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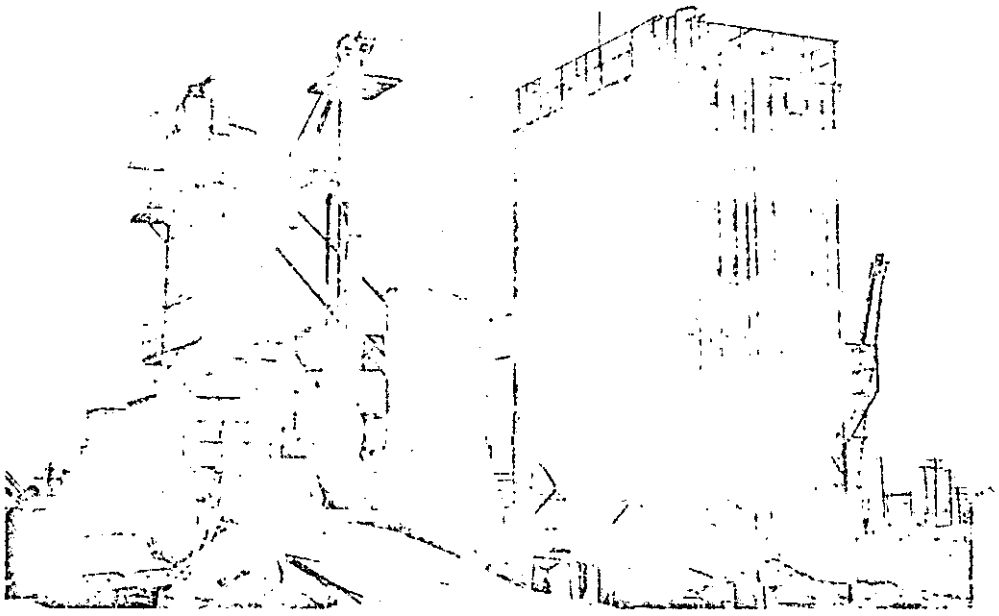

AIR POLLUTION CONTROL PRACTICES

hot-mix asphalt paving batch plants

"BLACK TOP"

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Hot-mix asphalt paving plant operations and the associated air pollution control problems are presented. Field observations and test data are included for full scale installations. Comparisons are made for various types of control equipment and their effectiveness. The dry cyclonic units offer the least cost expenditures, lowest space requirements, and can collect the fines in a usable condition. Wear can often be a problem, and their efficiency capabilities limit their use as total collection devices. They no longer are suitable as total collection units in many localities. Their role is being relegated to that of primary and secondary collectors. Wet collectors of several types, particularly the more sophisticated and high energy units, are capable of satisfying higher efficiency requirements. They offer space advantages and are in the medium cost range. Wear is generally no problem, however, corrosion can be a problem depending on the amount of sulphur in the rotary dryer burner fuel. Settling tanks, ponds, or pits are necessary for settling of the collected dust. The dust, as collected, is not readily reusable as mineral filler in the mix. Fabric collectors are capable of satisfying the most stringent codes. They offer the greatest cost advantage for material recovery to be used as mineral filler. First cost and space requirements of fabric filters are highest of the three classes of equipment discussed.

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Typical of the dust producing operations that are being closely evaluated today are those involving the non-metallic minerals industries. Hot mix asphalt paving batch plants fall in this category and because these facilities are normally located within city limits or in highly urbanized areas, the associated dust problems are of concern to control authorities, the public, and plant operators. The growing demand for bituminous paving materials will mean that more than average effort will be expended in this area during the coming years.

Dust control for these plants is not new. Even the earliest installations many years ago employed knock-out chambers or large diameter cyclones, as well as simple scrubbers. The dust, though not toxic, can be a considerable nuisance. In recent years much has been done to minimize the nuisance through change in plant design and operation. However, dust control apparatus is a necessity today. Air pollution control ordinances are now being adopted throughout the country, many with specific regulations aimed at this particular operation, and no new plant is installed today without specific provision for dust emission control. Perhaps the most stringent code yet adopted for controlling the air pollution aspects of hot mix asphalt batching plants and asphalt mixing and paving plants, is that of the City of Chicago. Chapters 17 to 24 of the Municipal Code of Chicago states that the particulate emissions "shall not exceed 0.10 grains per standard cubic foot of exhaust gas. No addition of diluting air shall be allowed downstream of any air pollution control device." In addition, the Code also contains a nuisance abatement and opacity regulation with Ringelmann No. 2 as a limiting value.

Description of Process

The process involves proportional feeding of cold aggregates, heating and drying of the aggregates to predetermined levels of moisture content, temperature and uniform mixing and coating with hot asphalt to produce a specific paving mix. After mixing, the hot paving mixture is discharged into trucks which transport it to the paving site. Transportation costs are an important cost factor in "black-top" and for this reason, the industry is composed of a large number of plants located close to points of utilization. Many of these plants are now being made mobile to enable them to move periodically during the paving season. While the paving material is still hot, it is loosely spread and then compacted into a smooth surface of road, driveway, parking lot, etc.

The asphalt mixes may be produced from a wide range of aggregate combinations determined by the specific grade requirement. Aggregates are classified as:

Coarse aggregate	(retained on No. 8 mesh sieve)
Fine aggregate	(passing No. 8 mesh sieve)
Mineral dust	(passing No. 200 mesh sieve)

The Asphalt Institute classifies hot mixing paving according to the relative amounts of coarse aggregate, fine aggregate and mineral dust. In addition to the aggregate composition, the amount and grade of asphalt used will determine the final mix characteristics. The asphalt will generally represent 5% of the total weight and the aggregate 95%. Coarse aggregates (up to 2½ in. in size) can be crushed limestone, slag, gravel, oyster shells, or other fractured material such as decomposed granite. The fine aggregates can be natural sand with added materials such as crushed limestone, slag, or gravel. Clay and silt are not permissible. Mineral dust, or mineral filler, can be crushed rock, limestone, hydrated lime, Portland cement, or other non-plastic mineral matter. The asphalt cement is made from refined petroleum and is a solid at ambient temperatures, becoming liquid at temperatures of 275° to 325°F.

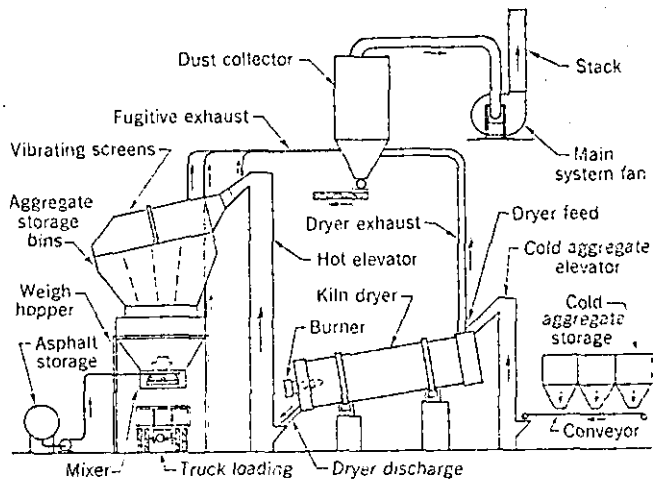

Figure 1. Typical asphalt batch plant flow diagram.

A typical flow diagram of a hot mix plant is shown by Figure 1. The plant usually consists of a cold aggregate elevator with means for feeding, rotary dryer, either oil or gas fired, hot aggregate elevator, screening and classifying system, weigh hoppers, mixer, and hot asphalt system. The cold aggregate is fed into the rotary dryer countercurrent to the hot combustion gases with temperatures ranging from 250° to 450°F. The rotary kiln, or drum dryer, is fitted with a series of internal flights so designed to raise the material and cascade it downward through a constant flow of hot exhaust gases from the combustion chamber. The flow which is normally in the range of 450 to 800 ft/min through the dryer, is provided by a system fan or exhauster. This flow not only relieves the dryer of the hot exhaust gases, but also removes the aqueous vapor produced by the presence of moisture in the aggregate. This induced draft fan maintains the feed end of the kiln dryer at a negative pressure, thereby speeding drying and aiding combustion. The hot combustion gases sweeping through the dryer entrain the dust from the interior of the dryer and the feed points.

Typical airflow requirements for a kiln dryer having a capacity of 275 tons per hour and removing 5% free moisture from the aggregate, would be in the range of 45,000 cfm. The term free moisture denotes the surface moisture and does not include the internal moisture content of the aggregate.

DRYER PARAMETERS

The heated and dried aggregate from the dryer drum is conveyed by a bucket elevator to the vibrating screen for classification and storage in the compartmented bin. At the time of batch mixing, selected amounts of the sized aggregates are dropped from the elevated storage bins to the weigh hopper. At this point, mineral filler or fines can be added directly to the weigh hopper by means of a separate feed. The weighed aggregate is then dropped to the paddle type mixer, where the hot asphalt is introduced. The mix is then discharged as a finished product into waiting trucks for transport to the job site.

Table I. Dust and fume data.

	Test C426		Test C-537	
Source	Vent Line[a]	Dryer	Vent Line[a]	Dryer
Gas volume, scfm	2 800	21 000	3 715	22 050
Gas temperature, °F	215	180	200	430
Dust loading, lb/hr	2 000	6 700	740	4720
Dust loading, gr/scf	81.8	37.2	23.3	25
Sieve analysis of dust, wt. %				
+100 mesh	4.3	17.0	0.5	18.9
−100 to +200 mesh	6.5	25.2	4.6	32.2
−200 mesh	89.2	57.8	94.9	48.9
Particle size distribution - 200 mesh, microns, wt. %				
0 - 5	19.3	10.1	18.8	9.2
5 - 10	20.4	11.0	27.6	12.3
10 - 20	21.0	11.0	40.4	22.7
20 - 50	25.1	21.4	12.1	49.3
Over 50	14.2	46.5	1.1	6.5

[a] Vent Line serves hot elevator, screens, bin, weigh hopper, and mixer.

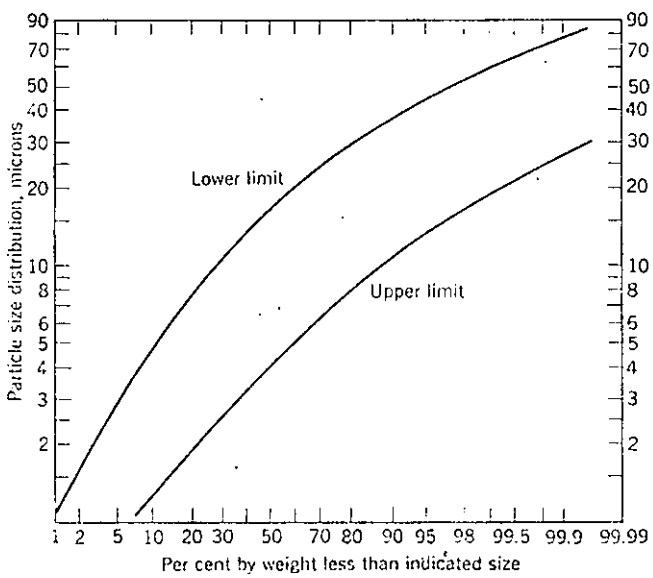

Figure 2. Composite asphalt plant dust particle size distribution analysis.

Dust Problem

Dust sources are the rotary dryer, hot aggregate elevator, vibrating screens, the hot aggregate storage bins, weigh hopper, mixer, and transfer points. The largest dust emission source is from the rotary dryer. In many cases, the dryer dust problem is handled separately from the other sources. However, more and more the dryer and ventlines or fugitive sources are combined with a single collector and single fan system.

The total ventilation requirements will be dependent on the plant size and specific operation. Typical of the total requirements of the plant requiring a dryer volume of 45,000 scfm would be an addition of 8 - 9000 scfm for the other vent and dust control points mentioned.

Dust loadings and particle size distribution vary considerably from plant to plant, and very little published data is available. Typical of conditions for two installations is shown in Table I (U. S. Dept. HEW — Publication 999-AP-40).

The dryer design and operation, particle size distribution of the feed materials, and the specific grade of black top mix will have a very decided effect on the particle size distribution and the collection problem in general. In all cases, we can generally rely on the ventline or fugitive system producing the finer particulates. On the basis of distribution, we find by comparison that vent-line dust ranges from 39 to 46% below 10 microns while dryer discharge dust indicates 21%. When evaluating further, we find that these results show vent-line distributions of 85.8 to 98.9% below 50 microns, while dryer effluent ranges from 53.5 to 93.5%. The values demonstrate vividly the wide variances in size distribution for different plants.

On the basis of total dust, *i.e.*, vent-line plus dryer effluent, we have been concerned with dust sizing in the range below 40 microns, and have confirmed the variances. Figure 2 is a plot resulting from field investigations on eight separate installations. Shown are the upper and lower limit values for a specific sample with the others falling within these values. The lower limit will indicate that as much as 28% below 10 microns can apply, or as high as 89% below 10 microns. In addition to verifying that the plant design, operation, feed materials, and grade of mix are important variables, it was determined that the source of the fine aggregate material was an important factor. The source of the fine aggregate often showed particle shape variations that could affect collector selection where stringent effluent conditions were to be satisfied.

Another major factor found to vary considerably was that of dust loading. Effluent dust loadings range from in excess of 200 grains/scf to 20 grains/scf. Strongly enough, the extremely high loading value was on a plant having a low velocity through the kiln dryer, while a mid-range value (approximately 75 grains/scf) resulted from a very high velocity. Plant operating factors such as vibrating screen loading and type of aggregate tend to have a strong influence on effluent dust loadings. Our field determinations indicate that dryer discharge dust loading will average in the range of 40 to 70 grains/scf.

Equipment

The choice of applicable control equipment 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, such as a large diameter cyclone, skimmer or knock-out chamber. They are often used as classifiers with the collected materials being returned to the hot aggregate elevator to combine with the dryer aggregate load. The air discharge from the primary is seldom discharged to the atmosphere, as even if a 90% collection efficiency is achieved, a dense plume is still evident. The primary collector effluent is therefore ducted to a secondary or even tertiary collection device. Simple cyclone or mechanical devices normally operate in the range of 50 to 90%, averaging generally around 85% efficiency by weight. The pressure drop will normally be in the range of 2.0 to 3.0 in. W.G. They do perform the important function of reducing dust loading for the subsequent collection device.

Multiple-tube, or high-efficiency cyclonic collectors often follow the simple primary. These units utilize multiplicities of individual cyclones, arranged in banks. Typical tube diameters vary from 3 in. to 10 in. and pressure drops can range from 4 to 6 in. W.G. Efficiency capabilities can reach into the low 90% range.

Figure 3 is typical of an installation utilizing both a dual primary cyclone and a multiple tube collector. It is also illustrative of the general arrangement with the cold aggregate feed to the kiln dryer and the return to the feed section. The clean air discharge from the cyclones is ducted to a top entry, multiple-tube cyclone collector, using 5½ in. dia. tubes, at a pressure drop of 4 in. W.G. Perhaps the most important aspect of this installation is the discharge stack appearance. The measured efficiency of this multiple tube collector system is slightly in excess of 93% by weight. While satisfactory in many localities, it could no longer meet a code equivalent to that of the City of Chicago.

The type of collection device most often applied in the past has been the wet collector. It has been used in literally countless different designs, shapes, and configurations, both singly and in multiples. Many are made by the plant operator or are proprietary with the asphalt plant manufacturer. Most prevalent, however, are the centrifugal-type spray chamber and baffled-type scrubber. These scrubbers generally will require spray water consumption of 4 to 10 gallons per 1000 scf of gas. The pressure drops for scrubbers will vary from 3 to 10 in. W.G. Water is sprayed at pressures of 50 to 100 psi. The most commonly used types are impingement devices, however, wear is no problem.

Typical of scrubber evaluations are those cited in Table II (HEW Publication 999-AP-40). In addition to the data originally presented, the scrubber inlet and outlet loadings are shown in terms of grains per cubic foot. Efficiencies for the eighteen systems tested range from a low of 84.2 to 99.3%. Varying inlet particle size distribution would, in part, be very important consideration affecting the performance. It is interesting to note the wide variations in inlet loadings. No information is available on the types or designs of primary collectors operating in conjunction with the scrubbers listed.

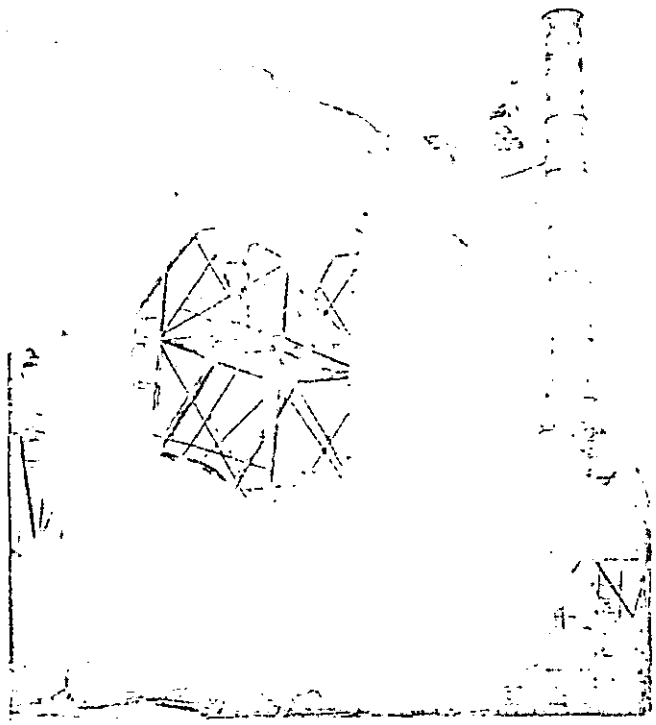

Figure 3. A typical installation utilizing both a dual primary cyclone and a multiple tube collector.

Table II. Test data from hot-mix asphalt paving plants controlled by scrubbers.

Test No.	Scrubbers Inlet No./hr	Scrubbers Inlet Loading gr/ft³	Scrubbers Discharge No./hr	Scrubbers Discharge Loading gr/ft³	% Eff.	Volume, scfm	Type of Scrubber
C-357	940	4.95	20.7	0.105	97.8	23 100	C[a]
C-82	427	2.51	35.6	0.21	91.6	19 800	C
C-379	4 110	18.3	37.1	0.165	99.1	26 200	C
C-365	2 170	9.84	47.0	0.214	97.8	25 700	C
C-372-B	121	0.773	19.2	0.123	84.2	18 200	C
C-372-A	76	0.492	10.0	0.064	86.8	18 000	C
C-369	352	2.32	24.4	0.177	93.0	16 100	C
C-393	4 260	25.5	26.9	0.161	99.3	19 500	T[b]
C-185	1 640	10.2	21.3	0.133	98.7	18 700	T
C-379	3 850	15.85	30.3	0.125	99.2	28 300	C
C-337	305	1.46	13.6	0.065	95.5	24 300	C
C-234	372	2.52	21.2	0.143	94.3	17 200	T
C-426	2 620	6.7	25.5	0.135	99.0	22 000	C
C-417	560	2.56	39.9	0.189	92.8	24 600	C
C-425	485	3.14	32.9	0.213	93.2	18 000	C
C-385	212	1.24	17.5	0.102	91.7	20 000	C
C-433	266	1.58	11.0	0.065	95.8	19 600	C
C-418	3 400	23.2	30.8	0.21	99.1	17 100	T

[a] C = Multiple centrifugal-type spray chamber.
[b] T = Baffled tower-scrubber.
Basic Test Data from U.S. Dept. HEW - Pub. 99-AP-40.

Figure 4 shows a typical asphalt plant scrubber operating with a weight efficiency slightly in excess of 90%. If we assume that regulations similar to the City of Chicago Code requiring 0.1 gr/ft³ are adopted for this industry, then more sophisticated wet collection apparatus must generally be employed. There are only three of the installations completely satisfying the 0.1 limitation, while two others nearly satisfy it and would probably be acceptable.

High energy scrubbers, venturi-type, can satisfy the emissions requirements. However, when the regulations also contain an opacity limit, the matter of evaluation can be troublesome to deal with.

In order to completely satisfy plant operators, the public, and the control authorities, the present solution is to use fabric collectors for final collection. They can be of the reverse-air pulse type, or even shaker. Inlet loadings are not critical and inefficient primary collectors can be used. New glass fabrics, as well as Nomex, enable collection at the elevated temperatures. Collection efficiencies of 99.9+ are no problem. Our evaluation of several of these installations during the past two years shows that not only can the 0.1 gr/ft³ limitation be met, but effluent loadings of 0.01 gr/ft³ are achieved. Inlet loadings were approximately 15 gr/ft³ under these conditions.

Air-to-cloth ratios will vary from 3.5/1 to 6.25/1 depending upon the specific type of fabric collector being used. The most commonly used fabrics have been dacron, glass, and Nomex. Pressure drops will vary from 4 to 5 in. W.G. The dew point of the exhaust gases will range from 140° to 160°F. and provision must be made to combat the condensation problem. Reverse air supply is normally heated, and the fabric filter collector housing should be insulated.

A typical fabric filter installation is shown on page 924. This unit is using a felted dacron bag material, handling approximately 40,000 cfm at 250°F. The reverse air collector has 240 bags, and is operating with a pressure drop of 4 in. W.G. The unit was operating at the time the picture was taken, as evidenced by the dryer burner operation.

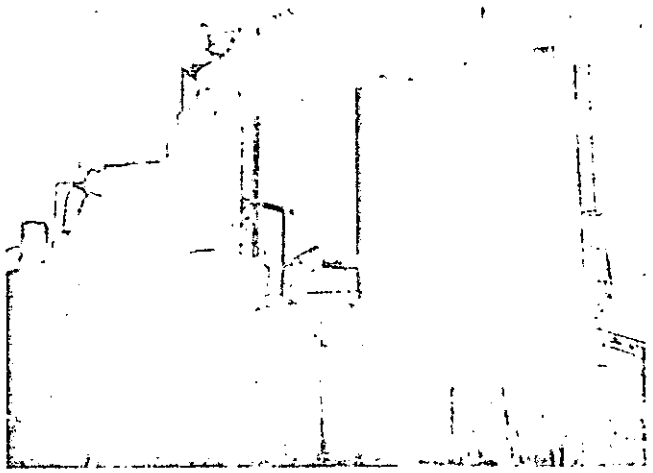

Figure 4. A typical asphalt plant scrubber operating with a weight efficiency slightly in excess of 90%.

Summary

In summary, it is important to point out some of the pertinent considerations involved in selection of the three various types of collection devices used on asphalt batch plants.

The dry cyclonic units offer the least cost expenditures, lowest space requirements, and can collect the fines in a usable condition. Wear can often be a problem, and their efficiency capabilities limit their use as total collection devices. They no longer are suitable as total collection units in many localities. Their role is being relegated to that of primary and secondary collectors.

Wet collectors of several types, particularly the more sophisticated and high-energy units, are capable of satisfying higher efficiency requirements. They offer space advantages and are in the medium cost range. Wear is generally no problem, however, corrosion can be a problem depending on the amount of sulfur in the rotary dryer burner fuel. Settling tanks, ponds, or pits are necessary for settling of the collected dust. The dust, as collected, is not readily reusable as mineral filler in the mix.

Fabric collectors are capable of satisfying the most stringent codes. They offer the greatest cost advantage for material recovery to be used as mineral filler. First cost and space requirements of fabric filters are highest of the three classes of equipment discussed.

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