pollution: sources and solutions in bituminous construction

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Pollution or the presence of substances in concentrations sufficient to interfere with comfort, safety, or health comes from many sources. The increased concern for the environment has resulted in the establishment of federal, state, and local controls on particulate, water, noise, odor, and noxious gas pollutants.

Construction operations using bituminous materials must conform to such regulations. For example, of the 53 states and territories surveyed by the National Asphalt Pavement Association, only 2 states, West Virginia and Florida, had specific hot-mix asphalt plant regulations (1). However, 33 states had legislation that would allow control agencies to establish regulation. That enabling legislation resulted in a substantial increase in the number of agencies with specific air pollution regulations for hot-mix asphalt plants (2). Furthermore, a substantial number of state and local governments have regulations that are applicable to industrial processes to control pollutants emitted from hot-mix asphalt plants.

Examples of specific regulations on hot-mix asphalt plants (2) are given below; those regulations include controls for particulate matter and smoke but do not include controls for water, noise, odor, and noxious gas.

1. Florida—No portable asphalt plant shall be operated within the state of Florida unless (a) the maximum discharge of particulate matter is 0.3 grains per standard cubic foot of dry gas or (b) it can be shown that within a circle centered on the plant and having a radius of 1 mile there are a maximum of 2 occupied residences.
2. Hawaii—0.85 lb of dust emission per 1,000 lb of exhaust gas (adjusted to 50 percent excess air).

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3. Kentucky—

Plant Production (tph)	Allowable Emission (lb/1,000 lb gas)
0 to 100	0.6
101 to 150	0.5
151 to 200	0.45
200+	0.35

4. Michigan—

Plant Production (tph)	Allowable Emission (lb/1,000 lb gas)
All stationary	0.3
Portable	
0 to 100	0.6
101 to 150	0.5
151 to 200	0.45
200+	0.35
Remote portable	0.3 or 1-mile buffer zone with no residences

5. New Hampshire—Permanent plants must have efficiency standard of 80 percent minimum efficiency for wet or dry collector. Portable plants must be located so as not to create a nuisance.

6. Oregon—Efficiency standard of 80 percent minimum collection efficiency by weight. Process weight table with cutoff at 60,000 lb/hour input (40 lb/hour output maximum).

7. Texas—Minimum buffer zone of 1 mile based on land use.

8. West Virginia—Process weight table, 50 lb/hour allowable emission at 600,000 lb/hour or more; smoke, greater than No. 1; Ringlemann not allowed.

9. Wisconsin—0.3 lb/hour per 1,000 lb of exhaust gas (proposed); smoke, greater than No. 2; Ringlemann not allowed (proposed).

10. Milwaukee County—0.3 lb/hour per 1,000 lb of exhaust gas; smoke, greater than No. 2; Ringlemann not allowed.

Similar pollution control ordinances may be or can be expected to be developed for all types of construction using bituminous materials. Thus, it is becoming increasingly important that the bituminous paving engineer become familiar with those regulations and develop methods to satisfy the intent of the regulations.

A recent study conducted by the Louisiana Department of Highways (3) indicated that in many states hot-mix plants may have difficulty meeting present requirements with existing equipment. Because the current trend toward stricter regulations is expected to continue, that problem can only increase in severity.

A recognition of the sources of pollution in bituminous construction will afford the opportunity to recognize potential solutions. This paper gives a brief summary of possible pollution sources and discusses methods to solve some of the problems. Correction of pollution can be achieved by use of auxiliary pollution control equipment, use of new and innovative equipment, and use of special mixtures.

SOURCES OF POLLUTION

Construction operations using bituminous material can be divided into central-plant mixing, road mixing, seal-coat and surface treatments, prime and tack-coat operations, and certain maintenance operations that use cold-laid mixtures. Typical bituminous materials used for those applications include asphalt cements for control mixing and for seal-coat and surface-treatment operations. Cutbacks and emulsions are used most often for road mixing, prime coats, and tack-coat operations.

The selection of the type of bituminous material to be used is often determined by construction and service demands. However, under certain conditions, any one of the common forms of bituminous binder can be used successfully. Under a wide range of conditions, both emulsified asphalts and cutback asphalts can be used satisfactorily. Thus, the selection of the bituminous material type may depend on pollution and economic constraints imposed for selected conditions.

The use of cutback asphalt in southern California has been severely limited because of the solvent requirements set by the Los Angeles County Air Pollution Control Districts. It is estimated that compliance with regulation will increase the cost of cutbacks about $4/ton (4). Additional control districts must be formed throughout California as required by state law and will likely adopt similar restrictive ordinances. Control on a national scale appears to be just ahead. It, therefore, seems appropriate to discuss possible pollution associated with those construction operations.

Central-Plant Mixing

Because the vast majority of central-plant mixing operations are hot-mix operations, this discussion will be limited to that operation. The sources of pollution will be separated into the categories of particulate pollution, water pollution, noise pollution, odor pollution, and noxious-gas pollution (5).

Particulate Pollution—Aggregate dust, fly ash, soot, and unburned droplets of fuel oil are the main particulates resulting from asphalt plant operations (Fig. 1, 10).

Aggregate dust is created during the aggregate storage operation, the drying operation, and the screening process. Aggregate dust can also be created by traffic within the batch plant area and by wind. However, the major source of dust is the dryer. For an average-sized dryer without a dust collecting system, 5 to 10 tons of dust per hour leave the drying chamber. Few, if any, of those dryers are in use in this country today. Fly ash and soot are formed during oil or gas combustion. Pollution due to drying of the aggregate is a far more serious problem than that due to heating the asphalt. Pollution associated with both the heat source and the aggregate dust in the drying operation makes the aggregate operation especially critical.

Fly ash results from impurities in fuel oil or incomplete combustion. The completeness of combustion, which is controlled by fuel quality and type and oxygen availability, controls to a large extent the amount of fly ash produced. Soot consists of unburned carbon particles emitted from the combustion process. The soot is often considered to be of a particle size less than 1 μm, and fly ash may be considered to fall between 1 and 100 μm.

Poor combustion control often results in unburned oil droplets beign either emitted from the stack or deposited on the aggregate in the dryer. The presence of that unburned fuel on the aggregate can create poor adhesion between the aggregate and asphalt and thus result in a pavement that ravels. A poorly functioning burner, lack of oxygen, or insufficient fuel oil heating contribute to the formation of that pollutant (5).

Water Pollution—Dust can be effectively controlled by the use of one of several types of wet washes. The washes usually require that the dust-water mixture be drained and subsequently deposited in settling ponds. Sometimes, however, the water is drained into rivers or lakes and, thus, creates a pollution problem. Contaminants contained in the water may consist of dust, oil, gasoline, asphalt, and soap. In addition, the water may be hot and acidic.

Noise Pollution—Noise at an asphalt plant is usually caused by the friction of metal against metal, aggregate against aggregate, and metal against aggregate; by the movement of compressed air into the atmosphere; and by the combustion of pressurized fuel in the burner (5). Maximum noise levels normally occur at or near the hot-bin screens, the pug mill, the exhaust fans, and the burners. Noise pollution is greatly reduced at partially enclosed and automated plants.

Odor and Noxious-Gas Pollution—Offensive odors and noxious gases are primarily produced during the fuel combustion process. The odors and gases produced vary with the type of fuel used, the burning temperature, and the efficiency of the combustion process. Odors from the stack area are normally caused by the use of high-sulfur content fuel or unburned natural gas. Odors emitted as the asphalt concrete is deposited into trucks are caused by the mix coming in contact with kerosene or fuel oil that is used to coat the truck bodies or from the volatilization of the light fraction of the asphalt cement. Noxious gases are most frequently carbon monoxide, sulfur dioxide, sulfur trioxide, nitrogen dioxide, and nitric oxide.

Road Mixing

Road-mixing operations use either cutback asphalts or emulsified asphalts because they can be mixed at relatively low temperatures. A petroleum distillate is used to "soften" the cutback asphalt, and water is used with emulsion asphalt. According to the U.S. Bureau of Mines, 4.06 million tons of cutback asphalt for paving use were shipped domestically in 1969. Thus, nearly 1 million tons of distillate were emitted as atmospheric pollutants. The loss of water, the liquefying agent for emulsions, creates little hazard.

Road-mix construction operations consist of roadbed preparation, windrowing of material, addition of asphalt, mixing aeration, and compaction. Each operation normally requires diesel- or gasoline-powered internal combustion engines that are sources of pollution. Dust created during the roadbed preparation, windrowing of material, and mixing is another pollutant.

The asphalt distribution, mixing, aeration, and compaction furnish the time necessary for a large portion of the volatiles to escape to the atmosphere. If sufficient aeration is not allowed to occur during the construction operations, volatiles, which may be noxious and odorous, may be given off during extended periods.

Seal Coats, Surface Treatments, Prime Coats, and Tack Coats

Most seal-coat, surface-treatment, prime-coat, and tack-coat operations involve spraying bituminous material on either a base course (surface treatment or prime coat) or old surfacing material (seal coat or tack coat). Those spraying operations, in which motorized equipment and heaters are used (Fig. 2, 10), create the following pollutants:

1. Exhaust gases from motorized equipment and asphalt heaters,
2. Gases and odors from the overheating of asphalt cements and the volatilization of the lighter molecular weight fraction of the asphalt cement,
3. Volatiles from cutback asphalt,
4. Dust from construction equipment on the unsurfaced roadway and from spreading and compacting aggregate or chip seals, and
5. Asphalt blowing from the spray bar under windy conditions.

Although the quantity of those pollutants is not large compared to the quantity of total pollutants, it is large enough to be visible and thus can be expected to come under more severe restrictions.

Slurry-seal operations use emulsions to form a slurry in a small mixing chamber at the rear of a transport truck and emit a certain amount of dust and exhaust gases. Maintenance materials used for pothole repair and leveling work often contain a significant amount of volatiles that escape during storage and use. Dust-laying and road-oiling operations also involve the spraying of bituminous materials that create pollution in a manner similar to that associated with seal coats.

POLLUTION CONTROL

Pollution control can be achieved in a number of ways; in this paper, those ways are divided into 3 categories: auxiliary equipment, new equipment, and special bituminous mixtures.

Auxiliary Equipment

Most of the auxiliary equipment used in bituminous mixing and handling operations has been developed to control pollution at central-mixing plants (5). A brief summary of that equipment is presented below.

Dust-Control Systems—Dust-control systems must be adequate to control emissions from the dryer, screen cover, weigh and mix area, and hot elevators (fugitive air). Common devices used include expansion chambers, skimmers, centrifugal dry collectors, wet washers, and bag house dust collectors. Those devices are often used in series to achieve adequate control. Typical systems include the dry-wet system, dry-dry-wet system, and dry system (5).

The dry-wet system often consists of a centrifugal dry dust collector, fan, and wet washer. If adequate washers are used and the plant is not operating above capacity, that type of equipment will produce sufficient dust collection to meet many existing air pollution codes. Although that type of system is relatively inexpensive compared to other control systems, its disadvantage is that fines collected in the wet process must be disposed of. The fines are often placed in settling basins; thus, construction, cleaning, and disposal of wet mud or sludge could be a major problem (5).

The dry-dry-wet system often consists of a large-diameter primary centrifugal dry dust collector or a high-efficiency cyclone grouping, a fan, and a wet washer located at the discharge side of the fan. That system, which uses a secondary dust-collection system, has the advantage of collecting a significant amount of dust that would normally become sludge in settling ponds (5). Dry systems usually make use of a bag house dust collector. Under certain conditions the bag house may be preceded by a centrifugal dry dust collector or skimmer. The use of bag houses of sufficient capacity will normally ensure that an asphalt plant can operate within pollution control limits (5).

Figure 3 and 4 (5) show examples of dry dust collectors and wet washers.

Dust in the plant area can be controlled by one or by a combination of several of the following actions:

1. Stockpiles can be protected from wind by proper placement, by construction of windbreaks, or by storage of aggregates in bins or silos;
2. Control of vehicle speed and use or paved driveways and approaches will greatly reduce dust created by trucks (dust control chemicals might be used on unpaved areas);
3. Frequent cleaning to eliminate accumulated dust and waste materials can be employed.

Water Control Systems—Wet washers usually require settling basins. A well-designed settling basin is large enough for settlement to take place and for the water to cool. Chemical flocculents, drag chains, screws, or other dewatering devices can be used to hasten the settlement and removal of sludge from those ponds (5).

Noise Control Systems—Noise control can be achieved by soundproofing, using employee protection devices, and removing personnel from high noise areas. Automated plants have reduced noise in hot-mix plants.

Odor and Noxious Gas Control Systems—Control of odor and noxious gases can be achieved by proper selection of fuels (low-sulfur content) and by the use of more efficient combustion systems. Pollutants in road-mixing operations and in seal-coat and surface-treatment operations can be reduced by using pollution control devices on all vehicles, by using emulsions rather than cutbacks, by working materials in a damp condition, and by controlling construction traffic speeds.

New Equipment

Pollution control ordinances have been adopted only recently in most states and local governments. As a result, equipment manufacturers have made improvements to their equipment.

A relatively new mixing concept that combines the aggregate heating and mixing process in a single operation in the rotating drum offers promise of a relatively pollution-free plant (6). That operation appears to offer several advantages.

1. Pit run or screened aggregates can be stockpiled in a moist condition, thus, eliminating the normal hot-screening process and reducing the dust pollution in the plant yard and cold-feed areas.
2. Aggregates are mixed with asphalt in the same drum in which they are heated, and, consequently, dust that usually passes out the stack is trapped.

Figure 1. Typical operation of asphalt plant.

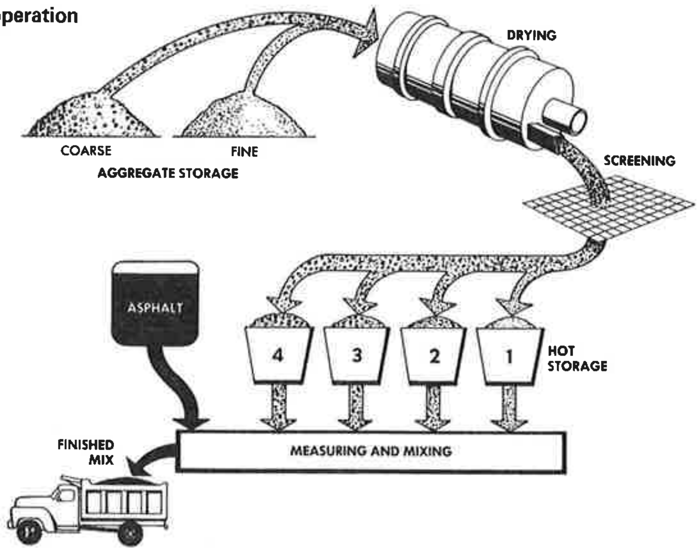


Figure 2. Asphalt distributor.

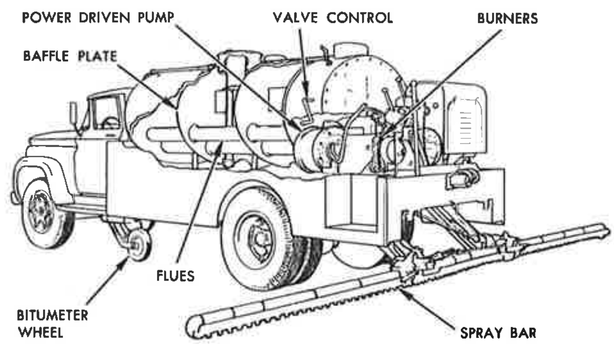


Figure 3. Dry dust collectors.

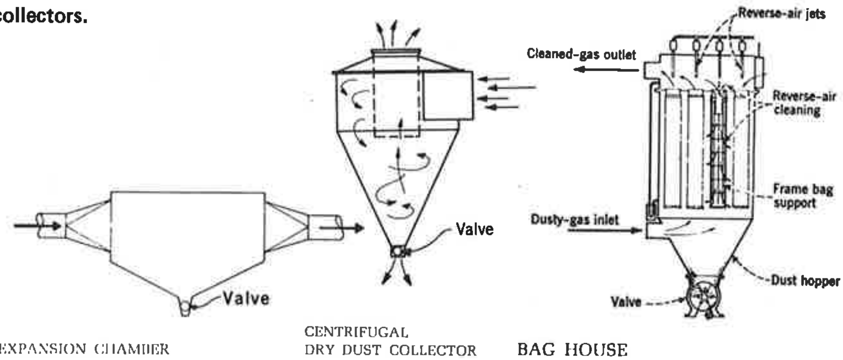
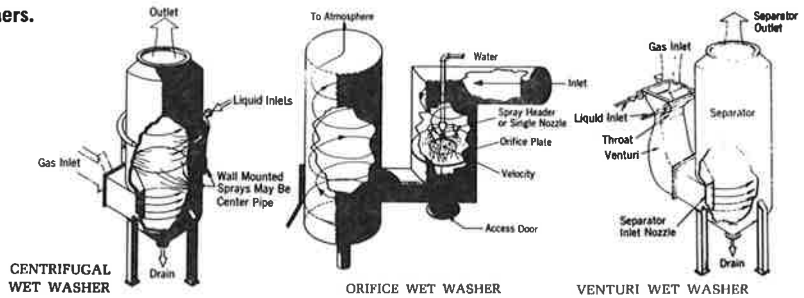


Figure 4. Wet washers.



3. Required mixing temperatures are lower because water is present in the mix, and, thus, overheating of the asphalt and subsequent pollution are greatly reduced.
4. Depending on the location and local regulations, the need for auxiliary dust control equipment is lessened or eliminated.

Research and development of the dryer drum concept are currently under way (6, 7, 8, 9). A study of the Shearer process is being conducted by the Federal Highway Administration in the state of Washington to investigate both mixture quality and air pollution control. Further development and testing appear to be warranted even though several state highway departments have already elected to permit that type of production at least as an alternate in the bidding.

Pollution associated with the plant yard and the immediate plant area often cannot be effectively controlled because of the large amount of plant areas and pollutants associated with present auxiliary equipment. Therefore, the hot-mix producers should not be surprised if pollution standards require that the entire plant be enclosed. The pollutants would be collected within the enclosure and subjected to dry-collection processes such as bag houses to reduce dust and other pollutants. Wet washers may not be satisfactory because of the added problems with water pollution and additional costs.

Special Mixtures

Special mixtures may be developed to control pollution. Those mixtures would probably contain a small amount of fines, require bituminous binders that would satisfactorily coat and mix at relatively low temperatures, and require aggregate gradation control that could be easily obtained with natural aggregates. A number of hypothetical mixtures that would be satisfactory are suggested below.

Mixtures containing reduced amounts of fine material could be used effectively as stabilized base material and as open-plant mix seals. A mix that would have the appearance of popcorn or marbles glued together with asphalt could be used as a base course or drainage layer provided adequate durability could be obtained. Open-plant mix surfaces could be effectively used to provide drainage on pavement surfaces to reduce the potential for hydroplaning (11). Mixtures with reduced fines content (produced by a wet separation process) will reduce the amount of dust produced in the dryer and fugitive air systems and in the stockpile, cold-feed, and hot-screening processes.

Bituminous binder that will coat and mix at relatively low temperatures offers significant advantages. Emulsified asphalts appear to be worthy of serious consideration, provided a quality asphalt concrete mixture can be obtained.

A cost analysis of emulsions rather than asphalt cement for asphalt-aggregate mixtures of approximately equal quality indicates that first cost favors emulsion mixes only slightly. The probability of job success is generally less with emulsion mixes, and the expected pavement life is decidedly less on an equal-thickness basis.

The use of cutback asphalts appears to be limited because of the emission of volatiles. In fact, Los Angeles County, California, prohibits the use of cutback for that reason.

Natural aggregates that can be mixed with little processing to produce desired gradation offer significant advantages. Those materials can be used without stockpiling in multiple locations, do not require secondary screening, and can be effectively used for base courses and selected surface courses.

Pollution from the production of aggregates occurs mainly in the form of dust. Processing that requires crushing and dry screening usually creates more pollutants than processes that use naturally occurring aggregates and wet screening and sizing operations.

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