M0049F

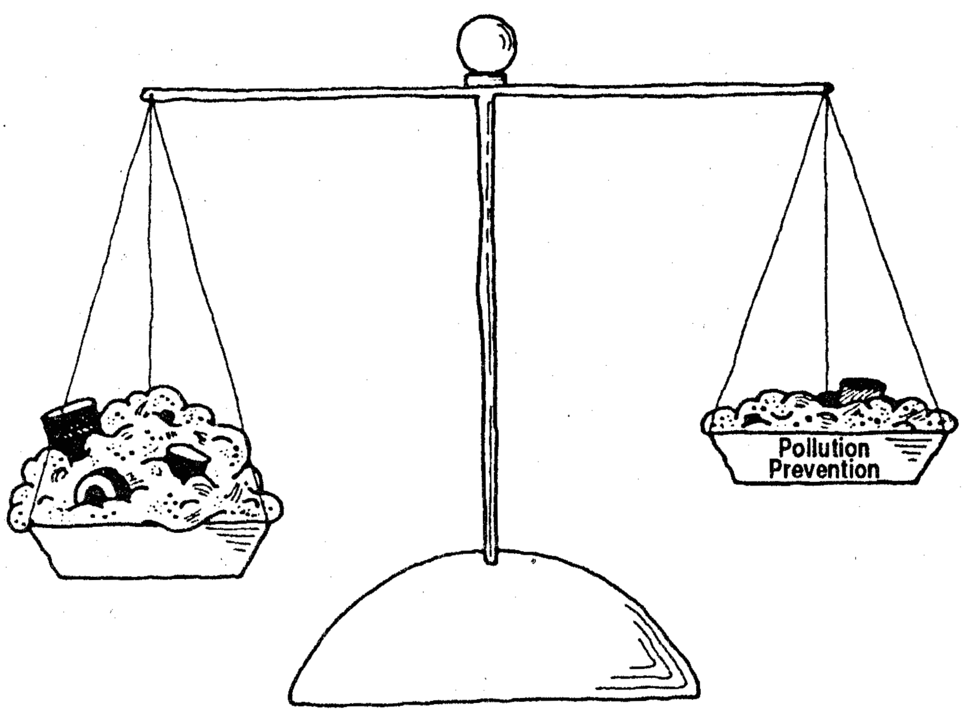
31296 PDF

Illinois Environmental
Protection Agency

OFFICE OF POLLUTION PREVENTION

Asphalt Production and Application

June 1995



Printed on Recycled Paper

300-5407-001

STUDENT MANUAL

Asphalt Production and Application Pollution Prevention and Recycling

August 1995

Prepared for

Pollution Prevention Office
Illinois Environmental Protection Agency
2200 Churchill Road
Springfield, IL 62794-9276

Roger L. Price, P.E., Project Manager

ACKNOWLEDGEMENTS

The Center for Hazardous Materials Research (CHMR) extends special thanks to the National Asphalt Pavement Association and the Asphalt Recycling & Reclaiming Association for the information provided that was invaluable in the preparation of this document.

TABLE OF CONTENTS

PAGE

TABLE OF CONTENTS
(Cont.)

PAGE

LIST OF AND FIGURES AND TABLES

1.0 INTRODUCTION

1.1 BACKGROUND

Hot mix asphalt (HMA) is a commonly used paving material for roadways, parking lots, and driveways. HMA can also be used as liners for reservoirs, landfills, and other containment purposes.

To produce HMA, paving aggregates are dried and heated and then mixed and coated with asphalt cement to produce hot, homogeneous asphalt paving mixture. HMA production plants are available as permanent plants, skid-mounted plants, or as portable plants.

In general, two basic types of HMA plants are currently in use in the U.S.: batch plants and continuous mix plants. The continuous mix category consists of two different types of facilities: the older continuous mix plant and the modern drum mix plant. The drum mix category includes both parallel flow and counterflow plants. These plants differ based on (1) how they dry and heat the aggregate and (2) how they coat the aggregates with asphalt cement.

Two types of drying and heating methods are available, both of which use a direct-fired, rotating drum. One method is counterflow drying in which the aggregates move opposite the flow of the exhaust gases. This drying process is used in the original batch processing equipment and in recent design changes to the drum mix process. The other drying process is a parallel flow process in which the aggregates and exhaust gas move through the drum in the same direction.

Aggregates can be coated with asphalt cement in two ways. The original method, which still predominates, is to apply the coating in batches. A development in the mid-1970s introduced the asphalt cement into the lower end of the rotating drum of the parallel flow drying process. This coating method is called drum mixing--hence the name parallel flow drum mix plant. Recent design modifications now allow drum mixing to be performed with the counterflow drying process (i.e., counterflow drum mixing plant).

Section 3.0 contains more detailed information about batch, parallel flow drum mix, and counterflow drum mix plants. The older continuous mix plants are rarely used today and are not discussed further.

1.2 NUMBER OF ASPHALT MANUFACTURING FACILITIES

Table 1 provides a breakdown of asphalt plants by plant type for the United States and for Illinois.

TABLE 1 ASPHALT PLANT BREAKDOWN BY PLANT TYPE			
	U.S.	Illinois	
		Operational	Non-Operational
Batch	2,300	112	13
Parallel flow drum mix	1,000	45	8
Counterflow drum mix	300	15	0
Older continuous mix	Negligible	9	0
TOTAL	3,600	181	21

Source: National Asphalt Pavement Association; Illinois Department of Transportation

Roughly 85 percent of plants constructed today are of the counterflow drum mix design, while batch plants and parallel flow drum mix plants account for approximately 10 percent and 5 percent respectively.

1.3 RAW MATERIALS

HMA is a carefully balanced mixture of graded aggregates and asphalt cement. Raw materials in HMA manufacturing include:

- *Aggregates*, such as crushed stone, gravel, sand, and mineral dust, comprise about 92 to 96 percent of the total mixture by weight. The aggregate mixture can also include reclaimed asphalt pavement (RAP).
- *Asphalt cement*, the black, sticky coating material produced by petroleum refineries, generally makes 4 to 8 percent of the mixture and serves as the glue to bind the aggregate together. It is important to note that although similar in appearance, asphalt cement is not coal tar.
- *Fuel*, such as natural gas or fuel oil, is used for the burner on a dryer or drum mixer.
- Very small amounts of *solvents* are also used for quality control tests.
- *Diesel fuel* and other *solvents* are used to clean slag conveyors, belts, sprockets, and other equipment.
- *Release agents* are used to prevent HMA from sticking to the bed of the haul truck during delivery of the mix. Non-petroleum based materials, such as lime water or one of a variety of commercial products, are commonly used release agents. Although it is not recommended, diesel fuel is also used as a release agent by some paving companies.

1.4 WASTE STREAMS

The primary waste streams from an asphalt manufacturing plant are air pollutant emissions. Other wastes include:

- Off-specification and waste asphalt
- Wastewater and sludges (if wet collectors are used for air pollution control)
- Fine particulate matter (from primary dry collectors and baghouses)
- Small amounts of spent solvent (used for quality control testing)
- Diesel fuel and other release agents (used for equipment cleaning).

The primary waste streams from laydown and compaction are:

- Excess HMA
- Old asphalt removed from the road surface during surface preparation
- Residual asphalt, wastewater, and sludges from equipment cleaning
- Fugitive emissions from surface preparation and other paving activities.

Many of these waste streams are ultimately recycled in either the manufacturing or paving processes. For instance, off-specification and waste asphalt, excess HMA, and old asphalt can be recycled to make new HMA or pulverized and used as road-base material. Fine particulate matter from air pollution control equipment can be recycled in the HMA manufacturing process. Residual asphalt cleaned from equipment can also be recycled to the manufacturing process or used as base material.

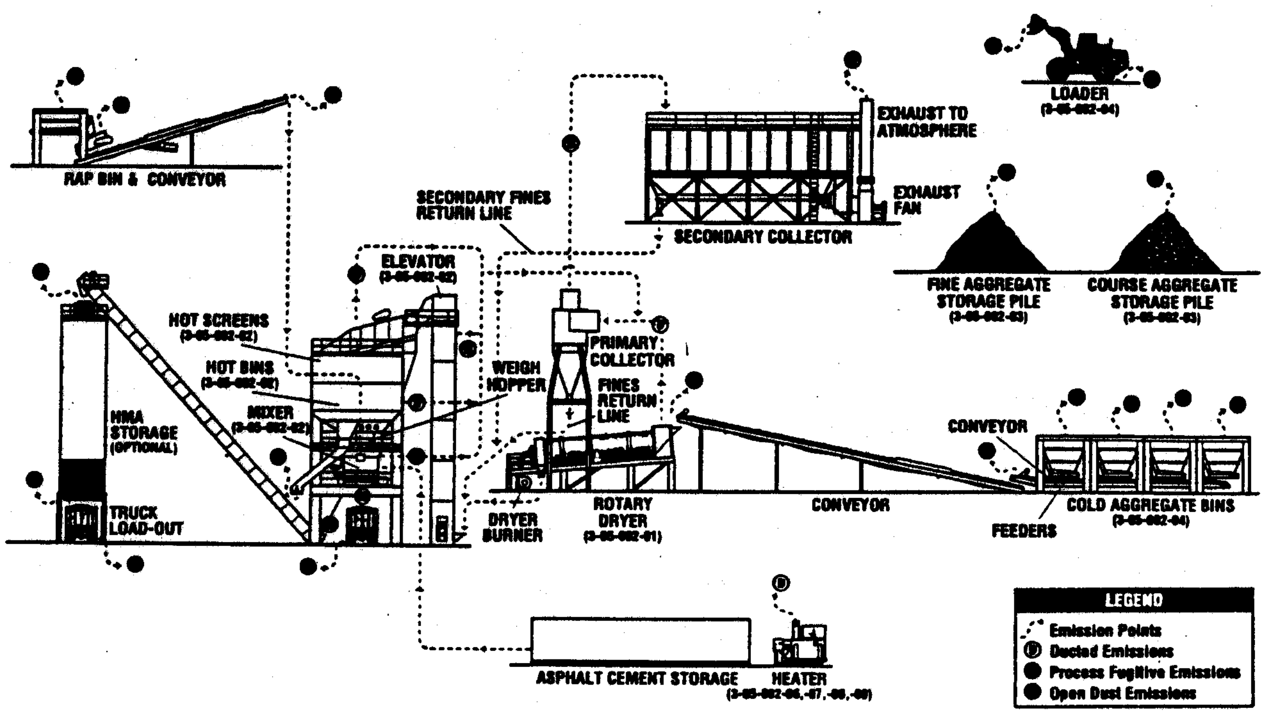
Waste streams such as wastewater and sludges, solvents, diesel fuel, and other release agents that are not recycled in the manufacturing process must be disposed of properly. Typically, wastewater from wet collectors is routed to a settling pond or clarifier for solids removal. It should be noted that Illinois has adopted 40 CFR 443 pertaining to asphalt concrete paving and roofing that prohibits the discharge of process wastewater to navigable waters.

Solvents, diesel fuel, and release agents must also be collected in separate, properly labeled containers and disposed of or recycled at an approved, off-site facility.

2.0 PROCESS INFORMATION

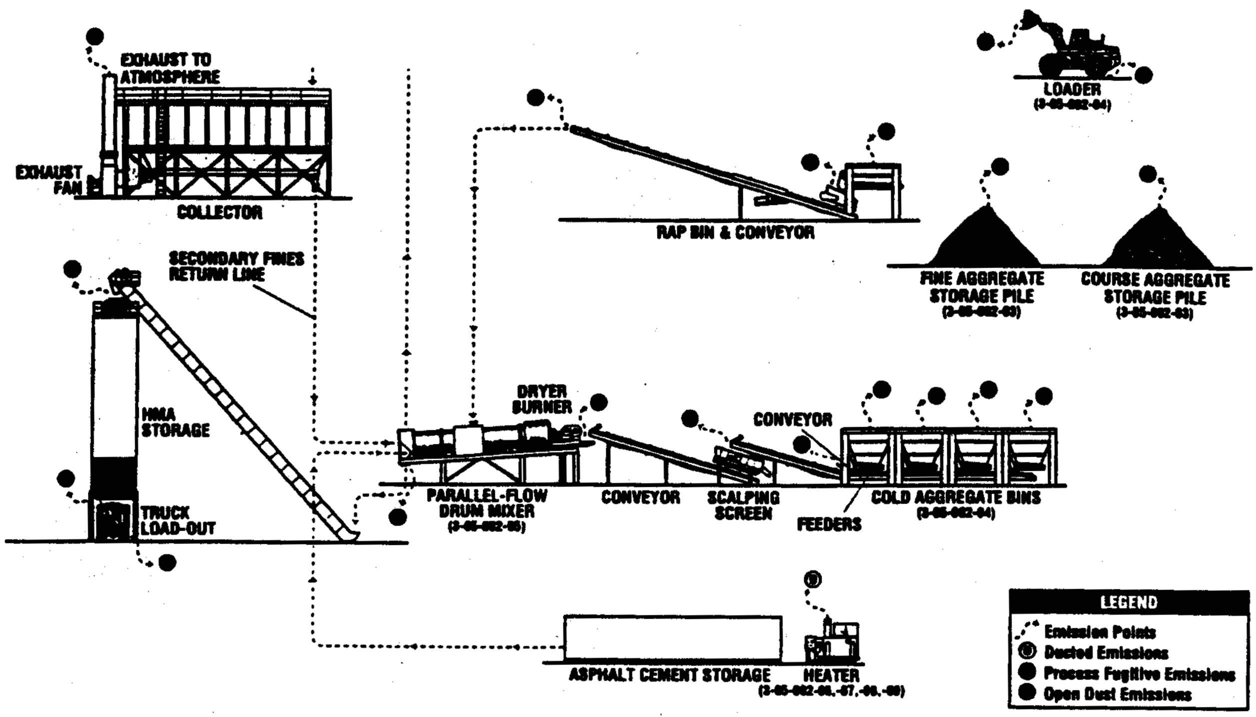
Figures 1 through 3 show general process flow diagrams for batch, parallel flow drum mix, and counterflow drum mix asphalt paving plants.

FIGURE 1
BATCH MIX PLANT



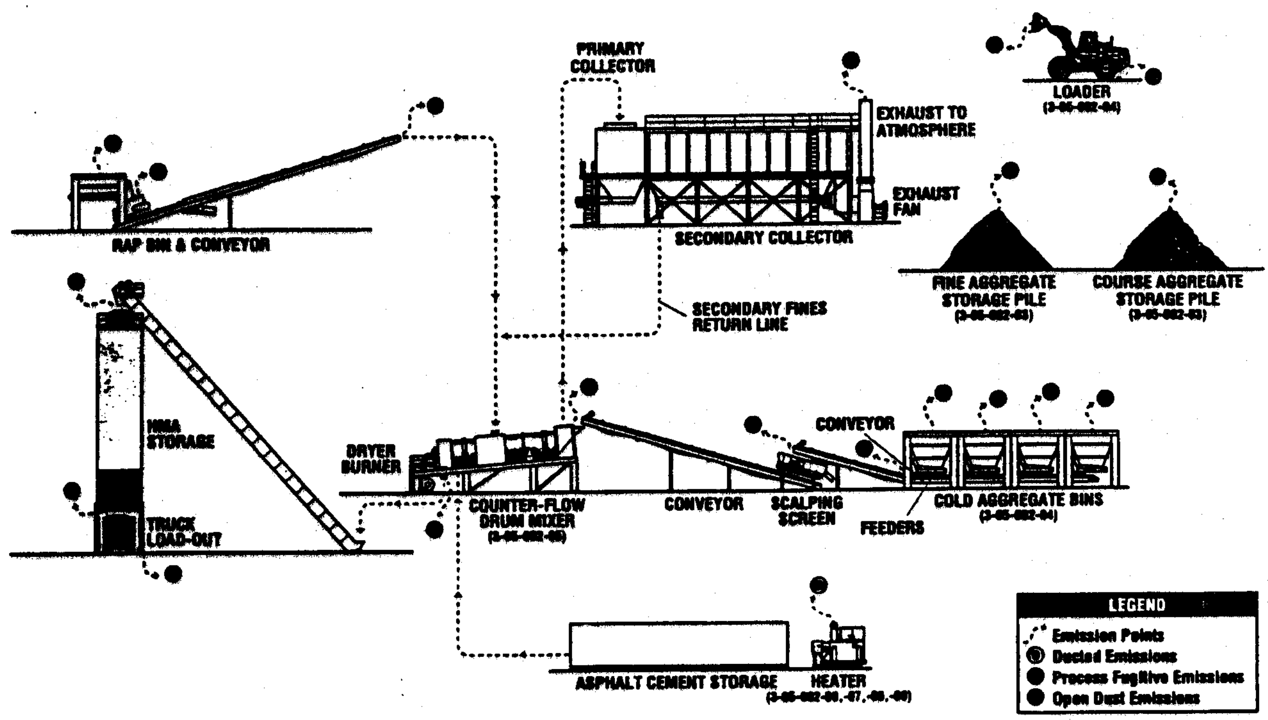
Source: National Asphalt Pavement Association

FIGURE 2
PARALLEL FLOW DRUM MIX PLANT



Source: National Asphalt Pavement Association

FIGURE 3
COUNTERFLOW DRUM MIX PLANT



Source: National Asphalt Pavement Association

3.0 DISCUSSION OF PRODUCTION PROCESSES

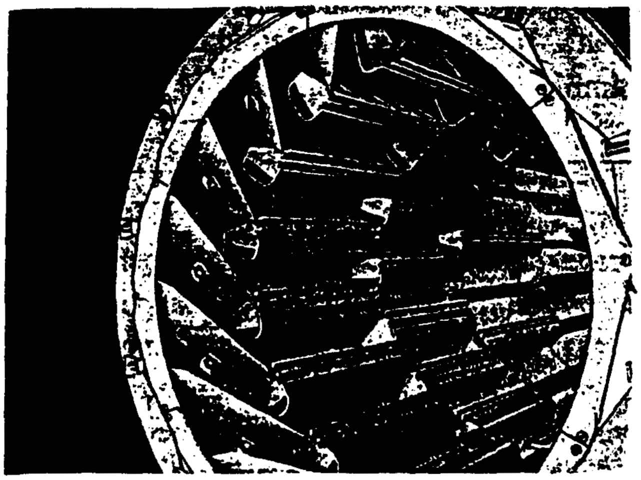
The following sections describe the activities associated with (1) asphalt manufacturing and (2) asphalt laydown and compaction.

3.1 ASPHALT MANUFACTURING

3.1.1 Batch Mix Plants

In a batch mix plant, aggregate is hauled from storage piles and placed in the appropriate hoppers of the cold feed unit. The material is metered from the hoppers onto a conveyor belt and transported into a fuel-fired rotary dryer (typically gas or oil). Dryers are equipped with "flights" (See Figure 4) designed to shower or veil the aggregate inside the drum to promote drying.

FIGURE 4
DRYER FLIGHTS



Source: Hot-Mix Asphalt Paving Handbook

The dried, hot aggregate exits the dryer and is transported via a bucket elevator to the top of a mixing tower. In the mixing tower, vibrating screens sort the aggregate into as many as four different sizes, and sorted aggregate is then dropped into individual "hot" bins according to size or grade. To control aggregate size ratio in the final batch mix, the various hot bins are opened over a weigh hopper until the desired amount of each size fraction is obtained. RAP may also be added at this point. Meanwhile, liquid asphalt cement is pumped from a heated storage tank into a separate weigh bucket above the pugmill.

Aggregate is then dropped from the weigh hopper into the pugmill mixer and dry-mixed for 6 to 10 seconds to uniformly distribute the aggregate fractions. The liquid asphalt cement is then transferred to the pugmill where the wet-mix with the aggregate begins. Total mixing time can be as short as 28 seconds and is usually less than 60 seconds. The hot mix asphalt is then conveyed to a hot storage silo or dropped directly into a truck and hauled to the job site.

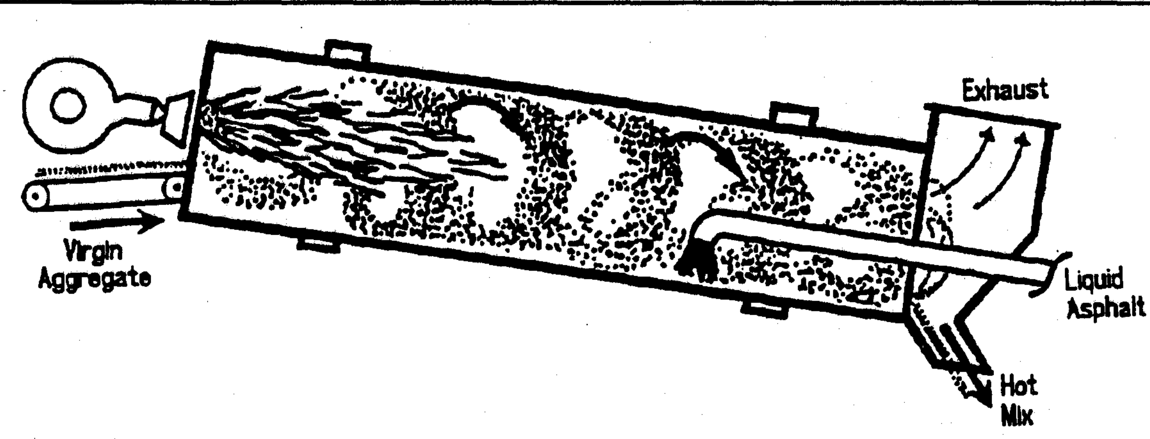
3.1.2 Parallel Flow Drum Mix Plants

The parallel flow drum mix process is a continuous mixing process using proportioned cold feed controls for the aggregate and liquid asphalt cement. 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.

In this process, aggregate from cold feed bins is proportioned by size and introduced into the drum at the burner end. As the drum rotates, the aggregate and hot combustion gases move toward the other end of the drum in parallel. As the aggregates tumble down the dryer, they are lifted by flights inside the drum and dropped through the hot gas stream to promote drying. As the dry aggregates move to the rear half of the drum, liquid asphalt cement is injected into the drum. The asphalt cement flow is controlled by a variable flow pump that is electronically linked to the aggregate feed (and RAP if used) weigh belt scale(s). The liquid asphalt cement enters the drum at a lower temperature zone along with any RAP and particulate matter captured by the control system. The mixture is discharged at the end of the drum and conveyed to a surge bin or storage silo where it is loaded into haul trucks in batches. The exhaust gases also exit the end of the drum and pass to the primary dry collection system. Figure 5 shows a parallel flow drum mixer.

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, lowering the load on the downstream collection equipment. For this reason, most parallel flow drum mixers are equipped only with primary collection equipment (usually a baghouse or venturi scrubber). However, the mixing of aggregate and liquid asphalt cement in the hot combustion zone may create organic emissions not present in other processes.

FIGURE 5
PARALLEL FLOW DRUM MIXER



Source: Hot-Mix Asphalt Paving Handbook

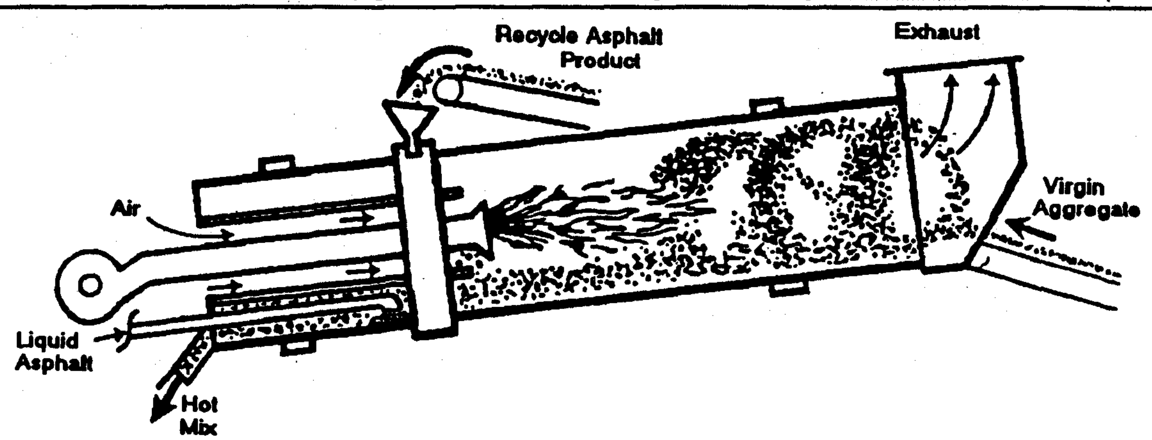
3.1.3 Counterflow Drum Mix Plants

This variation of the continuous mix process was developed to improve heat transfer inside the drum and to reduce plant emissions. Unlike the parallel flow drum mix plants, in counterflow drum mix plants aggregates enter the drum at the upper end. Because the burner is located at the lower end, the aggregates move down the drum against, or counter to, the flow of exhaust gases.

Liquid asphalt cement is injected behind the burner flame zone so as to remove the materials from direct contact with hot exhaust gases. Its flow is controlled by a variable flow pump that is electronically linked to the aggregate (and RAP if used) weigh belt scale(s). Like the asphalt cement, any RAP and particulate matter from the primary and secondary collectors are introduced into the drum behind the burner and do not contact the hot exhaust gases. Actual mixing occurs behind the burner in the mixing section extension of the drum. A counterflow drum mixer is pictured in Figure 6.

Because the liquid asphalt cement, virgin aggregate, and RAP are mixed in a zone removed from the exhaust gas stream, counterflow mix plants will likely have lower organic emissions than parallel flow drum mix plants. A counterflow drum mix plant can normally process RAP at ratios up to 50 percent with little or no observed effect upon emissions.

FIGURE 6
COUNTERFLOW DRUM MIXER



Source: Hot-Mix Asphalt Paving Handbook

3.1.4 Waste Streams and Pollution Control Equipment

The primary waste streams from an asphalt manufacturing plant are air pollutant emissions. Other wastes include off-specification and waste asphalt (which is ultimately recycled), wastewater and sludges (if wet collectors are used for air pollution control), fine particulate matter (from primary dry collectors and baghouses which is returned to the manufacturing process), small amounts of spent solvent (used for quality control testing), and diesel fuel and other release agents (used for equipment cleaning).

The focus of this section will be on air emissions since they are the major source of pollutants from HMA plants. HMA plants produce both particulate and gaseous emissions, as described below:

Particulate Emissions

The primary air pollutant of concern at HMA plants is particulate matter (PM) from process operations. The U.S. EPA New Source Performance Standard for HMA facilities prohibits emissions of particulate matter in excess of 0.04 grains per standard cubic foot dry (gr/dscf) of exhaust gas. It also restricts visible emissions to less than 20 percent opacity. The dryer/drum mixer is the primary source of process particulate matter for both batch and drum mix operations.

Pollution control equipment found on batch and drum mix plants usually consists of some combination of dry collectors, wet collectors, and/or baghouses. Generally, the dry collector, such as a cyclone or an expansion chamber with a baghouse, acts as the primary collection device used to remove the larger fine particles. These chambers are often used as classifiers to return collected material directly to the mix or to the hot elevator where it is combined with the dried aggregate. To capture remaining PM, the primary collector effluent is ducted to a secondary collection device, such as a fabric filter baghouse or a venturi wet scrubber. A wet scrubber requires a settling pond or sludge clarifier for wastewater treatment. Fines collected in the baghouse are returned to the plant or are disposed.

Fugitive emissions can also pose problems at HMA facilities. Potential sources of fugitive emissions include vehicular traffic on paved and unpaved roads, aggregate stockpiles, and aggregate processing. At batch mix plants, the mixing tower is also a potential source of fugitive emissions. At most batch mix plants, fugitive emissions from the mixing tower are collected by an industrial ventilation or "scavenger" system and vented to the primary dust collection system from the dryer or to a separate collection device.

Gaseous Emissions

Gaseous emissions result from combustion in the burner for the dryer and are dependent on the fuel and burner type. Possible pollutants include normal products of combustion (e.g., carbon dioxide, water, nitrogen oxides, and if sulfur is present in the fuel, sulfur oxides) and products of incomplete combustion (e.g., carbon monoxide, hydrocarbons as unburned fuel, formaldehyde, etc.) resulting from improper air to fuel mixtures and quenching of the burner flame.

In parallel flow drum mix plants, small amounts of volatile organic compounds (VOCs) may also be generated from incomplete combustion and from the heating and mixing of liquid asphalt cement inside the drum. The processing of RAP may aggravate the problem because of the increase in mixing zone temperature necessary to indirectly heat RAP to the desired mix temperature. As the VOCs cool after discharge from the process stack, condensation can form a fine liquid aerosol that appears as a "blue smoke" plume.

Counterflow mix plants will likely have lower organic emissions than parallel flow drum mix plants because the liquid asphalt cement, aggregate, and RAP are mixed in a zone removed from the hot exhaust gas stream. The organic compounds that do occur in counterflow drum mix plants are likely products of incomplete combustion and may include very small amounts of hazardous air pollutants (HAPs) such as BTEX (benzene, toluene, ethylbenzene, xylene), polycyclic aromatic hydrocarbons, and/or formaldehyde.

3.2 ASPHALT LAYDOWN AND COMPACTION

Asphalt laydown and compaction consists of four key steps:

- Surface preparation
- Mix delivery
- Mix placement
- Compaction.

These steps, as well as equipment cleanup, are described in the following sections.

3.2.1 Surface Preparation

The performance of HMA pavement under traffic is directly related to the condition of the surface on which the pavement layers are placed. For HMA laid on top of existing asphalt layers, the present surface should be free of potholes and major distress, reasonably smooth, and clean. At a minimum, preparation may include:

- Removal and replacement of failed areas
- Patching of potholes
- Cleaning and sealing of cracks
- Filling in ruts or removal by cold milling.

Similarly, preparation for placement of HMA over a portland cement concrete pavement may include:

- Removal of severely distressed concrete slabs and replacement with full-depth slab-repair techniques using concrete or HMA
- Repair of underlying subbase or subgrade material
- Repair of spalled areas at joints using partial-depth slab replacement
- Stabilization of rocking slabs
- Resealing of joints
- Cleaning of pavement surface with mechanical brooms and air blowing and/or water flushing equipment.

In addition, a tack coat must be applied to either an existing asphalt or concrete pavement surface before an overlay is constructed. The tack coat, applied by a pressure distributor, is used to ensure a good bond between the existing pavement surface and the new HMA overlay. Tack and base coats are typically water-based emulsions.

When HMA pavement is to be placed directly on subgrade soil or untreated granular base layer, the subgrade or base course is checked to ensure that the material meets all applicable requirements for moisture content, density, smoothness, and ability to support the weight of traffic loads. Under some circumstances, a prime coat will be placed on a granular base layer before paving begins.

3.2.2 Mix Delivery

After manufacturing, HMA is hauled from the production plant to a laydown machine at a job site. Three primary types of trucks are typically used to transport the mix: end dump, bottom (or belly) dump, and live bottom (conveyor) trucks. These trucks differ in how they unload the mix at the paver.

- *End dump* trucks deliver the mix directly into the hopper of the paver. The mix is unloaded by raising the truck bed and allowing the mix to slide down the bed into the hopper.

- A *bottom or belly* dump truck delivers the mix to the roadway in front of the paver. The mix is deposited from underneath the truck bed into a windrow. It is essential that the correct amount of mix be placed in the windrow to assure that the paver hopper does not run out of mix or become overloaded with too much mix.

- A *live bottom* truck uses a conveyor belt or slat conveyor in the bottom of the truck bed to discharge the mix without the need to raise the bed. As with end dump trucks, the mix is placed directly into the hopper of the paver.

Regardless of the type of truck used, the bed of the haul truck must be clean, reasonably smooth, and free of major indentations before mix can be placed inside. Once the truck bed is clean, it is coated with a release agent to prevent HMA from sticking to the bed. Non-petroleum based materials, such as lime water or one of a variety of commercial products, are commonly used release agents. However, diesel fuel is still used occasionally. Appendix A contains the Illinois Department of Transportation list of approved truck release agents.

3.2.3 Mix Placement

Asphalt pavers are used to place the HMA to the desired width and thickness while producing a satisfactory mat texture. The paver consists of two primary units: the tractor and the screed. The tractor unit transfers the HMA mixture from the receiving hopper on the front of the paver to the spreading screws at the back of the machine. The screed unit, which acts as a leveling device, is attached to the tractor unit at only one point on each side of the paver. This arrangement allows the screed to "float" on the HMA mix and provide initial texture and compaction to the HMA as it passes out from under the screed. An asphalt paver is shown in Figure 7.

3.2.4 Compaction

Compaction is the most important variable that affects the ultimate performance of a HMA pavement. Adequate compaction of the mix increases the fatigue life, decreases permanent deformation (rutting), reduces oxidation or aging, decreases moisture damage, increases strength and stability, and decreases low-temperature cracking.

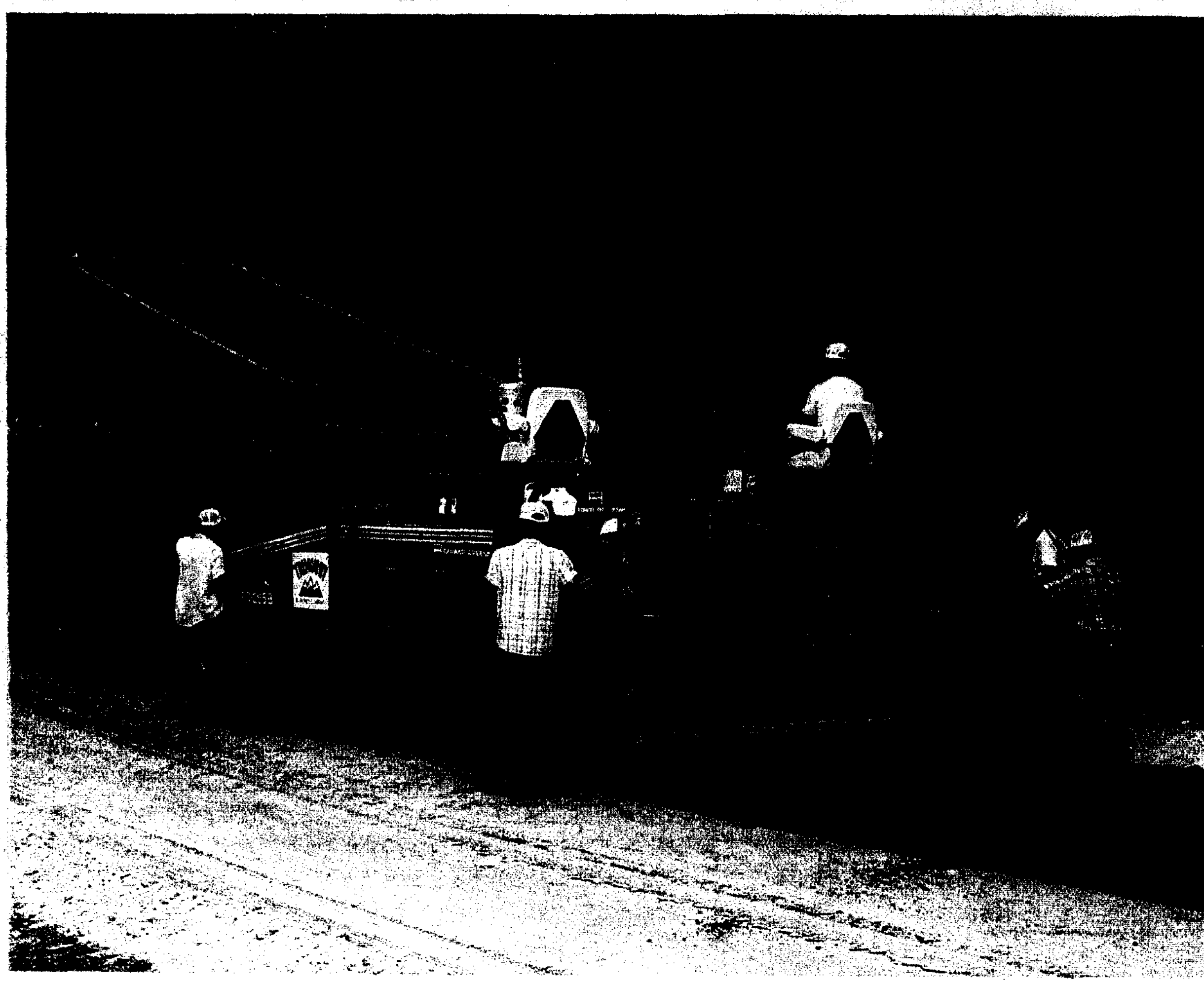
Three types of self-propelled compaction equipment are currently being used: static steel wheel rollers, pneumatic tire rollers, and vibratory rollers. The type and weight of equipment used to compact the asphalt mix has a significant effect on the degree of density that can be obtained in a given number of passes of a particular roller.

3.2.5 Equipment Cleanup

Pavers are cleaned to remove residual asphalt. Cleaning methods are not standardized, but often include a spray application of diesel fuel to loosen asphalt coatings. Less toxic citrus-based cleaners (limonenes) are also used. If a water rinse is used, the wastewater must be collected and treated. In addition, some pavers utilize manual scraping to facilitate cleaning and reduce solvent use.

The asphalt collected from cleaning can then be recycled. Proper disposal of all wastewater treatment sludges is necessary.

FIGURE 7
ASPHALT PAVER



Source: Barber-Greene, a division of Caterpillar Paving Products, Inc.

4.0 RECYCLING OPPORTUNITIES

According to a 1993 survey conducted by the Asphalt Recycling & Reclaiming Association, recycling and reclaiming existing asphalt pavement kept over 16 million tons of asphalt out of North American landfills. A number of techniques are available to either reclaim or recycle asphalt on site or at an off-site asphalt manufacturing plant. The following describes these recycling/reclamation methods.

4.1 COLD PLANING

Cold planing is the automatically controlled cold milling of pavement to restore the surface to a specified profile. Bumps, ruts, and other surface irregularities are removed, leaving a uniform textured surface. The surface can be used immediately as a driving surface or it can be overlaid with a minimum amount of HMA to provide a smooth driving surface. The material generated by the cold planing process can be recycled by cold or hot processes or used as taken from the roadway to improve existing bases and roads.

Cold planing can be used for a number of road reconstruction and rehabilitation applications including removal of wheel ruts and washboarding, restoration of deteriorating truck lanes, improvement of poor skid resistance, improvement of bonding surface prior to overlay, and correction of pavement profile and cross-section.

Cold planing provides benefits such as:

- Reclaimed material for future use
- Minimal traffic interruption
- Lowered cost (extending the maintenance budget to potentially provide more miles of pavement rehabilitation).

4.2 COLD IN-PLACE RECYCLING

Cold recycling is a road construction technique that reuses the existing pavement structure. All work takes place on the existing pavement surface and requires no transportation of material. Flexible pavements up to 6 inches in thickness are pulverized and blended with a liquid stabilizing agent to increase their load carrying capacity. The cold recycled bituminous material is placed and compacted by a laydown machine or, in some cases, with a motor grader. Compaction to obtain the required density is achieved by either a heavy pneumatic, vibratory, or static steel roller, or a combination of rollers.

Testing of the material to be recycled is very important. A number of cold recycling agents along with various types of emulsions that restore the old asphalt cement to very near its original characteristics are available.

Advantages of cold in-place recycling include:

- Low mobilization costs
- Reduced hauling costs
- Minimal traffic interruption.

4.3 FULL DEPTH RECLAMATION

In full depth reclamation, the full flexible pavement section and a predetermined portion of the underlying materials are uniformly crushed, pulverized, or blended, resulting in a stabilized base course. Additional stabilization may be obtained through the use of available additives. Full depth reclamation is accomplished using traveling hammermills, crushing units, and/or stabilizers.

By addressing the entire pavement section, full-depth reclamation offers:

- Increased load-bearing strength of the base
- Utilization of 100 percent of existing materials
- Decreased construction time.

4.4 HOT IN-PLACE RECYCLING

In the hot in-place recycling process, the existing asphalt pavement is thoroughly heated to a depth of 1.5 to 2 inches before being collected into a windrow by rotary scarifiers. Onboard mixing chambers then rework the material and combine it with controlled amounts of virgin mix and/or rejuvenating agents. The material is then spread and compacted as a homogeneous mix.

In a variation of this process, rejuvenating agents are measured and mixed with the loosened, scarified material while an overlay of new hot mix is added and compacted over the recycled layer.

Hot in-place recycling is an effective technique to restore pavement with rutting, cracking, or other problems in the upper 2 inches of the road surface. Advantages of the process include:

- Minimal traffic interruption
- Lowered rehabilitation costs
- Minimal increase in roadway elevation.

4.5 HOT RECYCLING

Hot recycling involves the use of RAP as a feed material in HMA manufacturing. Nearly all of the new HMA plants built today have RAP processing capability. When RAP is used to produce recycle mixes, conductive heat transfer from the aggregates is relied on to reach necessary mix temperature, since it is difficult to process RAP through the combustion and heating zones of the dryer. As a result, the virgin aggregates must be "superheated" to a temperature higher than 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 the temperature, to provide sufficient heat for the RAP to reach temperature. In addition, in the presence of very hot gases, volatiles that degrade the asphalt cement can be released from the RAP. Therefore, the amount of RAP used in the recycle mix is usually only 10 to 20 percent of the HMA composition and rarely more than 50 percent.

When RAP is used in the batch mixing process, it is added to the hot aggregates in one of three locations: the bottom of the bucket elevator, the hot bins, or the weigh hopper. In a parallel flow drum mixing plant, RAP is introduced at some point along the length of the dryer, generally as far away from the combustion zone as possible, but with enough drum length remaining to dry and heat the material adequately before it reaches the coating zone. In counterflow drum mix plants, the RAP is usually introduced into the coating chamber.

4.6 CASE STUDY: MICROWAVE PROCESS FOR ASPHALT PAVEMENT RECYCLING

The City of Los Angeles, California has the largest municipal street paving operation in the world. Each year, its Bureau of Street Maintenance repaves and repairs approximately 150 miles of deteriorated roadways with 800,000 tons of HMA. The Bureau employs 4 full-time milling crews that remove up to 250,000 tons of old asphalt yearly during their road maintenance and rehabilitation work. Los Angeles has been manufacturing HMA with a 15 percent RAP composition for years.

Prior to 1987, Los Angeles repaved its streets with HMA produced by 2 city-owned plants and outside sources. The city plants each used a mixture of about 85 percent virgin material and 15 percent RAP. When operating at their combined maximum production rate of 600,000 tons per year, the plants consumed about 90,000 tons of RAP annually. The remaining RAP (at least 160,000 tons) was disposed in a landfill. The HMA supplied by outside sources was produced from virgin ingredients.

In 1987, the city began seeking ways to recycle more RAP due to an impending landfill shortage. During that year, the city learned of a process that uses direct microwave heating to produce high-quality HMA using little, if any, virgin aggregate. The process was developed by CYCLEAN, Inc. of Austin, Texas. That same year the city began using CYCLEAN's process. Under a contractual agreement, the city ships RAP to a CYCLEAN asphalt reclamation plant installed at a city-owned facility in the northeast San Fernando Valley. The plant uses the city's RAP to produce HMA meeting pavement mix specifications as required by the contract. This plant supplements the 2 city-owned plants that continue to produce HMA using 15 percent RAP.

The CYCLEAN plant converts RAP directly into HMA at production rates of up to 135 tons per hour. RAP entering the plant is combined with new aggregate (if required) and crushed and screened to 1.5 inches in diameter or less to assure uniform absorption of heat. The feed materials are then routed to a rotary kiln heater in which they are blended and heated to over 220°F to remove moisture. Resulting exhaust air is passed through a baghouse for particulate removal, and also can be heated by a gas-fired oxidizer to eliminate white plumes caused by water vapor exhaust. The preheated material is then conveyed to a mixer where an oil-based rejuvenating agent is added to restore asphalt cement viscosity and flexibility. This mixture is conveyed through an enclosed tunnel, where microwave generators heat the mixture to about 300°F. Because the aggregate is polar and the asphalt cement is non-polar, only the aggregate is directly heated by the microwave energy. After being heated, the aggregate slowly transfers heat to the asphalt cement without burning it. The resulting HMA is conveyed to heated storage silos for city pickup and use.

Advantages of the process include:

- ***Lower production and road maintenance costs*** - Substituting RAP for new aggregate and asphalt cement reduces material costs by over 30 percent and eliminates costs associated with RAP disposal. Consequently, roads are kept in good condition for less money.

- ***Ready supply*** - In the Los Angeles area, high quality aggregate is often unavailable locally and has to be shipped a great distance. Because RAP is generated as roads are prepared for repaving, it is available at or near its point of use.

- ***Conserved resources*** - Each ton of RAP used to make HMA saves about 1,900 pounds of aggregate and 12.5 gallons of asphalt cement. Moreover, each ton of RAP saves about 14 cubic feet of landfill space, thus reducing the need for landfill space.

The biggest disadvantage of the process, and the reason it has not been used substantially to date, is that many local and state street and transportation department specifications limit the RAP content in HMA to 20 percent for their paving jobs. According to CYCLEAN, the 20 percent limit on RAP content is not a function of HMA quality but rather that conventional HMA plants can only recycle up to 20 percent RAP. However, some states are beginning to approve HMA from the CYCLEAN process as acceptable for any paving work. CYCLEAN is continuing to work with other states to gain specific approval for their process or to have specifications altered to accept HMA with greater RAP content.

In addition, operating problems noted in Los Angeles, although very infrequent, have included (1) difficulty in obtaining adequate mix temperatures and (2) carryover of fines balls into paving grade mix.

5.0 POLLUTION PREVENTION OPPORTUNITIES

5.1 POLLUTION PREVENTION OPPORTUNITIES DURING ASPHALT MANUFACTURING

Most pollution prevention opportunities during asphalt manufacturing can be grouped into three general areas: (1) material storage and handling, (2) plant operations, and (3) pollution control equipment.

5.1.1 Material Storage and Handling

The following suggestions for material storage and handling can help to reduce both fugitive and gaseous emissions at an HMA facility.

Pave driving surfaces

The most frequent sources of particulate fugitive emissions at an HMA facility are unpaved driving surfaces. Paving the driving surfaces, or using wet-down agents, helps to reduce the dust stirred up by vehicular traffic.

Strategically place aggregate stockpiles

Coarse aggregate stockpiles should be positioned to shield fine aggregate stockpiles from prevailing winds to reduce fugitive dust emissions.

Keep the moisture content of the aggregate and RAP as low as possible

High moisture content in the aggregate and RAP increases the cost of drying, reduces production capacity of the plant, and may contribute to the formation of carbon monoxide and unburned fuel emissions. To reduce the moisture content of the aggregate in stockpiles, covering of the aggregate piles--particularly the fine aggregate--with a roof should be considered. In addition, stockpiles should be built on a clean, dry, and stable foundation. Positive drainage for each pile should be provided.

5.1.2 Plant Operations

The following suggestions can help to optimize plant performance and reduce wastes.

Ensure that the drum has the proper number of flights

When a chamberless burner replaces one equipped with a combustion chamber on an existing HMA facility, the proper flighting must be installed at the burner end of the drum to prevent aggregates from interfering with the flame, thereby maximizing combustion efficiency and reducing carbon monoxide and hydrocarbon emissions.

Monitor the drum mixing process for unburnt fuel

Unburnt fuel problems can be recognized in several ways. The sound of the burner should be monitored. A uniform, constant roar is desirable. A coughing, sputtering, or spitting sound may mean that the burner is not able to combust the fuel properly. Brown stains or a lesser asphalt cement film thickness on the coarser aggregate particles at the discharge end of the drum mixer also indicate unburnt fuel problems. In addition, a flame eye, an electronic device used to sense the color of the burner flame, can be employed to monitor the hue of the burner flame and shut down the burner if the color does not indicate complete combustion of the fuel.

Evaluate the fuel used for the burner

The burning of some fuels (i.e., fuel oil) may result in greater emissions of particulate matter than with other cleaner fuels such as natural gas. In addition, some asphalt plants have switched from oil to wood fuel to reduce sulfur emissions.

Ensure the proper density of the veil of aggregate inside the drum near the midpoint of the drum length

Veil density is the key to the efficient drying operation of the drum mixer and economical fuel usage. The completeness of the veil can be determined by comparing the discharge temperature of the mix with the temperature of the exhaust gases at the stack. The stack temperature should be no more than 20°F higher than the mix discharge temperature if the veil of aggregate inside the drum is complete across the cross-sectional area of the drum (assuming that no cooling air is added in the emission control system).

The density of the veil of aggregate inside the drum can be increased through the use of kicker flights, dams, donuts, or retention rings near the midpoint of the drum length. Lowering the slope of the drum to increase the dwell or residence time of the aggregate in the drum can also increase the veil density.

Preheat RAP prior to introduction in the pugmill

When recycling is performed in the batch mixing process, RAP is added to the hot aggregates after they have left the drum, either in the boot of the hot elevator or directly into the pugmill. The addition of unheated RAP into the process can result in a significant fugitive emission problem if the fugitive-dust air handling system on the mixing tower has not been properly modified. Unheated RAP causes a sudden, rapid release of steam as moisture in the RAP evaporates upon mixing 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 to eliminate the release of steam.

Optimize feed point of RAP to reduce visible hydrocarbon emissions

If possible, use a split-feed system to introduce RAP to the drum mixer to avoid overheating and release of volatiles. Even with a split-feed system, care must be taken to ensure an adequate veil density so that the temperature of exhaust gases is not too high at the RAP entry point.

Very few plants use a single-feed system for asphalt recycling because of the inherent emission control problems. However, if a single-feed system is used to deliver both RAP and new aggregate to the burner end of the drum mixer, several techniques can be used, alone or in combination, to protect the asphalt-coated material from direct contact with the flame. In one method, water is sprayed on the combined aggregate on the charging conveyor before it enters the drum. A second method involves increasing the speed of the slinger conveyor under the burner to propel the combined aggregates farther down the drum. The greater the distance between the asphalt-coated materials and the flame, the less hydrocarbon emissions are generated. A third alternative is the use of a heat shield to reduce contact of the combined aggregate with the flame.

Optimize exhaust gas temperature

The generation of visible hydrocarbon emissions from the stack indicates that the temperature of the exhaust gases inside the drum is too high at the point where the asphalt cement or RAP is injected into the drum.

Optimize burner efficiency

Burner efficiency has a direct effect on the formation of gaseous emissions from combustion. A number of operating guidelines should be observed to optimize efficiency, including:

- Select the fuel with proper consistency for complete atomization at the time of combustion. For example, No. 2 fuel oil will burn at ambient temperatures without preheating. However, heavy fuel oil, such as No. 5 or No. 6., must be preheated before burning in order to atomize the fuel properly for complete combustion.
- Closely monitor burner efficiency by measuring O_2 and CO in the drum as close to the flame as possible.
- Closely control the excess air in the drum.
- Eliminate air leaks to ensure the proper volume of air at the burner to combust the fuel completely.
- Install a damper in the ductwork to control the amount of air entering the system.

Patch holes in the ductwork between the end of the dryer or drum mixer and the emission control equipment

Patching all holes in the ductwork prevents the exhaust fan from drawing in excess air and reducing the amount of air available for combustion at the burner. In addition, holes may allow the escape of fine particulate matter. Although this is unlikely because the scavenger air system operates under a negative pressure, patching ensures that all dust in the exhaust gases is drawn into the emission control equipment.

5.1.3 Pollution Control Equipment

If wet collectors are used, consider switching to baghouses

The use of a baghouse eliminates the wastewater and sludges generated by a wet scrubber and the costs associated with disposal of these wastes. In addition, the baghouse dust can usually be recycled in the manufacturing process.

5.2 POLLUTION PREVENTION OPPORTUNITIES DURING ASPHALT LAYDOWN AND COMPACTION

Suggestions to reduce waste during asphalt laydown and compaction include:

Avoid the use of diesel fuel as a truck bed lubricant

Non-petroleum based materials, such as lime water or one of a variety of commercial products, should be used for release agents. A listing of Illinois DOT approved release agents is provided in Appendix A. In addition to the environmental problems diesel fuel can cause, excess diesel fuel can accumulate in the bed of the truck and cause changes in the properties of the binder material.

Use less toxic solvents for equipment cleanup

Limonene cleaners, commercially available terpenes made from oils of lemon or orange, are listed as GRAS (Generally Recognized as Safe) substances in the Code of Federal Regulations. Diesel fuel and other toxic solvents should not be used for equipment cleanup.

Employ mechanical cleaning methods

Manual scraping of equipment helps to reduce the amount of solvent needed for cleaning.

Use high pressure spray nozzles

If water is used to rinse equipment, use high pressure spray nozzles to reduce the volume of water needed.

6.0 OBSTACLES TO POLLUTION PREVENTION

6.1 REGULATORY OBSTACLES

Environmental regulations are one of the driving forces behind waste minimization and pollution prevention programs. However, regulatory requirements can sometimes act as barriers to the overall goal of pollution prevention programs. Examples of potential barriers include:

- **Regulatory deadlines** may force industry to focus their limited resources for pollution controls to implement a "quick fix" solution. Lifting the pressures of the deadline could enable the company to re-evaluate their operating procedures in order to create a more comprehensive, long-term compliance plan that incorporates pollution prevention practices. This cost-effective approach to compliance would benefit the facility while reducing pollution emissions.

- **Permitting delays** may also inhibit or delay the use of innovative approaches to pollution prevention. If the pollution prevention practice involves more time, energy, and resources to gain regulatory acceptance than standard end-of-pipe treatment, industry may opt to continue traditional operations. In addition, the reclamation, recycling, or acceptance of another plant's waste as a feedstock may also require compliance with other environmental regulations.

- Current **compliance** with regulations may act as a disincentive to pollution prevention activities. For example, a facility that is already operating in compliance may not realize the long-term benefit of investing more time and resources to develop or expand pollution prevention activities.

6.2 OTHER OBSTACLES

In addition to regulatory obstacles, other barriers may negatively impact the implementation of pollution prevention programs. Such barriers range anywhere from production to waste treatment procedures and need to be considered when designing a pollution prevention program. For instance, an interesting issue in the asphalt paving and recycling industry involves increased pressure to use tires and other waste materials in asphalt. Although this practice may help to find beneficial uses for these waste streams, it may in some cases cause additional emissions or make asphalt recycling more difficult.

Any pollution prevention program is bound to encounter initial challenges that may hinder the desired level of effectiveness. Therefore, it is essential for facilities to consider several options and alternatives when formulating the basis for a pollution prevention program. Facilities that have had initial waste reduction successes must strive to overcome these barriers to sustain on-going, continuous improvement. Appendix B, which discusses how to develop a "Best-in-Class" Facility-Level Pollution Prevention Program, may provide ways to help overcome these challenges.

APPENDIX A

ILLINOIS DEPARTMENT OF TRANSPORTATION
LIST OF APPROVED TRUCK RELEASE AGENTS

Illinois Department of Transportation
LIST OF APPROVED TRUCK RELEASE AGENTS
July 1995

Company	Release Agent	Dilution Ratio	Date Approved
ALZO, Incorporated 6 Gulfstream Blvd. Matawan, NJ 07747 Attn: Stanton H. Cramer	Releeze	30:1	05/89
American Lubricants Co. P. O. Box 696 Dayton, OH 45401 Phone: 513-222-2851 Attn: Sam Hall, Sales Manager	Quick Release #2000 Quick Release #2001 Quick Release #1209	No less than 30:1 30:1 50:1	05/93 12/94 05/91
Arr-Maz Products 621 Snively Ave. Winter Haven, FL 33880 Phone: 813-293-7884 Attn: Raymond J. Mertz, Manager	TBRA #7191 TBRA #8254	50:1 50:1	12/94 12/94
Associated Chemists/Templex 4401 S.E. Johnson Creek Blvd. Portland, OR 97222 Phone: 503-659-1708 Attn: Chris Beach	642 Release Agent	30:1	02/92
Astec Corporation 7750-650 Zionsville Road Indianapolis, IN 46268	Glide Off	40:1	07/95
CAM Construction, Ltd. 300 Daniel Boone Trail P. O. Box 861 South Roxana, IL 62087 Phone: 618-254-3855 Attn: Lou Ackers	Reclamite	No less than 10:1	01/95
Certified Laboratories P. O. Box 2493 Ft. Worth, TX 76113-2493 Phone: 309-243-9247 Attn: Mike Crismole	Certisuds	4:1	01/95
The ChemMark Corp. 3140-K South Peoria St., Suite 115 Aurora, CO 80014 Phone: 303-725-3880 Attn: Mark Delong, President	Thermal-Slide Black Magic 13 Black Magic for Rubber	 As is As is	03/91 02/95 02/95

Illinois Department of Transportation
LIST OF APPROVED TRUCK RELEASE AGENTS
July 1995

Company	Release Agent	Dilution Ratio	Date Approved
ChemStation 200 Ford Drive, Unit B New Lenox, IL 60451 Phone: 815-485-5163 Attn: Rod Smith	HD5565 HD5320 VC2660	No less than 10:1 30:1 20:1	07/93 12/93 07/94
Delta Foremost Chemical Corp. 3915 Air Park St. P. O. Box 30310 Memphis, TN 38130-0310 Phone: 800-238-5150 Attn: Charles E. Burks, Chemist	Foremost F-1425	20:1	01/95
Drummond American 24 Barclay Court Decatur, IL 62522 Phone: 217-429-6537 Attn: Doug Pope	Riptide	No less than 8:1	05/91
DuBois Chemical Co. 3630 E. Kemper Rd. Sharonville, OH 45241-2046 Phone: 800-438-2647 Attn: David Foutch	Poly-Slip Diver-Slip	30:1 30:1	09/91 01/95
Exxon Chemical 1012 Terra Drive Milton, WI 53563-0388 Phone: 608-868-6811 Attn: William E. Welch	Release Rite	10:1	12/93
Fine Organics Corp. 205 Main St. P. O. Box 687 Lodi, NJ 07644 Phone: 800-526-7480 Attn: Dennis Esposito	FO Release FO Release II	100:3 100:3	10/91 12/93
First AYD Corporation 450 S. Lombard, Unit C Addison, IL 60101 Phone: 708-627-0001 Attn: Dave Steger, General Manager Attn: Louis Szklanecki, Product Manager	Asphalt Slide #962 Better Asphalt Slide #519 Best Asphalt Slide #57 Cherry Slide Asphalt Slide with Silicone	20:1 15:1 15:1 15:1 20:1	04/93 04/93 04/93 04/94 07/95
Foresight, Inc. 2313 Timber Ridge Road St. Jacob, IL 62281 Phone: 618-667-2827 Attn: Norman Seim, President	Foresight RE-1500	15:1	05/95

Illinois Department of Transportation
LIST OF APPROVED TRUCK RELEASE AGENTS
July 1995

Company	Release Agent	Dilution Ratio	Date Approved
G. E. Chemicals, Inc. 1401 Johnson Ferry Rd., Suite 328 Al Marietta, GA 30062 Phone: 800-677-4717 Attn: Keith R. Keller, Sales Engineer	Release	30:1	06/91
E. A. Harper & Co., Inc. P. O. Box 1578 Newport News, VA 23607 Phone: 513-222-2851 Attn: James D. Parisher	Quick Release #1209	No less than 50:1	05/91
Interchem Environmental 9135 Barton Overland Park, KS 66214 Phone: 913-599-0800 Attn: Steve Howell, Consultant	AR-X	As is	07/94
Martinsville Emulsion Products P. O. Box 5384 Martinsville, VA 24115 Phone: 703-957-2172	Mepcoat-103	48:1	06/91
R. D. McMillen Enterprises 19 Cottage Grove Springfield, IL 62707 Phone: 800-543-5376 Attn: Don W. Smith, Sales Rep.	Dyna Mac	32:1	04/94
NCC, Incorporated 1000 Johnson Ferry Rd. Building A, Suite 120 Marietta, GA 30067 Phone: 800-241-4547 Attn: Bill Clay	JL-268 JL-1000	25:1 40:1	01/95 01/95
National Chemsearch 1001 Graig Road, Suite 306 St. Louis, MO 63146 Phone: 800-325-8896 Attn: Bill Harrison, Sales Rep.	Chemsearch Concentrate	10:1	03/92
Presto Chemical Co. P. O. Box 1294 Roswell, GA 30075 Phone: 404-442-1970 or 800-992-9023 Attn: Margie Miller or Nick Pittman	Kwick Release Bio-Kream	40:1 No less than 40:1	01/95 04/93

Illinois Department of Transportation
LIST OF APPROVED TRUCK RELEASE AGENTS
July 1995

Company	Release Agent	Dilution Ratio	Date Approved
Puritan/Churchill Chemical Co. 1012 Delevan St. Lincoln, IL 62565 Phone 309-342-0191 or 800-747-2999 Attn: Don W. Smith or Dave Mach Consultants	Churchill L-901 Churchill L-911	30:1 180:1	06/92 04/94
RTEC Development 639 Tully Road, #L San Jose, CA 95111 Phone: 800-742-2122 Attn: Dwaine O'Myer, Vice President	Stay Clean	No less than 11:1	07/93
R.U.S. Enterprise 3811 Ferdinand Place, Suite 42 P. O. Box 9148 Cincinnati, OH 45209 Phone: 513-731-4452 Attn: Wendall S. Bradford, President	Enviro Release Slip	40:1	03/92
Rochester Midland Corp. 4213 North Keenland Avenue Peoria, IL 61614 Phone: 309-688-5252 Attn: Mike McCavitt, Branch Manager	Slipeazee Slipeazee SB Slipeazee 2000 Slipeazee Natural	No less than 30:1 30:1 20:1 20:1	04/91 04/91 01/95 04/95
S.S.I. Chemical 614 Chattin Dr. Canton, GA 30115 Phone: 404-345-2570 Attn: Paul A. Wilson, President	DMX-7	No more than 10:1	09/94
S & S Industrial Services Corp. 1345 Perl Street Waukesha, WI 53186 Phone: 414-548-8040 Attn: Robert Hendershott, Chemist	AR-611	30:1	04/93
Scanroad, Incorporated 4914 Fort Ave. P. O. Box 7677 Waco, TX 76714-7677 Phone: 800-772-7677 Attn: Jim Wright, Sales Manager	Perm-Slip	25:1	03/92
Selig Chemical Industries R. R. 1, Box 189 Mason, IL 62443 Phone: 618-238-4929 Attn: Joe Bushue	Tar Slide 37-sx-39		04/91

Illinois Department of Transportation
LIST OF APPROVED TRUCK RELEASE AGENTS
July 1995

Company	Release Agent	Dilution Ratio	Date Approved
Spartan Chemical Co., Inc. 110 N. Westwood Ave. P. O. Box 3495 Toledo, OH 43607 Phone: 419-531-5551 or 800-537-8990 Attn: Frank A. Domalski Quality Supervisor	SD-20	50:1	01/95
Tarmac Products, Inc. 219 N. 7 Highway Blue Springs, MO 64014-2784 Phone: 816-228-0882 Attn: Georginna Banks, Acct. Manager	Silkit	No less than 50:1	10/92
Tec-Logix Industries, Inc. P. O. Box 888748 Atlanta, GA 30356 Phone: 404-579-5199 Attn: William Gardner	Teclon-50	50:1	01/95
Texas Refinery Corp. 2754 Marjorie Lane Manito, IL 61546 Phone: 309-968-6648 Attn: Michael Trainer, Sales Rep.	Big Red Cleaner	30:1	03/93
Texo Corporation 2801 Highland Ave. Cincinnati, OH 45212 Phone: 513-731-3400 Attn: Craig A. Burkart Products Specialist	Texope-515	30:1	09/91
Transportation Industries Diversey Corporation 255 E. Fifth. St., Suite 1200 Cincinnati, OH 45202 Phone: 513-762-7319 Attn: Eric C. Hines	Slide Eze	30:1	04/93
Vibrant Products P. O. Box 28911 Atlanta, GA 30358 Phone: 800-972-0175 Attn: Vivian Britton, Sales Executive	JL 1000 Blend Envirofoam PK-180 Foamex	No less than 30:1 30:1 30:1	07/93 07/93 07/93

Illinois Department of Transportation
LIST OF APPROVED TRUCK RELEASE AGENTS
July 1995

Company	Release Agent	Dilution Ratio	Date Approved
Ron Villines & Associates, Inc. 1151 Villaview Drive Manchester, MO 63021 Phone: 314-849-8055 Attn: Ron Villines, President	044 Biodegradable	10:1	03/94
Vonachen Industrial Supplies P. O. Box 3156 Peoria, IL 61614-0156 Phone: 815-426-6529 Attn: Todd Arseneau	Release Agent "V"	As is	03/95
Wilson Supply Co. 2902 Amber Lane Dallas, GA 30132 Phone: 800-251-0485 Attn: Tom Leddy	"AFR" (4763)	30:1	04/95
Zep Manufacturing Co. 1310 Seaboard Industrial Blvd., N.W. P. O. Box 2015 Atlanta, GA 30301 Phone: 404-352-1680 Attn: Philip Ellis, Technical Services	Zep R-6690	7:1	01/91

APPENDIX B

HOW TO DEVELOP A "BEST-IN-CLASS" FACILITY LEVEL POLLUTION PREVENTION PROGRAM

HOW TO DEVELOP A "BEST-IN-CLASS" FACILITY-LEVEL POLLUTION PREVENTION PROGRAM

Many facilities have already implemented numerous important and significant source reduction initiatives. In order to build on these successes, and further strengthen a facility's pollution prevention program, it is useful to compare the facility's program to a "benchmark" derived from facility level pollution prevention programs, which are widely regarded as "best-in-class."

In spite of significant initial successes, numerous facilities have discovered that pollution prevention should be an on-going process of continuous improvement. These facilities have found that, over time, even further ***cost-effective*** reductions can be achieved by integrating and institutionalizing the pollution prevention program within the facility's daily business practice.

In addition, public demands for continuously improving environmental performance is causing federal and state governments to adopt legislation and regulations that are meant to encourage cost-effective source reduction.

However, it is becoming increasingly clear that many of these new requirements are prescriptive in nature and tend to add nonproductive elements to the pollution prevention process. Regulatory-driven reporting requirements, process requirements, record keeping, and prescribed methods of reduction all have the potential to restrict pollution prevention progress and stifle the creativity and innovation needed for substantial progress.

Many industries view institutionalized continuous pollution prevention improvement as essential for supporting industry's overall pro-active efforts designed to satisfy public demand and reduce the perceived need for any such additional regulatory-driven requirements. By striving for "best-in-class" status, many more industries can provide an important contribution to this effort.

A useful approach is to perform an evaluation of a facility's pollution prevention program compared to the results of the Facility Level Pollution Prevention Benchmarking Study performed by The Business Roundtable (BRT) and published in November 1993.

Of all the facilities that met the BRT's Benchmarking Project Team's selection criteria for a "Best-in-Class" facility level pollution prevention program, the following six were selected for the BRT's benchmarking study:

COMPANY	FACILITY LOCATION	CHEMICAL USER OR MANUFACTURER
Procter & Gamble	Mehoopany, PA	Chemical User
Intel	Aloha, Oregon	Chemical User
Du Pont	La Porte, Texas	Chemical Manufacturer
Monsanto	Pensacola, Florida	Chemical Manufacturer
3M	Columbia, Missouri	Chemical User
Martin Marietta	Waterton, Colorado	Chemical User

The study identified the following 18 critical/essential or important elements found to be common for "best-in-class" facility level pollution prevention programs.

1. Facilities had a clear facility-wide understanding of the definition of pollution prevention -- and had either facility or corporate pollution prevention mission/vision/policy statements.

2. Facilities had a method for identifying and documenting all wastes and emissions.

3. Facilities had pollution prevention goals.

4. Facilities used a facility champion or facilitator or focal point person to lead the program.

5. Facility management was committed to provide necessary resources to support pollution prevention activities. Pollution prevention was a core value at the facility.

6. Facilities integrated pollution prevention into the existing business planning procedure rather than relying on separate pollution prevention plans.

7. Priorities were assigned to waste streams.

8. Cross-functional teams were used. There was an organized effort to motivate employees to suggest and implement pollution prevention initiatives.

9. In order for the facility to sustain its pollution prevention program, most pollution prevention projects had to be cost-effective in order to be implemented. Unlike compliance projects, pollution prevention projects had to compete in the normal capital process.

10. Pollution prevention progress was tracked and communicated.

11. Facilities used quality tools in their pollution prevention program.

12. Many facilities tied responsibility and accountability for wastes, emissions, and pollution prevention results to the generating operation.

13. The facility did not seek to change its culture, but rather integrated and institutionalized the pollution prevention initiative into its existing culture.

14. Facility recognition programs are used to help sustain employee motivation.

15. Facilities had access to corporate and other outside resources to support implementation of the facility's pollution prevention programs.

16. Effective communication, both within the facility and between facilities, increased pollution prevention awareness.

17. Pollution prevention was integrated into pre-manufacturing (research, development, and design) decisions or choices.

18. Facilities used new technology to achieve significant improvement.

Any assessment of a facility's pollution prevention program should also be heavily influenced by the results of a Quality Environmental Management (QEM) project conducted by the President's Commission on Environmental Quality (PCEQ) under former President Bush. The results of that (QEM) project are summarized in the Commission's January 1993 report entitled Total Quality Management: A Framework For Pollution Prevention. The report recommends the following TQM frame-work for pollution prevent-ion, called "Quality Environmental Management" or "QEM."

1. Establish Management Commitment

   - involve stakeholders
   - define and allocate resources
   - empower employees

2. Develop A Quality Action Team

   - organize a cross-functional team
   - use existing resources and processes
   - establish two-way commun-ication with management

3. Awareness and Process Training

   - timely
   - practical

4. Determine Environmental Impact of Existing Operations

   - use QEM tools and methods as appropriate
   - identify and fill critical information gaps
   - consider how to measure improvements

5. Develop and Select Improvement Projects

   - develop project selection criteria
   - collect only additional data needed to make decisions
   - establish metric baseline

6. Implement Improvement Projects

   - inform all site employees of impending improvement project
   - empower the QAT to implement the project or obtain the additional resources necessary

7. Measure the Results

   - develop metrics
   - adjust as necessary

8. Standardize/Institutionalize Improvement and Begin New Cycle

   - integrate improvements into other processes and institutionalize such actions as a company "best practice"
   - communicate actions to stakeholders
   - recognize team and individual performance achievements in ways consistent with company culture
   - continue the process

The following provides a summary of a few of the key findings of the President's Commission on Environmental Quality (TQM) report.

- TQM and Pollution Prevention (P2) are complementary concepts -- emission or waste reduction opportunities are most successful when groups of employees with diverse skills and experiences are fully empowered to identify sources of pollution and to make innovative, cost-effective recommendations for addressing identified sources. TQM tools are useful at every step in this process.

- Successful P2 efforts, while dependent on a systematic and rigorous analysis, rely heavily on flexibility in actual application

- There is no universal metric for tracking performance, but there are a number of metrics which can be tailored to a company's needs.

- Consultation and collaboration with stakeholders interested in emission or waste reductions are critical in developing credible progress reports

- Understanding the barriers and incentives to effectively implementing a P2 program is key to increasing corporate commitment & success. Incentives may include:

  - cost savings
  - technological innovation
  - increased public acceptance
  - better relations with regulators

  Barriers typically include:

  - limited resources
  - inertia
  - uninformed management or employees
  - accounting systems that do not measure environmental costs or values
  - fear of compromising product quality or production efficiency
  - technology limitations

- Even an excellent pollution prevention project must often compete for scarce time (people) and financial resources against several other important projects -- many of which may provide other valuable social benefits such as new jobs, improved process safety, etc.

- Effective QEM is a continuous improvement process

Indeed, in recent years, literally hundreds if not thousands of pollution prevention success stories have been published, which demonstrate the simultaneous economic and environmental benefits of the pollution prevention approach to improving environmental performance. Numerous pollution prevention guidance documents have also been published to help businesses develop their own pollution prevention programs. Any number of these success stories and guidance documents can be used as a benchmark for assessing a facility's pollution prevention program.

Since 1986, CHMR has provided focused pollution prevention technical assistance and training for business and industry both nationally and internationally. Based on this 9 years of accumulated pollution prevention focused knowledge and experience, it is our position that the two reports discussed previously provide the best and most concise resource to serve as a basis for this assessment.

In summary, facilities should continue to take steps necessary to focus on and provide organizational support needed to promote pollution prevention facility-wide, and thereby achieve "best-in-class" status.

> *"Industry has historically worked to maximize the efficient use of resources (materials, labor, energy, etc.) needed for the manufacture of its products. Techniques such as recycling, improving operational procedures, modifying processes and even developing new technologies have all been used to reduce the amount of resources needed to produce a product. In recent years, "pollution prevention" and "source reduction" have become key objectives of many industries for improving environmental performance. Many of the same techniques used to maximize resource utilization can be used to reduce the environmental impact that manufacturing facilities can have on the environment."*
>
> *Position Paper on Pollution Prevention*
> *The Business Roundtable*
> *March 8, 1994*

APPENDIX C

REFERENCES

REFERENCES

Air & Waste Management Association, *Air Pollution Engineering Manual*, 1992.

American Association of State Highway and Transportation Official, Federal Aviation Administration, Federal Highway Administration, National Asphalt Pavement Association, U.S. Army Corps of Engineers, *Hot-Mix Asphalt Paving Handbook*, July 1991.

Asphalt Recycling and Reclaiming Association, Association literature.

City of Pittsburgh Asphalt Manufacturing Plant, Personal communication.

Daniel, Bobby E., "Evaluation of Emissions from Paving Asphalt," *U.S. EPA Control Technology Center News*, July 1994.

Donegal Construction Company, Personal communication.

Electric Power Research Institute, "Microwave Process for Asphalt Pavement Recycling," *TechApplication*, 1992.

Illinois Asphalt Pavement Association, Personal communication.

Minnesota Asphalt Pavement Association, Personal communication.

National Asphalt Pavement Association, "Dealing With Title V Operating Permits -- The 'Synthetic Minor' Alternative," Special Report 175, February 1995.

National Asphalt Pavement Association, Personal communication.

Pennsylvania Department of Transportation, Personal communication.

Rason Asphalt, Inc., Personal communication.

U.S. Environmental Protection Agency, *Air Pollution Engineering Manual*, Second Edition, May 1973.