higher emission levels of PM and trace metals. Chlorine in waste oils also typically exceeds the levels in virgin oils. High levels of halogenated solvents are often found in waste oil as a result of the additions of contaminant solvents to the waste oils.

When cold mix asphalt cement is heated, organic fumes (i.e., VOC) may be released as visible emissions if the asphalt is cut with lighter ends or other additives needed for a specification; however, these emissions are not normally seen when heating asphalt cement, as the boiling point of asphalt cement is much higher (Patterson, 1995). In drum mix plants, hydrocarbon (e.g., aldehydes) and PAH emissions may result from the heating and mixing of liquid asphalt inside the drum as hot exhaust gas in the drum strips light ends from the asphalt. The magnitude of these emissions is a function of the process temperatures and constituents of the asphalt being used. The mixing zone temperature in parallel flow drums is largely a function of drum length and flighting. The processing of RAP materials, particularly in parallel flow plants, may also increase VOC emissions, because of an increase in mixing zone temperature during processing. In counterflow drum mix plants, the liquid asphalt cement, aggregate, and sometimes RAP, are mixed in a zone not in contact with the hot exhaust gas stream. Consequently, counterflow drum mix plants will likely have lower VOC emissions than parallel flow drum mix plants. In batch mix plants, the amount of hydrocarbons (i.e., liquid aerosol) produced depends to a large extent on the temperature of the asphalt cement and aggregate entering the pug mill (EPA, 1995a; Gunkel, 1992). Particulate emissions from parallel flow drum mix plants are reduced because the aggregate and asphalt cement mix for a longer time. The amount of PM generated within the dryer in this process is usually lower than that generated within batch dryers, but because the asphalt is heated to higher temperatures for a longer period of time, organic emissions (gaseous and liquid aerosol) are typically greater than in conventional batch plants (EPA, 1991a).

2.4 CONTROL TECHNIQUES

Control techniques and devices typically used at HMA facilities are described below and presented in Table 3.2-1. Control efficiency for a specific piece of equipment will vary depending not only on the type of equipment and quality of the maintenance/repair program at a particular facility, but also the velocity of the air through the dryer.

2.4.1 PROCESS AND PROCESS FUGITIVE PARTICULATE CONTROL (INCLUDING METALS)

Process and process fugitive particulates at HMA plants are typically controlled using primary and secondary collection devices. Primary devices typically include cyclone and settling chambers to remove larger PM. Smaller PM is typically collected by secondary devices, including fabric filters and venturi scrubbers. PM from the dry control devices is usually collected and mixed back into the process near the entry point of the asphalt cement in drum-mix plants. In addition to PM and PM₁₀ emissions, particulate control also serves to remove trace metals emitted as particulate. These controls are primarily used to reduce PM emissions from the dryer; however at batch mix plants, these controls are also used for post-dryer sources, where fugitive emissions may be scavenged at an efficiency of 98 percent (NAPA, 1995).

Cyclones

The cyclone (also known as a "mechanical collector") is a particulate control device that uses gravity, inertia, and impaction to remove particles from a ducted stream. Large diameter cyclones are often used as primary precleaners to remove the bulk of heavier particles from the flue gas before it enters a secondary or final collection system. A secondary collection device, which is more effective at removing particulates than a primary collector, is used to capture remaining PM from the primary collector effluent.

In batch plants, cyclones are often used to return collected material to the hot elevator and to combine it with the drier virgin aggregate (EPA, 1995a; Gunkel, 1992; Khan, 1977; NAPA, 1995).

Multiple cyclones

A multiple cyclone consists of numerous small-diameter cyclones operating in parallel. Multiple cyclones are less expensive to install and operate than fabric filters, but are not as effective at removing smaller particulates. They are often used as precleaners to remove the bulk of heavier particles from the flue gas before it enters the main control device (EPA, 1995a; Gunkel, 1992; Khan, 1977).

Settling Chambers

TABLE 3.2-1**TYPICAL HOT-MIX ASPHALT PLANT EMISSION CONTROL TECHNIQUES**

Emission Source	Pollutant	Control Technique	Typical Efficiency (%)
Process	PM and PM ₁₀	Cyclones	50 - 75 ^{a,b}
		Multiple cyclones	90 ^c
		Settling chamber	<50 ^b
		Baghouse	99 - 99.97 ^{a,d}
		Venturi scrubber	90 - 99.5 ^{d,e}
	VOC	Dryer and combustion process modifications	37 - 86 ^{f,g}
	SO _x	Limestone	50 ^{b,e}
		Low sulfur fuel	80 ^c
Fugitive dust	PM and PM ₁₀	Paving and maintenance	60 - 99 ^g
		Wetting and crusting agents	70 ^b - 80 ^c
		Crushed RAP material, asphalt shingles	70 ^h

^a Control efficiency dependent on particle size ratio and size of equipment.

^b Source: Patterson, 1995c.

^c Source: EIIP, 1995.

^d Typical efficiencies at a hot-mix asphalt plant.

^e Source: TNRCC, 1995.

^f Source: Gunkel, 1992.

^g Source: TNRCC, 1994.

^h Source: Patterson, 1995a.

Settling chambers, also referred to as knock-out boxes, are used at HMA plants as primary dust collection equipment. To capture remaining PM, the primary collector effluent is ducted to a secondary collection device such as a baghouse, which is more effective at removing particulates (EPA, 1995a, Khan, 1977).

Baghouses

Baghouses, or fabric filter systems, filter particles through fabric filtering elements (bags). Particles are caught on the surface of the bags, while the cleaned flue gas passes through. To minimize pressure drop, the bags must be cleaned periodically as the dust layer builds up. Fabric filters can achieve the highest particulate collection efficiency of all particulate control devices. Most HMA plants with baghouses use them for process and process fugitive emissions control. The captured dust from these devices is usually returned to the production process (EPA, 1995a; Gunkel, 1992).

Venturi Scrubbers

Venturi scrubbers (sometimes referred to as high energy wet scrubbers) are used to remove coarse and fine particulate matter. Flue gas passes through a venturi tube while low pressure water is added at the throat. The turbulence in the venturi promotes intimate contact between the particles and the water. The wetted particles and droplets are collected in a cyclone spray separator (sometimes called a cyclonic demister). Venturi scrubbers are often used in similar applications to baghouses (EPA, 1995a; Gunkel, 1992).

In addition to controlling particulate emissions, the venturi scrubber is likely to remove some of the process organic emissions from the exhaust gas (Gunkel, 1992). While the high-pressure venturi scrubber is reliable at controlling PM, it requires considerable attention and daily maintenance to maintain a high degree of PM removal efficiency (Gunkel, 1992).

2.4.2 FUGITIVE PARTICULATE EMISSIONS CONTROL

Driving Surfaces

Unpaved driving surfaces are commonly maintained by utilizing wet-down techniques using water, or other agents. In some areas unpaved roadways may alternatively be covered with crushed recycled material (e.g., tires, asphalt shingles) with equal success. In recent years, there has been a trend toward paving the driving surfaces to eliminate fugitive particulates. Facilities with paved surfaces may additionally employ sweeping or vacuuming as maintenance measures to reduce PM emissions (EPA, 1995a; Gunkel, 1992; TRNCC, 1994).

Aggregate Stockpiles

Watering of the stockpiles is not typically used because of the burden it puts on the heating and drying process (Gunkel, 1992). Occasionally, crusting agents may be applied to aggregate piles. These crusting agents have served fairly well to mitigate fugitive dust emissions in these instances (TNRCC, 1994). There are many variables that affect the fugitive dust emissions from stockpiles including moisture content of the material, amount of fines (< 200 mesh), and age of pile (i.e., older piles tend to loose their surface fines). Pre-washed aggregate, from which fines have been removed, may be used for additional PM control (Patterson, 1995a).

2.4.3 VOC (INCLUDING HAP) CONTROL

VOCs are the total organic compounds emitted by the process minus the methane constituent. Once the exhaust stream cools after discharge from the process stack, some VOCs condense to form a fine liquid aerosol or "blue smoke" plume. A number of process modifications or restrictions have been introduced to reduce blue smoke, including installation of flame shields, rearrangement of flights inside the drum, adjustments of the asphalt injection point, and other design changes (EPA, 1995a; Gunkel, 1992). Periodic burner tune-ups may reduce VOC emissions by about 38 percent (Patterson, 1995a). Burner combustion air can be optimized to reduce emissions by monitoring the pressure drop across induced draft burners with a photohelic device tied to an automatic damper that adjusts the exhaust fan (Patterson, 1995a).

Organic vapors from heated asphalt cement storage tanks can be reduced by condensing the vapors with air-cooled vent pipes. In some cases, tank emissions may be routed back to combustion units. Organic emissions from heated asphalt storage tanks may also be controlled with carbon canisters on the vents or by other measures such as condensing precipitation or stainless steel shaving condensers (Wiese, 1995). Although not common, organic emissions from truck-loading of asphaltic concrete can be controlled by venting into the dryer (EPA, 1995a). This is usually practiced in non-attainment areas.

2.4.4 SULFUR OXIDES CONTROL

Low Sulfur Fuel

This approach to reducing SO_x emissions reduces the sulfur fed to the combustor by burning low sulfur fuels. Fuel blending is the process of mixing higher sulfur content fuels with lower sulfur fuels (e.g., low sulfur oil). The goal of effective fuel blending is to provide a fuel supply with reasonably uniform properties that meet the blend specification, typically including sulfur content, heating value, and moisture content (EIIP, 1995).

Aggregate Adsorption

Alkaline aggregate (i.e., limestone) may adsorb sulfur compounds from the exhaust gas. In exhaust streams controlled by baghouses, SO_x may be reduced by limestone dust that coats the baghouse filters (Patterson, 1995). Consequently, limestone aggregate may maximize the removal of sulfur compounds (Gunkel, 1992). Sulfur compounds from the exhaust gas may also be adsorbed by a venturi scrubber with recirculated water containing limestone (Wiese, 1995).

2.4.5 NITROGEN OXIDES CONTROL

Low Nitrogen Fuels

Fuels lower in nitrogen content may reduce some NO_x emissions (NAPA, 1995). At temperatures above 1300°C , however, conversion from high-nitrogen fuels to low-nitrogen fuels may not substantially reduce NO_x emissions, as thermal NO_x contributions will be more significant (Nevers, 1995). Consequently, NO_x emissions are generally inversely related to CO emissions (NAPA, 1995).

Staged combustion systems such as low NO_x burners that are used to reduce NO_x emissions in other industries, are not typically employed in the HMA industry due to economic and engineering considerations (NAPA, 1995). Recirculation of the exhaust gas may be precluded by the relatively high moisture content (e.g., 30 percent) of the gas stream. Exhaust recirculation in these instances may cause some flame quenching around the edges and could contribute to higher VOC and CO emissions when sealed burners are not used (Patterson, 1995a).

OVERVIEW OF AVAILABLE METHODS

3.1 DESCRIPTION OF EMISSION ESTIMATION METHODOLOGIES

There are several methodologies available for calculating emissions from HMA plants. The method used is dependent upon available data, available resources, and the degree of accuracy required in the estimate. In general, site-specific data is preferred over industry averaged data such as *AP-42* emission factors for more accurate emissions estimates (EPA, 1995a). (Each state may have a different preference or requirement and so it is suggested that the reader contact the nearest state or local air pollution agency before deciding on which emission estimation methodology to use.) This document evaluates emission estimation methodologies with respect to accuracy and does not mandate any emission estimation method. For purposes of calculating peak season daily emissions for State Implementation Plan inventories, refer to the EPA *Procedures* manual (EPA, May 1991).

This section discusses the methods available for calculating emissions from HMA plants and identifies the preferred method of calculation on a pollutant basis. These emission estimation methodologies are listed in no particular order and the reader should not infer a preference based on the order they are listed in this section. A discussion of the sampling and analytical methods available for monitoring each pollutant is provided in Chapter 1, *Introduction to Stationary Point Source Emissions Inventory Development*.

Emission estimation techniques for auxiliary processes, such as using EPA's TANKS program to calculate storage tank emissions, are also discussed in Chapter 1.

3.1.1 STACK SAMPLING

Stack sampling provides a "snapshot" of emissions during the period of the stack test. Stack tests are typically performed during either representative (i.e., normal) or worst case conditions, depending upon the requirements of the state. Samples are collected from the stack using probes inserted through a port in the stack wall, and pollutants are collected in or on various media and sent to a laboratory for analysis. Pollutant concentrations are obtained by dividing the amount of pollutant collected during the test by the volume of the sample. Emission rates are then determined by multiplying the pollutant concentration by the volumetric stack gas flow rate. Because there are many steps in the stack sampling procedures where errors can occur, only experienced stack testers should perform such tests.

3.1.2 EMISSION FACTORS

Emission factors are available for many source categories and are based on the results of source tests performed at an individual plant or at one or more facilities within an industry. Basically, an emission factor is the pollutant emission rate relative to the level of source activity. Chapter 1 of this volume of documents contains a detailed discussion of the reliability, or quality, of available emission factors. EPA-developed emission factors for criteria and hazardous air pollutants are available in *AP-42*, the *Locating and Estimating Series* of documents, and the Factor Information Retrieval (FIRE) System.

3.1.3 FUEL ANALYSIS

Fuel analysis data can sometimes be used to predict emissions by applying mass conservation laws. For example, if the concentration of a pollutant, or pollutant precursor, in a fuel is known, emissions of that pollutant can be calculated by assuming that all of the pollutant is emitted or by adjusting the calculated emissions by the control efficiency. This approach is appropriate for SO₂.

3.1.4 CONTINUOUS EMISSION MONITORING SYSTEM (CEMS) AND PREDICTIVE EMISSION MONITORING (PEM)

A CEMS provides a continuous record of emissions over time. Various principles are employed to measure the concentration of pollutants in the gas stream and are usually based on photometric measurements. Once the pollutant concentration is known, emission rates are obtained by multiplying the pollutant concentration by the volumetric gas flow rate. Stack gas flow rate can also be measured by continuous monitoring instruments; but it is more typically determined using manual methods (e.g., pitot tube traverse). At low pollutant concentrations, the accuracy of this method may decrease. Instrument drift can be problematic for CEMS and uncaptured data can create long-term, incomplete data sets.

PEM is based on developing a correlation between pollutant emission rates and process parameters. A PEM may be considered a specialized usage of an emission factor. Correlation tests must first be performed to develop this relationship. At a later time emissions can then be calculated using process parameters to predict emission rates based on the results of the initial source test.

3.2 COMPARISON OF AVAILABLE EMISSION ESTIMATION METHODOLOGIES

Table 3.3-1 identifies the preferred and alternative emission estimation approach(s) for selected pollutants. Table 3.3-1 is ordered according to the accuracy of the emission estimation approach. The reader and the local air pollution agency must decide which emission estimation approach is applicable based on costs and air pollution control requirements in their area. The preferred method chosen should also recognize the time specificity of the emission estimate and the data quality. The quality of the data will depend on a variety of factors including the number of data points generated, the representativeness of those data points, and the proper operation and maintenance of the equipment being used to record the measurements.

3.2.1 STACK SAMPLING

Without considering cost, stack sampling is the preferred emission estimation methodology for process NO_x , CO, VOC, THC, PM, PM_{10} , metals and speciated organics. EPA reference methods and other methods of known quality can be used to obtain accurate estimates of emissions at a given time for a particular facility.

3.2.2 EMISSION FACTORS

Due to their availability and acceptance in the industry, emission factors are commonly used to prepare emission inventories. However, the emission estimate obtained from using emission factors is based upon emissions testing performed at similar facilities and may not accurately reflect emissions at a single source. Thus, the user should recognize that, in most cases, emission factors are averages of available industry-wide data with varying degrees of quality and may not be representative of averages for an individual facility within that industry. Emission factors are the preferred technique for estimating fugitive dust emissions for aggregate stockpiles and driving surfaces, as well as process fugitives.

3.2.3 FUEL ANALYSIS

Fuel analysis can be used as an approximation if no emission factors or site specific stack test data are available. Once the concentration of sulfur in a fuel is known, SO_2 emissions can be calculated based on mass conservation laws, assuming negligible adsorption by alkaline aggregates.

TABLE 3.3-1
SUMMARY OF PREFERRED EMISSION
ESTIMATION METHODS FOR HOT-MIX ASPHALT PLANTS

Parameter	Preferred Emission Estimation Approach Ordered by Accuracy ^a
SO ₂	1. Stack sampling data 2. CEMS/PEM 3. Fuel analysis 4. EPA/state published emission factors ^b
NO _x	1. Stack sampling data 2. CEMS/PEM data 3. EPA/state published emission factors ^b
CO	1. Stack sampling data 2. CEMS/PEM data 3. EPA/state published emission factors ^b
VOC	1. Stack sampling data 2. EPA/state published emission factors
THC ^c	1. Stack sampling data 2. CEMS/PEM data 3. EPA/state published emission factors ^b
PM	1. Stack sampling data ^d 2. EPA/state published emission factors ^e
PM ₁₀	1. Stack sampling data ^d 2. EPA/state published emission factors ^e
Heavy metals	1. Stack sampling data 2. EPA/state published emission factors ^b

TABLE 3.3-1**(CONTINUED)**

Parameter	Preferred Emission Estimation Approach Ordered by Accuracy^a
Speciated organics	1. Stack sampling data 2. EPA/state published emission factors ^b

^a Preferred emission estimation approaches do not include considerations such as cost. The costs, benefits, and relative accuracy should be considered prior to method selection. Readers are advised to check with local air pollution control agency before choosing a preferred emission estimation approach.

^b Assumes emission factors are not based on site-specific fuel analysis.

^c THC = total hydrocarbons.

^d Preferred method for process and process fugitive emissions.

^e Preferred method for fugitive dust.

3.2.4 CEMS AND PEM

HMA plants would not likely estimate emissions using CEMS and PEM. HMA plants have conditions unfavorable to generating accurate CEM data including, high vibrations, high moisture content of the stack gas, and dust. Nightly shutdown of CEMS would also adversely affect their performance. In some instances, however, CEMS may be used to estimate emissions of NO_x, CO, and THC. This method may be used, for example, when detailed records of emissions are needed over time. Similarly, stack gas flow rate may be monitored using a continuous flow rate monitor, including pitot tubes, ultrasonic, and thermal monitors (Patterson, 1995a).

PEM is a predictive emission estimation methodology whereby emissions are correlated to process parameters based on an initial series of stack tests at a facility. For example, VOC emissions may occur from asphalt mixtures produced at various temperatures with different combustion fuels and varying quantities of asphalt cement, aggregates, RAP, and crumb rubber. Similarly, sulfur dioxide emissions may be controlled by scrubbers that operate at variable pressure drops, alkalinity, and recirculation rates. These parameters may be monitored during the tests and correlated to the pollutant emission rates. Following the correlation development, parameters would be monitored to periodically predict emission rates. Periodic stack sampling may be required to verify that the predictive emission correlations are still accurate; if not, new correlations are developed.

4

PREFERRED METHODS FOR ESTIMATING EMISSIONS

Without consideration of cost, the preferred method for estimating emissions of most pollutants emitted from HMA plants is the use of site-specific recent stack tests. Each state may have a different preference or requirement and so it is suggested that the reader contact the nearest state or local air pollution agency before deciding on which emission estimation methodology to use. This section provides an outline for calculating emissions from HMA plants based on raw data collected by stack tests.

Table 3.4-1 lists the variables and symbols used in the following discussions.

4.1 EMISSION CALCULATIONS USING STACK SAMPLING DATA

Stack sampling test reports often provide emissions data in terms of lb/hr or grain/dscf. Annual emissions may be calculated from these data using Equations 3.4-1 or 3.4-2. Stack tests performed under a proposed permit condition or a maximum emissions rate are likely to be higher than the emissions which would result under normal operating conditions. The emission testing should only be completed after the purpose of the testing is known. For example, emission testing for particulate emissions may be different than emission testing for New Source Performance Standards (NSPS) because the back-half catch portion is not considered.

This section shows how to calculate emissions in lb/hr based on stack sampling data. Calculations involved in determining particulate emissions from Method 5 data are used as an example. Because continuous PM monitors have not been demonstrated for this industry, the only available methods for measuring PM emissions are EPA Methods 5 or 17 and EPA Method 201A for PM₁₀. EPA Method 5 is used for NSPS testing. If condensible PM is needed in the emissions estimate, the test method selected must be configured accordingly.

TABLE 3.4-1**LIST OF VARIABLES AND SYMBOLS**

Variable	Symbol	Units
Concentration	C	parts per million volume dry (ppmvd)
Molecular weight	MW	lb/lb-mole
Molar volume	V	385.5 ft ³ /lb-mole @ 68°F and 1 atmosphere
Flow rate	Q _a	actual cubic feet per minute (acfm)
Flow rate	Q _d	dry standard cubic feet per minute (dscfm)
Emissions	E _x	typically lb/hr of pollutant x
Annual emissions	E _{tpy,x}	ton/year of pollutant x
Filter catch	C _f	grams (g)
Fuel use	Q _f	typically, lb/hr
PM concentration	C _{PM}	grain/dscf
Metered volume at standard temperature and pressure	V _{m,STP}	dscf
Moisture	R	percent
Temperature	T	degrees fahrenheit
Asphalt production	A	ton/hr
Annual operating hours	OpHrs	hr/yr

An example summary of a Method 5 test is shown in Table 3.4-2. The table shows the results of three different sampling runs conducted during one test event. The source parameters measured as part of a Method 5 run include gas velocity and moisture content, which are used to determine exhaust gas flow rates in dscfm. The filter weight gain is determined gravimetrically and divided by the volume of gas sampled (as shown in Equation 3.4-1) to determine the PM concentration in grains per dscf. Note that this example does not present the condensible PM emissions.

Pollutant concentration is then multiplied by the volumetric flow rate to determine the emission rate in pounds per hour, as shown in Equation 3.4-2 and Example 3.4-1.

$$C_{PM} = C_f / V_{m,STP} * 15.43 \quad (3.4-1)$$

where:

C_{PM}	=	concentration of PM or grain loading (grain/dscf)
C_f	=	filter catch (g)
$V_{m,STP}$	=	metered volume of sample at STP (dscf)
15.43	=	15.43 grains per gram

$$E_{PM} = C_{PM} * Q_d * 60/7000 \quad (3.4-2)$$

where:

E_{PM}	=	hourly emissions in lb/hr of PM
Q_d	=	stack gas volumetric flow rate (dscfm)
60	=	60 min/hr
7000	=	7000 grains per pound

TABLE 3.4-2
TEST RESULTS - METHOD 5

Parameter	Symbol	Run 1	Run 2	Run 3
Total sampling time (minutes)	min	120	120	120
Moisture collected (grams)	g	395.6	372.6	341.4
Filter catch (grams)	C_f	0.0851	0.0449	0.0625
Average sampling rate (dscfm)	dscfm	0.34	0.34	0.34
Standard metered volume, (dscf)	$V_{m,STP}$	41.83	40.68	40.78
Volumetric flow rate (acfm or dscfm)	Q_a or Q_d	17,972	17,867	17,914
Concentration of particulate (grains/dscf)	C_{PM}	0.00204	0.00110	0.00153
Particulate emission rate (lb/hr)	E_{PM}	4.84	2.61	3.63

Example 3.4-1

PM emissions calculated using Equations 3.4-1 and 3.4-2 and the stack sampling data for Run 1 (presented in Table 3.4-2 are shown below).

$$\begin{aligned}
 C_{PM} &= C_f / V_{m,STP} * 15.43 \\
 &= (0.085 / 41.83) * 15.43 \\
 &= 0.03 \text{ grain/dscf} \\
 E_{PM} &= C_{PM} * Q_d * 60 / 7000 \\
 &= 0.03 * 17,972 * (60 \text{ min/hr}) * (1 \text{ lb}/7000 \text{ grains}) \\
 &= 4.84 \text{ lb/hr}
 \end{aligned}$$

The information from some stack tests may be reported in pounds of particulate per pounds of exhaust gas (wet). Use Equation 3.4-3 to calculate the dry particulate emissions in lb/hr.

$$E_{PM} = Q_a / 1000 * 60 * 0.075 (1 - R) * (528 / 460 + T) \quad (3.4-3)$$

where:

$$\begin{aligned}
 E_{PM} &= \text{hourly emissions in lb/hr PM} \\
 Q_a &= \text{actual cubic feet of exhaust gas per minute (acfm)} \\
 1000 &= 1000 \text{ lb exhaust gas per lb of PM} \\
 60 &= 60 \text{ min/hr} \\
 0.075 &= 0.075 \text{ lb/ft}^3 \\
 R &= \text{moisture percent (\%)} \\
 528 &= 528^\circ\text{F} \\
 460 &= 460^\circ\text{F} \\
 T &= \text{stack gas temperature in } ^\circ\text{F}
 \end{aligned}$$

4.2 EMISSION FACTOR CALCULATIONS

Emission factors are commonly used to calculate emissions for fugitive dust sources and when site-specific monitoring data are unavailable. EPA maintains a compilation of emission factors in AP-42 for criteria pollutants and HAPs (EPA, 1995a). A supplementary source for toxic air pollutant emission factors is the Factor Information and Retrieval (FIRE) data system (EPA, 1994). FIRE also contains emission factors for criteria pollutants.

Much work has been done recently on developing emission factors for HAPs and recent AP-42 revisions have included these factors (EPA, 1995a,b). In addition, many states have developed their own HAP emission factors for certain source categories and require their use in any inventories including HAPs. Refer to Chapter 1 of Volume III for a complete discussion of available information sources for locating, developing, and using emission factors as an estimation technique.

Emission factors developed from measurements for a specific mixer or dryer may sometimes be used to estimate emissions at other sites. For example, a company may have several units of similar model and size; if emissions were measured from one dryer or mixer, an emission factor could be developed and applied other similar units. It is advisable to have the emission factor reviewed and approved by state/local agencies or the EPA prior to its use.

The basic equation for using an emission factor to calculate emissions is the following:

$$E_x = EF_x * \text{Activity or Production Rate} \quad (3.4-4)$$

where:

$$\begin{array}{ll} E_x & = \text{emissions of pollutant } x \\ EF_x & = \text{emission factor of pollutant } x \end{array}$$

Calculations using emission factors are presented in Examples 3.4-2 and 3.4-3.

4.3 EMISSION CALCULATIONS USING FUEL ANALYSIS DATA

Fuel analysis can be used to predict SO₂ and other emissions based on application of conservation laws, if fuel rate (Q_f) is measured. The presence of certain elements in fuels may be used to predict their presence in emission streams. This includes elements such as sulfur which may be converted to other compounds during the combustion process.

Example 3.4-2

Example 3.4-2 shows how potential hourly VOC combustion emissions may be calculated for a parallel flow drum mixer using a total organic compound (TOC) emission factor from AP-42, Table 11.1-8, for an oil-fired dryer. The asphalt plant is assumed to operate 1,200 hours per year.

$$\begin{aligned}
 EF_{\text{TOC}} &= 0.069 \text{ lb/ton asphalt produced} \\
 \text{Maximum asphalt production rate} &= 350 \text{ ton/hr} \\
 \text{TOC emissions} &= EF_{\text{TOC}} * \text{asphalt production rate} \\
 &= 0.069 * 350 \\
 &= 24.15 \text{ lb/hr} * 1 \text{ ton/2000 lb} * 1200 \text{ hr/yr} \\
 &= 14.5 \text{ ton/yr}
 \end{aligned}$$

Example 3.4-3

Example 3.4-3 shows how potential hourly xylene emissions may be calculated for a batch mix HMA plant with a natural gas-fired dryer based on a xylene emission factor from AP-42, Table 11.1-9. The HMA plant is assumed to operate 1,200 hours per year.

$$\begin{aligned}
 EF_{\text{xylene}} &= 0.0043 \text{ lb/ton asphalt produced} \\
 \text{Xylene emissions} &= EF_{\text{xylene}} * \text{maximum asphalt production rate} \\
 &= (0.0043 \text{ lb/ton}) * 350 \text{ ton/hr} \\
 &= 1.5 \text{ lb/hr} * 1 \text{ ton/2000 lb} * 1200 \text{ hr/yr} \\
 &= 0.9 \text{ ton/yr}
 \end{aligned}$$

The basic equation used in fuel analysis emission calculations is the following:

$$E_x = Q_f * \text{Pollutant concentration in fuel} * \left(\frac{MW_p}{MW_f} \right) \quad (3.4-4)$$

where:

E	=	emissions of pollutant x
Q_f	=	fuel use (lb/hr)
MW_p	=	Molecular weight of pollutant emitted (lb/lb-mole)
MW_f	=	Molecular weight of pollutant in fuel (lb/lb-mole)

For instance, SO₂ emissions from oil combustion can be calculated based on the concentration of sulfur in the oil. This approach assumes complete conversion of sulfur to SO₂. Therefore, for every pound of sulfur (MW = 32 g) burned, two pounds of SO₂ (MW = 64 g) are emitted. The application of this emission estimation technique is shown in Example 3.4-4.

Example 3.4-4

This example shows how SO₂ emissions can be calculated from oil combustion based on fuel analysis results and the fuel flow information, if available. The asphalt plant is assumed to operate 1,200 hours per year.

E_{SO₂} may be calculated using Equation 3.4-4.

Assume a given Q_f	=	5,000 lb/hr
Given percent weight sulfur (% S) in fuel	=	1.17

$$\begin{aligned}
 E_{SO_2} &= Q_f * \text{pollutant concentration in fuel} * (MW_p/MW_f) \\
 &= (5,000) * (1.17/100) * (64/32) \\
 &= 117 \text{ lb/hr} * \text{ton}/2000 \text{ lb} * 1,200 \text{ hr/yr} \\
 &= 70.2 \text{ ton/yr}
 \end{aligned}$$

5

ALTERNATIVE METHODS FOR ESTIMATING EMISSIONS

5.1 EMISSION CALCULATIONS USING CEMS DATA

To monitor SO₂, NO_x, THC, and CO emissions using a CEMS, a facility uses a pollutant concentration monitor, which measures concentration in parts per million by volume dry air (ppmvd). Note that a CEMS would not likely be used to monitor emissions for an extended period due to the unfavorable conditions at an HMA plant. Flow rates should be measured using a volumetric flow rate monitor. Flow rates estimated based on heat input using fuel factors may be inaccurate because these systems typically run with high excess air to remove the moisture out of the drum (Patterson, 1995). Emission rates (lb/hr) are then calculated by multiplying the stack gas concentrations by the stack gas flow rates.

Table 3.5-1 presents example CEMS data output averaged for three periods for a parallel flow drum mixer. The output includes pollutant concentrations in parts per million dry basis (ppmvd), diluent (O₂ or CO₂) concentrations in percent by volume dry basis (%v,d), and emission rates in pounds per hour (lb/hr). These data represent a "snapshot" of a drum mixer operation. While it is possible to determine total emissions of an individual pollutant over a given time period from these data assuming the CEM operates properly all year long, an accurate emission estimate can be made by summing the hourly emission estimates if the CEMS data are representative of typical operating conditions.

Although CEMS can report real-time hourly emissions automatically, it may be necessary to manually estimate annual emissions from hourly concentration data. This section describes how to calculate emissions from CEMS concentration data. The selected CEMS data should be representative of operating conditions. When possible, data collected over longer periods should be used. It is important to note that prior to using CEMS to estimate emissions, a protocol should be developed for collecting and averaging the data.

TABLE 3.5-1**EXAMPLE CEM OUTPUT AVERAGED FOR A PARALLEL FLOW DRUM MIXER FIRING WASTE FUEL OIL**

Period	O ₂ (%V)	Concentration (C) (ppmvd)				Stack Gas Flow Rate (Q) (dscfm)	Emission Rate (E) (lb/hr)				Asphalt Production Rate (A) (ton/hr)
		SO ₂	NO _x	CO	THC		SO ₂	NO _x	CO	THC	
0830-1039	10.3	150.9	142.9	42.9	554.2	18,061	27.15	25.71	3.38	24.93	287
1355-1606	10.1	144.0	145.7	41.8	582.9	17,975	25.78	26.09	3.27	26.09	290
1236-1503	11.8	123.0	112.7	128.4	515.1	18,760	22.99	21.06	10.50	24.06	267

Source: EPA, 1991b.

Hourly emissions can be based on concentration measurements as shown in Equation 3.5-1 and Example 3.5-1.

$$E_x = \frac{(C * MW * Q * 60)}{(V * 10^6)} \quad (3.5-1)$$

where:

E_x	=	hourly emissions in lb/hr of pollutant x
C	=	pollutant concentration in ppmvd
MW	=	molecular weight of the pollutant (lb/lb-mole)
Q	=	stack gas volumetric flow rate in dscfm
60	=	60 min/hr
V	=	volume occupied by one mole of ideal gas at standard temperature and pressure (385.5 ft ³ /lb-mole @ 68°F and 1 atm)

Actual emissions in tons per year can be calculated by multiplying the emission rate in lb/hr by the number of actual annual operating hours (OpHrs) as shown in Equation 3.5-2 and Example 3.5-1.

$$E_{tpy,x} = E_x * OpHrs/2000 \quad (3.5-2)$$

where:

$E_{tpy,x}$	=	annual emissions in ton/yr of pollutant x
E_x	=	hourly emissions in lb/hr of pollutant x
$OpHrs$	=	annual operating hours in hr/yr

Emissions in pounds of pollutant per ton of asphalt produced can be calculated by dividing the emission rate in lb/hr by the asphalt production in rate (ton/hr) during the same period (Equation 3.5-3) as shown below. It should be noted that the emission factor calculated below assumes that the selected period (i.e., hour) is representative of annual operating conditions and longer time periods should be used when available. Use of the calculation is shown in Example 3.5-1.

$$E_{tpy,x} = E_x/A \quad (3.5-3)$$

where:

$$\begin{aligned} E_{\text{tpy},x} &= \text{emissions of pollutant } x \text{ (lb/ton) per ton of asphalt produced} \\ E_x &= \text{hourly emissions in lb/hr of pollutant } x \\ A &= \text{asphalt production (ton/hr)} \end{aligned}$$

Example 3.5-1

This example shows how SO₂ emissions can be calculated using Equation 3.5-1 based on the average CEMS data for 8:30-10:39 shown in Table 3.5-1.

$$\begin{aligned} E_{\text{SO}_2} &= (C * MW * Q * 60)/(V * 10^6) \\ &= 150.9 * 64 * 18,061 * 60/(385.5 * 10^6) \\ &= 27.15 \text{ lb/hr} \end{aligned}$$

Emissions in ton/yr (based on a 1,200 hr/yr operating schedule) can then be calculated using Equation 3.5-2; however, based on the above period this estimate should be calculated from the average CEMS data for year using Equation 3.5-1:

$$\begin{aligned} E_{\text{tpy},\text{SO}_2} &= E_{\text{SO}_2} * \text{OpHrs}/2,000 \\ &= 27.15 * (1,200/2,000) \\ &= 16.29 \text{ ton/yr} \end{aligned}$$

Emissions, in terms of lb/ton asphalt produced, are calculated using Equation 3.5-3:

$$\begin{aligned} E_{\text{tpy},\text{SO}_2} &= E_{\text{SO}_2}/A \\ &= 9.46 * 10^{-2} \text{ lb SO}_2/\text{ton asphalt produced} \end{aligned}$$

5.2 PREDICTIVE EMISSION MONITORING

Emissions from the HMA process depend upon several variables, which are discussed in Section 3 of this chapter. For example, VOC process emissions for a given plant may vary with several parameters, including: the type of fuel burned; the relative quantities of asphalt constituents (e.g., RAP, crumb rubber, and emulsifiers); aggregate type and moisture content; the temperature of the asphalt constituents; the mixing zone temperature; and, fuel combustion rate. An example emissions monitoring that could be used to develop a PEM

protocol would need to account for the variability in these parameters and, consequently, may require a complex testing algorithm.

To develop this algorithm, correlation testing of the process variables could be conducted over a range of potential operating conditions using EPA Method 25 or Method 25A to measure THC emissions and EPA Method 6A or Method 6C to measure SO₂ emissions. Potential testing conditions covering several parameters are shown in Table 3.5-2. Based on the test data, a mathematical correlation can be developed which predicts emissions using these parameters. This method may be cost prohibitive for a single source.

TABLE 3.5-2**PREDICTIVE EMISSION MONITORING ANALYSIS^a**

Test Number	Temperature of Asphalt Constituents	Mixing Zone Temperature	Fuel Firing Rate
1	B	H	H
2	B	H	M
3	B	H	L
4	B	M	H
5	B	M	M
6	B	M	L
7	B	L	H
8	B	L	M
9	B	L	L

^a H = high.
M = medium.
L = low.
B = baseline.

6

QUALITY ASSURANCE/QUALITY CONTROL

The consistent use of standardized methods and procedures is essential in the compilation of reliable emission inventories. QA and QC of an inventory is accomplished through a set of procedures that ensure the quality and reliability of data collection and analysis. These procedures include the use of appropriate emission estimation techniques, applicable and reasonable assumptions, accuracy/logic checks of computer models, checks of calculations, and data reliability checks. Figure 3.6-1 provides an example checklist that could aid the inventory preparer at a HMA plant. Volume VI, *QA Procedures* of this series describes additional QA/QC methods and tools for performing these procedures.

Volume II, Chapter 1, *Introduction to Stationary Point Source Emission Inventory Development*, presents recommended standard procedures to follow that ensure the reported inventory data are complete and accurate. The QA/QC section of Chapter 1 should be consulted for current EIIP guidance for QA/QC checks for general procedures, recommended components of a QA plan, and recommended components for point source inventories. The QA plan discussion includes recommendations for data collection, analysis, handling, and reporting. The recommended QC procedures include checks for completeness, consistency, accuracy, and the use of approved standardized methods for emission calculations, where applicable. Chapter 1 also describes guidelines to follow in order to ensure the quality and validity of the data from manual and continuous emission monitoring methodologies used to estimate emissions.

6.1 CONSIDERATIONS FOR USING STACK TEST AND CEMS DATA

Data collected via CEMS, PEM, or stack tests must meet quality objectives. Stack test data must be reviewed to ensure that the test was conducted under normal operating conditions, or under maximum operating conditions in some states, and that it was generated according to an acceptable method for each pollutant of interest. Calculation and interpretation of accuracy for stack testing methods and CEMS are described in detail in *Quality Assurance Handbook for Air Pollution Measurements Systems: Volume III. Stationary Source Specific Methods (Interim Edition)*.

The acceptance criteria, limits, and values for each control parameter associated with manual sampling methods, such as dry gas meter calibration and leak rates, are summarized within the tabular format of the QA/QC section of Chapter 1. QC procedures for all instruments

Item	Y/N	Corrective Action (complete if "N"; describe, sign, and date)
1. Have the toxic emissions been calculated and reported using approved stack test methods or using the emission factors provided from AP-42, FIRE, and/or NAPA (National Asphalt Pavement Association)? Have asphalt production rates been included? Each facility should request from their state agency guidance on which test methods or emission factors should be used.		
2. Fugitive emissions are required for the inventory, but will not count towards a Title V determination unless the facility is NSPS affected. Presently, in the case of the asphalt plants, only particulate emissions for the process as defined in 40 CFR 60.90 are NSPS affected. Have fugitive emissions been calculated?		
3. If emission factors are used to calculate fuel usage emissions, have fuel usage rates been determined for the dryer and for the asphalt heater separately? If the AP-42 dryer emission factors are used, they already contain emissions from fuel combustion in the dryer.		
4. Again, request guidance from the state regulatory agency on whether or not to calculate toxic emissions from fuel usage. Most toxic emission factors usually are inclusive of the asphalt and the fuel. Has the state agency been contacted for guidance?		
5. Have stack parameters been provided for each stack or vent which emits criteria or toxic pollutants? This includes the fabric filter or scrubber installed on the asphalt dryer/mixer, the asphalt cement heaters, and any storage silos other than asphalt concrete storage.		

**FIGURE 3.6-1. EXAMPLE EMISSION INVENTORY DEVELOPMENT
CHECKLIST FOR ASPHALT PLANTS**

Item	Y/N	Corrective Action (complete if "N"; describe, sign, and date)
6. Check with the state regulatory agency to determine whether emissions should be calculated using AP-42 emission factors: <u>Dryer/Mix Type:</u> Rotary Dryer (Batch Mix): Conventional Plant (3-05-002-01) Drum (Mix) Dryer: Hot Asphalt Plant (3-05-002-05) <u>Diesel Generators:</u> Industrial diesel reciprocating (2-02-001-02) <u>Asphalt Heaters:</u> "In Process Fuel Use Factors" (Residual, 3-05-002-07; Distillate, 3-05-002-08; Natural Gas, 3-05-002-06; LPG, 3-05-002-09).		
7. Have you considered storage piles (3-05-002-03)(includes handling of piles) from both Batch and Drum Plants?		
8. If required by the state, has a site diagram been included with the emission inventory? This should be a detailed plant drawing showing the location of sources/stacks with ID numbers for all processes, control equipment, and exhaust points.		
9. Have examples of all calculations been included?		
10. Have all conversions and units been reviewed and checked for accuracy?		

FIGURE 3.6-1. (CONTINUED)

used to continuously collect emissions data are similar. The primary control check for precision of the continuous monitors is daily analysis of control standards. The CEMS acceptance criteria and control limits are listed within the tabular format of the QA/QC section of Chapter 1.

Quality assurance should be delineated in a Quality Assurance Plan (QAP) by the team conducting the test prior to each specific test. The main objective of any QA/QC effort for any program is to independently assess and document the precision, accuracy, and adequacy of emission data generated during sampling and analysis. It is essential that the emissions measurement program be performed by qualified personnel using proper test equipment. Also, valid test results require the use of appropriate and properly functioning test equipment and use of appropriate reference methods.

The QAP should be developed to assure that all testing and analytical data generated are scientifically valid, defensible, comparable, and of known and acceptable precision and accuracy. EPA guidance, is available for assistance in preparing any QAP (EPA, October, 1989).

6.2 CONSIDERATIONS FOR USING EMISSION FACTORS

The use of emission factors is straightforward when the relationship between process data and emissions is direct and relatively uncomplicated. When using emission factors, the user should be aware of the quality indicator associated with the value. Emission factors published within EPA documents and electronic tools have a quality rating applied to them. The lower the quality indicator, the more likely that a given emission factor may not be representative of the source type. When an emission factor for a specific source or category may not provide a reasonably adequate emission estimate, it is always better to rely on actual stack test or CEMS data, where available. The reliability and uncertainty of using emission factors as an emission estimation technique are discussed in detail in the QA/QC Section of Chapter 1.

6.3 DATA ATTRIBUTE RATING SYSTEM (DARS) SCORES

One measure of emission inventory data quality is the DARS score. Four examples are given here to illustrate DARS scoring using the preferred and alternative methods. The DARS provides a numerical ranking on a scale of 1 to 10 for individual attributes of the emission factor and the activity data. Each score is based on what is known about the factor and the activity data, such as the specificity to the source category and the measurement technique employed. The composite attribute score for the emissions estimate can be viewed as a statement of the confidence that can be placed in the data. For a complete discussion of DARS and other rating systems, see the *QA Source Document* (Volume VI, Chapter 4) and

the QA/QC Section within Volume II Chapter 1, *Introduction to Stationary Point Sources Emission Inventory Development*.

Each of the examples below is hypothetical. A range is given where appropriate to cover different situations. The scores are assumed to apply to annual emissions from an HMA plant. Table 3.6-1 gives a set of scores for an estimate based on CEMS/PEM data. A perfect score of 1.0 is achievable using this method if data quality is very good. Note that maximum scores of 1.0 are automatic for the source definition and spatial congruity attributes. Likewise, the temporal congruity attribute receives a 1.0 if data capture is greater than 90 percent; this assumes that data are sampled adequately throughout the year. The measurement attribute score of 1.0 assumes that the pollutants of interest were measured directly. A lower score is given if the emissions are speciated using a profile, or if the emissions are used as a surrogate for another pollutant. Also, the measurement/method score can be less than 1.0 if the relative accuracy is poor (e.g., >10 percent), if the data are biased, or if data capture is closer to 90 percent than to 100 percent.

The use of stack sample data can give DARS scores as high as those for CEMS/PEM data. However, the sample size is usually too low to be considered completely representative of the range of possible emissions making a score of 1.0 for measurement/method unlikely. A typical DARS score for stack sample data is generally closer to the low end of the range shown in Table 3.6-2.

Two examples are given for emissions calculated using emission factors. For both of these examples, the activity data is assumed to be measured directly or indirectly. Table 3.6-3 applies to an emission factor developed from CEMS/PEM data from one dryer or mixer and then applied to a different dryer or mixer of similar design and age. Table 3.6-4 gives an example for an estimate made with an AP-42 emission factor. The AP-42 factor is a mean and could overestimate or underestimate emissions for any single unit in the population. Thus, the confidence that can be placed in emissions estimated for a specific unit with a general AP-42 factor is lower than emissions based on source-specific data. This assumes that the source-specific data were developed while the HMA plant was operating under normal conditions. If it was not operated under normal conditions then the AP-42 emission factor may be a better characterization of the emissions from the HMA plant.

The example in Table 3.6-3 shows that emission factors based on high-quality data from a similar unit will typically give better results than a general factor. The main criterion affecting the score is how similar the unit used to generate the factor is to the target dryer or mixer.

If sufficient data are available, the uncertainty in the estimate should be quantified. If sufficient data are not available, a qualitative analysis of uncertainty is still recommended. Some methods and examples are described in *QA Procedures* (Volume VI, Chapter 3).

TABLE 3.6-1
DARS SCORES: CEMS/PEM DATA^a

Attribute	Emission Factor Score	Activity Data Score	Composite Scores		Comment
			Range	Midpoint	
Measurement/ method	0.9 - 1.0	0.9 - 1.0	0.81 - 1.0	0.91	Lower scores given if relative accuracy poor (e.g., >10 percent) or data capture closer to 90 percent.
Source definition	1.0	1.0	1.0 - 1.0	1.0	
Spatial congruity	1.0	1.0	1.0 - 1.0	1.0	
Temporal congruity	1.0	1.0	1.0 - 1.0	1.0	
Weighted Score	0.98 - 1.0	0.98 - 1.0	0.95 - 1.0	0.98	

^a Assumes data capture is 90 percent or better, representative of entire year, monitors sensors, and other equipment is properly maintained.

TABLE 3.6-2
DARS SCORES: STACK SAMPLE DATA^a

Attribute	Emission Factor Score	Activity Data Score	Composite Scores		Comment
			Range	Midpoint	
Measurement/method	0.7 - 1.0	0.7 - 1.0	0.49 - 1.0	0.745	
Source definition	1.0 - 1.0	1.0 - 1.0	1.0 - 1.0	1.0	
Spatial congruity	1.0 - 1.0	1.0 - 1.0	1.0 - 1.0	1.0	
Temporal congruity	0.7 - 1.0	0.7 - 1.0	0.49 - 1.0	0.745	Lower scores given if emissions vary temporally and sample does not cover range.
Weighted Score	0.85 - 1.0	0.85 - 1.0	0.75 - 1.0	0.878	

^a Assumes use of EPA Reference Method, high quality data.

TABLE 3.6-3**DARS SCORES: SOURCE-SPECIFIC EMISSION FACTOR^a**

Attribute	Emission Factor Score	Activity Data Score	Composite Scores		Comment
			Range	Midpoint	
Measurement/method	0.9 - 1.0	0.8 - 1.0	0.72 - 1.0	0.86	Factor score for this attribute depends entirely on data quality.
Source definition	0.5 - 0.9	0.8 - 0.9	0.4 - 0.81	0.61	Factor score lowest if unit differs much from original source of data.
Spatial congruity	1.0 - 1.0	1.0 - 1.0	1.0 - 1.0	1.0	
Temporal congruity	1.0 - 1.0	0.5 - 0.9	0.5 - 0.9	0.7	
Weighted Score	0.85 - 0.98	0.78 - 0.95	0.66 - 0.93	0.79	

^a Assumes factor developed from PEM or CEMS data from an identical emission unit (same manufacturer, model).

TABLE 3.6-4
DARS SCORES: AP-42 EMISSION FACTOR^a

Attribute	Emission Factor Score	Activity Data Score	Composite Scores		Comment
			Range	Midpoint	
Measurement/method	0.6 - 0.8	0.8 - 1.0	0.48 - 0.7	0.59	Score depends on quality and quantity of data points used to develop factor.
Source definition	0.5 - 0.9	0.8 - 0.9	0.4 - 0.81	0.605	Emission factor score will be low if variability in source population is high.
Spatial congruity	0.6 - 0.8	1.0 - 1.0	0.6 - 0.8	0.7	Factor score lower if geographic location has significant effect on emissions.
Temporal congruity	0.5 - 0.9	0.5 - 0.9	0.25 - 0.81	0.53	Lower scores given if emissions vary temporally and sample does not cover range.
Weighted Score	0.55 - 0.85	0.78 - 0.95	0.43 - 0.78	0.61	

^a Assumes activity data (e.g., fuel use) or surrogate is measured directly in some manner.

The reader should note that the presentation of the DARS scores here is shown as a hypothetical example, only. Although the highest DARS score results from the use of CEMS, this estimation technique will not practically be applied or used by the majority of facilities operating. Due to technical feasibility issues and costs incurred by applying CEMS to a HMA plant, stack testing or emission factors may provide the best choice when selecting an appropriate method for estimating emissions (even though stack testing or emission factors did not receive the highest DARS score). The reader should always contact their state regulatory agency for approval of selected methodologies or techniques. Also, it should be noted that this hypothetical application of DARS does not mandate any emission estimation method, but only offers the reader a means for selecting any one method over another.

DATA CODING PROCEDURES

This section describes the methods and codes available for characterizing emission sources at HMA facilities. Consistent categorization and coding will result in greater uniformity among inventories. The SCCs are the building blocks on which point source emissions data are structured. Each SCC represents a unique process or function within a source category that is logically associated with an emission point. Without an appropriate SCC, a process cannot be accurately identified for retrieval purposes. In addition, the procedures described here will assist the reader preparing data for input to the Aerometric Information Retrieval System (AIRS) or a similar database management system. For example, the use of the SCCs provided in Table 3.7-1 are recommended for describing HMA operations. Refer to the CHIEF bulletin board for a complete listing of SCCs for HMA plants. While the codes presented here are currently in use, they may change based on further refinement by the emission inventory user community. As part of the EIIP, a common emissions data exchange format is being developed to facilitate data transfer between industry, states, and EPA. Details on SCCs for specific emission sources are as follows:

- **Process Emissions:** For asphaltic concrete production processes, be careful to use only one SCC for each process. Use the codes for either the batch or continuous process or for the drum mix process, depending on which process is used. The process-specific codes should be used as often as possible; however, "Entire Unit" and "General" codes are available. If the "Entire Unit" code is used, do not use the chemical-specific or process-specific codes as this would double-count emissions. AP-42 emission factors for dryer emissions include all stack emissions (including products of combustion from the dryer burner).
- **In-Process Fuel:** In-process fuel includes SCCs for asphalt cement heaters. These emissions are separate and apart from dryer emissions.
- **Generators:** Diesel generators may be used at portable HMA plants to generate electricity. These emissions are not included in emission factors for process emissions.

- **Storage Tanks:** Storage tanks may be used in the asphaltic concrete production process to store fuel such as oil. Potential emissions from storage tanks will likely be insignificant. The codes in Table 3.7-1 are recommended to describe fuel storage emissions.
- **Fugitive Emissions:** Fugitive emissions from asphaltic concrete production result primarily from the storage and handling of raw materials and finished product. The miscellaneous codes may be used for fugitive emission sources without a unique code. Remember to use the comment section to describe the emissions.

Control device codes applicable to asphaltic concrete production are presented in Table 3.7-2. These should be used to enter the type of applicable emissions control device into the AIRS Facility Subsystem (AFS). The "099" control code may be used for miscellaneous control devices that do not have a unique identification code.

If there are significant sources of fugitive emissions within the facility, or sources that have not been specifically discussed thus far, they should be included in the emissions estimates if required by the state. Conditions vary from plant to plant, thus, each specific case cannot be discussed within the context of this document.

TABLE 3.7-1

**SOURCE CLASSIFICATION CODES FOR ASPHALTIC CONCRETE
PRODUCTION (SIC CODE 2951)**

Source Description	Process Description	SCC	Units
Process Emissions			
Batch or continuous mix process	Rotary dryer	3-05-002-01	Tons HMA produced
	Hot elevators, screens, bins, and mixer	3-05-002-02	Tons aggregate processed
Drum mix process	Drum mixer: hot asphalt plants	3-05-002-05	Tons HMA produced
General process	General process/specify in comments	3-05-002-99	Tons produced
	In-place recycling - propane	3-05-002-15	Tons produced
In-Process Fuel			
Asphalt heater fuel use	Residual oil	3-05-002-07	1000 gallons burned
	Distillate oil	3-05-002-08	1000 gallons burned
	Natural gas	3-05-002-06	Million ft ³ burned
	Waste oil	3-05-002-10	1000 gallons burned
	Liquid petroleum gas	3-05-002-09	1000 gallons burned
Generators			
Diesel	Reciprocating	2-02-001-02	Horsepower hours
Fugitive Emissions			
Fugitive emissions	Raw material storage piles	3-05-002-03	Tons aggregate processed
	Cold aggregate handling	3-05-002-04	Tons aggregate processed
	Storage silo	3-05-002-13	Tons HMA produced
	Truck load-out	3-05-002-14	Tons HMA loaded
	Miscellaneous fugitive emissions	3-05-888-01 to 05	Vehicle miles travelled
	Haul roads - general	3-05-002-90	Tons product

TABLE 3.7-2
AIRS CONTROL DEVICE CODES

Control Device	Code
Settling chamber: high-efficiency	004
Settling chamber: medium-efficiency	005
Settling chamber: low-efficiency	006
Single cyclone	075
Multiple cyclone	076
Centrifugal collector: high-efficiency	007
Centrifugal collector: medium-efficiency	008
Centrifugal collector: low-efficiency	009
Fabric filter: high temperature	016
Fabric filter: medium temperature	017
Fabric filter: low temperature	018
Wet fan	085
Spray tower	052
Venturi scrubber	053
Baffle spray tower	052
Miscellaneous control device	099

Source: EPA, January 1992.

8

REFERENCES

Code of Federal Regulations. July 1, 1987. Title 40, Part 60, Appendix A. Office of the Federal Register, Washington, DC.

EIIP. March 1995. *Preferred and Alternative Methods for Estimating Air Emissions from Boilers, Review Draft*. Emission Inventory Improvement Program, Point Sources Committee. Prepared under EPA Contract No. 68-D2-0160, Work Assignment No. 41. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina.

EPA. 1986. *Test Methods for Evaluating Solid Waste, Report No. SW-846, Third Edition*. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, DC.

EPA. April 1989. *Estimating Air Toxic Emissions from Coal and Oil Combustion Sources*. EPA-450/2-89-001. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina.

EPA. October 1989. *Preparing Perfect Project Plans*. EPA-600/9-89/087. U.S. Environmental Protection Agency, Risk Reduction Laboratory, Cincinnati, Ohio.

EPA. September 1991a. *Emission Testing for Asphalt Concrete Industry. Site Specific Test Plan and Quality Assurance Project Plan. Mathy Construction Company Plant 6*. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina.

EPA. September 1991b. *Asphalt Emission Test Report. Mathy Construction Company, LaCrosse, Wisconsin*. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina.

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

EPA. January 1992. *AIRS User's Guide, Volume XI: AFS Data Dictionary*. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina.

EPA. 1994. *Factor Information and Retrieval (FIRE) Data System, Version 4.0*. Updated Annually. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina.

EPA. January 1995a. *Compilation of Air Pollutant Emission Factors. Volume I: Stationary Point and Area Sources, Fifth Edition, AP-42. Section 11.1, Hot-Mix Asphalt Plants*. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina.

EPA. January 1995b. *Compilation of Air Pollutant Emission Factors. Volume I. Stationary Point and Area Sources, Fifth Edition, AP-42. Section 3.3-1, Stationary Internal Combustion Sources*. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina.

EPA. January 1995c. *Compilation of Air Pollutant Emission Factors. Volume I. Stationary Point and Area Sources, Fifth Edition, AP-42. Section 1.11, Waste Oil Combustion*. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina.

Fore, Gary, of National Asphalt Pavement Association, Lanham, Maryland.
Telecommunication with Robert Harrison, Radian Corporation. August 18, 1995.

Gunkel, Kathryn O'C. 1992. *Hot-Mix Asphalt Mixing Facilities*. Buonicore, Anthony J., and Wayne T. Davis, Editors. *Air Pollution Engineering Manual*. Van Nostrand Reinhold, New York, New York.

Khan, Z.S., and T.W. Hughes. November 1977. *Source Assessment: Asphalt Hot-Mix*. EPA-600/2-77-107n. U.S. Environmental Protection Agency, Industrial Environmental Research Laboratory, Cincinnati, Ohio.

National Asphalt Pavement Association (NAPA). February 1995. *Dealing with Title V Operating Permits: the Synthetic Minor Alternative*. Special Report 175. Lanham, Maryland.

Nevers, Noel. 1995. *Air Pollution Control Engineering*. McGraw-Hill, Incorporated.

Patterson, Ralph, of Wisconsin Department of Natural Resources. May 2, 1995a.
Memorandum to Theresa Kemmer Moody, Radian Corporation, *Comments on Preferred and Alternative Methods for Estimating Air Emissions from Hot-Mix Asphalt Plants.*

Patterson, Ralph, of Wisconsin Department of Natural Resources. June 16, 1995b.
Telecommunication with Robert Harrison, Radian Corporation.

Patterson, Ralph, of Wisconsin Department of Natural Resources. October 26, 1995c.
Memorandum to Theresa Kemmer Moody, Radian Corporation, *Comments on Preferred and Alternative Methods for Estimating Air Emissions from Hot-Mix Asphalt Plants.*

Stultz, Steven C., and John B. Kitto, Editors. 1992. *Steam, Its Generation and Use.* The Babcock and Wilcox Company.

Texas Natural Resource Conservation Commission, Office of Air Quality. January 1994.
Asphalt Concrete Plants: Emissions Calculations Instructions. Compiled by TNRCC Mechanical Section Engineers, Austin, Texas.

Wiese, Lynda, of Wisconsin Department of Natural Resources. June 15, 1995.
Memorandum to Theresa Kemmer Moody, Radian Corporation. *Comments on Preferred and Alternative Methods for Estimating Air Emissions from Hot-Mix Asphalt Plants.*

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APPENDIX A

EXAMPLE DATA COLLECTION FORM AND INSTRUCTIONS FOR HOT-MIX ASPHALT PLANTS

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EXAMPLE DATA COLLECTION FORM INSTRUCTIONS

1. This form may be used as a work sheet to aid the plant engineer in collecting the information necessary to calculate emissions from HMA plants. The information requested on the form relates to the methods (described in Sections 3 through 5) for quantifying emissions. This form may also be used by the regulatory agency to assist in area wide inventory preparation.
2. The completed forms should be maintained in a reference file by the plant engineer with other supporting documentation.
3. The information requested on these forms is needed to complete emission calculations. If the information requested does not apply to a particular dryer, mixer, or unit, write "NA" in the blank.
4. If you want to modify the form to better serve your needs, an electronic copy of the form may be obtained through the EIIP on the CHIEF bulletin board system (BBS).
5. If hourly or monthly fuel use information is not available, enter the information in another unit (quarterly or yearly). Be sure to indicate on the form what the unit of measure is.
6. Use the comments field on the form to record all useful information that will allow your work to be reviewed and reconstructed.

EXAMPLE DATA COLLECTION FORM - HOT-MIX ASPHALT PLANTS

GENERAL INFORMATION	
Facility/Plant Name:	
SIC Code:	
SCC:	
SCC Description:	
Location:	
County:	
City:	
State:	
Parent Company Address:	
Plant Geographical Coordinates (if portable, state so):	
Latitude:	
Longitude:	
UTM Zone:	
UTM Easting:	
UTM Northing:	
Contact Name:	
Title:	
Telephone Number:	
Source ID Number:	AIRS or FID?
Type of Plant (i.e., batch, drum):	
Permit Number:	
Permitted Hours of Operation (per year):	
Actual Hours of Operation (per year):	
Hours/Day:	
Days/Weeks:	
Weeks/Year:	

EXAMPLE DATA COLLECTION FORM - HOT-MIX ASPHALT PLANTS

COMBUSTION OPERATIONS				
ASPHALT CEMENT HEATERS:				
Unit ID No.:	Fuel A	Fuel B	Fuel C	Comments
Fuel Type:				
Year:				
Maximum Hourly Fuel Use (units):				
Total Annual Fuel Use (units):				
Maximum Capacity of Heater(s) (Million Btu/hr):				

Note: Complete this form for each type of fuel used and for each unit.

EXAMPLE DATA COLLECTION FORM - HOT-MIX ASPHALT PLANTS

COMBUSTION OPERATIONS				
DRYERS:				
Unit ID No.:	Fuel A	Fuel B	Fuel C	Comments
Fuel Type:				
Year:				
Composition (% sulfur)				
Composition (metals)				
Maximum Hourly Fuel Use (units):				
Monthly Fuel Use (units):				
January:				
February:				
March:				
April:				
May:				
June:				
July:				
August:				
September:				
October:				
November:				
December:				
Total Annual Fuel Use (units):				

EXAMPLE DATA COLLECTION FORM - HOT-MIX ASPHALT PLANTS

GENERATORS:				
Size: Horsepower or kilowatts:				
Unit ID:	Fuel A	Fuel B	Fuel C	Comments
Fuel Type:				
Year:				
Maximum Hourly Fuel Use (units):				
Total Annual Fuel Use (units):				
STACK/VENT INFORMATION				
Please fill out the following information for each stack/vent. Attach additional sheets as needed.				
STACK PARAMETER	STACK ID NUMBER	STACK ID NUMBER	STACK ID NUMBER	
Source(s) Vented:				
Latitude/Longitude:				
UTM Zone:				
UTM Easting:				
UTM Northing:				
Height (feet):				
Diameter (feet):				
Temperature (°F):				
Velocity (FPS):				
Flow Rate (ACFM):				
Stack/Vent Direction: (vert./horiz./fugitive)	(circle one) V H F	(circle one) V H F	(circle one) V H F	
Stk. Capped (yes/no):				

EXAMPLE DATA COLLECTION FORM - HOT-MIX ASPHALT PLANTS

PRODUCTION OPERATIONS			COMMENTS
Year:			
Asphalt Produced (tons):			
Maximum Design Capacity of Plants (tons/hr) (This should be standardized at 5% moisture):			
Liquid Asphaltic Cement Used (tons):			
Tons of RAP Processed:			
Tons of Mineral Filler Used from Silos:			
AIR POLLUTION CONTROL EQUIPMENT			
Please fill out the following information for each control device. Attach additional sheets as needed.			
Control Type	Location	Efficiency (%)	How calculated?
EXAMPLE: Fabric Filter	Dryer Exhaust	99	Vendor's specs

Note: Please copy blank form and attach additional sheets as needed.

EMISSION ESTIMATION RESULTS

Unit ID No.: _____

Pollutant	Emission Estimation Method ^a	Emission Factor Throughput	Emission Factor ^b	Emissions Factor Units	Annual Emissions	Emission Units	Comments
VOC							
NO _x							
CO							
SO ₂							
PM ₁₀							
Total Particulate							
Hazardous Air Pollutants (list individually)							

^a Use the following codes to indicate which emission estimation method is used for each pollutant:

CEMS/PEM = CEM/PEM

Emission Factor = EF

Stack Test Data = ST

Other (indicate) = O

Fuel Analysis = FA

^b Where applicable, enter the emission factor and provide the full citation of the reference or source of information from where the emission factor came. Include edition, version, table, and page numbers if AP-42 is used.

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