Sec. 11.1
Ref. 2

# Hot Mix Asphalt Mixing Facilities

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## INTRODUCTION

Hot Mix Asphalt (HMA) paving material is a scientifically proportioned mixture of graded aggregates and asphalt cement. The aggregates; which includes stone, sand, and mineral dust, and can include Reclaimed Asphalt Pavement (RAP); make up about 92% to 96% of the total mixture by weight. In addition to serving as paving materials for roadways, parking lots, race tracks, etc., HMA can also serve as liners for reservoirs, landfills, and for other containment purposes. It is a unique paving material in that when it is removed from the roadway, parking lot, etc., it can be recycled back into new HMA paving materials, providing a pavement as good as one produced from all virgin materials.

The process of producing of HMA involves drying and heating the aggregates to prepare them for the asphalt cement coating. The asphalt cement is typically stored at 300°F. There are two types of drying and heating methods available, both of which use a direct-fired, rotating drum. One method is counter-flow drying, whereby the aggregates move opposite the flow of the exhaust gases. This is the drying process used in the original process equipment and in recent design modifications to the drum mix process. The other drying process employed is parallel-flow, where the aggregates and exhaust gas move through the drum in the same direction.

There are two ways to coat the aggregates with asphalt cement. The original method is, which still predominates, to perform the coating in batches. A development in the mid-1970's introduced the asphalt cement into the lower end of the rotating drum of the parallel-flow drying process. This method of coating is called drum mixing. Recent design modifications now allow drum mixing to be performed with the counter-flow drying process.

## PROCESS DESCRIPTION

The aggregates are dried in a rotating, slightly inclined, direct-fired drum. They are introduced into the end of the drum at the top of the incline. The interior of the drum is equipped with flights which are shaped pieces of iron ("Iron" is a term typically used to refer to the equipment materials of fabrication, even though the drum and its interior are typically fabricated with mild steel) that carry the aggregates up through the rotation of the drum while allowing them to shower through the hot exhaust gas. This process is called veiling. The design and installation of the flights have the most significant impact on the drying efficiency of the equipment. Dwell time; which is effected by the slope of the drum, its rotational speed, and also the flight design; is the second most important factor affecting drying efficiency. After drying the aggregates are heated typically to temperatures ranging from 275°F to 325°F prior to coating with asphalt cement. The temperature of the aggregates is extremely important relative to bonding of the asphalt cement.

### PRODUCING HMA RECYCLE MIXES

When RAP is used to produce recycle mixes, it must depend primarily on conductive heat transfer from the aggregates to reach temperature because it is difficult to process RAP through the combustion and heating zones. RAP in the presence of very hot gases can smoke, and the asphalt cement that is part of the RAP is likely degraded to the point of impacting the quality of the final product. The amount of RAP used in a recycle mix can range up to 50% by weight. The existing process methods limit the amount of RAP that can be used because of the dependence on conductive heat transfer. The virgin aggregates must be "superheated," that is, heated beyond the desired mix temperature to provide the heat required by the RAP. Therefore, the total amount of virgin aggregates fed to the process can be reduced only so much before there is not enough aggregate, regardless of temperature, to provide sufficient heat for the RAP to reach temperature.

## THE BATCH MIXING PROCESS

In the batch mixing process (Figure 1), the aggregates will leave the drum at about 20°F to 25°F higher than the desired mix temperature as measured in the transport vehicle. The exhaust gas temperature at its exit point should be lower than the aggregate temperature at its exit point. In terms of heat transfer and fuel efficiencies the lowest possible exhaust gas temperature is desired. However, the type of particulate control equipment used will dictate how low the exhaust gas temperature can be (if a baghouse is used, exhaust gas temperatures at or near the dew point of the gas can result in condensation of moisture in the baghouse). The aggregates are carried to the top of the mixing tower in an elevator, typically referred to as the "Hot Elevator." At the top of the mixing tower is a set of screens that vibrate to classify the dried aggregates into the various sizes. Each screen transfers the aggregate it collects to a separate storage bin immediately below the screen deck. The effective diameter in the screen cloths decreases with each screen, from the top screen to the bottom screen.

The storage bins in the mixing tower, typically called hot bins, are insulated and/or heated. The individual sizes of aggregate are transferred from the hot bins to a weigh bucket in the proportions specified by the customer. From the weigh bucket, the aggregates are dropped into the mixing chamber, called the pugmill, which is equipped with two mixing shafts. The aggregates are "dry-mixed" for a few seconds to distribute the various sizes uniformly throughout the pugmill before the asphalt cement is added. Meanwhile, the asphalt cement is transferred to its weigh bucket, prior to adding it to the mixed aggregate. "Wet-mixing", where the aggregates and asphalt cement are combined, takes place for a few seconds more in the pugmill. The combined dry and wet mixing time will rarely exceed 42 seconds.

When recycling is performed in the batch mixing process, the RAP is added to the hot aggregates <u>after</u> it has left the drum, either in the boot of the hot elevator or directly into the pugmill. This can result in a significant fugitive emission problem if the fugitive dust air handling system on the mixing tower has not been properly modified. The problem is 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) aggregates in the pugmill. In recent years, one equipment manufacturer has developed process equipment to preheat the RAP prior to introduction to the pugmill which eliminates the release of steam. The maximum amount of RAP generally recommended when recycling in the batch mixing process is about 20% to 25% by weight of the total mix. If higher amounts of RAP are going to be used on a regular basis, it is usually necessary to go to one of the drum mixing processes.

**FIGURE 1. THE BATCH MIX PROCESS FACILITY**

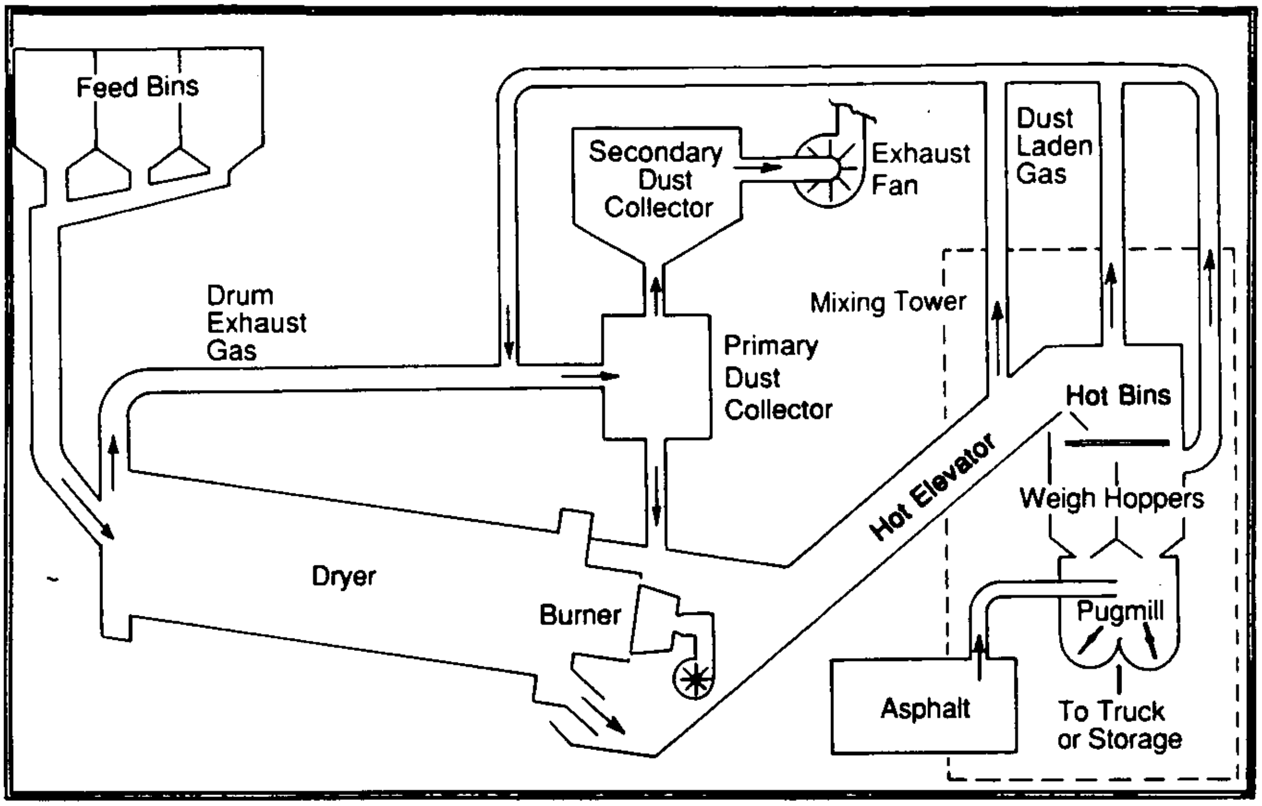
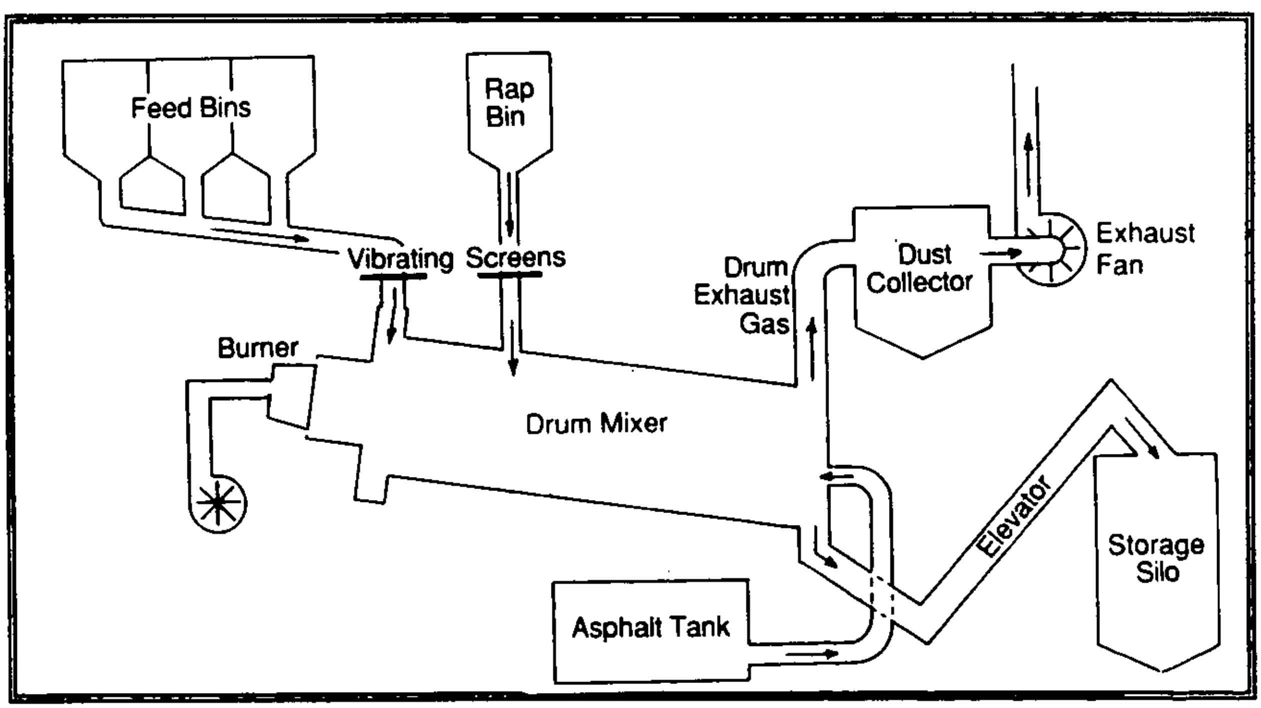



**FIGURE 2. THE PARALLEL-FLOW DRUM MIX PROCESS**



THE PARALLEL-FLOW DRUM MIXING PROCESS

In this process (Figure 2), the aggregates are proportioned through a cold feed system prior to introduction to the drying process. The asphalt cement is introduced into the drum in approximately the lower third of the drum. The aggregates are coated with asphalt cement as they veil to the end of the drum. The mix is discharged at a little more than the desired mix temperature as measured in the transport vehicle. RAP is introduced at some point along the length of the drum, generally as far away from the combustion zone as possible, but with enough drum length remaining to adequately dry and heat the material prior to reaching the coating zone. The amount of virgin aggregates and virgin asphalt cement fed to the process are adjusted according to the amount of RAP used and the condition of the asphalt cement in the RAP relative to the specified mix design being produced.

THE COUNTER-FLOW DRUM MIXING PROCESS

The aggregates are proportioned through a cold feed system prior to introduction to the drying process. After drying and heating take place the aggregates are transferred to a chamber which is part of the drum, and which is not exposed to the exhaust gas, to be coated with the asphalt cement. There are a couple of different, distinct designs to accomplish this. The purpose being to prevent stripping of the asphalt cement by the exhaust gas and the resulting emissions and odors.

When recycle mixes are produced in a counter-flow drum mixing process, the RAP is introduced, usually, into the coating chamber. However, this limits the percentage of RAP that can be incorporated into a recycle mix, as compared to recycling in the parallel-flow drum mixer. In the event higher percentages of RAP are required, some designs introduce the additional RAP into the heating section of the drum to utilize the heat available from the exhaust gas.

BURNERS FOR HMA MIXING FACILITIES

There are two types of burners relative to the introduction of combustion air into the process and two types relative to the use of combustion chambers. In combination with each other there are four types of burner systems that can be found at HMA facilities, which can have a direct impact on the formation of gaseous emissions from combustion. The burners can be designed to handle just about any type of fuel--natural gas, light fuel oils, liquified petroleum gas, heavy fuel oils, waste fuel oils, and coal.

The original type of burner design, and the most prevalent, is generally referred to as a 70/30 burner, or induced draft burner, by the HMA Industry. It means that 70% of the total combustion air required (stoichiometric and excess air) is induced into the system around the burner by the exhaust fan, and 30% of the combustion air is introduced into the system through the burner and used for atomization purposes. While they are generally called 70/30 burners, the actual ratio could be 65/35, 60/40, 55/45, etc. Frequently, these burners are the targets of noise complaints and are enclosed with sound attenuators.

The other type of burner is called a 100% air burner or forced draft burner. One hundred percent of the combustion air passes (or is forced) through the burner into the system. This type of burner is an inherently quieter burner than the induced draft burner. Additionally, it is usually more fuel efficient under proper operating and maintenance conditions.

Originally, burners were designed and installed with refractory-lined combustion chambers. However, burners today are generally designed and installed without these chambers. When a chamberless burner replaces one equipped with a combustion chamber on an existing HMA facility, it is essential that flighting at the burner end of the drum be installed to prevent aggregates from interfering with the flame, thereby maximizing combustion efficiency. Drum length is an essential design factor in parallel-flow drum mixers because of the need to provide a properly sized combustion zone, a drying and heating zone, and a coating section.

## AIR EMISSIONS CHARACTERIZATION

### PROCESS PARTICULATE EMISSIONS

The air pollutant resulting from this process that has been of primary concern and is regulated with a USEPA New Source Performance Standard (NSPS) is particulate matter. The NSPS for HMA facilities prohibits emissions of particulate in excess of 0.04 grains per dry standard cubic foot of exhaust gas (gr/DSCF). It also restricts visible emissions to less than 20% opacity.

### FUGITIVE PARTICULATE EMISSIONS

Fugitive emissions can be a problem at the site of an HMA mixing facility, but can be controlled. There are several potential sources of fugitive emissions--unpaved driving surfaces, aggregate stock piles, and, in the case of a batch mixing facility, the mixing tower. On batch mixing facilities that were constructed as NSPS facilities, the mixing tower is generally controlled with an auxiliary air handling system that discharges to the main particulate control system, or to a separate particulate control system. The former setup is the type most commonly found.

The most frequent sources of particulate fugitive emissions at the site of an HMA facility are unpaved driving surfaces. In years past, it has been common to maintain unpaved driving surfaces primarily by utilizing wet down techniques when the dust stirred up by vehicular traffic became excessive. In recent years, there has been a trend toward paving the driving surfaces to eliminate this problem.

Fugitive emissions from the aggregate stock piles may be a problem in strong winds. Crusting agents have served fairly well to mitigate this problem. Watering the stock piles is not used, because of the burden it puts on the process that is designed to remove moisture from the aggregates. It is rare that fugitive emissions exceed visible emission limits set by some states for fugitive particulate emissions.

## GASEOUS EMISSIONS

Because combustion is utilized in the process it is not unreasonable to expect gaseous air pollutant emissions. The possible pollutants are carbon monoxide, hydrocarbons as unburned fuel, oxides of nitrogen, and if sulfur is present in the fuel, oxides of sulfur. Unfortunately, since there has not been much emphasis on documenting and quantifying gaseous emissions from the HMA mixing process, little data exists in the public domain relative to these emissions. There has been some attempt on the part of the equipment manufacturers to identify the source or cause of these emissions. As a result, some equipment manufacturers have, or are currently doing so, modified or developed equipment designed to minimize the cause of most of these gaseous pollutants.

### Oxides of sulfur emissions

A study conducted by E.I. du Pont de Nemours & Co., Inc.[1] (Forsten, date unknown) in assessing gas stream compositions relative to baghouse fabric choices found that there was up to a 50% reduction of sulfur in the stack gases compared to the amount anticipated on the basis of fuel analyses. It has been believed within the HMA industry that the aggregates adsorb the sulfur compounds from the exhaust gas, and that the higher the lime content of the aggregate, the better the removal of sulfur compounds that is effected.

### Carbon Monoxide and Hydrocarbons (Unburned Fuel)

Carbon monoxide and hydrocarbons can result primarily for one reason. If the burner is of the type that does not utilize a refractory combustion chamber, but instead uses the end of the drum to which it is connected, improper flighting in the first few feet of the drum that allows aggregates to veil through the flame causes quenching. A secondary cause of these gaseous pollutants may be excess air entering the combustion process, particularly in the case of an induced draft burner. In addition, the moisture content of the aggregate may contribute to the formation of carbon monoxide and unburned fuel emissions.

A two-year study conducted by the HMA industry in New Jersey in cooperation with the New Jersey Department of Environmental Protection (NJDEP) found that these design elements appear to be crucial to the control of carbon monoxide formation and minimization of unburned fuel emissions. In general, HMA facilities with proper combustion zone design and/or air handling equipment had relatively low concentrations of carbon monoxide and hydrocarbons. Facilities that had high concentrations of these two pollutants in the first year were modified for the second year of stack sampling and exhibited reductions from 37% to 71% from the first year results. Table 1 lists the results of this stack sampling program.[2] This study was but a small sampling of HMA facilities relative to fuels burned, equipment configuration, aggregate conditions, process temperatures and other operating parameters, process rates with respect to the rated process capacity, mix design, etc. Therefore, these data cannot be considered conclusive at this point in time.

USEPA conducted a study of VOC emissions from parallel-flow drum mixers and published the results in 1981 (EPA-600/2-81-026) using Reference Method (RM) 25. The results of this study are not discussed here because since that time USEPA has determined that when the product of the concentration of moisture as measured

**TABLE 1. CARBON MONOXIDE AND HYDROCARBON EMISSIONS RESULTS FROM NEW JERSEY STACK SAMPLING PROGRAM**

| Sample No. | CO (ppm) | CO (#/hr) | THC (ppm) | THC (#/hr) |
|---|---|---|---|---|
| FACILITY 1 | | | | (drum mixer) |
| WM-1/87 | 3,265 | 324.2 | 158 | 9.0 |
| WM-2/87 | 2,401 | 235.1 | 227 | 12.7 |
| WM-3/87 | 2,651 | 272.1 | 705 | 41.5 |
| Avg. 1987 | 2,772 | 277.2 | 363 | 21.1 |
| WM-1/88 | 76 | 8.2 | 114 | 7.1 |
| WM-2/88 | 62 | 6.2 | 165 | 9.4 |
| WM-3/88 | 59 | 6.2 | 91 | 5.6 |
| WM-4/88 | 57 | 5.7 | 142 | 8.1 |
| WM-5/88 | 64 | 5.9 | 68 | 3.6 |
| Avg. 1988 | 63 | 6.5 | 116 | 6.8 |
| Avg. 1988[1] | 61 | 6.1 | 116 | 6.9 |
| % CHANGE | -97.7% | -97.7% | -68.1% | -67.8% |
| % CHANGE[2] | -97.8% | -97.8% | -68.2% | -67.3% |
| FACILITY 2 | | | | (batch mixer) |
| RL-1/87 | 3,287 | 313.8 | 358 | 19.6 |
| RL-2/87 | 938 | 115.0 | 195 | 13.7 |
| RL-3/87 | 2,973 | 261.3 | 257 | 12.9 |
| Avg. 1987 | 2,399 | 230.0 | 270 | 15.4 |
| RL-1/88 | 2,427 | 318.4 | 147 | 11.0 |
| RL-2/88 | 636 | 59.6 | 90 | 4.8 |
| RL-3/88 | 3,469 | 705.5 | 470 | 54.7 |
| RL-4/88 | 69 | 7.2 | 67 | 4.0 |
| RL-5/88 | 45 | 5.9 | 58 | 4.4 |
| RL-6/88 | 178 | 18.7 | 82 | 4.9 |
| Avg. 1988 | 1,137 | 185.9 | 152 | 14.0 |
| Avg. 1988[1] | 827 | 100.7 | 97 | 6.2 |
| % CHANGE | -52.6% | -19.2% | -43.6% | -9.2% |
| % CHANGE[2] | -65.5% | -56.2% | -64.3% | -59.7% |

| Sample No. | CO (ppm) | CO (#/hr) | THC (ppm) | THC (#/hr) |
|---|---|---|---|---|
| **Table 1 (continued)** | | | | |
| FACILTY 3 | | | | (batch mixer) |
| WE-1/87 | 170 | 24.2 | 19 | 1.5 |
| WE-2/87 | 114 | 15.7 | 13 | 1.0 |
| WE-3/87 | 169 | 24.5 | 9 | 0.7 |
| Avg. 1987 | 151 | 21.5 | 14 | 1.1 |
| WE-1/88 | 51 | 6.1 | 19 | 1.3 |
| WE-2/88 | 66 | 15.3 | 0 | 0.0 |
| WE-3/88 | 27 | 4.3 | 5 | 0.5 |
| Avg. 1988 | 48 | 8.6 | 8 | 0.6 |
| % CHANGE | -68.3% | -60.0% | -41.5% | -46.5% |
| AVERAGE OF 1987 SAMPLES | 1,776 | 176.2 | 216 | 12.5 |
| AVERAGE OF 1988 SAMPLES | 520 | 83.8 | 108 | 7.8 |
| AVERAGE ALL SAMPLES | 1,011 | 120.0 | 150 | 9.7 |
| % CHANGE FROM 1987 TO 1988 | -70.7% | -52.4% | -50.0% | -37.6% |

in the stack gas multiplied by the concentration of carbon dioxide as measured in the stack gas is 100 or greater, a positive bias in the results occurs. Since it is rare that the stack gas moisture content and carbon dioxide content product is less than 100 in the stack gas of a typical HMA mixing process, except under conditions of excessive dilution which is frequently due to air leaks into the system, the results of EPA-600/2-81-026 could be considered questionable. USEPA conducted side-by-side testing of RM 25 and a modification of the method that was expected to eliminate the bias with the New Jersey stack sampling program in 1987. The results indicated that the modification did not work.

Process Hydrocarbon Emissions

When asphalt cement is heated fumes are released. Additionally, the industry has determined that light ends stripped from the asphalt cement by the exhaust gas can be an air pollution problem, primarily as a visible emission. The emission occurs as a detached plume that is blue to grayish white in color. The extent to which the visible emission occurs is directly impacted by process temperatures--the higher the exhaust gas temperature, the worse the visible emission is. In recent years, equipment manufacturers have developed equipment modifications that minimize this problem. Odor is another emission problem from this process and is traced directly to contact between the exhaust gas and the asphalt cement.

There has been concern that the introduction of RAP into the drum in contact with the exhaust gas contributes to the visible emissions, and possibly the odors. Under adverse operating conditions, these concerns are valid. However, it has not been confirmed that RAP contributes to these visible emissions under well-controlled operating conditions in a properly designed HMA mixing facility.

The State of Maryland Air Management Administration conducted a study to determine whether these light ends stripped from the asphalt cement were entirely volatile organic compound (VOC) emissions, and if not, to what extent were the emissions VOCs[3]. The results of the study indicated that only a small percentage by weight of the hydrocarbon emissions were VOCs. These results were presented at the 78$^{th}$ Annual Meeting of the Air Pollution Control Association in June 1975. The VOC emission factors that were developed from this study are listed in Table 2, and are based on asphalt cement consumption, as opposed to product production.

Fugitive Hydrocarbon Emissions

The potential sources of fugitive hydrocarbon emissions are the vents in HMA storage silos, the vents in asphalt cement storage tanks, and the transport vehicle loading area. To what extent these emissions contain VOCs has not be determined. However, given the means by which asphalt is derived, it is unlikely that there are any significant levels of VOCs in these fugitive emissions. The fugitive emissions from storage silos and the loading area can frequently occur as visible emissions. The fugitive emissions from asphalt cement storage generally occur during charging of the tank with asphalt cement, and may occur as visible emissions.

AP-42 Emission Factors

USEPA's Compilation of Air Pollution Emission Factors (AP-42) provides emission factors for various gaseous pollutants. Unfortunately, the emission data come from stack sampling at only one HMA facility, and AP-42 gives the factors the lowest confidence rating possible. The HMA Industry, through its national organization, the National Asphalt Pavement Association (NAPA), is developing a program to gather and evaluate existing, unpublished data for gaseous air pollutant emissions resulting from stack sampling of HMA facilities. NAPA is also organizing a stack sampling program, working with USEPA, to gather the necessary data required to develop new emission factors for gaseous air pollutant emissions from the HMA mixing process. The emission factors provided in AP-42 are listed in Table 3.

TOXIC AIR POLLUTION EMISSIONS

Toxic emissions resulting from the process of a HMA mixing facility have not been fully studied under various conditions. Since toxic air pollutants continue to be an issue, primarily with communities around HMA facility operations; and, since a large proportion of states have enacted or proposed regulations governing emissions of toxic air pollutants; and since the Clean Air Act Amendments of 1990 address them (as Hazardous Air

Pollutants (HAPs)), NAPA has included in the protocol of its stack sampling program sampling requirements for possible toxic air pollutants.

**TABLE 2. VOC EMISSION FACTORS DEVELOPED BY MARYLAND STUDY**

| SAMPLE NO. | Pounds VOC/ton liquid asphalt | | | |
|---|---|---|---|---|
| | **Plant A** | **Plant B** | **Plant C** | **Plant D** |
| MM-5-1 | 0.658 | 0.232 | 0.259 | 0.309 |
| MM-5-2 | 1.279 | 0.258 | 0.278 | 0.151 |
| AVG. | 0.969 | 0.245 | 0.269 | 0.230 |
| V-1-1 | 0.417 | 0.381 | 0.188 | 0.818 |
| V-1-2 | 0.209 | 0.228 | 0.286 | 0.943 |
| V-1-3 | 0.228 | 0.257 | 0.305 | 0.818 |
| AVG. | 0.283 | 0.289 | 0.260 | 0.860 |
| V-2-1 | 0.188 | 0.193 | 0.313 | 0.485 |
| V-2-2 | 1.072 | 0.224 | 0.261 | 0.581 |
| V-2-3 | 0.444 | 0.295 | 0.583 | 0.680 |
| AVG. | 0.568 | 0.237 | 0.386 | 0.561 |
| Air Pollution Control Equipment Type | Baghouse | Low pressure Venturi | Low pressure Venuri | Baghouse |

Comments:

1. Average of factors (using 5% of MM-5 results): 0.604 lb. VOCs/ton asphalt cement
2. MM-5 refers to Modified Method 5 sampling method. Mass spectrophotometry was used to analyze the sample. It was estimated that approximately 5%, by weight, of the MM-5 sample was comprised C-9 to C-13 chains which are VOCs, according to USEPA's vapor pressure definition for VOCs.
3. V-x-x refers to the Volatile Organic Sampling Train (VOST) sampling method, which appeared to capture up to C-9 chains. These samples were also analyzed by mass spectrophotometry.

## AIR POLLUTION CONTROL MEASURES

### PARTICULATE CONTROL EQUIPMENT

Two types of control equipment are used for control of particulate emissions from the HMA mixing process. The most common, and most prevalent in most states, is the baghouse. The baghouse is essentially a dry scrubber used to remove particulate entrained in the exhaust gas of the process prior to discharge into the environment. Some manufacturers of the parallel-flow drum mixing process, where asphalt cement is in

**TABLE 3. EMISSION FACTORS FOR SELECTED GASEOUS POLLUTANTS FROM A CONVENTIONAL ASPHALTIC CONCRETE PLANT STACK**

(reprinted from USEPA's Compilation of Air Pollution Emission Factors (AP-42), Section 8.1--Asphaltic Concrete Plants, October 1986 edition, Table 8.1-5.)

| Material emitted | Emission Factor Rating | Emission Factor | |
|---|---|---|---|
| | | g/Mg | lb/ton |
| Sulfur oxides (as $SO_2$) | C | 146 x S | 0.292 x S |
| Nitrogen oxides (as $NO_2$) | D | 18.0 | 0.036 |
| Volatile organic compounds | D | 14.0 | 0.028 |
| Carbon monoxide | D | 19.0 | 0.038 |
| Polycyclic organic material | D | 0.013 | 0.000026 |
| Aldehydes | D | 10.0 | 0.02 |
| Formaldehyde | D | 0.075 | 0.00015 |
| 2-Methylpropanal (isobutyraldehyde) | D | 0.65 | 0.0013 |
| 1-Butanal (n-butyraldehyde) | D | 1.2 | 0.0024 |
| 3-Methylbutanal (isovaleraldehyde) | D | 8.0 | 0.016 |

S = sulfur content of fuel by weight

hydrocarbons ≙ VOC ?

?

contact with the exhaust gas, claim that a reduced dust loading into the control equipment results from impingement of fines entrained in the exhaust gas into the asphalt cement, thereby allowing a higher air-to-cloth ratio in the baghouse for these processes. Condensation of hydrocarbons on the baghouses is always a possibility and poses a serious fire hazards. For the most part, the industry has learned to operate this equipment to minimize this hazard, and the number of fires and explosions occurring at these operations has decreased significantly over the last 10 years.

The other type of particulate control equipment is the venturi wet scrubber. It is not uncommon to find wet scrubbers that are not venturi in design, but these types are usually found on HMA mixing facilities that are not covered by the NSPS for HMA facilities. Generally, a high pressure (20 inches, water gauge) venturi scrubber is required to meet the NSPS requirements. In addition to controlling particulate emissions, the venturi scrubber is likely to remove some of the process hydrocarbon emissions from the exhaust gas before discharge into the environment. Because of the high power requirements and water discharge permitting issues, and also as a result of pressure exerted by some state air quality agencies, the wet scrubber is not as frequently installed on HMA facilities.

The baghouse has proven to be very reliable relative to meeting the NSPS requirements for particulate loading of the exhaust gas discharged to the environment. The high pressure venturi scrubber is also reliable, but it requires considerable attention and daily and weekly maintenance to maintain a high degree of particulate removal efficiency.

## GASEOUS AND TOXIC AIR POLLUTION CONTROL MEASURES

Since no pressure has been exerted on the HMA industry relative to the control of gaseous and/or toxic air pollutant emissions, add-on air pollution control equipment has not been evaluated for this process. However, the results of the New Jersey stack testing program for carbon monoxide and hydrocarbons indicate that operating management practices and proper process equipment design can significantly reduce the release of these two gaseous air pollutants into the environment.

## KEY WORDS LIST

Hot mix asphalt
- asphaltic concrete
- asphalt concrete
- bituminous concrete
- blacktop
- asphalt pavement
- asphalt cement

Process
- particulate emissions
- drum mixer
- batching plant

Emission Source
- volatile organic compounds
- carbon monoxide
- particulate matter

**AP42 Section:** 11.1

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**Title:** Written communication from R. Gary Fore,
National Asphalt Pavement Association, Lanham,
MD, to Ronald Myers, U. S. Environmental Protection Agency,
Research Triangle Park, NC,

June 1, 1994.

AP-42 Section 11.1
REFERENCE 3

# NAPA

**NATIONAL ASPHALT PAVEMENT ASSOCIATION**

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Mike Acott, President

June 1, 1994

Mr. Ronald E. Meyers
Emission Inventory Branch
United States Environmental Protection Agency
Research Triangle Park, North Carolina 27711

Dear Ron:

NAPA's Emission Testing Task Force met on May 18, 1994 to consider EPA's 3/11/94 Draft AP-42, Section 8.1 document. This task force is made up of ten Hot Mix Asphalt (HMA) Industry professionals including major plant manufacturers, HMA contractors, and environmental engineers.

The NAPA task force members were virtually unanimous in concluding that a rewrite of sections 8.1.1 and 8.1.2 (including referenced figures 8.1-1 and 8.1-2) would assist in clarifying today's plant design, configuration, and operating characteristics. This is particularly important, we feel, because the technology has been a constantly evolving process over the past several years as the Industry has strived to reduce emissions and comply with applicable regulations. Clarity in process understanding should assist in the most appropriate application of available emission factors.

Please note that our task force has not proposed specific changes to the emission factors tables as they are currently drafted. We do feel, however, that it would be desirable to add a supplementary table (prior to final publishing) which distinguishes Parallel Flow Drum Mix data from Counterflow Drum Mix data since the two designs are remarkably different. Should this recommendation be accepted, NAPA would be glad to assist you with suggested format and data.

Also please note that line diagram figures have been redrawn to reflect today's plant layout and configuration. In addition, Figure 8.1-3 has been added to make the distinction between Parallel Flow Drum Mix Plants and Counterflow Drum Mix Plants. The redrafted text addresses each design in order and by reference to the appropriate plant layout figure.

Ron, NAPA's mission is to be helpful and to assist your organization in providing a high quality, credible document for public use. Please advise regarding how we can best assist your organization in the completion of this AP-42 update.

Thanks for your consideration.

Sincerely,

Gary

R. Gary Fore
Director of Regulatory Affairs

Enclosures

DRAFT
2852/460101
3/11/94

# 5.0 DRAFT AP-42 SECTION 8.1

## 8.1 HOT MIX ASPHALT PRODUCTION

### 8.1.1 General [1,2,23,42]

Hot Mix Asphalt (HMA) paving materials are a mixture of well graded, high quality aggregate (which can include Reclaimed 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% by weight of the total mixture. Aside from the amount and grade of asphalt cement used, mix characteristics are determined by the relative amounts and types of aggregate and RAP used. A certain percentage of fine aggregate (less than 74 micrometers (µm) in physical diameter) is required for the production of good quality HMA.

HMA paving materials can be manufactured by: 1) Batch Mix Plants, 2) Continuous Mix (mix outside drum) Plants, 3) Parallel Flow Drum Mix Plants, and 4) Counterflow Drum Mix Plants. This order of listing generally reflects the chronological order of development and use within the HMA Industry.

There are approximately 3,600 active asphalt plants in the United States. Of these, approximately 2,300 are Batch Plants, 1,000 are Parallel Flow Drum Mix Plants, and 300 are Counterflow Drum Mix Plants. About 85% of plants being manufactured today are of the Counterflow Drum Mix design, while Batch Plants and Parallel Flow Drum Mix plants account for 10% and 5% respectively.

Continuous Mix Plants (type 2 above) represent a very small fraction of the plants in use (1/2 % or less) and, therefore, are not discussed further nor is any data presented for this type of plant.

An HMA Plant can be constructed as a permanent plant, a skid mounted (easily relocated) plant, or as a portable plant. All plants can have RAP processing capabilities. Virtually all of the plants manufactured today have RAP processing capability. Following is a description of each plant type:

Batch Mix Plants--Figure 8.1-1 shows the batch mix HMA production process. Raw aggregate normally is stockpiled near the plant. The bulk aggregate moisture content typically stabilizes between 3% to 5% by weight.

Processing begins as the aggregate is hauled from the storage piles and is placed in the appropriate hoppers of the cold feed unit. The material is metered from the hoppers onto a conveyer belt and is transported into a fuel fired rotary dryer (typically gas or oil). Dryers are equipped with flights designed to shower the aggregate inside the drum to promote drying efficiency.

As the hot aggregate leaves the dryer, it drops into a bucket elevator and is transferred to a set of vibrating screens where it is classified into as many as four different grades (sizes) and dropped 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 are obtained. RAP may be added at this point also. 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 aggregate-to-asphalt cement ratio in the final mix.

The aggregate from the weigh hopper is dropped into the pugmill (mixer) and dry-mixed for 6-10 seconds. The liquid asphalt is then dropped into the pugmill where it is mixed for an additional period of time. Total mixing time is usually less than 60 seconds. Then the hot mix is conveyed to a hot storage silo or dropped directly into a truck and hauled to the job site.

Parallel Flow Drum Mix Plants--Figure 8.1-2 shows the Parallel Flow Drum Mix Process. This process is a continuous mixing type process using 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 the material but also to mix the heated and dried aggregates with the liquid asphalt cement. Aggregate, which has been proportioned by gradations, is introduced to the drum at the burner end. As the drum rotates, the aggregates as well as the combustion products move toward the other end of the drum in parallel. Liquid asphalt cement flow is controlled by a variable flow pump which is electronically linked to the virgin aggregate and RAP weigh scales. The asphalt cement is introduced in the mixing zone midway down the drum in a lower temperature zone along with any RAP and particulate matter from collectors.

The mixture is discharged at the end of the drum and conveyed to a surge bin or HMA storage silos. The exhaust gases also exit the end of the drum and pass on to the collection system.

Parallel Flow Drum Mixers have an advantage in that mixing in the discharge end of the drum captures a substantial portion of the aggregate dust, therefore lowering the load on the downstream collection equipment. For this reason, most Parallel Flow Drum Mixers are followed only by primary collection equipment (usually a baghouse or venturi scrubber). However, because the mixing of aggregate and liquid asphalt cement occurs in the hot combustion product flow, organic emissions (gaseous and liquid aerosol) may be greater than in other processes.

Counterflow Drum Mix Plants--Figure 8.1-3 shows a Counterflow Drum Mix Plant. In this type of plant, the material flow in the drum is opposite or counterflow to the direction of exhaust gases. In addition, the liquid asphalt cement mixing zone is located behind the burner flame zone so as to remove the materials from direct contact with hot exhaust gases.

Liquid asphalt cement flow is controlled by a variable flow pump which is electronically linked to the virgin aggregate and RAP weigh scales. It is injected into the mixing zone along with any RAP and particulate matter from primary and secondary collectors.

Because the liquid asphalt cement, virgin aggregate and RAP are mixed in a zone removed from the exhaust gas stream, Counterflow Drum Mix Plants will likely have organic emissions (gaseous and liquid aerosol) that are lower than Parallel Flow Drum Mix Plants. A Counterflow Drum Mix Plant can normally process RAP at ratios up to 50% with little or no observed effect upon emissions. Today's Counterflow Drum Mix Plants are designed for improved thermal efficiencies.

Recycle Processes--In recent years, the use of RAP has been initiated in the HMA Industry. Reclaimed asphalt significantly reduces the amount of new (virgin) rock and asphalt cement needed to produce HMA.

In the reclamation process, old asphalt pavement is removed from the road base. This material is then transported to the plant, and is crushed and screened to the appropriate size for further processing. The paving material is then heated and mixed with new aggregate (if applicable), and the proper amount of new asphalt cement is added to produce a high quality grade of HMA.

There are three methods that can be used to heat RAP before adding the asphalt cement: direct flame heating, indirect flame heating, and superheated aggregate.

Direct flame heating is typically performed with a drum mixer, wherein all materials are simultaneously mixed in the revolving drum. Superheated aggregate also plays a significant heat transfer role. This is accomplished through appropriate design of the RAP injection point and other drum design changes. The first experimental attempts at RAP processing used a standard drum mix plant and introduced the RAP and virgin aggregate concurrently at the burner end of the drum. Problems with excessive blue smoke emissions led to several process modifications, such as the addition of heat shields and the use of split feeds.

## 8.1.2 Emissions and Controls [23,42]

Emission points at batch and drum mix asphalt plants discussed below refer to Figures 8.1-1, 8.1-2, and 8.1-3 respectively.

Batch Mix Plants--As with most facilities in the mineral products industry, batch mix HMA plants have two major categories of emissions: those that are vented to the atmosphere through some type of stack, vent, or pipe (ducted sources), and those that are not confined to ducts and vents but are emitted directly from the source to the ambient air (fugitive sources). Ducted emissions are usually collected and transported by an industrial ventilation system with one or more fans or air movers, eventually to be emitted to the atmosphere through some type of stack. Fugitive emissions result from process and open sources, and consist of a combination of gaseous pollutants and particulate matter (PM).

The most significant source of ducted emissions from Batch Mix HMA Plants is the rotary drum dryer. Emissions from the drum consist of water as steam evaporated from the aggregate, particulate matter, and small amounts of VOCs of various species (including HAPs) derived from combustion exhaust gases.

Other potential process sources include the hot-side conveying, classifying, and mixing equipment, which are vented to either the primary dust collector along with the dryer gas or to a separate dust collection system. The vents and enclosures that collect emissions from these sources are commonly called "fugitive air" or "scavenger" systems. The scavenger system may or may not have its own separate air mover device, depending on the particular facility. The emissions captured and transported by the scavenger system are mostly aggregate dust, but they may also contain gaseous volatile organic compounds (VOCs) and fine aerosol of condensed liquid particles. This liquid aerosol is created by the condensation of gas into particles during cooling of organic vapors volatilized from the asphalt cement in the pugmill. The amount of liquid aerosol produced depends to a large extent on the temperature of the asphalt cement and aggregate entering the pugmill. Organic vapor and its associated aerosol are also emitted directly to the atmosphere as process fugitives during truck loadout, from the bed of the truck itself during transport to the job site, and from the asphalt storage tank. In addition to low molecular weight VOCs, these organic emission streams may contain small amounts of polycyclic compounds. Both the low molecular weight VOCs and the polycyclic organic compounds can include HAPs. The ducted emissions from the heated asphalt storage tanks may include VOCs and combustion products from the tank heater.

The choice of applicable control equipment for the dryer exhaust and vent line ranges from dry mechanical collectors to scrubbers and fabric collectors. Attempts to apply electrostatic precipitators have met with little success. Practically all plants use primary dust collection equipment with large diameter cyclones, skimmers or settling chambers. These chambers are often used as classifiers to return collected material to the hot elevator and to combine it with the drier aggregate. To capture remaining particulate matter, the primary collector effluent is ducted to secondary collection device. Most plants use either a baghouse or a venturi scrubber for secondary emissions control.

There are also a number of open dust sources associated with batch mix HMA plants, including vehicular traffic generating fugitive dust on paved and unpaved roads, aggregate material handling, and other aggregate processing operations. Fugitive dust may range from 0.1 μmm to more than 300 μm in aerodynamic diameter. On average, 5% of cold aggregate feed is less than 74 μm (minus 200 mesh). Fugitive dust that may escape collection before primary control generally consists of PM with 50% to 70% of the total mass less than 74 μm. Uncontrolled PM emission factors for various types of fugitive sources in HMA plants can be found in Section 11.2.3 of this document.

Parallel Flow Drum Mix Plants--The most significant ducted source emissions is the rotary drum dryer itself. Emissions from the drum consist of water as steam evaporated from the aggregate, particulate matter, and small amounts of VOCs of various species (including HAPs) derived from combustion exhaust gases, liquid asphalt cement, and RAP, if utilized. The VOCs result from incomplete combustion and from the heating and mixing of liquid asphalt cement inside the drum. The processing of RAP materials may aggravate the problem because of an increase in mixing zone temperature when processing RAP.

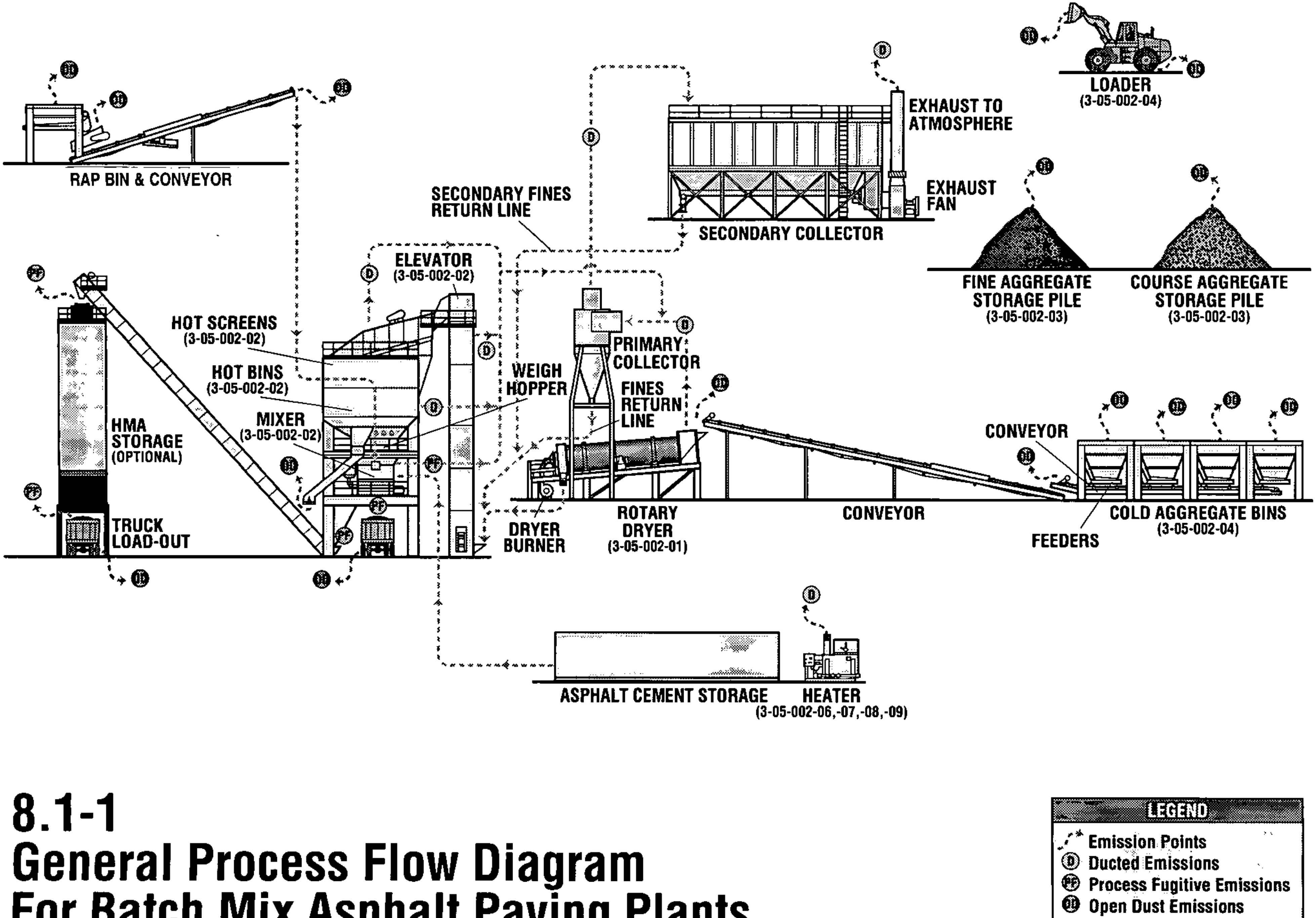
Once the VOCs cool after discharge from the process stack, some condense to form a fine liquid aerosol or "blue smoke" plume.

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.

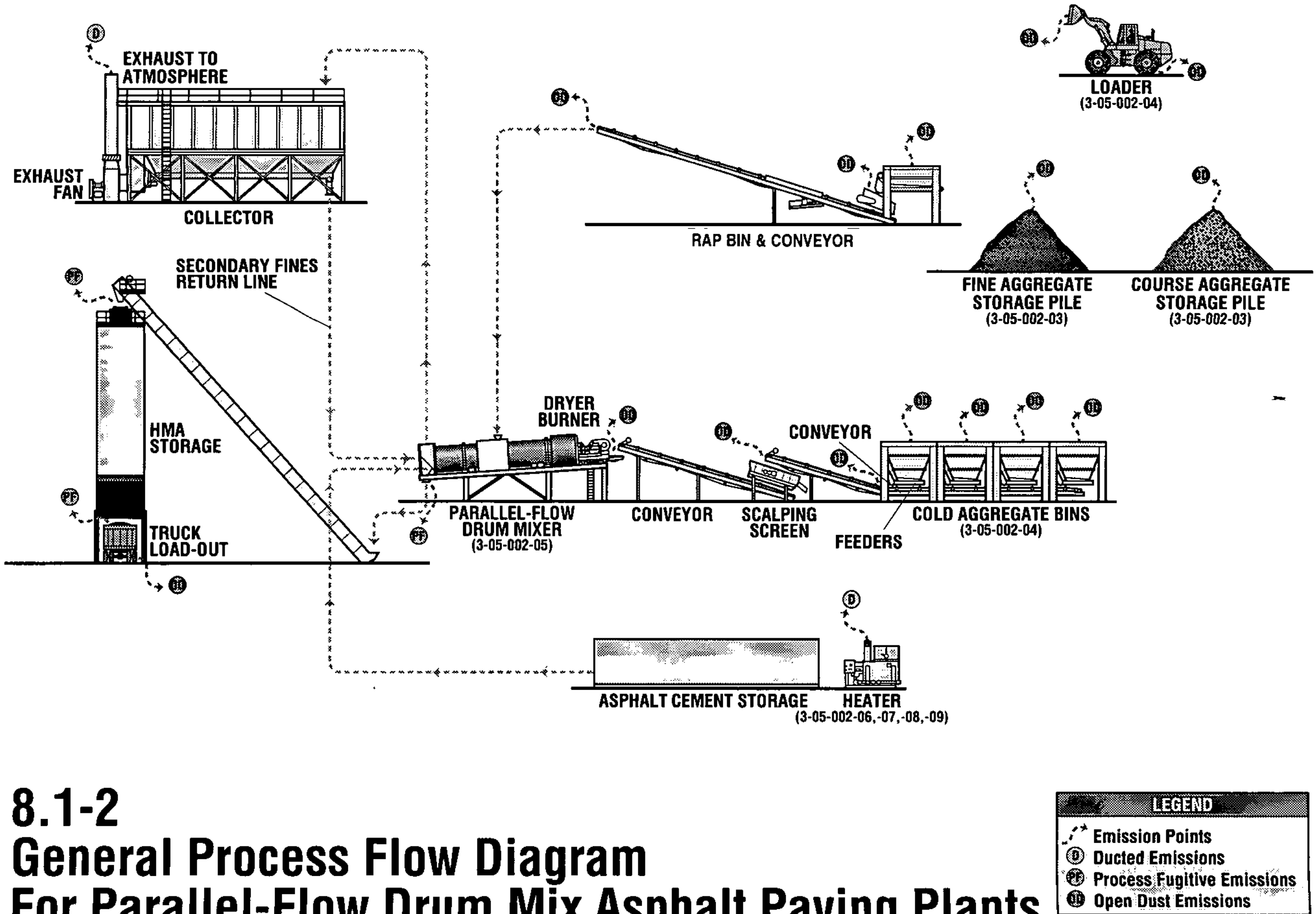
Counterflow Drum Mix Plants--The most significant ducted source of Particulate Emissions is the rotary drum dryer in a Counterflow Drum Mix Plant. Emissions from the drum consist of water as steam evaporated from the aggregate, particulate matter, and small amounts of VOCs of various species (including HAPs) derived from combustion exhaust gases, liquid asphalt cement, and RAP, if utilized.

Because liquid asphalt cement, aggregate, and sometimes RAP, are mixed in a zone not in contact with the hot exhaust gas stream, Counterflow Drum Mix Plants will likely have VOC emissions that are lower than Parallel Flow Drum Mix Plants. The organic compounds that do occur in Counterflow Drum Mix Plants are likely products of a slight inefficient combustion. As documented in boiler fuel combustion, these products can include HAPs.

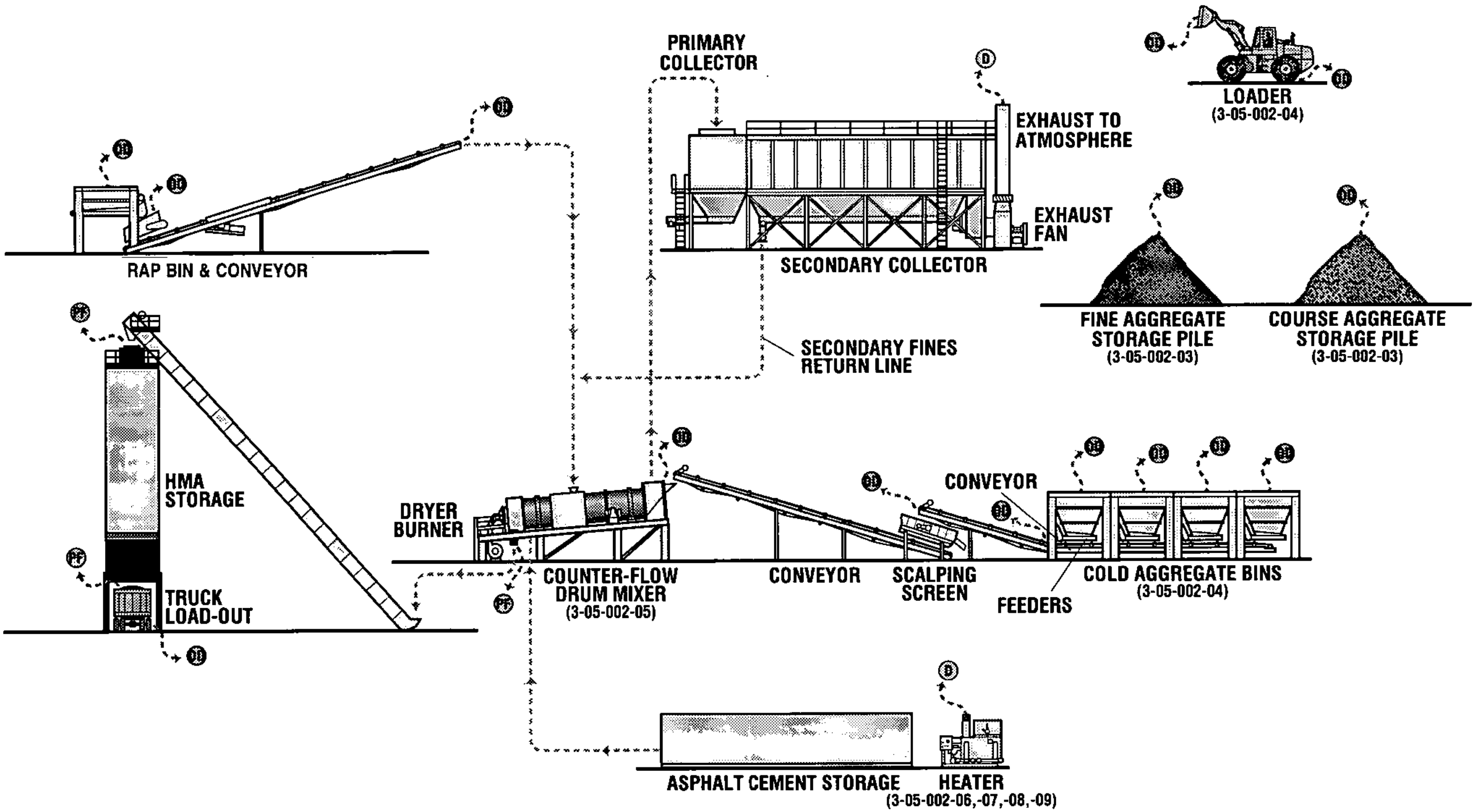
Parallel and Counterflow Drum Mix Plants--Process Fugitive Emissions associated with batch plants from hot screens, elevators and the pugmill are not present in the drum mix processes. However, there may be a minimal amount of fugitive VOCs produced from the transport and handling of the hot mix from the drum mixer to the storage silo and also from the load out operations to the delivery trucks. Since the drum process is continuous, these plants must have surge bins or storage silos. The open dust sources associated with drum mix plants are similar to those of batch mix plants with regard to truck traffic, aggregate material feed and handling operations.




# 8.1-1
# General Process Flow Diagram For Batch Mix Asphalt Paving Plants




# 8.1-2
# General Process Flow Diagram For Parallel-Flow Drum Mix Asphalt Paving Plants




# 8.1-3
# General Process Flow Diagram For Counter-Flow Drum Mix Asphalt Paving Plants