United States
Environmental Protection
Agency

Office of Air Quality
Planning and Standards
Research Triangle Park NC 27711

EPA-450/3-79-014
June 1979

Air

EPA

# A Review of Standards of Performance for New Stationary Sources - Asphalt Concrete Plants

**ENVIRONMENTAL PROTECTION AGENCY**

**40 CFR Part 60**

**[FRL 1231-3]**

## Standards of Performance for New Stationary Sources: Asphalt Concrete; Review of Standards

AGENCY: Environmental Protection Agency (EPA)

ACTION: Review of Standards.

SUMMARY: EPA has reviewed the standard of performance for asphalt concrete plants (40 CFR 60.9, Subpart I). The review is required under the Clean Air Act, as amended August 1977. The purpose of this notice is to announce EPA's intent not to undertake revision of the standards at this time.

DATES: Comments must be received by October 29, 1979.

ADDRESS: Comments should be submitted to the Central Docket Section (A-130), U.S. Environmental Protection Agency, 401 M Street, S.W., Washington, D.C. 20460, Attention: Docket No. A-79-04.

FOR FURTHER INFORMATION CONTACT: Mr. Robert Ajax, telephone: (919) 541-5271. The document "A Review of Standards of Performance for New Stationary Sources—Asphalt Concrete" (EPA-450/3-79-014) is available upon request from Mr. Robert Ajax (MD-13), Emission Standards and Engineering Division, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina 27711.

SUPPLEMENTARY INFORMATION:

### Background

In June 1973, EPA proposed a standard under Section 111 of the Clean Air Act to control particulate matter emissions from asphalt concrete plants. The standard, promulgated on March 8, 1974, limits the discharge of particulate matter into the atmosphere to a maximum of 90 mg/dscm from any affected facility. The standard also limits the opacity of emissions to 20 percent. The standard is applicable to asphalt concrete plants which commenced construction or modification after June 11, 1973.

The Clean Air Act Amendments of 1977 require that the Administrator of the EPA review and, if appropriate, revise established standards of performance for new stationary sources at least every 4 years [Section 111(b)(1)(B)]. Following adoption of the Amendments, EPA contracted with the MITRE Corporation to undertake a review of the asphalt concrete industry and the current standard. The MITRE review was completed in January 1979. Preliminary findings were presented to and reviewed by the National Air Pollution Control Techniques Advisory Committee at its meeting in Alexandria, Virginia, on January 10, 1979. This notice announces EPA's decision regarding the need for revision of the standard. Comments on the results of this review and on EPA's decision are invited.

### Findings

*Overview of the Asphalt Concrete Industry*

The asphalt concrete industry consists of about 4,500 plants, widely dispersed throughout the Nation. Plants are stationary (60 percent), mobile (20 percent), or transportable (20 percent), i.e., easily taken down, moved and reassembled. Types of plants include batch-mix (91 percent), continuous mix (6.5 percent), or dryer-drum mix (2.5 percent). The dryer-drum plants, which are becoming increasingly popular, differ from the others in that drying of the aggregate and mixing with the liquid asphalt both take place in the same rotary dryer. It is estimated that within the next few years, dryer-drum plants will represent up to 85 percent of all plants under construction.

Current national production is about 263 to 272 million metric tons (MG)/year, with a continued rise expected in the future. It is estimated that approximately 100 new and 50 modified plants become subject to the standard each year. Operation is seasonal, with plants reportedly averaging 666 hours/year although many operate more extensively.

*Particulate Matter Emissions and Control Technology*

The largest source of particulate emissions is the rotary dryer. Both dry (fabric filters) and wet (scrubbers) collectors are used for control and are both capable of achieving compliance with the standard. However, all systems of these types have not automatically achieved control at or below the level of the standard.

Based on data from a total of 72 compliance tests, it was found that 53 or about three-fourths of the tests for particulate emissions showed compliance. Thirty-three of the 53 produced results between 45 and 90 $Mg^3$/dscm (.02 and .04 gr/dscf). Of the 47 tests of fabric filters or venturi scrubber controlled sources over 80 percent showed compliance. The available data do not provide details on equipment design and an analysis of the cause of failures has not been performed. However, EPA is not aware of any instances in which a properly designed and installed fabric filter system or high-efficiency scrubber has failed to achieve compliance with the standard. The fact that certian facilities controlled by fabric filters and high-efficiency scrubbers have failed to comply is attributed to faulty design, installation, and/or operation. This conclusion and these data are consistent with data and findings considered in the development of the present standard.

On the basis of these findings, EPA concludes that the present standard for particulate matter is appropriate and that no revision is needed.

Much less test data are available for opacity than for particulates. Of the 26 tests for which opacity levels are reported, only 5 failed to show compliance with the opacity standard. However, none of these 5 met the standard for particulate matter. Of the 21 plants reported as meeting the current standard for opacity, 19 met the particulate standard. On the basis of these data, EPA concludes that the opacity standard is appropriate and should not be revised. While the data do indicate that a tighter standard may be possible, the rationale and basis used to establish the present standard are considered to remain valid.

*Enforcement of the Standard*

Because the cost of performance tests which are required to demonstrate compliance with the standard are essentially fixed and are independent of plant size, this cost is disproportionately high for small plants. Due to this, the issue was raised as to whether formal testing could be waived and lower cost, alternative means be established for determining compliance at small plants. Support for such a waiver can be found in the fact that emission rates are generally lower at these plants and errors in compliance determinations would not be large in terms of absolute emissions. However, testing costs at all sizes of plants are small in relation to the cost of asphalt concrete production over an extended period and these costs can be viewed as a legitimate expense to be considered by an owner at the time a decision to construct is made. A number of State agencies presently require, under SIP regulations, initial and in some cases annual testing of asphalt concrete plants. Moreover, available compliance test data show that performance of control devices is variable and even with installation of accepted best available control technology the standard can be exceeded by a significant degree if the control system is not properly designed, operated, and maintained. Relaxing the requirement for formal testing thus could lead to a proliferation of low quality or marginal control equipment which would require costly repair or retrofit at a later time.

A further performance testing problem indentified in the review of the standard concerns operation at less than full production capacity during a compliance test. When this occurs, EPA normally accepts the test result as a demonstration of compliance at the tested production rate, plus 23 Mg (25 tons)/hr. To operate at a higher production rate, an owner or operator must demonstrate compliance by testing at that higher rate. Industry representatives view this limitation as an unfair production penalty. It is noted in particular that reduced production is sometimes an unavoidable consequence associated with use of high moisture content aggregate. Furthermore, it is argued that facilities which show compliance at the maximum production rate associated with a given moisture level can be assumed to comply at higher production rates when moisture is lower. However, this argument assumes that the uncontrolled emission rate from the facility does not increase as production rate increases and EPA is not aware of data to support this assumption.

As a general policy it is EPA's intent to minimize administrative costs imposed on owners and operators by a standard, to the maximum extent that this can be done without sacrificing the Agency's responsibility for assuring compliance. Specifically, in the cases cited above, EPA does not intend to impose costly testing requirements on small facilities or any facilities if compliance with the standard can be determined through less costly means. However, EPA at this time is not aware of a procedure which could be employed at a significantly lower cost to determine compliance with an acceptable degree of accuracy. Although opacity correlaters with grain loading and serves as a valid means for identifying excess emissions, due to dependence on stack diameter and other factors opacity alone is not adequate to accurately assess compliance with the mass rate standard. Similarly, the purchase and installation of a baghouse or venturi scrubber does not in itself necessarily imply compliance. EPA is concerned that approval of such equipment without compliance test data or a detailed assessment of design and operating factors would provide an incentive for installation of low cost, under-designed equipment. This would place vendors of more costly systems which are well designed and properly constructed and operated at a competitive disadvantage; in the long term this would not only increase emissions but would be to the detriment of the industry.

EPA has, however, concluded that a study program to investigate alternative compliance test and administrative approaches for asphalt plants is needed. An EPA contractor working for the Office of Enforcement has initiated a study designed to assess several administrative aspects of the standard, including possible low cost alternative test methods; administrative mechanisms to deal with the problem of process variability during testing; and physical constraints affecting the ability to perform tests. If the results of this program, which is scheduled to be completed later in 1979, show that the regulations or enforcement policies can be revised to lower costs, such revisions will be adopted.

*Hydrocarbon Emissions*

While the principal pollutant associated with asphalt concrete production is particulate matter, the trend noted previously toward dryer-drum mix plants has raised question as to the significance of hydrocarbon emissions from these facilities. In the dryer-drum mix plant, drying of the aggregate as well as mixing with asphalt and additional fines takes place within a rotary drum. Because the drying takes place within the same container as the mixing, emissions are partly screened by the curtain of asphalt added so that the uncontrolled particulate emissions from the dryer are lower than from conventional plants. In contrast, it has been reported that the rate of hydrocarbon emissions may be substantially higher than from conventional plants. However, data recently reported from one test in a plant equipped with fabric filters showed only traces of hydrocarbons in dust and condensate and did not support this suggestion. Thus, while these data do not indicate a need to revise the standard, more definitive data are needed on hydrocarbon emission rates and related process variables. This has been identified as an area for further research by EPA.

An additional source of hydrocarbon emissions in the asphalt industry is the use of cutback asphalts. Although not directly associated with asphalt concrete plants, this represents a significant source of hydrocarbon emissions. As such, the need for possible standards of performance pertaining to use of cutback asphalt was rasied in this review. The term cutback asphalt refers to liquified asphalt products which are diluted or cutback by kerosene or other petroleum distillates for use as a surfacing material. Cutback asphalt emits significant quantities of hydrocarbons—at a high rate immediately after application and continuing at a diminishing rate over a period of years. It is estimated that over 2 percent of national hydrocarbon emissions result from use of cutback asphalt.

The substitution of emulsified asphalts, which consist of asphalt suspended in water containing an emulsifying agent, for cutback asphalt nearly eliminates the release of volatile hydrocarbons from paving operations. This substitute for petroleum distillate is approximately 98 percent water and 2 percent emulsifiers. The water in emulsified asphalt evaporates during curing while the non-volatile emulsifier is retained in the asphalt.

Because cutback asphalt emissions result from the use of a product rather than from a conventional stationary source, the feasibility of a standard of performance is unclear and the Agency has no current plans to develop such a standard. However, EPA has issued a control techniques guideline document, *Control of Volatile Organic Compounds from Use of Cutback Asphalt* (EPA-450/2-77-037) and is actively pursuing control through the State Implementation Plan process in areas where control is needed to attain oxidant standards. Because of area-to-area differences in experience with emulsified asphalt, availability of suppliers, and ambient temperatures, the Agency believes that control can be implemented effectively by the States.

*Asphalt Recycling Plants*

A process for recycling asphalt paving by crushing up old road beds for reprocessing through direct-fired asphalt concrete plants has been recently implemented on an experimental basis. Plants using this process, which uses approximately 20 to 30 percent virgin material mixed with the recycled asphalt, are subject to the standard and at least two have demonstrated compliance. However, preliminary indications are that the process may have difficulty in routinely attaining the allowable level of particulate emissions and/or that the cost of control may be higher than a conventional process. The partial combustion of the recycled asphalt cement reportedly produces a blue smoke more difficult to control than the mineral dusts of plants using virgin material.

It is EPA's conclusion that there is no need at this time to revise the standard as it affects recycling, due to its limited practice and due to the data showing that compliance can be achieved at facilities which recycle asphalt. However, this matter is being studies further under the previously noted study by an EPA contractor.

*Educational Program for Owners and Operators*

The asphalt industry consists of a large number of facilities which in many cases are owned and operated by small businessmen who are not trained or experienced in the operation, design, or maintenance of air pollution control equipment. Because of this, the need to comply with emission regulations, and the changing technology in the industry (i.e., the introduction of dryer-drum plants, recycling, the possible move toward coal as a fuel, and the use of emulsions), the need for a training and educational program for owners and operators in the operation and maintenance of air pollution control equipment has been voiced by industry. This offers the potential for cost and energy savings along with reduced pollution.

To meet this need, EPA's Office of Enforcement, in cooperation with the National Asphalt Paving Association, conducted a series of workshops in 1978 for asphalt plant owners and operators. Only limited future workshops are currently planned. However, EPA will consider expansion of the programs if a continued need exists.

Dated: August 2[illegible], 1979.

Douglas Costle,

*Administrator*

[FR Doc. 79-[illegible] Filed 8-30-79; 8:45 am]

BILLING CODE 6560-01-M

EPA-450/3-79-014

# A Review of Standards of Performance for New Stationary Sources - Asphalt Concrete Plants

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June 1979

This report has been reviewed by the Emission Standards and Engineering Division, Office of Air Quality Planning and Standards, Office of Air, Noise and Radiation, Environmental Protection Agency, and approved for publication. Mention of company or product names does not constitute endorsement by EPA. Copies are available free of charge to Federal employees, current contractors and grantees, and non-profit organizations - as supplies permit - from the Library Services Office, MD-35, Environmental Protection Agency, Research Triangle Park, NC 27711; or may be obtained, for a fee, from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.

Publication No. EPA-450/3-79-014

## ABSTRACT

This report reviews the current Standards of Performance for New Stationary Sources: Subpart I - Asphalt Concrete Plants. Emphasis is given to the state of control technology, extent to which plants have been able to meet current standards, experience of representatives of industry and of EPA officials involved with testing and compliance, economic costs, environmental and energy considerations, and trends in the asphalt industry. Information used in this report are based upon data available as of June 1978. Recommendations are made for possible modifications and additions to the standard, including future studies needed of unresolved issues.

ACKNOWLEDGMENT

The authors wish to acknowledge Ms. Sally Price who contributed so much to the preparation of this document. Her time and patience in editing and overseeing the preparation of this report is greatly appreciated.

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## 1.0 EXECUTIVE SUMMARY

The objective of this report is to review the New Source Performance Standard (NSPS) for asphalt concrete plants in terms of developments in control technology, economics and new issues that have evolved since the original standard was promulgated on March 8, 1974. Possible revisions to the standard are analyzed in the light of compliance test data available for plants built since the promulgation of the NSPS. The NSPS review includes the particulate standard (currently 90 milligrams/dry standard cubic meter (mg/dscm) or 0.04 grains/dry standard cubic foot (gr/dscf) and the opacity standard (currently less than 20 percent). The following paragraphs summarize the results and conclusions of the analysis as well as the recommendations for future action.

### 1.1 Overview of Asphalt Concrete Industry

The asphalt concrete industry, which currently consists of about 4500 plants, is widely dispersed throughout the nation. Plant locations correlate well with populations and numbers of motor vehicles. Plants are stationary (60 percent), mobile (20 percent) or transportable (20 percent), i.e., easily taken down, moved and reassembled. Types of plants include batch-mix (91 percent), continuous mix 6.5 percent) or dryer-drum mix (2.5 percent). The dryer-drum plants, which are becoming increasingly popular, differ from the others in that drying of the aggregate and mixing with the liquid asphalt both take place in the same rotary dryer. It is estimated that within the next few years, dryer-drum (drum-mix) plants will represent up to 85 percent of all plants under construction.

Current national production is about 263 to 272 million metric tons (Mg)/year (290 to 300 million tons), with a continued rise in the future. EPA estimates 100 new and 50 modified plants become subject to NSPS each year.

Most plants have a mixer capacity of under 218 Mg (240 tons)/hour with the average being 160 Mg (176 tons)/hour. Operation is seasonal, with plants averaging only 666 hours/year although many operate more extensively.

## 1.2 Control Technology Available

The largest source of particulate emissions is the rotary dryer. The exit gas carries small particles of the mineral aggregate that makes up over 90 percent of the asphalt concrete product. Emissions also occur from screens, elevators and weigh hoppers. Both particulates and opacity in the exit gas reflect the presence of fine particles. Both dry (fabric filters) and wet (scrubbers) collectors are used for particulate control. Although many plants use primary collectors for large particles and more efficient secondary collectors for fines, recent experience supports the use of a single collector that may be either a baghouse (used in 40 percent of the plants) or a high-efficiency scrubber (used in 24 percent of the plants).

A principle underlying NSPS is the establishment of the best technological system (BTS) of continuous emission reduction, taking into consideration costs, and non-air quality health and environmental impacts. For particulate control from asphalt concrete plants, two control systems qualify as BTS. These are the fabric filter system and the high-energy scrubber of the variable-throat venturi-type operated at a sufficient level of energy to provide efficient dust removal equivalent to that of a fabric filter. It is important to note that not all systems of these types automatically achieve control at or below the NSPS level. The systems selected must be properly designed, installed, operated and maintained in order to ensure NSPS compliance.

The reduction in particulate emissions is estimated to be 7700 Mg (8500 tons) each year from plants that have become subject to the standard in that year. Thus, in 1978 a reduction of approximately 30,800 Mg (3400 tons) is estimated to have occurred. This reduction has been achieved at a cost (capital plus operating) to owners of about 15 to 24 cents/Mg of product (14 to 22 cents/ton), depending principally upon the control system employed, the extent to which fines are recycled, and the plant size.

## 1.3 Test Results

Quantitative data from 72 tests conducted for compliance with NSPS were made available by EPA regional personnel with the aid of the Compliance Data System (CDS). About three-fourths of the tests for particulate emissions showed rates less than NSPS. Of the 26 tests for which detailed results on opacity were reported, 21 showed a percentage less than the 20 percent NSPS level.

Specific equipment design, operating status and condition of control systems were not available. In addition, for 13 of the 72 tests even the general type of control system was not identified. Of the 47 that identified as either a baghouse or venturi scrubber, over 80 percent achieved compliance. Fourteen of the tests (four of which had unspecified control systems) showed emissions of less than 90 mg/dscm (0.04 gr/dscf) but higher than 68 mg/dscm (0.03 gr/dscf), which is the standard in a few states.

The test results comprise a sample large enough to support valid statistical inference as to the state of control systems as installed and operated. It may be estimated on this basis that the average percentage of baghouse and venturi scrubber systems which actually achieve compliance under the broad range of conditions represented in the tests is between about 69 and 91 pecent. The fraction could be less than two-thirds, at the 99 percent confidence level. No data are available to support analysis of the conditions under which some plants with baghouses or venturi scrubbers achieved significantly lower emission rates than others.

The small sample of data and the broad tolerances within which opacity readings were reported do not permit detailed analysis of the results. However, the consensus of EPA regional officials is that the particulate requirement dominates that for opacity.

## 1.4 Possible Changes: Analysis, Conclusions and Recommendations

### 1.4.1 Industry Trends

The most important development in the ashphalt concrete industry regarding emissions is the increased usage of dryer-drum mix plants, which is predicted to account for approximately 85 percent of the new plants in the next few years. These plants provide an uncontrolled emission rate for particulates that appears to be lower by one or more orders of magnitude than either the batch or the continuous-mix plants. However, because of the nature of the process, the hydrocarbon emission rate from the dryer-drum plant may be higher than the rate from conventional plants.

### 1.4.2 NSPS for Particulates

The current NSPS of 90 mg/dscm (0.04 gr/dscf) for particulate emissions is being satisfactorily met. No basis exists for relaxing the standard. However, it is also concluded that no change should be made in current NSPS at the present time for the following reasons:

1. Test results show that although many plants are meeting NSPS with currently available BTS, the margin of compliance is too small to justify tighter standards.

2. The possible environmental gain would be slight.

### 1.4.3 NSPS for Opacity

Stricter standards for opacity are feasible but unwarranted. The opacity standard is, by intent, set at a level which will be achieved by any source which does not exceed the particulate mass standard. Thus, meeting the NSPS particulate level implies that opacity will be less than the current maximum of 20 percent and changing the NSPS for opacity would, therefore, not in itself reduce particulate emission. Hence, any environmental gain would be minor and not worth the additional increased administrative and procedural efforts.

#### 1.4.4 Fugitive Emissions

A major source of fugitive emissions in batch and continuous process plants is now controlled by venting to the control system emissions from screens, elevators, weighing and handling, and the dryer. No NSPS for additional control of fugitive emissions is considered to be warranted at present.

#### 1.4.5 Monitoring

The intermittent nature of the asphalt concrete industry makes it a difficult process to monitor. Periodic monitoring would be technologically useful but practical constraints dominate the situation. The purchase, installation, operating and maintenance costs of monitors is relatively prohibitive. In addition, skilled technical operators are not available at the plants. Additional regulations to require monitoring are not warranted at this time.

#### 1.4.6 Formal Particulate Testing

A significant impetus has been generated by some EPA regional personnel and asphalt concrete plant owners to consider the elimination of formal particulate testing for small plants (plants of less than 150 tons/hr), which have well designed operational control systems of the types that are known to be capable of meeting NSPS. The result would be substantial savings to the industry and minimal environmental risk. There are minimal risks associated with elimination of certification testing for small plants. However, there are considerations militating against a policy that does not require testing for plants which have proven control systems. The most important of these is the fact that test data show that the mere presence of a fabric filter or venturi scruber system does not guarantee compliance with NSPS. The particulate test is a way of ensuring that the control system vendor has provided a well designed system that complies with the NSPS under actual operating conditions.

### 1.4.7 Other Pollutants

Other pollutants ($NO_x$, $SO_2$, HC and CO) are emitted in very small amounts when compared with:

- Total national emissions
- Rates achieved by controlled industries
- Rates for particulate emissions, even under current NSPS.

No apparent need exists at this time to consider NSPS for emissions of $NO_x$, $SO_2$, or CO from any plant or for HC emissions from batch or continuous plants. However, the unknown rate of HC emissions from dryer-drum plants should be determined, since it may be higher than that from other processes.

The largest and most significant source of HC emissions from the asphalt industry is in application of asphalt diluted with volatile HC fluids, i.e., "cutback." Emissions from this source continue for more than 3 years after the asphalt is placed as pavement. The use of water-based emulsified asphalt wherever feasible would reduce HC emissions and achieve energy savings. While a cutback standard would not apply to asphalt plant emissions per se, EPA should investigate regulatory approaches to controlling emissions from this source.

### 1.4.8 Future Work

Certain technical areas relating to NSPS for asphalt concrete plants should be investigated. It is recommended specifically that further development activities address the rate of uncontrolled HC and particulate emissions from dryer-drum plants, and investigate the possiblity of less costly control devices to achieve NSPS for dryer-drum plants.

Investigation of these areas would be useful in any future consideration of possible new or modified NSPS for asphalt concrete plants.

## 2.0 INTRODUCTION

The Clean Air Act of 1977 requires that the NSPS for control of emissions from designated facilities be reviewed every 4 years. Such review may lead to revision of the NSPS or of the regulations governing them as presented by the U.S. Environmental Protection Agency. This report analyzes current NSPS for asphalt concrete plants with respect to the adequacy of current standards, the need for their revision, and the probable effects of the standards on the industry and on the emissions generated. Finally, recommendations are developed for EPA.

The levels of performance achievable under the best technological system (BTS) of continuous emission reduction are compared with existing NSPS in Section 4.3. Estimated energy needs, environmental effects produced by emission controls, and potential effects on industrial operations are also considered. Results of testing emissions from asphalt plants under NSPS are analyzed based on detailed information obtained from some 70 tests, primarily for particulate emissions, which were monitored by EPA regions and/or state agencies.

Possible revisions to the standards are analyzed with attention given to the recommendations submitted by personnel in the 10 EPA regions. Factors examined are changes in acceptable emission levels, additions to the list of pollutants controlled, process facilities from which emissions are measured and controlled, and regulations governing testing and monitoring procedures.

The probable effects of changes in standards and/or associated regulations with respect to industrial trends and possible research and development needs created by process or control changes are presented as conclusions. Specific recommendations are made regarding whether standards and/or regulations should be changed or retained, as well as unresolved issues to be addressed.

## 3.0 CURRENT STANDARDS FOR ASPHALT CONCRETE PLANTS

### 3.1 Facilities Affected

An asphalt concrete plant may be stationary, transportable, or mobile. The stationary plants are permanent fixtures that can not be moved. All asphalt concrete plants built before 1925 are stationary plants. The term stationary has been expanded in the current terminology to include transportable plants that have been built within the past 50 years (NAPA, 1978). Transportable plants are modular units that permit easy disassembly, relocation and reassembly. The transportable plant is not to be confused with the mobile unit (often referred to as portable) which is actually constructed on wheels (NAPA, 1978).

Each asphalt concrete plant planned for, under construction, or under modification as of June 11, 1973, is subject to the NSPS listed in 40 CFR 60. Plant facilities controlled include dryers; systems for screening, handling, storing, and weighing hot aggregate; systems for loading, transferring, and storing mineral filler; systems for mixing asphalt concrete; and/or systems for loading, transferring, and storing that can be associated with emission control systems. An asphalt concrete plant is defined as any facility that is used to manufacture asphalt concrete by heating and drying aggregate and mixing the aggregate with asphalt cements (40 CFR 60.91). Plants planned or constructed prior to the proposal of the standards are exempt from the regulations unless a physical change to the plant causes an increase in the amount of air pollutants emitted, or unless the plant qualifies as a reconstruction. Routine maintenance, repair and replacements; relocation of a transportable plant or of a mobile plant; change of aggregate; and transfer of ownership are not considered to be modifications that require an existing plant to comply with the standard (40 CFR 60.14).

## 3.2 Controlled Pollutants and Emission Levels

The pollutants to be controlled by asphalt concrete plants are particulate emissions. The standards for asphalt concrete plants were first proposed to be 68 mg/dscm which is equivalent to 0.03 gr/dscf for particulate emissions and 10 percent for opacity (40 CFR 60.1). After proposal and evaluation of comments presented by the asphalt industry and others, the standards were made slightly less stringent:

> On or after the date on which the (required) performance test... is completed, no owner or operator...shall discharge or cause the discharge into the atmosphere from any affected facility any gases which:
> (1) Contain particulate matter in excess of 90 mg/dscm (0.04 gr/dscf).
> (2) Exhibit 20 percent opacity or greater (40 CFR 60.92).

The opacity standards help an operator of an asphalt concrete plant to determine whether his particulate emission control equipment is operating and maintained properly. An observed opacity of more than 20 percent is an indication that the particulate emissions standard of 90 mg/dscm may be violated (39 FR 9308, March 8, 1974).

## 3.3 Compliance Testing

Performance tests to verify compliance with particulate and opacity standards for asphalt concrete plants must be conducted within 60 days after the plant has reached its full capacity production rate, but not later than 180 days after the initial startup of the facility. Unless exceptions are approved by EPA, each performance test consists of three hour-long runs with a sampling rate of at least 0.9 dscm/hr (0.53 dscf/min). The standard applies to the arithmetic mean of the three runs (40 CFR 60.8).

No continuous monitoring requirement currently exists for particulate NSPS for asphalt concrete plants.

## 3.4 Terms Applicable to Asphalt Concrete Plants

Several terms that apply to asphalt concrete plants are defined by 40 CFR 60 and are listed below.

- Affected facility - with reference to a stationary source, any apparatus to which a standard is applicable.
- Commenced - an owner or operator has undertaken a continuous program of construction or modification or an owner or operator has entered into a contractual obligation to undertake and complete, within a reasonable time, a continuous program of construction or modification.
- Modification - any physical change in, or change in the method of operation of, an existing facility which increases the amount of any air pollutant (to which a standard applies) emitted into the atmosphere by that facility or which results in the emission of any air pollutant (to which a standard applies) into the atmosphere not previously emitted.
- Opacity - the degree to which emissions reduce the transmission of light and obscure the view of an object in the background.

- Particulate matter - any finely divided solid or liquid material, other than uncombined water, as measured by Method 5 of Appendix A to this part or an equivalent or alternative method.

- Reconstruction - the replacement of components of an existing facility to such an extent that:

  (1) The fixed capital cost of the new components exceeds 50 percent of the fixed capital cost that would be required to construct a comparable entirely new facility, and

  (2) It is technologically and economically feasible to meet the applicable standards set forth in this part.

- Run - the net period of time during which an emission sample is collected. A run may be either intermittent or continuous.

- Shutdown - the cessation of operation of an affected facility for any purpose.

- Startup - the setting in operation of an affected facility for any purpose.

### 3.5 Regulatory Basis for Waivers

Operations during periods of startup, shutdown, and malfunction shall not constitute representative conditions of performance tests. Such operations are thus exempt from the standard. In addition, when systems of emission reduction which are meeting the mass standard do not meet the opacity limits, the source is exempt from the opacity standard at that time (39 FR 9309, March 8, 1974) and an ad hoc opacity standard will be established for that plant.

# 4.0 STATUS OF CONTROL TECHNOLOGY

## 4.1 Scope of Industrial Operations

### 4.1.1 Nature of Present and Projected Plant Operations

For the past 50 years most asphalt concrete plants have been modularly constructed so that they can be transported from one location to another. These transportable plants can be disassembled for movement. Mobile plants are constructed on wheels. Sixty percent of all asphalt concrete plants are transportable, 20 percent are mobile, and the remaining 20 percent are stationary units (NAPA, 1977).

In 1976, 64 percent of the transportable and stationary plants ranged from 109 Mg (120 tons)/hr capacity production rate to 218 Mg (240 tons)/hr. Twenty-nine percent of the mobile plants fell in this size range, while 30 percent were continuous mixer units. Sixty-one percent of hot mix asphalt concrete plants had hot storage (surge) facilities, of which 54 percent had a production capacity of under 181 Mg (200 tons) and 46 percent a capacity of over 181 Mg (200 tons) (NAPA, 1977). The surge facility makes it easier for a plant to operate continuously throughout the duration of a test, with no problems encountered in the three separate test runs required. Most asphalt concrete companies place (lay) their own hot mix (Table 4-1), and approximately 16 percent operate gravel pits or quarries. Approximately 16 percent produce Portland cement concrete in addition to asphalt concrete.

TABLE 4-1

INTEGRATION OF COMPANY OPERATIONS

| Operation | Number of Companies 1975 | 1976 |
|---|---|---|
| Produces hot mix asphalt | 293 | 299 |
| Places (lays) hot mix asphalt produced by your company | 264 | 269 |
| Owns pit or quarry | 152 | 153 |
| Produces Portland cement concrete | 48 | 46 |
| Company is contractor for: | | |
| Road construction | 254 | 260 |
| Other types of construction | 159 | 160 |
| Distributes asphalt emulsion | 44 | 45 |
| Distributes liquid asphalt | 44 | 46 |

Source: NAPA, 1977.

As of April 1977 there were an estimated 4539 transportable, stationary and mobile asphalt concrete plants operating in the U.S. (JACA Corp., 1977). During a comprehensive study, 3579 of these were formally identified by JACA Corporation. The EPA Compliance Data System (CDS)* has formally identified 1751 plants. Thus, a considerable discrepancy between the JACA list and the CDS is evident. Only 486 (13.2 percent) of those found by JACA Corporation were considered subject to NSPS. This figure compares with an informal estimate by

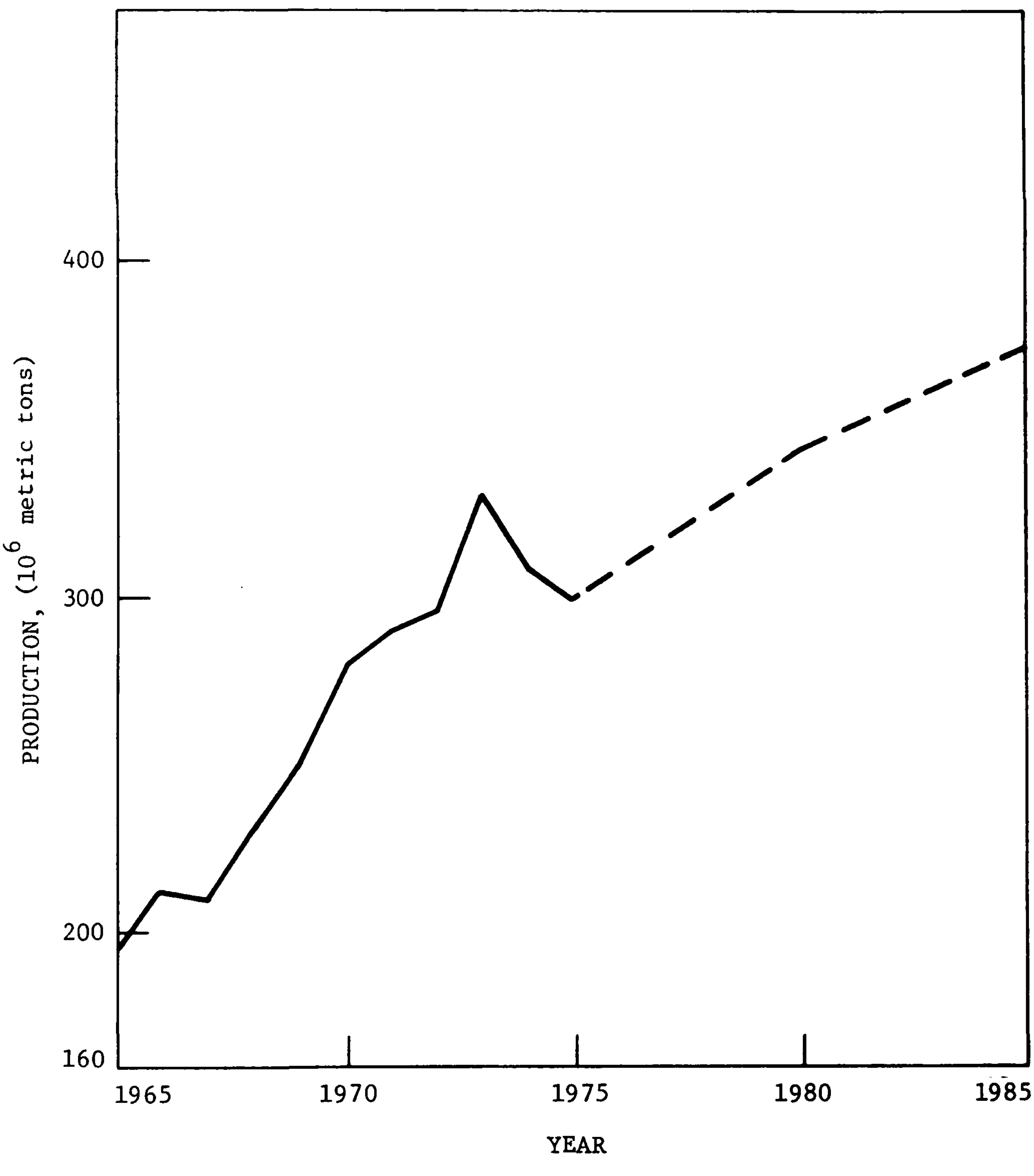
* CDS is a computerized management information system operated by EPA for tracking compliance and enforcement information pertaining to all facilities subject to NSPS, National Emission Standards for Hazardous Air Pollutants (NESHAPS) and/or State Implementation Plans (SIPs).

NAPA of 15 percent subject to NSPS (NAPA, 1978). As of February 8, 1977, 15 asphalt concrete plants (Table 4-2) were identified in the CDS as being either planned or under construction. This does not mean that no others are under construction or in the planning stage. The CDS files are known to be incomplete in regard to future plants, reflecting the fact that regional information often becomes available on a piecemeal basis. In some cases, information is not received up until the time of plant operation (MITRE Corp., 1978). The 15 future plants specifically identified through CDS represent only 10 percent of the 150 plants estimated to come under NSPS regulations annually (100 new plants plus 50 modifications per year). This estimate (EPA, 1974) correlates reasonably well with the nearly 500 plants identified as new in the JACA survey, and with the informal NAPA estimate (1978) that about 15 percent of the 4500 plants in the U.S. are subject to NSPS.

Production of asphalt concrete declined in both 1975 and 1976 (NAPA, 1977), but is projected to increase steadily to 1985 (Figure 4-1).

### 4.1.2 Geographic Distribution of Asphalt Plants

Unlike some industries which tend to be concentrated geographically, asphalt concrete plants are dispersed throughout the 50 states. Because of the principal uses of asphalt for paving highways, roads, parking surfaces and the like, the distribution of plants by state




SOURCE: Khan and Hughes, 1977.

**FIGURE 4-1**
**ASPHALT HOT MIX PRODUCTION, 1965-1985**

TABLE 4-2

ASPHALT CONCRETE PLANTS SUBJECT TO NSPS

| Region | As a Percentage of all Existing Plants in the Region[a] | Plants Planned or Under Construction | |
|---|---|---|---|
| | | Number[b] | As a Percentage of all Plants in the Region Known to be Subject to NSPS [c] |
| I | 10.1 | 2 | 10.0 |
| II | 11.3 | 1 | 2.8 |
| III | 9.3 | 2 | 3.3 |
| IV | 9.3 | 0 | 0 |
| V | 10.0 | 2 | 2.5 |
| VI | 24.3 | 5 | 7.4 |
| VII | 6.7 | 2 | 16.6 |
| VIII | 21.0 | 0 | 0 |
| IX | 40.7 | 0 | 0 |
| X | 14.0 | 1 | 4.0 |

[a]Based on JACA Corp., 1977. Not all plants are subject to NSPS.

[b]MITRE Corp., 1978.

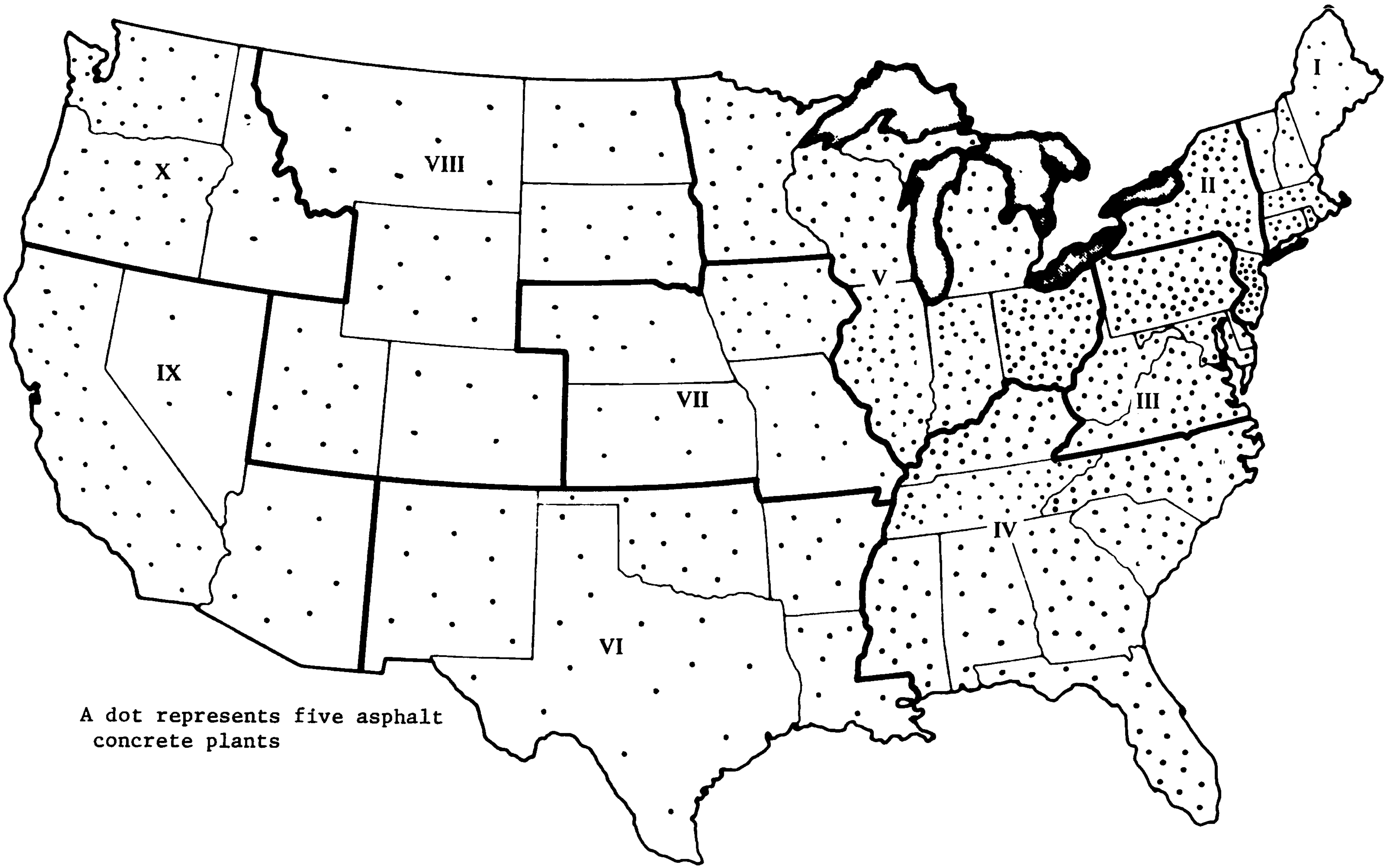
[c]The ratio of known new plants to plants that actually do come on line (usually considerably more in number than the number of known new plants) is about the same for all regions.

correlates reasonably well with highway miles, vehicle miles traveled, and population. While the effects of emissions from asphalt plants and from any changes in NSPS or governing regulations may be felt more in industrial areas and regions of high population density, these effects will occur nationwide rather than in the few localities containing most of the plants.

Figure 4-2 shows the distribution of existing asphalt plants within the states in each of these 10 EPA regions. This distribution can be compared with vehicle registration and population density as shown in Figures 4-3 and 4-4, respectively. Most asphalt concrete plants are located in the Northeast, along the Ohio and Mississippi River basins, and on the West Coast (Figure 4-2). Population densities and urban areas appear to follow roughly the same pattern (Figure 4-4). Figure 4-5 presents estimates of regional percentages of total plants that are subject to NSPS as reflected in the JACA Corporation survey (1977).

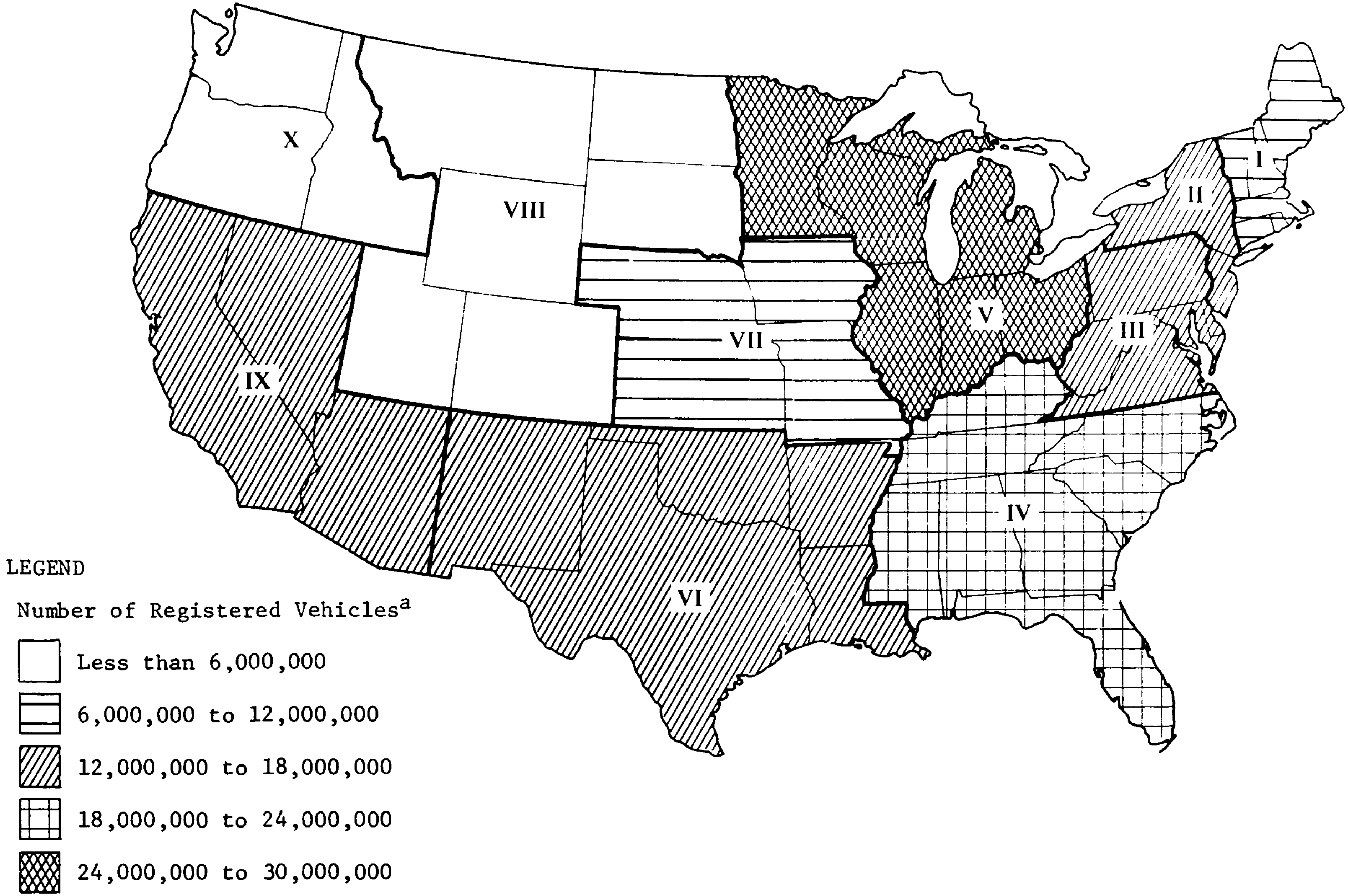
4.1.3 Plant Size Capacity

The operating capacities of asphalt concrete plants range from 36 to 544 Mg (40 to 600 tons)/hr. The most prevalent plant size is less than 218 Mg (240 tons)/hr (NAPA, 1977). This overall average has not changed significantly for newer plants due to the large number of smaller mobile units which are currently operational. The overall average productivity rate is about 160 Mg (176 tons)/hr (Khan and Hughes, 1977). Figure 4-6 shows the average operating capacity of new asphalt concrete plants by region according to CDS. Plants in Regions I and VIII, for which average operating size was not available, are estimated to fall within the 145 to 181 Mg (160 to 200 tons) and 255 to 290 Mg (281 to 320 tons)/hr categories, respectively. based on numbers of plants. The pattern of distribution shown in the Figures 4-1 through 4-5 suggests that the eastern



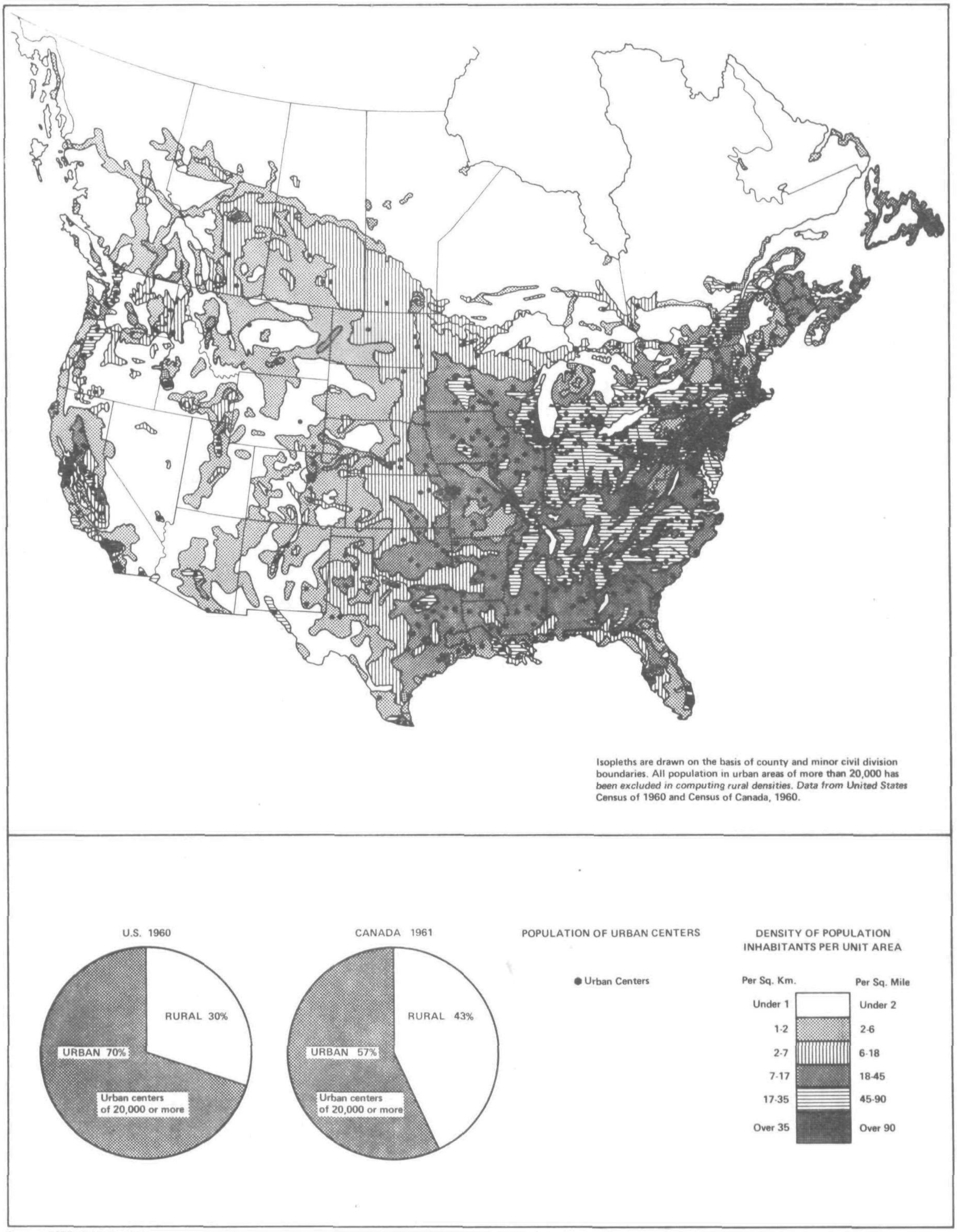

[a]As identified by JACA Corp., 1977.

**FIGURE 4-2**
**GEOGRAPHIC DISTRIBUTION OF EXISTING ASPHALT CONCRETE PLANTS[a]**



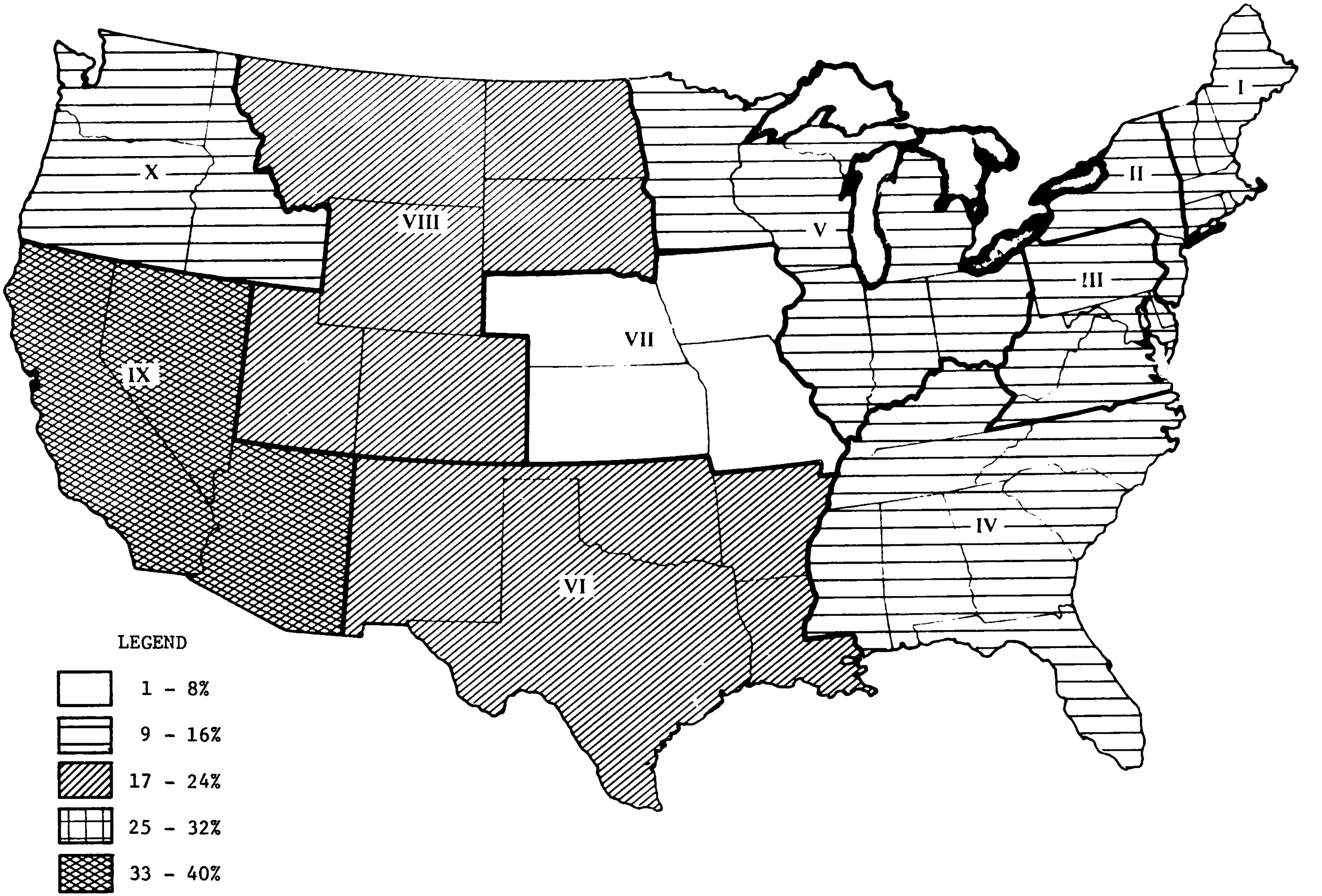

[a]Based on The World Almanac and Book of Facts 1978.

**FIGURE 4-3**
**1976 VEHICLE REGISTRATION IN EACH REGION**



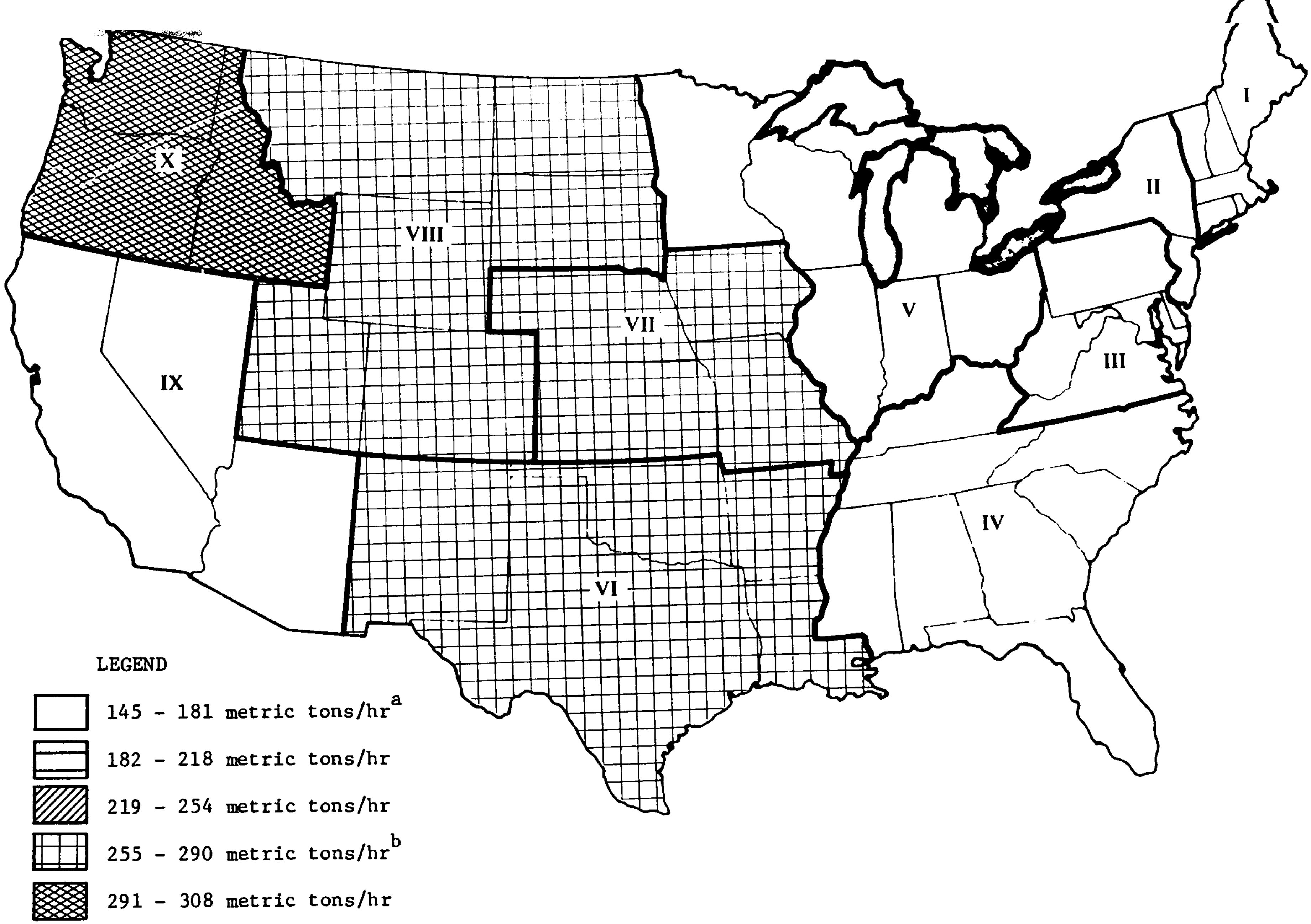

Source: ESPENSHADE, 1970.

**FIGURE 4-4**
**POPULATION OF UNITED STATES AND CANADA**




[a] As of April 1977. Based on Jaca Corp., 1977.

**FIGURE 4-5**
**REGIONAL PERCENTAGES OF EXISTING[a] ASPHALT CONCRETE PLANTS SUBJECT TO NSPS**




[a] Region I - size unavailable - size based on previous pattern tendencies.

[b] Region VIII - size unavailable - size based on previous pattern tendencies.

SOURCE: Mitre/Metrek Survey

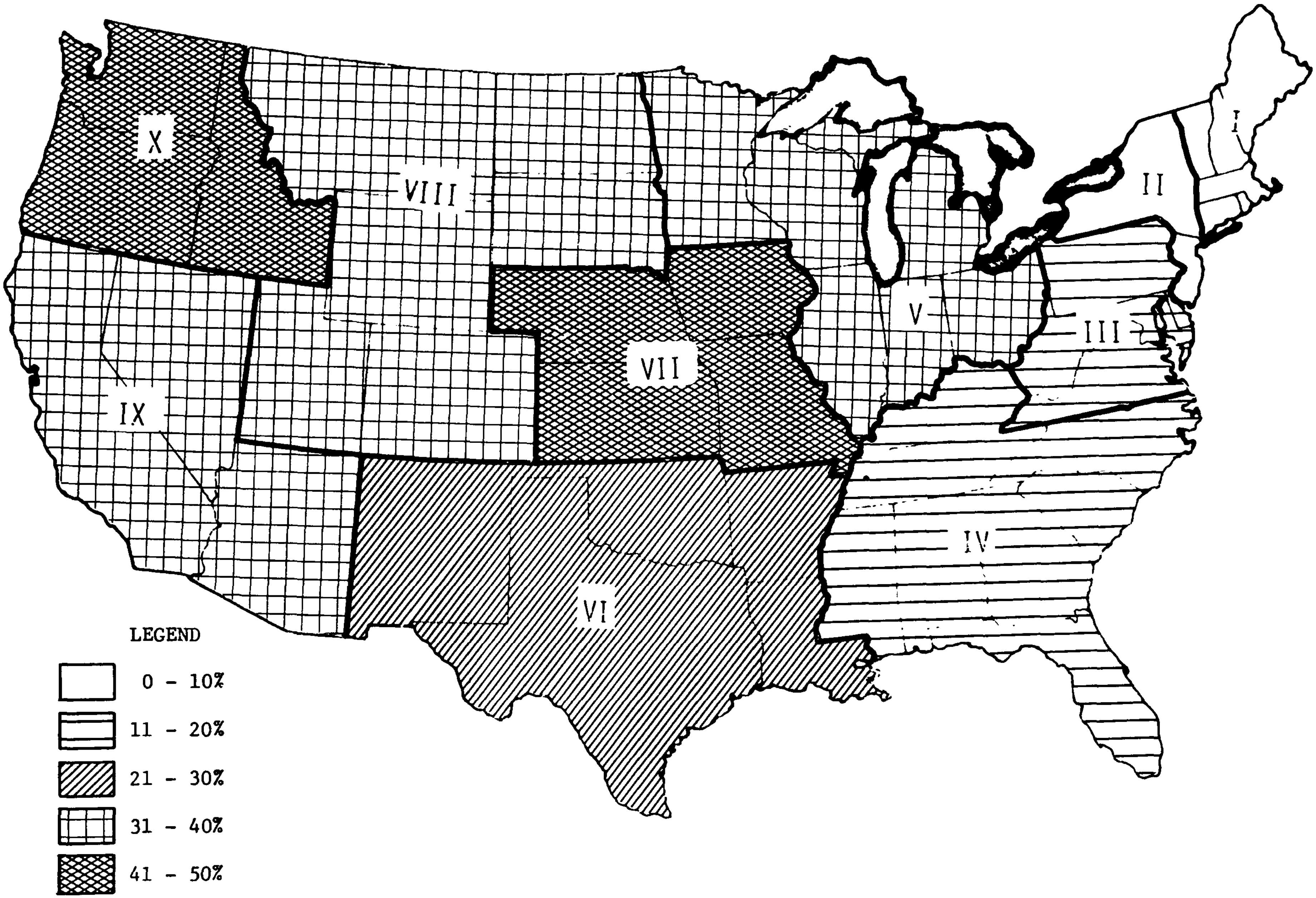
**FIGURE 4-6**
**REGIONAL AVERAGE OPERATING CAPACITY**
**OF ASPHALT CONCRETE PLANTS SUBJECT TO NSPS**

half of the U.S. (Regions I, II, III, IV, V) has older, smaller, transportable or stationary plants built before the promulgation of the NSPS. This pattern also appears in Region IX. These plants do not operate as efficiently as the newer, larger, transportable units (NERC, 1973), a fact which may explain the need for more construction of plants in the six regions. Regions VI, VII, and VIII have relatively large average plant operating capacities, with less than 25 percent of the existing sources subject to NSPS.

#### 4.1.4 Summary

In summary, most of the newer plants subject to NSPS are located in Regions IV, V and IX; while a higher percentage of plants in Regions I, II, VII and X were generally built before 1973 and are not subject to NSPS.

Mobile asphalt concrete plants are more prevalent in the remote and less populated areas of the country where vast expanses of land separate urban areas. On the other hand, "stationary [and transportable] plants are located in urban areas where there is a continuing market for paving and resurfacing work. Mobile plants are usually involved in highway projects since they can be ... [easily] located..." (Khan and Hughes, 1977). Figure 4-7 shows mobile plants as a percent of the total number of asphalt concrete plants in each region. When comparing Figures 4-5 and 4-7, it appears that Region IX has newer and more mobile sources than any other region, with the exception of Region VIII. Region VI, which contains an average




[a]As identified by NAPA, 1977.

**FIGURE 4-7**
**RATIO OF MOBILE ASPHALT CONCRETE PLANTS TO TOTAL NUMBER IN EACH REGION[a]**

proportion of asphalt concrete plants subject to NSPS, has a similar percentage of mobile plants. Regions X and VII contain few plants subject to NSPS and have the highest percentage of mobile plants. Regions I, II, III and IV, which contain the more populated areas, have fewer mobile asphalt plants; whereas Regions VI, VII, VIII, IX and X contain a larger percentage of highway systems and nonurban areas and, therefore, more mobile asphalt units.

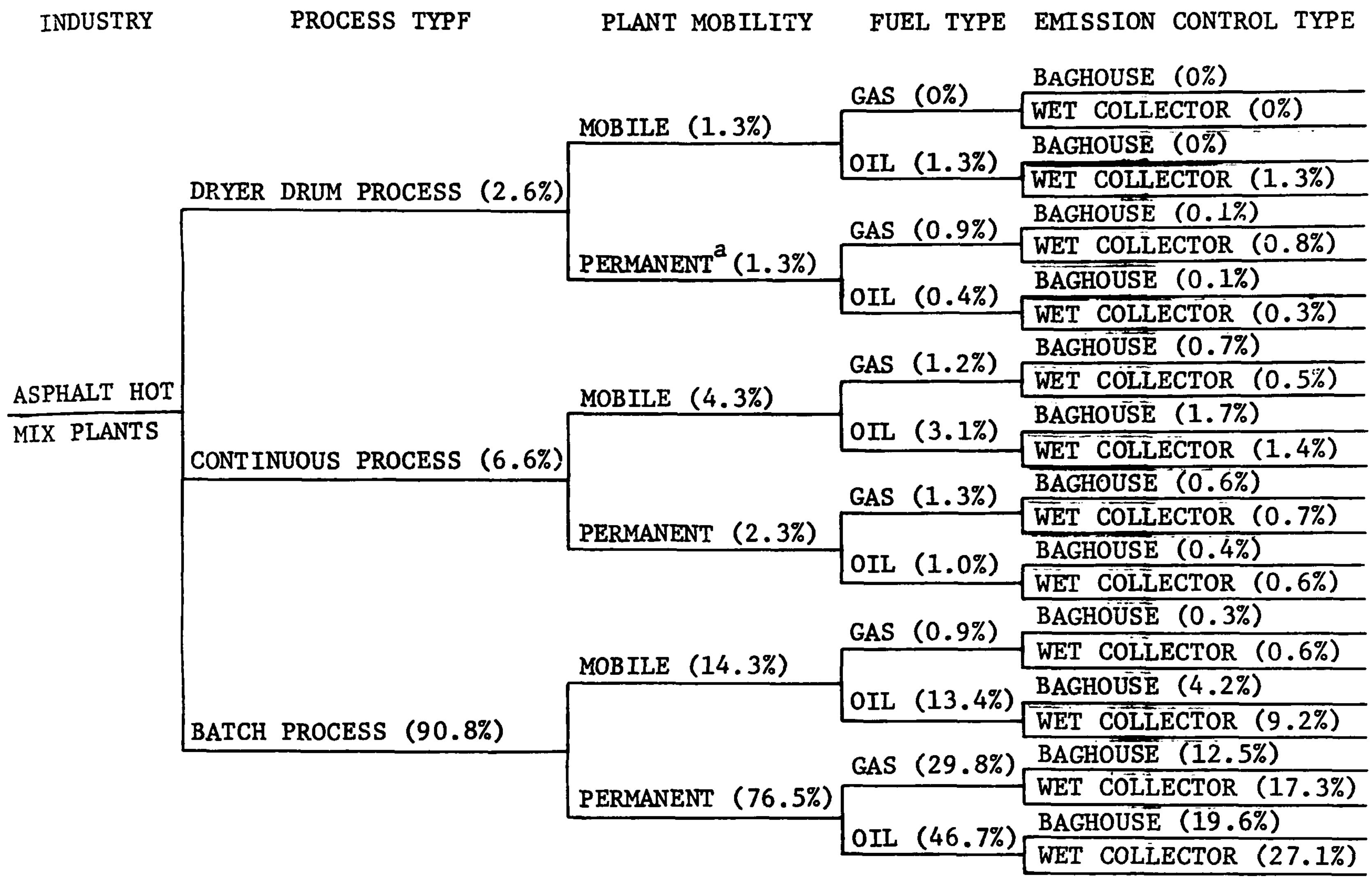
It is difficult to be totally accurate in determining plant distribution, since both transportable and mobile plants can and sometimes do cross state and regional boundaries.*

## 4.2 Control Methods to Meet NSPS

### 4.2.1 Overview

In asphalt hot-mix production a combination of aggregates, ranging from small stones to fine particles such as sand, is mixed with liquid asphalt. There are three major types of processes: batch, continuous mix, and dryer-drum (drum-mix) (Figure 4-8). In all three processes, cold-feed aggregate is heated in a rotary dryer and most of the moisture is carried out by an exhaust fan. After this operation, hot liquid asphalt is blended with the mineral aggregate to produce the desired product. The batch process now accounts for over 90 percent of all asphalt production. The mixing takes

* A complete and accurate account of the number of mobile units needs to be determined. CDS does not differentiate transportable and stationary from mobile consistently, due to inaccurate data and inconsistent use by regions.




Numbers in parentheses represent
% of total industry

0% indicates no industry response

SUMMARY

| PLANT MOBILITY | | FUEL TYPE | EMISSION CONTROL TYPE | |
|---|---|---|---|---|
| PERMANENT PLANTS | (80%) | GAS (34%) | BAGHOUSE | (40%) |
| MOBILE PLANTS | (20%) | OIL (66%) | WET COLLECTOR | (60%) |

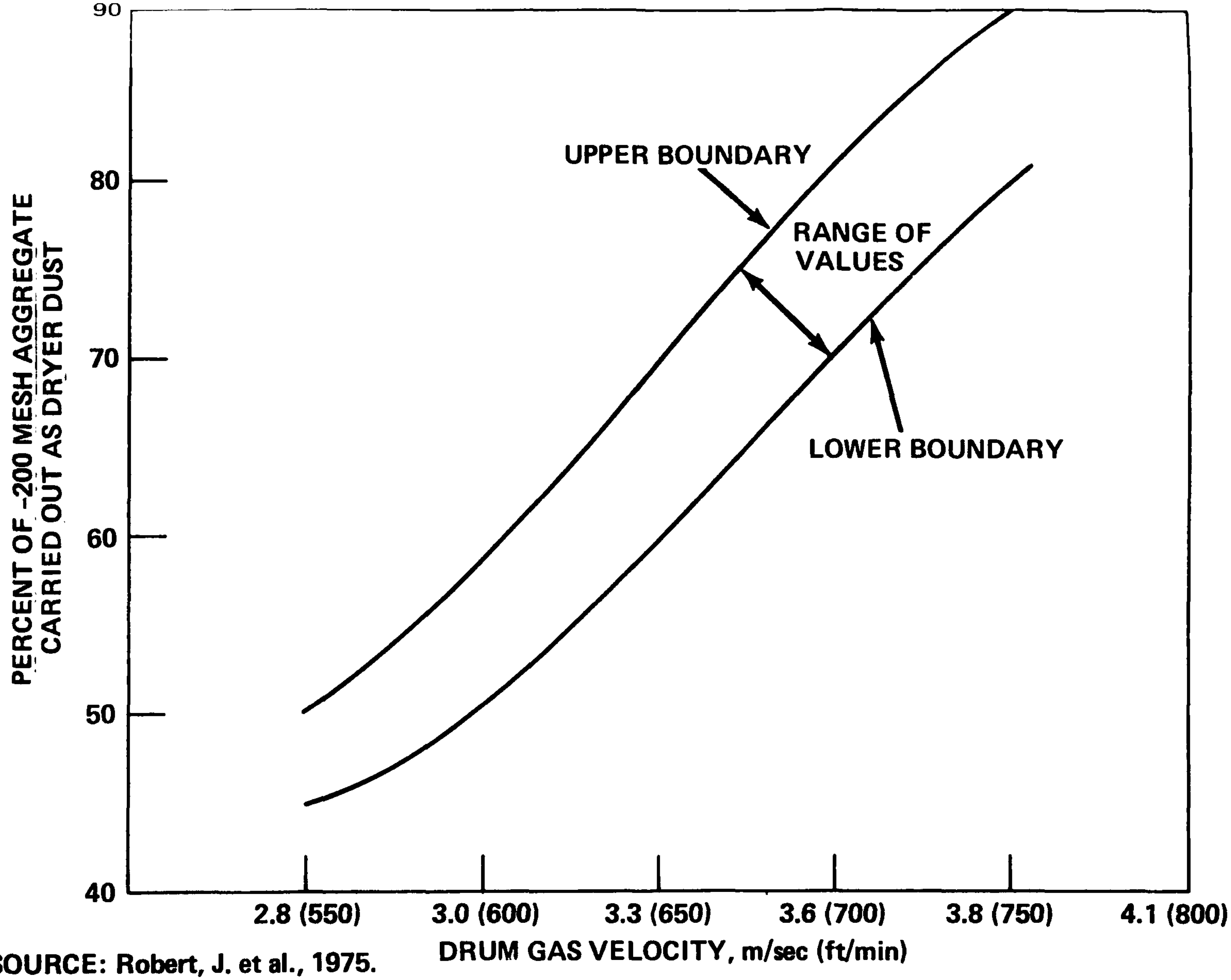
SOURCE: Khan and Hughes, 1977.
[a]Permanent includes stationary and transportable

**FIGURE 4-8**
**ASPHALT HOT MIX INDUSTRY**

place in batches and each batch requires roughly 1 minute. Thus, a plant with a mixer size of 2.7 Mg (3 tons) has a rated capacity of 163 Mg (180 tons)/hr. In the continuous mix process, aggregate and liquid asphalt are metered through separate control systems in the desired proportions on a continuous basis. In both processes, drying and mixing occur as distinct operations in separated enclosed components of the plant. The dryer-drum or drum mix process differs from these two processes in that drying of the aggregate and mixing with the liquid asphalt occur in different compartments of a drum dryer (Khan and Hughes, 1977; NAPA, 1978).

Exhaust gases from the dryer comprise about 80 to 90 percent of the total gas flow in the system. Most of the dust loading of particles from the process is contained in the gas from the dryer. Exit velocities typically range from 2.3 to 4.6 m/sec (450 to 900 ft/min). It has been found that a 50-percent increase in exit gas velocity will lead to an increase of 125 to 150 percent in dust carry-out from the dryer (Crim et al., 1971; Barber-Greene, 1976) as shown in Figure 4-9.

Opacity and particulate loadings both reflect particles in the emissions from an asphalt concrete plant. The control of particulates basically controls opacity and may be achieved with the use of one or more devices for trapping or removing the particles.




SOURCE: Robert, J. et al., 1975.

**FIGURE 4-9**
**DRYER DUST LOADING AS FUNCTION OF PERCENT OF FINES INPUT AND DRUM GAS VELOCITY**

#### 4.2.2 Types Available

Control devices used in asphalt concrete plants may be classified as either wet or dry. Dry devices range in complexity from the simple settling chamber or knockout box, through cyclones utilizing centrifugal force, to a baghouse using fabric filters. Wet devices are washers (also commonly called scrubbers) that range in complexity from the low-energy spray chamber, through centrifugal or cyclonic wet washers at low to medium energy levels, to the high-energy venturi scrubbers.* Distribution of control systems among the types of asphalt plants is shown in Figure 4-8.

4.2.2.1 Dry Collectors. In the settling box the velocity of the carrier gas is reduced to a point such that gravity causes some of the particles to fall out of the air stream. This device is effective only for particles greater than about 40 microns. Centrifugal or cyclone collectors use changes in direction and speed of the air stream as it passes through an enclosed area to settle out progressively smaller sized particles. Small diameter cyclone units operate more efficiently. In dealing with an air volume too great for a small unit, several small cyclones can be placed in a parallel operation as a multiple cyclone collector (sometimes termed a "multi-clone"). The load is, thus, divided among numerous small cyclones mounted in a common housing. The fine particles recovered

* A discussion of venturi scrubbers and energy levels associated with high efficiency is given in Section 4.3.1.

by a dry collector such as a settling box or cyclone unit are valuable as fines for recycling into the asphalt product. Hence, such a device has for many years been used in nearly all asphalt concrete plants as an essential part of production. Although the efficiency of dry collectors is typically too low to meet current NSPS particulate levels, they may still be employed as primary collectors ahead of a more efficient control system termed a secondary collector (NAPA, 1975; Danielson, 1973; Barber-Greene, 1976).

As a dry system for meeting NSPS, a bag collector (more precisely, a "fabric filter" dust collector) is widely used. An estimated 40 percent of all asphalt plants are now fitted with such devices as shown in Figure 4-8 (Khan and Hughes, 1977). In a bag collector, the dust-laden exhaust gases from the dryer, as well as those from so-called ventlines carrying "scavenger air" with dust particles from other components of the process, are drawn through a filtering fabric, the fibers of which capture the dust particles. The filter cloth is most commonly arranged in the form of a cylindrical bag to handle the large volume of exhaust gas. The bag is commonly fitted over cylindrical wire forms called "cages" to support the bag in operating condition and to give maximum cloth exposure within minimum space. Effective operation in asphalt concrete plants reportedly results from a filter of 14-ounce Nomex, needled, scrimback felt at an air-to-cloth ratio of 6:1, although ratios ranging from 9:1 to 4:1 and even lower may be employed.

A number of bags assembled into a single airtight unit make up what is termed a baghouse. The dust is trapped on the dirty side of the bag so that clean air passes out by means of the exhaust fan. Dust cake deposited on the dirty side of the bags actually aids in trapping the smaller particles in the exhaust gas, up to a point. However, removal of the dust cake at regular intervals is required for effective performance so as to maintain the design exhaust capacity of the fabric filter system. Uninterrupted operations can be maintained by cleaning only a portion of the baghouse at a time. Fabric filters or baghouses are generally regarded as the most efficient control system available for asphalt concrete plants under current technology for removal of particulates (NAPA, 1975, 1978; Soderberg, 1974; Danielson, 1973; Barber-Greene, 1976).

4.2.2.2 Wet Collectors. Wet collectors or scrubbers introduce water into the gas stream to condition the fine particles so as to increase their effective size for easier removal and/or to trap the particles in a liquid film that washes them away. Wet collector efficiency is a function of several variables, including resistance to air flow measured as pressure drop, or the amount of pressure lost due to friction and condensation between two points, such as the inlet and outlet of the collector. In general, the higher the pressure drop the more efficient the wet collector.

Venturi scrubbers as typically used by asphalt concrete plants have a pressure drop of about 51 centimeters (cm) (20 in.). A venturi scrubber consists of a convergent section and a divergent section. As dust-laden gas enters the convergent section, the constriction increases both gas stream velocity and velocity of the particles relative to the droplets of water interjected at a typical ratio of about 30 liters (8 gal/min) to each 28.3 $m^3$ (1000 $ft^3$)/min of gas flow. The high velocity gas stream atomizes the liquid into a fine mist. Dust is entrapped in the water and the droplets agglomerate to a relatively large size. In the divergent section, the dust-laden gas is slowed down. Changes of direction in the gas flow result in further impaction and agglomeration. In the separator the liquid is thrown to the walls by centrifugal forces and then through gravity drains to the bottom. Clean gas passes out through the upper portion of the separator, while the liquid typically drains into a settling pond (Kahn and Hughes, 1977; NAPA, 1975).

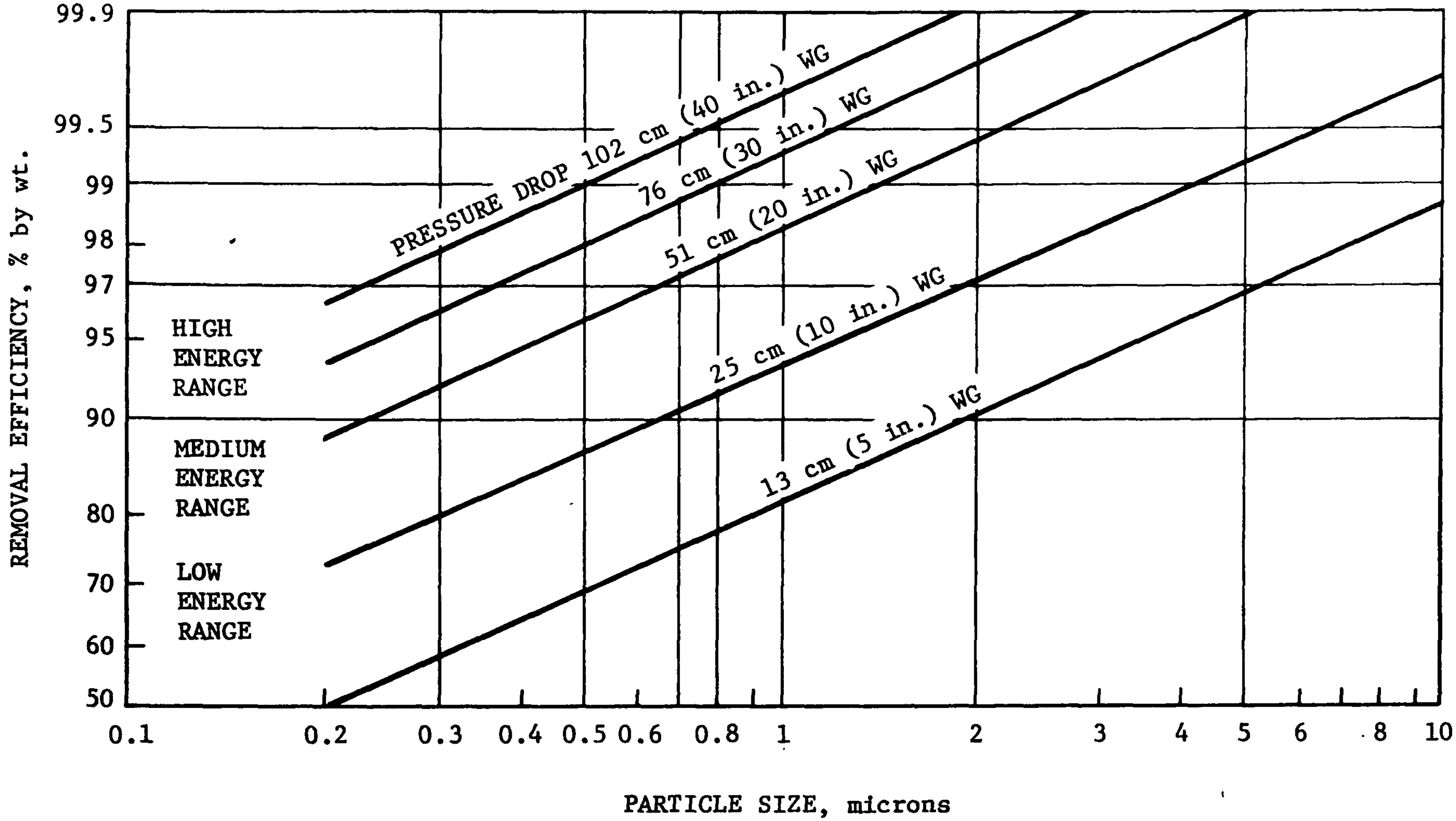
Venturi scrubbers are often categorized by their operating characteristics and capabilities. The terms "high gas velocity," "medium energy," and "high efficiency" are frequently applied, but are not defined quantitatively in the available literature. Although some indication of their range of application is implied by the following discussion the description is not clear. In the background document for NSPS, EPA (1973) stated that "In order to reduce emissions by about 99.7 percent as required by the proposed standard, fabric filters or medium energy venturi scrubbers, normally preceded by a cyclone or multiple cyclone, are used to collect dust from the dryer." Reported test results include those in which plants controlled by venturi scrubbers with a pressure drop in the range of 25 to 48 cm (10 to 19 in.) water gauge (WG) emitted particulates at a rate less than the proposed standard of 90 mg/dscm (0.04 gr/dscf). Venturi scrubbers with a pressure drop up to 51 cm (20 in.) WG are common in the asphalt concrete industry. The Scrubber Handbook (Calvert et al., 1972) cites test data for asphalt concrete plants in which venturi scrubbers with pressure drops in the range of 35 to 50 cm (about 14 to 20 in.) provided the control system.

Pressure drops in the range of 25 to 51 cm (10 to 20 in.) are considered to provide an efficiency of about 97 percent for particles of at least 1 micron (Robert et al., 1975). Indications are that in the range of 102 cm (40 in.) WG pressure drop, efficiencies exceeding 99 percent may be attained in removing submicron particles (Calvert et al., 1972; Robert et al., 1975; Soderberg, 1974; American Air Filter Co., 1978).

The distinction between "medium" and "high energy" scrubbers appears to occur with a pressure drop of 51 to 76 cm (20 to 30 in.) WG. Some sources, however, consider the venturi scrubber to represent a "high energy" scrubber, the centrifugal and cyclonic as low energy scrubbers, and the orifice as a medium energy wet collector (Robert et al., 1975). Figure 4-10 shows the efficiencies of venturi-type scrubbers with specified pressure drops as a function of particle size and indicates the range of "medium" and "high energy" scrubbers.

Gas velocities used with venturi scrubbers may range from 61 m/sec (200 ft/sec) to 152 m/sec (500 ft/sec) or as much as 213 m/sec (700 ft/sec). No indication has been found in the literature of cutoff points for "high velocity" as contrasted with "low" or "medium velocity" within this range (Calvert et al., 1972; Robert et al., 1975).

4.2.2.3 Aggregate Size Distribution. Aggregate comprises more than 90 percent of asphalt hot mix product (Khan and Hughes, 1977). The size distribution of the aggregate entering the dryer is an important factor in determining what the inlet loading to the control system will be. At a given velocity of the gas stream only some of the particles will become airborne, depending on their size, weight and shape. Because smaller particles become airborne more easily with the dryer gases than the larger ones, the inlet loading to the collector is strongly influenced by the amount of mineral dust in the aggregate (Khan and Hughes, 1977; Robert et al., 1975). Baghouses are much less sensitive to this variable than venturi scrubbers.




Sources: Robert, et al., 1975;
Soderberg, 1974.

**FIGURE 4-10**
**VENTURI SCRUBBER FRACTIONAL EFFICIENCIES**
**FOR VARIOUS PRESSURE DROPS**

### 4.2.3 Efficiencies Achieved

Efficiency is expressed throughout this report as

$$\text{a percentage} = 100 \times \frac{\text{output loading}}{\text{input loading}}$$

The efficiency achievable for any collection device (assuming proper maintenance and operation) may vary under different conditions. Wet collector efficiency is affected by the amount of power supplied in forcing the gas stream through the collector--a function of the pressure drop, or amount of pressure lost, due to friction and condensation between inlet and outlet. An increase in pressure drop by a factor f times the original value is reflected as an increase in power required of $f^2$ i.e., increasing the pressure from 41 to 51 cm (16 to 20 in.) or 1.25 times the original value requires 25/16 as much power or an increase of 9/16).

Overall efficiencies may be as low as 60 percent for large-diameter dry cyclones, as much as 95 percent for small diameter cyclones and multiclones, and as high as 94 percent for spray type wet scrubbers (Crim et al., 1971). Only scrubbers such as the venturi and the baghouse can generally be relied on to achieve efficiencies of well over 99 percent in particulate removal. The higher efficiencies (in the range greater than 99.5 percent) are reportedly easier to achieve with a baghouse system. The range of efficiencies for various control devices as a function of particle size is given in Table 4-3. Data are limited for the smallest particles (< 7 microns). None of the references cited in Table 4-3 reported results specifically for asphalt concrete plants. Collection efficiencies of baghouses for submicron particles reflect a wide range based on test data from utility and industrial boilers, lime recovery at a pulp mill, and laboratory studies of fabric performance. Engineering experience reports increasing reliance on either the baghouse or the venturi scrubber as a single collection device; however, dry primary collectors are still used as precleaners and have particular application in one or both of the following:

- Providing a cost-effective means to filter out particulates to be recycled as fines for use in the aggregate.
- Reducing the dust-loading on the final collection device by removing particles of the size and nature which could impede its operation (e.g., larger particles which form too porous a cake in a baghouse filter) (NAPA, 1975).

### 4.2.4 Operation of Controls in Asphalt Plants

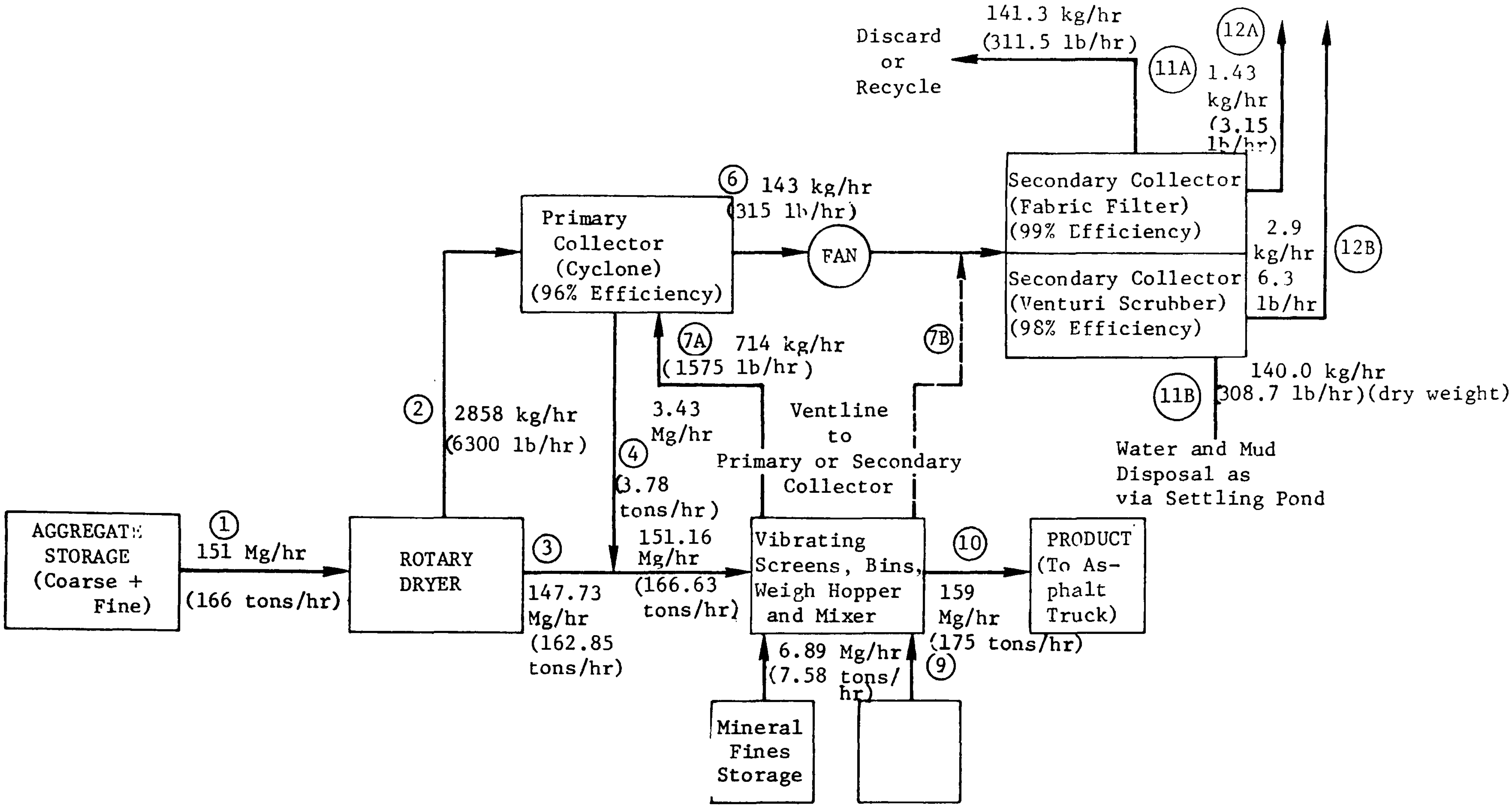
A simplified flow diagram with materials balance applicable to a batch process or continuous mix operation in an asphalt plant is shown in Figure 4-11. A plant of representative size has been assumed at 159 Mg (175 tons)/hr of product output. The use of both primary and secondary collectors for control of emissions is illustrated. Differences in the dryer drum plant are also explained.

TABLE 4-3

COLLECTION EFFICIENCIES AS FUNCTION OF PARTICLE SIZE
(-200 Mesh)

| Particle Size (Microns) | Low-Resistance Cyclones (Percent) | Multicones (Percent) | Wet Collectors[a] (Percent) | Cyclone Scrubbers, Wet Fans (Percent) | High Pressure Venturis (Percent) | Baghouse (Percent) |
|---|---|---|---|---|---|---|
| >74 | 99[b] | ≥99[c] | ≥99[c] | >99[c] | >99.9[c,d] | >99.9[c,e] |
| >30 | 80-90[b] | 95-99[c] | ≥99[c] | ≥99[c] | >99.9[c,d] | >99.9[b,e] |
| >10 | 50-80[b] | 80-95[b] | 97-99[c] | ≥99[c] | 99-99.9[c,d] | 99-99.9[b,i] |
| >5 | ≤20[b] | 40-50[b] | 90-96[b] | 98-99 | 99-99.9[g] | 97-99.9[i,h,l] |
| >1 | | | 50-60[b] | 95-98[b] | 98-99.7[g] | 97-99.9[i,l] |
| >0.5 | | | >50[f] | >50[f] | 95-98[g] | 85-99[j,k] |
| >0.3 | | | | | 90-95[g] | 70-99[j,k,l] |

[a]e.g. - Gravity Spray Tower.
[b]NAPA, 1975.
[c]Khan and Hughes, 1977.
[d]Patankar and Foster, 1978.
[e]Standard Havens, 1978.
[f]Danielson, 1973.
[g]Robert et al., 1975, Soderberg, 1974.
[h]Pressure drop of 38 to 51 cm (15 to 20 in.) WG.
[i]Harmon, 1977.
[j]Lamb et al., 1978.
[k]McKenna, 1974.
[l]Bradway and Cass, 1975; 1976.




SOURCE: Khan and Hughes, 1977; NAPA, 1975; Danielson, 1973.

**FIGURE 4-11**
**MATERIALS FLOW FOR REPRESENTATIVE ASPHALT PLANT**
**(BATCH OR CONTINUOUS MIX)**

Aggregate of appropriate mix is fed (see Figure 4-11) into the rotary dryer (Stream 1) at a controlled rate. The aggregate, which is generally composed of locally available material, will contain both coarse-sized crushed rock and fines. Fines typically comprise less than 10 percent of the total weight (Crim et al., 1971). Moisture content of the cold aggregate is usually 3 to 5 percent by weight; however, ranges well above 10 percent are encountered.* The rotary dryer is an inclined rotating cylinder (usually employing oil or gas as fuel) into which the aggregate is fed at the raised end and discharged at the lower end. A dryer exhaust temperature of between $90^{o}$ and $100^{o}C$ (~$200^{o}$ and $250^{o}F$) is often considered to be optimum, although temperatures up to $175^{o}C$ (~$350^{o}F$) are encountered (Khan and Hughes, 1977, 1977; NAPA, 1975; Foster, 1977).

The rotary dryer is the principal source of particulate emissions in a hot-mix asphalt plant (Stream 2). Based on the EPA emission factor for uncontrolled particulate emissions of 22.5 kg/Mg (45 lb/ton) of product (EPA, 1973a) and on the assumption of 80 percent emission contribution by the dryer (Khan and Hughes, 1977; Danielson, 1973), a 159 Mg (175 ton)/hr plant is estimated to emit 2858 kg (6300 lb) of particulates per hour from the dryer. In

*The National Asphalt Paving Association (NAPA) provides tables showing balance between air flow and available heat under various conditions for ranges of aggregate moisture content between 4 and 15 percent (NAPA, 1975).

Figure 4-11 these emissions are shown entering the primary collector, for which a dry cyclone is assumed to be the representative type operating at a 96 percent efficiency (Khan and Hughes, 1977). In many plants no primary collector is provided, and all emissions go to the secondary collector.

The vibrating screens, bins, weigh hopper and mixer are also sources of particulate emissions which be controlled. These areas are normally enclosed. The dust emitted is carried by ventline to the control system (Stream 7A or 7B). The materials balance depicted in Figure 4-11 is based on the assumption that the ventline emissions will move through the dry cyclone (Stream 7A) along with emissions from the dryer. However, in some plants these emissions bypass the primary collector and go directly to the secondary collector (Stream 7B) (Khan and Hughes, 1977; Danielson, 1973).

Two output streams from the primary collector are also shown in the figure. The primary collector removes an estimated 3.43 Mg (3.78 tons)/hr of particulates shown as being recycled (Stream 4) by a service conveyor back to the process. Here it is combined with the hot aggregate from the dryer (Stream 3) and hauled (Stream 5) by a bucket elevator to the vibrating screens. These screens sort the aggregate to predetermined uniform grades and drop it into an appropriate storage bin. Aggregate to be used is weighed and fed into a mixer. After a few seconds of dry mixing, asphalt is added and the blended material is discharged (Stream 10) into trucks for delivery.

The particulate emissions not captured by the primary collector pass (Stream 6) to a secondary collector. These emissions consist largely of very fine particles (less than 20 to 30 microns), for which the primary collector has a relatively low efficiency. This type of cyclone alone will not suffice to meet current NSPS, but may be used to facilitate recycling of larger particles (in the range of 74 microns, of which it may remove up to 100 percent) and to improve performance of the secondary control system. In Figure 4-11 dust-laden air from the primary collector is shown moving by exhaust fan to the secondary collector, although performance of some wet collectors may be improved by placing them ahead of the fan (Khan and Hughes, 1977; NAPA, 1975; Danielson, 1973).

A control device of the type shown in Figure 4-11 is usually crucial to meeting current NSPS for particulates. In a plant using a single collector, the device is likely to be either a baghouse (fabric filter system) or a wet scrubber of the venturi design. If ventline emissions bypass the primary collector, they enter the secondary collector directly (Stream 7B) along with the output of the cyclone.

Figure 4-11 shows typical results with the use of either a fabric filter (from which output emerges as Streams 11A or 12A) or a venturi scrubber (outputs as Streams 11B and 12B). Efficiencies hypothesized in the figure are slightly lower than those used as typical ratings (Khan and Hughes, 1977) since the emissions entering the secondary collector contain a high percentage (by weight) of particles below 30 microns and a significant percentage of particles in the 5-micron range. Efficiencies of all collectors (baghouses and venturis included) diminish when collecting the smaller range particles as shown in Table 4-3 (NAPA, 1975).

The fines filtered out by a baghouse (fabric filter) collector (Stream 11A) can be recycled along with particles from a primary collector or they can be discarded as solid waste. A survey of asphalt plants indicated that 53 percent recycled this material (Khan and Hughes, 1977). Particles removed by a wet scrubber must be disposed of as solid waste, typically through use of a settling pond.

Small changes in the materials balance (Figure 4-11) would be required under the assumption of only a single collector (venturi scrubber or fabric filter). Since the 714 kg (1575 lb)/hr of particulate emissions from the ventline would not be recycled via the primary collector, a small increase in the amount of material from storage would be required to offset the difference. Slightly higher atmospheric emissions from the single collector would be expected, although a very small increase in efficiencies on an overall weight basis would be likely as the larger particles would not already have been removed.

The outputs postulated for the hypothetical plant in Figure 4-11 from either secondary collector would be expected to meet current NSPS. A loading of 2.86 kg (6.3 lb)/hour (approximately 735 gr/min) at a flow rate of 520 dscm/min (18,375 dscf/min) would yield a grain loading of 90 mg/dscm (0.04 gr/dscf). A flow rate of 520 dscm/min (18,375 dscf/min) is not particularly high for a 159 Mg (175-ton)/hour plant (NAPA, 1975).

The dryer-drum mix plant differs from the unit shown in Figure 4-11 in that the aggregate, mineral fines and asphalt all go directly from storage into a dryer drum where mixing takes place. A block diagram of the flow in such a plant is shown in Figure 4-12.

The distribution of types of control systems among asphalt plants is shown in Figure 4-8.

#### 4.2.5 Control System Costs

Purchase, installation, and operation and maintenance costs of the various types of control systems increase with the approximate efficiency of the given system. In general, dry collectors are the least expensive, although baghouse systems are initially more expensive than wet collectors.

The increase in cost by control system type is not linear with the increase in range of overall efficiency. The incremental increase in efficiency provided by the baghouse system is likely to be relatively expensive as an initial investment.

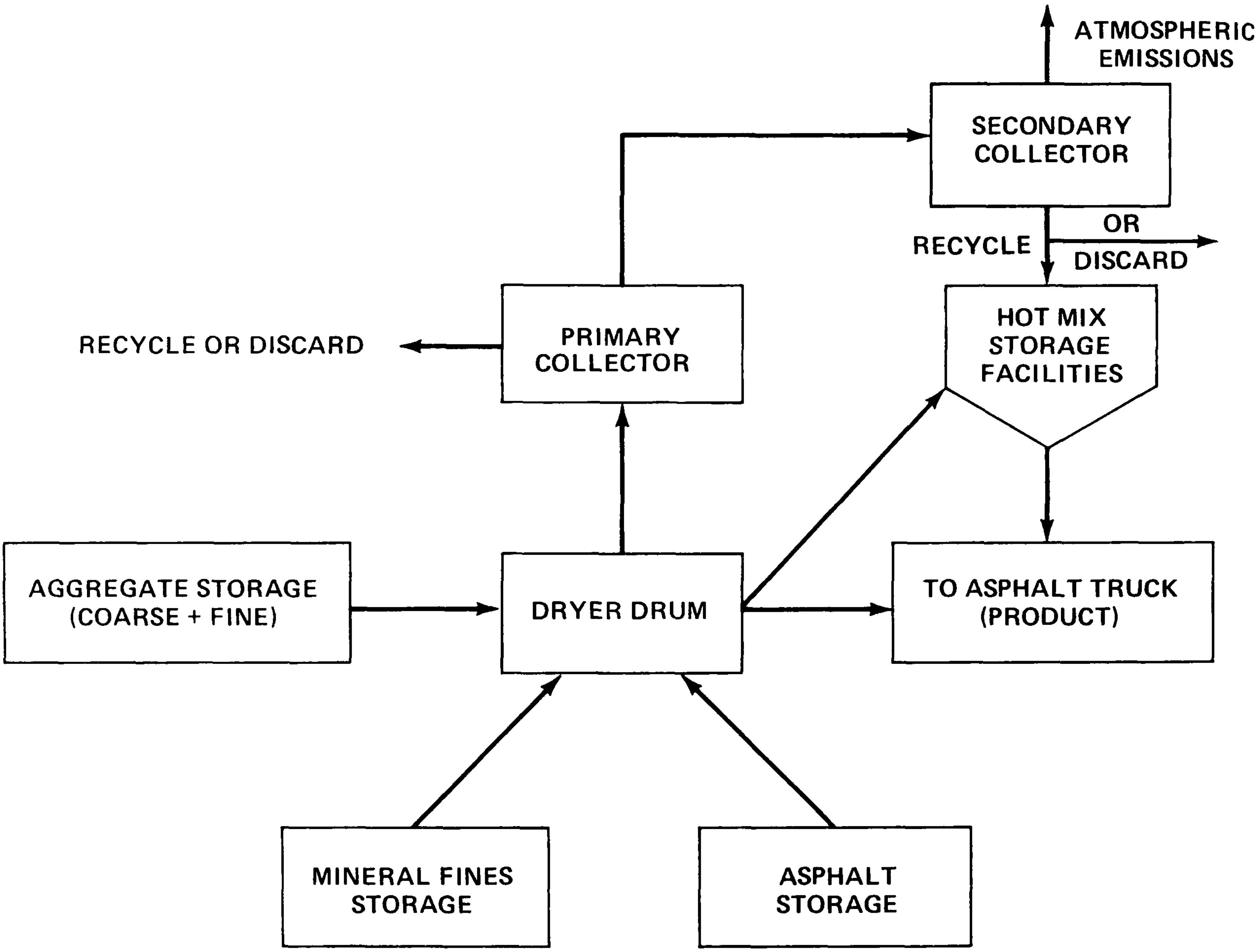



**FIGURE 4-12**
**TYPICAL FLOW IN A DRYER-DRUM MIX ASPHALT PLANT**

However, cost in cents per ton of asphalt product for the baghouse system can be offset at least partly by the recycling of valuable fines recovered. These fines would be disposed as solid waste at the owner/operator's expense when a scrubber is used. In addition, as energy costs increase, the economics of baghouses become increasingly attractive.

Theoretical calculations of expected costs to asphalt plants by EPA (1974) and estimates of expected costs by Crim (1971) as given in Table 4-4 are partly borne out by limited experimental data. The costs do not match on the basis of plant-size and dollar per actual cubic meter per minute (acmm) because the ratio of actual cubic meter per minute to product output in the observed operating situations was much higher than the ratio used in EPA's theoretical calculations. (For a plant of given size, the observed actual cubic meter per minute was on the order of 1.5 times the EPA estimate.)

One plant operating at 132 Mg (146 tons)/hr was reported as having a baghouse and fan installed for a total price of $115,000 at a cost of $91.83/acmm or $2.60 per actual cubic foot per minute (acfm). The EPA estimate for the same kind of installation in a 136 Mg (150 ton)/hr plant was $79,500 at an estimated cost of $97.13 to $112.32/acmm ($2.75 to $3.18/acfm). Another plant with a 272 Mg (300 ton)/hr capacity was reported as using a baghouse installed

TABLE 4-4

ESTIMATED COSTS FOR CONTROL SYSTEMS FOR REPRESENTATIVE PLANT SIZES

| PLANT CAPACITY | 136 Metric Tons (150 Tons)/Hour | | | | 272 Metric Tons (300 Tons)/Hour | | | |
|---|---|---|---|---|---|---|---|---|
| | Fabric Filters | | Venturi Scrubber | Multi-Centrifugal Scrubber | Fabric Filters | | Venturi Scrubber | Multi-Centrifugal Scrubber |
| Control Device | Without Dust Recovery | With Dust Recovery | | | Without Dust Recovery | With Dust Recovery | | |
| Inlet Gas Volume ACMM | 708 | 708 | 708 | 708 | 1416 | 1416 | 1416 | 1416 |
| Inlet Gas Volume ACFM | 25,000 | 25,000 | 25,000 | 25,000 | 50,000 | 50,000 | 50,000 | 50,000 |
| Control Efficiency (%) | 99.8 | 99.8 | 99.8 | 96.9 | 99.8 | 99.8 | 99.8 | 98.3 |
| Equipment Cost | $47,600 | $57,300 | $27,700 | $21,400 | $69,500 | $79,600 | $48,500 | $35,200 |
| Installation Cost | 20,400 | 22,200 | 29,600 | 26,300 | 29,200 | 31,100 | 47,600 | 41,400 |
| Total Installed Cost | 68,000 | 79,500 | 57,300 | 47,700 | 98,700 | 110,700 | 96,100 | 76,600 |
| Investment Cost ACMM | $96.07 | $112.32 | $80.88 | $67.46 | $69.58 | $78.06 | $67.81 | $54.04 |
| Investment Cost ACFM | $2.72 | $3.18 | $2.29 | $1.91 | $1.97 | $2.21 | $1.92 | $1.53 |
| Comparative Estimate of cost[a] ACMM | $88.30-141.28 | $88.30-141.28 | | $44.15-70.64 | $88.30-141.28 | $88.30-141.28 | | $44.15-70.64 |
| Comparative Estimate of cost[a] ACFM | $2.5-$4.00 | $2.5-$4.00 | Not Given | $1.25-$2.00 | $2.5-$4.00 | $2.5-$4.00 | Not Given | $1.25-$2.00 |
| Total Annual Cost[b] | $24,700[c] | $22,500[d] | $24,300[c] | $19,700[c] | $39.400[c] | $32,600[d] | $43,200[c] | $34,600[c] |
| Cost in ¢/unit Product Mg | 22.0¢ | 20.0¢ | 21.6¢ | 17.5¢ | 17.5¢ | 14.5¢ | 19.2¢ | 15.4¢ |
| Cost in ¢/unit Product Ton | 24.3¢ | 22.0¢ | 23.8¢ | 19.3¢ | 19.3¢ | 16.0¢ | 21.3¢ | 17.0¢ |

SOURCE (Except where otherwise stated): U.S. Environmental Protection Agency, 1974.

[a]Crim, J. A., et al., 1971.

[b]EPA figures include labor, materials, utilities, depreciation, interest and property taxes.

[c]Includes cost of dust disposal.

[d]Value of recovered fines subtracted from annual cost.

at a total cost of $106,000. This cost was $4000 less than the EPA estimate of $110,000 and much lower in $/acmm ($51.57) or $/acfm ($1.46) than the EPA estimate of $70.06/acmm ($2.21/acfm) (New York State, 1976; 1977).

Engineering experience indicates that the actual initial costs of a baghouse system can be up to three times higher than EPA's estimate of the actual initial costs of a venturi scrubber. Venturi scrubbers range from $40K and up for initial costs; whereas baghouses may run well over $100K (NAPA, 1978).

Engineering experience indicates that the cost of a baghouse system may represent one-fourth to one-third of the plant investment. This approximation is consistent with EPA predications that a model plant of 272 Mg (300 tons)/hr with a capital investment of $354,000 without control equipment would cost an additional $99,000 to $111,000 for a baghouse system, with the higher price being for a system that provided dust recovery.

The cost of controls to an asphalt plant must be expanded to include the cost for formal testing for particulates. Under the present regulations, this cost represents a one-time charge somewhat less than 1 percent of the total plant investment. Estimates vary as to test costs, but range from $2000 to $5000 with an overall average of about $2500 (NAPA, 1978). This figure is substantially lower than the upper level estimate of \$10,000 per test, indicated by EPA (1974). Replies from representative testing firms indicated a range of \$1500 to \$2500 for a one-time Method 5 particulate test which can be concluded in 1 day. This cost estimate does not include retesting or any indirect expenses incurred by the plant in preparing for and supporting the test (Valentine et al., 1978; Entropy Environmental, 1978; Snowden, 1978).

## 4.3 Comparison of Achievable Levels with NSPS

### 4.3.1 Best Available Control Technology

An important purpose and role of NSPS is the establishment of a level of efficiency achievable by BTS of continuous emission reduction (taking into consideration costs, and nonair quality health and environmental impact). It is generally anticipated that all plants subject to NSPS will need to be equipped with collector systems representing BTS. For removal of particulates from asphalt concrete plants, the NSPS have been set at a level reflecting efficiencies which BTS can achieve.

In the background document discussing the proposed standard, EPA (1973) stated (as part of the analysis of costs for new plants of typical size) "Either the fabric filter or the venturi scrubber will enable a new plant to comply with the proposed standards...." Particulate and opacity levels for asphalt concrete plants specified by current NSPS can indeed be met and even exceeded by BTS as represented in the use of these systems.

However, the mere fact that a control system is of the fabric filter or venturi scrubber type does not necessarily mean that it will represent BTS. Indeed, in reporting test results considered in formulating the NSPS for particulates, EPA reported (1974) that tests of two plants equipped with baghouses were not conisdered representative of good operation and maintenance.

Many authorities consider the fabric filter the ultimate in particulate control (Soderberg, 1974; Danielson, 1973). Baghouses are particularly effective in removing the finer particles through building up a dust cake which then "collects basically all dust particles irregardless of size" (Soderberg, 1974). The efficiency of venturi scrubbers against submicron particles is highly dependent upon the amount of energy supplied (as measured by pressure drop). Letters on file with EPA have indicated, however, the capability of manufacturers of both venturi scrubbers and baghouses to provide equipment meeting the NSPS particulate level (EPA, 1974).

The capability of fabric filters and high-energy venturi scrubbers to achieve the efficiency required by NSPS for particulates in asphalt concrete plants is illustrated in Figure 4-11. The theoretical calculations, based on typical ratings for the control systems, are supported by successful implementation of even more rigid standards in a few states and by reports of the test studies conducted. Efficiencies of control systems for particulates of various sizes (fractional efficiencies) are given in Table 4-3.

### 4.3.2 Effect of Different Control Levels

To the extent that BTS can regularly provide efficiencies exceeding those required by current NSPS, a change in levels presents no problems. However, the cost of installing and operating a control system is by no means a simple function of the efficiency required of the device and, hence, of emission levels achievable. For a given type of aggregate in a specific plant, a decrease in the grain loading permitted (i.e., a tightening of the standards) may be translated into higher costs for the industry if scrubbers are used.

The need for a control system that is more costly to install and/or to operate than one that would otherwise be required (as shown in the EPA comparisons of a baghouse and venturi scrubber with a less expensive and less efficient multiple centrifuge). This is of primary concern when comparing cost of control under NSPS vs no NSPS. However, it may also play a role in changing the NSPS.

Efficiency achieved by a venturi scrubber is a function of pressure drop through the device. The attempt to raise efficiency by increasing water flow rate, or the ratio of water in liters (gallons) to gas flow in cubic meters (cubic feet/minute), would result in a nominal increase in water consumption. The extent of the increase would be limited by the cutoff in efficiency gain above a rate of 1341/$m^3$/min (10 gal/10 $ft^3$/min) (Figure 4-10).

An increase in the amount of particulate removal in a venturi scrubber is roughly linear with an increase in pressure drop (as the gas to be cleansed is forced through the orifice at a faster rate, for example, by narrowing the throat); whereas the power requirements increase as the square of the pressure drop in centimeters (inches). Thus, an increase in the pressure drop of from 41 to 51 cm (16 to 20 in.) would raise power requirements to 1.56 times the original.

## 4.4 Energy Needs and Environmental Effects

### 4.4.1 Energy Requirements

The energy requirements for a baghouse (fabric filter) system represent no appreciable increase over those needed for a centrifuge or cyclonic system. Under this option, essentially no additional energy is expended to meet NSPS. However, the energy requirements for a venturi scrubber, based on estimates by EPA (1974), are about 67 percent higher than for a multicentrifugal scrubber in smaller plants and about 60 percent higher in larger asphalt concrete plants.

As shown in Table 4-5 about 24 percent of 150 new and modified plants a year would be using venturi scrubbers. These plants are assumed to be distributed by size so that 76 percent would have a capacity no greater than 218 Mg (240 tons/hr) and 24 percent would be larger (based on a survey of plants by NAPA, 1977).

The additional kilowatt-hours per year for these estimated 36 plants have been calculated to be approximately $2 \times 10^6$ (Table 4-5), based on NAPA estimates (Khan and Hughes, 1977; NAPA 1978) of an average of 666 hours/year of actual operation per plant or and additional requirement of 1.98 x $10^6$ J/Mg (0.67 hp-hr/ton) for a 136 Mg (150 ton)/hr plant and of 1.48 x $10^6$ J/Mg (0.5 hp-hr/ton) for a 272 Mg (300 ton)/hr plant.

The energy input to generate the electricity required can be estimated by using the factor of $10^7$ J ($10^4$ Btu) as an approximate guide for 1 kWh of electricity generation at central power plants (based on 33 percent conversion efficiency). However, higher factors are applicable for small generators typical of those used by mobile asphalt plants. These may be greater than 1.58 x $10^7$ J (1.5 x $10^4$ Btu) per kWh. Using this later figure would yield a requirement for 3.19 x $10^{13}$ J (3.02 x $10^{10}$ Btu) per year for the additional energy used by the 36 venturi scrubbers.

The additional requirement corresponds to approximately 680 Mg (5000 barrels) per year of oil, based on an estimate of 4.47 x $10^{10}$ J/Mg (5.8 x $10^6$ Btu/barrel) for distillate oil and 4.84 x $10^{10}$ J/Mg (6.3 x $10^6$ Btu/barrel) for residual oil. This is a very small amount of oil when compared with the average rate of oil consumption in the U.S. For the year 1976 an average 2.2 x $10^6$ Mg (1.7 x $10^7$ barrels) of oil per day were consumed in the U.S. (International Petroleum Encyclopedia, 1977).

TABLE 4-5

ADDITIONAL ENERGY REQUIREMENTS FOR PLANTS USING VENTURI SCRUBBERS

| Parameter | Plant Capacity <br> <218 Mg/Hour (<240 Tons/Hour) | <br> >218 Mg/Hour (>240 Tons/Hour) |
|---|---|---|
| Percent Plants[a] | 76 | 24 |
| Number of Plants | 114 | 36 |
| Number Using Scrubbers | 27 | 9 |
| Percent Using Scrubbers[b] | 24 | 24 |
| Average Number of Hours Operating per Year[c] | 666 | 666 |
| Horsepower Requirements[d] (Additional) | 100 | 150 |
| HP Hr/Yr for Plant | 66,600 | 99,900 |
| Total Additional Energy Requirements ($10^6$ kWh/yr) | 1.34 | 0.67 |

[a]NAPA, 1977.

[b]Khan and Hughes, 1977. Adapted from total percent of plants now using EPA-recommended control devices. Consistent with percent of venturi scrubbers observed in test results (Section 5).

[c]Khan and Hughes, 1977.

[d]EPA, 1974.

The figures for energy (fuel) usage to operate venturi scrubbers may be compared with overall fuel usage at asphalt plants as given by NAPA (1977a). Under stoichiometric conditions, which can in fact be approximately achieved, the energy required to heat and dry 1 Mg of typical aggregate is $2.81 \times 10^8$ J (241,600 Btu/ton). NAPA estimates the efficiency of the process to be 84.9 percent. Therefore the energy input required would be $3.31 \times 10^8$ J/Mg (284,600 Btu/ton) of aggregate. If a typical hot mix of 95 percent aggregate and 5 percent asphalt is prepared, the energy input would be $3.14 \times 10^8$ J/Mg (270,400 Btu/ton) of hot mix.

This energy usage can be compared with the energy required to provide the additional electricity used in the venturi scrubbers at stationary plants. Using the figures shown above for additional requirements for venturi scrubbers, combined with an electricity generation efficiency of 33 percent, yields the following energy input requirements at the power plant:

- For the 136 Mg (150 ton)/hour plant

  $5.93 \times 10^6$ J/Mg of hot mix
  ($5.10 \times 10^3$ Btu/ton of hot mix)

- For the 272 Mg (300 ton)/hour plant

  $4.43 \times 10^6$ J/Mg of hot mix
  ($3.81 \times 10^3$ Btu/ton of hot mix)

This is an increase of 1.9 percent in the energy required by the smaller plant and 1.4 percent in the energy required by the larger plant.

A similar analysis can be made for the case where it is assumed that all the plants are mobile and/or use portable generators fueled with distillate oil. In this case an electricity generation efficiency of 22 percent would yield the following energy input requirements.

- For the 136 Mg (150 ton)/hour plant

  $8.16 \times 10^6$ J/Mg of hot mix
  ($7.73 \times 10^3$ Btu/ton of hot mix)

- For the 272 Mg (300 ton)/hour plant

  $6.09 \times 10^6$ J/Mg of hot mix
  ($5.77 \times 10^3$ Btu/ton of hot mix)

This amounts to an increase of 2.9 percent in the energy required by the smaller plant and 2.1 percent in the energy required by the larger plant.

The increased cost per unit mass of product from stationary plants can be estimated by assuming that the power plant burns a typical fuel such as No. 6 residual oil with less than 1 percent content. The October 1978 market price for such oil in Chicago (typical) was $14.00 per barrel (Oil and Gas Journal, 1978). The cost of using such fuel to provide the additional energy required to operate the venturi scrubber becomes 1.25 cents/Mg of hot mix (1.13 cents/ton) for the 136 Mg (150 ton)/hr plant and 0.94 cents/Mg (0.85 cents/ton) for the 272 Mg (300 ton) per hour plant.

In a similar way the increased costs for mobile plants can be estimated by assuming that distillate oil is burned. The October 1978 market price for such oil in Chicago was $15.54/barrel (Oil and Gas Journal, 1978). The cost of using the fuel to provide the additional energy required to operate the venturi scrubbler becomes 2.28 cents/Mg of hot mix (2.07 cents/ton) for the smaller plants and 1.71 cents/Mg (1.55 cents/ton) for the larger plants.

In the final analysis, these increases in fuel consumption and costs cannot be considered an inevitable result of the particulate emissions standards set for asphalt concrete plants, since they would have been avoided by use of fabric filter control systems. The higher energy requirements result from choice of venturi scrubbers from the two representative control technologies. As operating data for plants subject to NSPS are not available, it is not known to what extent energy penalties (as well as loss of fines) associated with choice of venturi scrubbers actually offset higher capitalization costs for baghouses. However, as already noted, EPA (1973) has estimated baghouses as the more cost effective of the two options.

### 4.4.2 Environmental Effects

In addition to the increased consumption of fuel which occurs with scrubbers, possible significant environmental effects from NSPS for asphalt concrete plants represent principally the following:

- Reduction in particulate emissions to the atmosphere from asphalt plants.

- Increased solid waste disposal requirements from solid pollutants.
- Increased emission of atmospheric pollutants from additional horsepower generation resulting from choice of venturi scrubbers by plant owners.

4.4.2.1 Reduction in Particulate Emissions. Without the NSPS, particulate emissions from the 150 new and modified asphalt plants per year can be estimated to have been on the average 0.86 kg/Mg (1.7 lb/ton) of product, using the EPA emission factor for high-efficiency cyclones. With the NSPS, the emissions are conservatively estimated to have been on the average 0.015 kg/Mg (0.03 lb/ton) taking the average of emission rates for venturi scrubbers and baghouses (EPA, 1978c).

The total reduction in particulate emissions from new plants each year from 1974 through 1977 is estimated to be between 6985 and 8527 Mg (7700 and 9400 tons) (as calculated in Table 4-6). This represents about 12 percent of the annual emissions from all asphalt plants for the year 1975 as estimated by Khan and Hughes (1977). By the year 1977, a total of about 600 plants would have been operating for 4 years, their cumulative emission reduction amounts to over 76,200 Mg (84,000 tons) of particulates, or an amount greater than the 1975 annual total from all plants.

4.4.2.2 Increased Solid Waste Disposal. Reduction in atmospheric pollutants represents a partial trade-off with increased solid

TABLE 4-6

ESTIMATED REDUCTION IN PARTICULATE EMISSIONS FROM NSPS
(NEW AND MODIFIED ASPHALT PLANTS)

| Year | Asphalt Production $10^6$Mg ($10^6$ tons) | | Estimated Annual Emission of Particulates Thousand Mg (thousand tons) | | Estimated Reduction Thousand Mg (thousand tons) | |
|---|---|---|---|---|---|---|
| | Total | New Plants | 0.85 kg/Mg of Product (1.7 lb/ton of Product)[a] | 0.05 kg/Mg of Product (0.1 lb/ton of Product)[a] | Annual | Cumulative |
| 1974 | 319(352[b]) | 10.64(11.73) | 9.04 (9.97) | 0.16 (0.18) | 8.88(9.79) | 8.88(9.79) |
| 1975 | 267(294[b]) | 8.89(9.80) | 8.01 (8.33) | 0.13 (0.15) | 7.88(8.18) | 16.76(17.98) |
| 1976 | 264(291[b]) | 8.79(9.69) | 7.48 (8.24) | 0.13 (0.15) | 7.35(8.09) | 24.11(26.08) |
| 1977 | 263(290[c]) | 8.77(9.67) | 7.46 (8.22) | 0.13 (0.15) | 7.33(8.07) | 31.44(34.16) |
| TOTAL | | | 31.99 (34.76) | 0.55 (0.63) | 31.44(34.16) | 81.19(88.01) |

[a] EPA, 1978c.
[b] NAPA, 1977.
[c] Estimated.

waste. Particulates removed by wet scrubbing and approximately one-half of those recovered by fabric filters (the remainder being assumed to be recycled) must be so disposed. On this basis, 24 percent of about 7711 Mg (8500 tons) or about 1814 Mg (2000 tons) (on a dry-weight basis) must be disposed in settling ponds; and one-half of the remainder, or about 2903 Mg (3200 tons), must be disposed from fabric filters, making a total of about 4717 additional Mg (5200 tons) each year from plants that become subject to NSPS.

4.4.2.3 Emissions Due to Increased Fuel Usage. Based on promulgated NSPS for residual-oil-burning and natural-gas-burning plants, pollutants per year estimated to result additionally over the preceding year from increased energy requirements by venturi scrubbers are shown in Table 4-7. These additional emissions reflect the choice of a particular control system which is allowable but not necessary as a means of complying with NSPS.

TABLE 4-7

ESTIMATED ADDITIONAL EMISSION OF POLLUTANTS
FROM INCREASED ENERGY (HORSEPOWER) REQUIREMENTS
FOR VENTURI SCRUBBERS

| Specific Pollutant | Emission Factor[a] $gm/10^6J$(gm/hp-hr) | Annual (gm/yr)[b] ($10^6$) | Emissions (tons/yr)[c] |
|---|---|---|---|
| Carbon Monoxide | 73.6(199) | 537 | 593 |
| Exhaust Hydrocarbons | 2.47(6.68) | 18 | 20 |
| $NO_x$ | 1.91(5.16) | 14 | 15 |
| Aldehydes | 0.08(0.22) | 0.59 | 0.66 |
| $SO_x$ | 0.099(0.268) | 0.72 | 0.80 |
| Particulates | 0.121(0.327) | 0.88 | 0.98 |

[a]EPA, 1973, Part A, Section 3.3.3.

[b]Based on an additional 2.01 x $10^6$ kWh (2.7 x $10^6$ hp-hr) per year as calculated in Table 4-5.

[c]453.59 gm/lb.

## 5.0 INDICATIONS FROM TEST RESULTS

### 5.1 Test Coverage in Regions

A survey conducted by MITRE/Metrek obtained information on a total of 72 tests from CDS (Table 5-1). These tests cover the period since the promulgation of the standards in 1974. The sample represents approximately 14.9 percent of all asphalt concrete plants subject to NSPS as estimated by the JACA Corporation (1977). Of the 10 EPA regions, Region V was the only one that did not submit test data.

Tests for particulates and opacity are listed under the pollutant column in Table 5-1. At least one kind of pollutant compliance was determined in each test. A total of 36.5 percent tested for both particulates and opacity compliance, and 3.8 percent did not test for particulates. Of the 72 plants tested, 22.2 percent were not in compliance. Plant status is an identification of new sources as opposed to modified sources. Only four plants (5.5 percent) were successfully identified; and all were new sources.

The pollution control technology of most of the plants tested consisted of scrubbers (25 percent), baghouses (25 percent), or a combination of baghouses and cyclones (16.6 percent). Another 4 percent used cyclones, and 11.1 percent reported the use of other methods (or none) for particulates and opacity control. Approximately 19 percent did not report the technology used.

TABLE 5-1

MITRE/METREK SURVEY OF NSPS TEST DATA

| Region | Test No. | Compliance With NSPS[a] | Process Equipment | Pollutant Part (mg/dscm) | Pollutant Opac. (%) | Plant Status[b] | Control Technology |
|---|---|---|---|---|---|---|---|
| I: | 1 | x | Unknown | 3.4 | - | Unknown | Cyclone and aeropulse fabric filter |
| II: | 1 | x | Drum Dryer | 34.2 | 0 | Unknown | Barber-Greene Model CF Baghouse |
| | 2 | x | Drum Mix | 66.6 | - | Unknown | Venturi Scrubber |
| | 3 | x | Dryer | 6.4 | - | Unknown | McCarter size 1410 single cyclone; McCarter 540-D fabric filter with double bags of 540 Nomex 16 oz. baghouse |
| | 4 | x | Unknown | 77.6 | - | Unknown | Unknown |
| | 5 | x | Unknown | 76.7 | - | Unknown | Baghouse system |
| | 6 | - | Dryer | 198.0 | - | Unknown | Research Cottrell Flex Kleen Model 512 pulse jet type baghouse |
| | 7 | x | Unknown | 6.8 | - | Unknown | Dustex NOIS (Louver Collector) Dustex No. 2120 34 (Fabric Collector) Baghouse |
| | 8 | x | Stansteel Model (RM 120 A) | 48.4 | - | Unknown | Cyclone-Stansteel Model 9836 Baghouse-Stansteel Model S 0205 |
| | 9 | x | Unknown | 61.6 | - | Unknown | Stansteel reverse air baghouse--672 bags |
| | 10 | x | Unknown | 7.8 | - | Unknown | Aeropulse, Inc. 612-10; Modern Model 100 Fan and Chicago Blower 15LS-SQI Baghouse |
| | 11 | x | Rotary Dryer | 13.5 | - | Unknown | Cyclone collector and aeropulse bag collector model #756-10T |
| | 12 | x | Unknown | 22.8 | 0 | Unknown | Baghouse |
| III: | 1 | x | Dryer Mix | 73.0 | 0 | Unknown | Unknown |
| | 2 | x | Unknown | 80.1 | - | Unknown | Unknown |
| | 3 | x | Rotary Dryer | - | 0 to 20 | Unknown | Cyclone separator, baghouse with Nomex bags |
| | 4 | x | Unknown | 33.5 | - | Unknown | Barber-Greene Cyclone; Barber-Greene Baghouse |
| IV: | 1 | x | Unknown | 20.5 | - | Unknown | Unknown |
| | 2 | x | Unknown | 73.0 | <20 | Unknown | Venturi Scrubber |
| | 3 | x | Unknown | 63.9 | < 5 | Unknown | Baghouse |
| | 4 | x | Unknown | 63.9 | <10 | Unknown | Baghouse |
| | 5 | - | Unknown | 155.1 | 5 to 10 | Unknown | Baghouse |
| | 6 | x | Unknown | 68.4 | 10 | Unknown | Baghouse |
| | 7 | - | Unknown | 205.3 | - | Unknown | Washer and wet fan |
| | 8 | - | Unknown | 111.8 | - | Unknown | Scrubber - wet fan/air wash |
| | 9 | x | Unknown | 21.7 | - | Unknown | Dry Cyclone Collector and Baghouse |
| | 10 | - | Unknown | 180.2 | - | Unknown | Wet washer (Scrubber ?) |
| | 11 | x | Unknown | 9.8 | - | Unknown | Baghouse (Nomex) |
| | 12 | x | Unknown | 55.4 | - | Unknown | Primary Cyclone and Astec Baghouse |
| | 13 | x | Drum Mix | 64.3 | - | Unknown | Dual Venturi Scrubber |
| | 14 | x | Unknown | 89.0 | 0 | Unknown | Baghouse |
| | 15 | x | Unknown | 52.5 | 0 to 15 | Unknown | Venturi Scrubber |
| | 16 | x | Unknown | 13.7 | - | New Source | Baghouse |
| | 17 | - | Unknown | 84.4 | 10 to 40 | Unknown | Unknown |
| | 18 | x | Drum Mix | 66.9 | - | Unknown | Wet Scrubber |
| | 19 | x | Unknown | 79.9 | - | Unknown | Baghouse |
| | 20 | x | Unknown | 57.0 | - | Unknown | Baghouse |
| | 21 | - | Unknown | 105.0 | - | Unknown | Baghouse |
| | 22 | - | Unknown | 95.8 | - | Unknown | Venturi Scrubber |

TABLE 5-1 (Concluded)

| Region | Test No. | Compliance With NSPS[a] | Process Equipment | Pollutant Part. (mg/dscm) | Pollutant Opac. (%) | Plant Status[b] | Control Technology |
|---|---|---|---|---|---|---|---|
| V: | No tests submitted | | | | | | |
| VI: | 1 | x | Subpart I | 73.0 | - | Unknown | Venturi Scrubber |
| | 2 | x | Dryer | 68.0 | - | Unknown | Scrubber |
| | 3 | x | Dryer, Screening Tower, Roll crusher Mineral filler silo | 55.2 | - | Not Indicated | Baghouse |
| | 4 | - | Dryer | 155.1 | - | Unknown | Unknown |
| | 5 | - | Unknown | 2,236.0 | - | Unknown | Unknown |
| | 6 | x | Dryer | 37.6 | - | Unknown | Wet Scrubber |
| | 7 | x | Unknown | 45.9 | - | Unknown | Unknown |
| | 8 | - | Unknown | - | 64 | Unknown | Unknown |
| VII: | 1 | - | Unknown | 93.5 | 0.57 | Unkown | Unknown |
| | 2 | - | Barber-Greene (DM-60) | 1,357.6 | 25 to 30 | Unknown | Venturi Scrubber |
| | 3 | x | Unknown | 26.9 | 1.6 | Unknown | Cyclone |
| | 4 | x | Dryer Mixer | 18.0 | - | Unknown | Cyclone, baghouse, hood |
| | 5 | x | Rotary Dryer | 52.5 | 5 to 25 | Unknown | Cyclone, Flex-Clean Corp. Baghouse & Hood |
| | 6 | x | Drum Dryer | 23.3 | 1.6 | Unknown | Single Cyclone dry dust collector and impinger wet dust collector |
| | 7 | x | Unknown | 71.6 | - | Unknown | Boeing Venturi Scrubber |
| | 8 | x | Kiln Stack | 93.1 | 6.8 | New Source | Demister or Venturi Scrubber |
| VIII: | 1 | - | Rotary Dryer | 16,778.9 | - | Unknown | None |
| | 2 | x | Drum Dryer, Rotary Mixer | 70.7 | - | Unknown | Unknown |
| | 3 | - | Dryer | 6,778.6 | - | Unknown | None |
| | 4 | x | Unknown | 51.6 | - | Unknown | Unknown |
| | 5 | x | Unknown | 93.1 | - | Unknown | Baffle/Spray nozzle |
| | 6 | x | Unknown | 68.4 | - | Unknown | Cyclone, Scrubber tower |
| IX: | 1 | x | Unknown | 68.4 | <5 | Unknown | Baghouse-Cedaropids |
| | 2 | x | Unknown | 22.8 | - | Unknown | Cyclones and Baghouse |
| X: | 1 | x | Drum Mixer | 70.7 | <5 | Unknown | Stansteel Wet Scrubber Venturi |
| | 2 | x | Veneer Dryer | 18.3 | <1 | Unknown | Venturi Scrubber |
| | 3 | - | Dryer | 319.4 | <20 | Unknown | Unknown |
| | 4 | x | Unknown | 57.0 | - | Not Indicated | Unknown |
| | 5 | x | Mobile Drum Mix Dryer | 73.0 | 0 to 5 | New Source | Orifice Scrubber |
| | 6 | x | Continuous Mixer | 61.6 | 7 | New Source | Stansteel Model D Scrubber |
| | 7 | x | Drum Mixer | 80.0 | 17.5 | Unknown | Venturi Scrubber |
| | 8 | x | Drum Mixer | 70.7 | 10 | Unknown | Venturi Wet Scrubber |
| | 9 | x | Thermodrum | 41.1 | <5 | Unknown | Barber-Greene Venturi Wet Scrubber |

[a] 90 mg/dscm (0.04 gr/dscf) and 20% opacity.
[b] Indicates if plant is a new source or a modified source.

## 5.2 Analysis of Test Results

### 5.2.1 Particulates

A test for particulates typically requires measurement of the grain-loading observed in three individual sample runs. In the discussion which follows, a test result represents the reported average from the runs. The test data made available to MITRE/Metrek by the EPA regions consists of results from 72 such tests. Generally, there was one test per plant, however, two plants required retesting to achieve compliance. Hence, the 72 tests represent a total of 70 different plants (Table 5-2).

The results show 53 of the tests yielded an average grain loading of less than or equal to 90 mg/dscm (0.04 dscf), whereas 19 tests (including first runs from the plants that required retesting) failed to meet NSPS. Accordingly, 73.61 percent of the tests showed control systems efficient enough to meet current standards.

Results showed a narrow range. Most tests showed less than 228 mg/dscm (0.1 gr/dscf). Only five tests or 6.94 percent yielded a grain loading greater than 228 mg/dscm (0.1 gr/dscf). The five plants included two with no controls for which the grain loadings were very high. Control systems used with the other three plants were not indicated on the records provided.

TABLE 5-2

DISTRIBUTION OF PARTICULATE TEST RESULTS (AVERAGES) BY CONTROL SYSTEM

| Interval Range mg(gr) | Control System Type: Cyclone Scrubber | Baffle/ Spray Nozzle | Fabric Filter (Baghouse) | Fabric Filter and Cyclone | Venturi Wet Scrubber | Wet Scrubber | Wet Scrubber and Cyclone | Orifice Scrubber | None | Unknown |
|---|---|---|---|---|---|---|---|---|---|---|
| <22.5 (<.01) | 1 | | 4 | 6 | 1 | 0 | 0 | 0 | 0 | 1 |
| <45 (<.02) | 1 | | 2 | 1 | 1 | 1 | 1 | 0 | 0 | 0 |
| <67.5 (<.03) | | | 7 | 3[a] | 3 | 3 | 0 | 0 | 0 | 3 |
| <90 (<.04) | | | 3[a,b] | 0 | 6 | 0 | 0 | 1 | 0 | 4 |
| TOTAL ≤90 (<.04) | 2 | 0 | 16 | 10 | 11 | 4 | 1 | 1 | 0 | 8 |
| <113 (<.05) | | 1 | 2[a] | 1[a] | 1 | 1 | 0 | 0 | 0 | 1 |
| <183 (<.08) | | | 1 | 0 | 2 | 1 | 0 | 0 | 0 | 1 |
| <228 (<.10) | | | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| <2282 (<1.00) | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| >2282 (>1.00) | | | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 1 |
| TOTAL > .04 | 0 | 1 | 4 | 1 | 3 | 3 | 0 | 0 | 2 | 5 |
| TOTAL ≤90 mg/dscm | 2 | 1 | 20 | 11 | 14 | 7 | 1 | 1 | 2 | 13 |
| Percent (≤.04 gr/dscf) | 100.0 | 0.0 | 80.0 | 90.9 | 78.6 | 57.1 | 100.0 | 100.0 | 0.0 | 61.5 |

[a] 2 tests required for one plant
[b] Particulate loading = 0.039 gr/dscf for one plant.

SOURCE: Data made available through CDS file.

The data sample is large enough to support valid statistical inferences regarding the effectiveness of control systems installed in asphalt concrete plants subject to NSPS. The basic problem is that the data are not sufficiently detailed to allow a determination of whether the control systems, as installed, represented the BTS. As discussed in Section 4.3.1, a collector system does not necessarily represent BTS just because it is of the fabric filter or venturi scrubber type. Details are not available in the test data as to the condition of collector systems, the adequacy of installation, or the design and operating parameters (e.g., air-to-cloth ratio for fabric filters, pressure drop for venturi scrubbers). Thus, it is not clear how many of the venturi scrubbers tested could be termed "high-energy" with pressure drops in the range above 76 cm (30 in.) WG designed to be effective particularly against submicron particles as noted in Section 4.3.1. It is known that verturi scrubbers with pressure drop in the range of 51 cm (20 in.) WG and less are not uncommon in asphalt concrete plants.

While not specifically applicable to BTS, the test results do clearly reveal the success achievable with fabric filter devices and venturi scrubbers. Table 5-2 presents a breakdown of test results by type of control system employed. Controls used in 13 plants were not identified.

For baghouse systems (with or without a cyclone as a primary collector), 26 tests (83.9 percent) out of 31 met current standards.

Venturi scrubbers also achieved good results. Of the 14 tests for plants explicitly identified as using such devices, 11 (or 79 percent) met current NSPS.

Results recording the use of only scrubbers and/or wet washers are questionable. It is not certain whether any of the systems identified were venturi scrubbers. Of 10 tests reported as using scrubbers or washer and wet fan, seven met current NSPS, all at loadings less than or equal to 68 mg/dscm (0.03 gr/dscf).

A total of 45 plants were reported to be using either fabric filter (with or without a cyclone as primary collector) or a venturi scrubber. Of these 37 (82.2 percent) met current NSPS. This sample may be deemed large enough to use the normal approximation to the binomial distribution. On this basis the expected percent of such devices as installed and operated which will meet current NSPS lies between 64 and 92 at the 99 percent confidence level and between 69 and 91 at the 95 percent confidence level.

Of the 53 tests meeting NSPS, 14 gave results (averaged over the multiple runs) of between 68 and 90 mg/dscm (0.03 and 0.04 gr/dscf) (the total of 14 includes one unsuccessful test of a plant using fabric filters). All of the plants with known control methodologies for which results fall in this range were identified as using either baghouses or venturi scrubbers. The test samples show that of the control devices necessary to achieve stricter standards, over 25 percent of the devices that met present NSPS could not have met the stricter threshold of 68 mg (0.03 gr) prevailing in some states. These results do not imply that the systems represented BTS or that they could not have been designed to meet a more restrictive standard.

Results of these tests may be compared with other recent surveys reported. Based on available information there is no way to verify the extent of possible overlap among tests included in any of the samples.

Patankar and Foster (1978) report data on a sample of 63 dryer-drum mix plants. None of the plants used baghouses. Only 50 percent of the 18 systems using venturi scrubbers reduced particulate emissions to the level of 90 mg/dscm (0.04 gr/dscf) required by current NSPS. Only five plants (28 percent) showed emission levels less than or equal to 68 mg/dscm (0.03 gr/dscf). Of 24 low-energy wet scrubbers, seven (29 percent) met current NSPS and only two (8 percent) were tested at levels less than or equal to 68 mg/dscm (0.03 gr/dscf). No other type of device in the sample tests reduced particulate emissions to the level of current NSPS (although one cyclone or multicyclone showed marginal results at about 90 mg/dscm or 0.04 gr/dscf.

Khan and Hughes (1977) report a survey of 16 dryer-drum mix plants. The particulate emissions (Table 5-3) are reported on the basis of grams per second. Without information on the flow rate of exit gas in standard volume per minute, there is no way to

TABLE 5-3

EMISSION RATES FOR DRYER-DRUM MIX PLANTS

| Plant # | Average Production Rate (Mg/hr) | Uncontrolled Emissions Rate (gm/sec) | Uncontrolled Emissions Rate (gm/Mg) | Primary Collector Type | Primary Collector Emission Rate (gm/sec) | Primary Collector Emission Rate (gm/Mg) | Primary Collector Efficiency (%) | Secondary Collector Type | Secondary Collector Emission Rate (gm/sec) | Secondary Collector Emission Rate (gm/Mg) | Secondary Collector Efficiency (%) | Overall Efficiency (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 454 | 12.5 | 100 | cyclone | 0.47 | 3.75 | 96.2 | baghouse | $1 \times 10^{-4}$ | $8 \times 10^{-4}$ | 99.98 | >99.99 |
| 2 | 200 | 5.5 | 100 | none | — | — | — | cyclone scrubber | 0.04 | 0.65 | 99.3 | 99.3 |
| 3 | 159 | 4.4 | 100 | none | — | — | — | cyclone scrubber | 0.03 | 0.65 | 99.3 | 99.3 |
| 4 | 272 | 7.5 | 100 | cyclone | 0.28 | 3.75 | 96.2 | none | — | — | — | 96.2 |
| 5 | 272 | 7.5 | 100 | none | — | — | — | none | — | — | — | Not applicable |
| 6 | 454 | 12.5 | 100 | settling chamber | 4.16 | 33.0 | 66.67 | Venturi scrubber | 0.004 | $2.9 \times 10^{-3}$ | 99.9 | 99.97 |
| 7 | 251 | 6.7 | 100 | settling chamber | 2.29 | 32.5 | 66.67 | cyclone scrubber | 0.02 | 0.25 | 99.3 | 99.33 |
| 8 | 272 | 7.5 | 100 | none | — | — | — | Venturi scrubber | 0.01 | 0.05 | 99.9 | 99.9 |
| 9 | 181 | 5.0 | 100 | cyclone | 0.19 | 3.75 | 96.2 | none | — | — | — | 96.2 |
| 10 | 227 | 6.2 | 100 | none | — | — | — | baghouse | 0.001 | 0.02 | 99.98 | 99.98 |
| 11 | 363 | 10.0 | 100 | cyclone | 0.38 | 3.75 | 96.2 | none | — | — | — | 96.2 |
| 12 | 91 | 2.5 | 100 | none | — | — | — | baghouse | 0.0005 | 0.02 | 99.98 | 99.98 |
| 13 | 136 | 3.7 | 100 | multi-cyclone | 0.03 | 0.5 | 99.3 | Venturi scrubber | $3 \times 10^{-5}$ | 0.001 | 99.9 | 99.9 |
| 14 | 109 | 3.0 | 100 | cyclone | 0.11 | 3.75 | 96.2 | gravity spray tower | 0.001 | 0.003 | 99.1 | 99.1 |
| 15 | 259 | 10.0 | 100 | none | — | — | — | Venturi scrubber | 0.008 | 1.0 | 99.9 | 99.9 |
| 16 | 318 | 8.7 | 100 | none | — | — | — | Venturi scrubber | 0.08 | 0.85 | 99.9 | 99.9 |

SOURCE: Khan and Hughes, 1977.

convert these results to mass loading. However, the uncontrolled emission rates are given, enabling the percent of efficiency to be calculated and shown for each control system tested. It should be noted that a uniform value for uncontrolled emissions of 100 gm/Mg (0.2 lb/ton) is given for all plants in Table 5-3, which implies that this value did not result from observations made in tests, but rather assumptions. The average loadings as the ratio of reported mass of particulates to mass of product have also been calculated on the basis of reported yearly production rate and annual hours of operation.

The methodology of calculation used in deriving the data in Table 5-3 is not known. It may be noted that as reported the data yield essentially constant factors for loadings in grams/metric ton for efficiencies achieved by each type of control device. All of the control devices reported, with the exception of the settling chambers, would have met NSPS (less than or equal to 90 mg/dscm or 0.04 gr/dscf at any reasonable flow rate of stack gas that might be postulated. No secondary device would have been required for the cyclones (at a reported emission rate of 1.25 gm/Mg or 0.0025 lb/ton) or the multicyclones (at 0.5 gm/Mg or 0.001 lb/ton), given a rate of no higher than 41 scm (1312.5 scf) of gas per metric ton (ton) of product--a very low ratio indeed. This ratio corresponds to a flow rate for exit gas of less than 311.4 scm/min. (11,000 scfm) for a 454 Mg (500 ton)/hour plant (and correspondingly lower rates for smaller plants).

The emission figures in Table 5-3 may be compared with those expected from conventional plants in which the drying and mixing take place in separate components (i.e., batch and continuous mix plants). Using the EPA (1973a) estimate of 22.5 kg (45 lb) of particulates per metric ton (ton) of asphalt product on an uncontrolled basis, a plant with a control system providing 99.9 percent efficiency would have a controlled emission rate of 22.5 gm/Mg (0.045 lb/ton). A control system efficiency of 99.99 percent would lower the controlled emission rate to 2.25 gm/Mg (0.0045 lb/ton). By contrast, the emission rate in grams/metric tons (pounds/ton) for drum mix plants with baghouses and venturi scrubbers ranged from 1.0 gm/Mg (0.002 lb/ton) to as low as $8 \times 10^{-4}$ gm/Mg ($16 \times 10^{-7}$ lb/ton) (Table 5-3).

These differences are significant and somewhat at variance with both the results obtained in the actual tests as furnished by the EPA region shown in Table 5-1 and with the data reported by Patankar and Foster (1978). It is true that all of the 11 plants specifically identified as dryer drum mix passed the tests, in contrast with 19 failures in tests of plants not so identified. All except two of the plants specifically identified as drum mix used baghouse or venturi scrubber, with the exception of one control system not identified and one reported as an orifice scrubber. The large number of plants not identified in the test data (Table 5-1) as to process type precludes a detailed comparison of results for dryer drum mix vs. conventional plants.

Nothing in the EPA regional test data specifically supports or denies the assumption that these are substantially lower controlled emission rates for drum-mix than for conventional plants, as suggested by Table 5-3.

5.2.2 Opacity

Much less test data are available from the regional sources for opacity than for particulates. Of the 26 tests for which opacity is reported as a percent, only five (or less than 20 percent) failed to meet the NSPS of opacity less than or equal to 20 percent. None of these five met current NSPS for particulates.* Results are shown in Figure 5-1.

It is difficult to assess the correlation between opacity and particulate emissions from the test data available. Many of the results were reported only as not exceeding a specified high threshold (such as 20 percent), and it is not clear how far the readings were below the stated upper limit. Of the 21 plants reported as meeting the current NSPS for opacity, only two (less than 10 percent) also failed to meet particulate standards. Both of these were observed between 5 and 10 percent. The five plants for which readings

*One of the tests reported opacity results in a manner that prevented determination of the particulate grain loading associated with the opacity level (measured at over 60 percent).

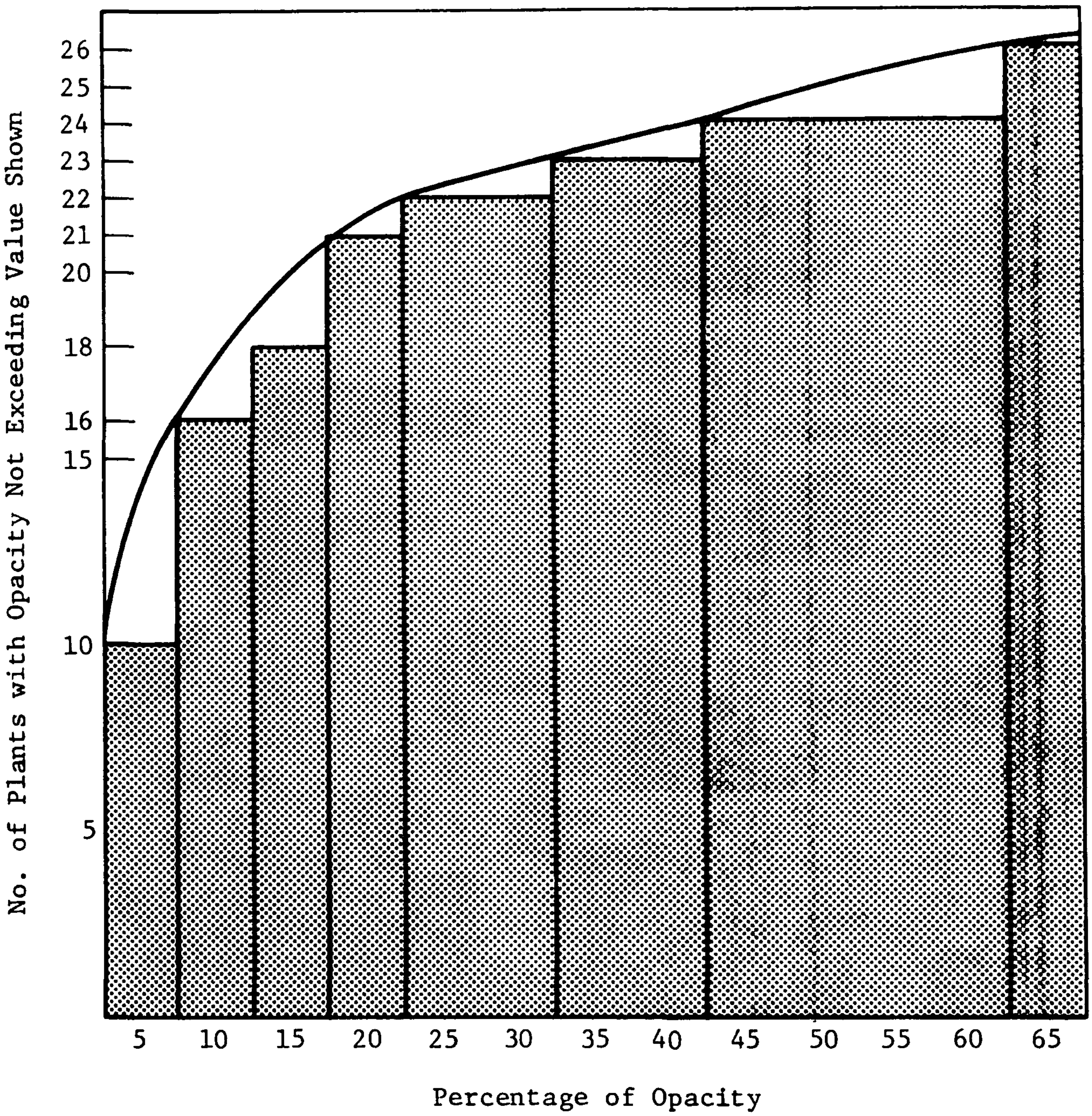



**FIGURE 5-1**
**RESULTS OF OPACITY TESTS**

were reported only as less than or equal to 15 or 20 percent (all of which met particulate standards) might have had much lower percentages of opacity determined by more detailed reporting of results.

The small data base available supports the policy underlying asphalt NSPS that an opacity reading of greater than 20 percent will be associated with control equipment not functioning at the level required to meet particulate standards.

## 6.0 ANALYSIS OF POSSIBLE REVISIONS TO NSPS

### 6.1 Source and Nature of Revisions

The revisions considered in this section are based on suggestions from EPA officials, particularly those at the 10 regions (MITRE Corp., 1978); from representatives of the asphalt concrete industry and private concerns involved with control equipment and plant testing; from analysis of published literature; and from analyses of available data.

These potential revisions fall under the following headings:

- New levels for pollutants now controlled by NSPS.
- Fugitive emissions.
- Changes in tests and procedures, including monitoring requirements.
- Control of other pollutants emitted by asphalt concrete plants.

The analysis of possible revisions considered potential changes from the following points of view:

- Near-future developments and trends in the industry.
- Impacts that changes might have on the environment and on industry.
- Administrative procedures involved in compliance.

### 6.2 Industry Development and Trends

Among the significant industrial developments that have affected or are likely to affect NSPS for asphalt concrete plants is the trend toward dryer-drum mix plants in the asphalt industry. Other important developments include the recycling of asphalt pavement and the use of hot-water emulsion mixes.

### 6.2.1 Control Devices

The use of fabric filters or baghouses and high-efficiency wet scrubbers has been particularly effective in achieving compliance with the standard. EPA (1973; 1974) and Kinsey (1976) predicted that either baghouses or venturi scrubbers would be required to reduce emissions to a level less than or equal to 90 mg/dscm (0.04 gr/dscf). As shown by the sample test results discussed in Section 5, some 80 percent of plants tested which used fabric filters or orifice or venturi scrubbers achieved compliance--a slightly higher ratio than for plants in general. Estimates of the percent of industry usage of baghouses and venturi scrubbers range from 56 to 70 (Khan and Hughes, 1977; NAPA, 1978). It is not known how many of these control collector systems actually represent BTS.

Baghouses account for approximately 40 percent of all control systems used in asphalt concrete plants, and the trend is toward an "all dry" control system using fabric filter devices as the single or secondary, and critical, collector (Khan and Hughes, 1977; NAPA, 1978). Use of the fabric filter collector has grown significantly within the last 4 years. At present, particularly good results are obtained by use of 397 gm (14-oz) Nomex filter bags employing a cloth-to-air ration of about 1:6.

Venturi wet scrubbers have also proved effective. A pressure drop of from 36 to 51 cm (14 to 20 inches) is typical (NAPA, 1978). Venturi scrubbers are employed by about 16 percent of the industry as secondary collectors and orifice scrubbers by about 8 percent (Khan and Hughes, 1977). In the past few years they have been particularly favored by dryer-drum mix plants; about 37 percent of a sample of 49 drum mix plants with various control devices used venturi scrubbers (Patankar and Foster, 1978).

### 6.2.2 Dryer-Drum Mix Plants

The dryer-drum mix plant represents what has been termed a "recently revitalized process for manufacturing asphalt hot mix" (Kahn and Hughes, 1977). Drying of the aggregate as well as mixing with asphalt and additional fines takes place within a rotary drum, so that the whole process is simplified. Equipment requirements are reduced and important gains in operational efficiency result, including reduced manpower requirements. The capital cost of a dryer-drum mix plant is estimated to be only 75 to 85 percent that of a conventional plant (Robert et al., 1975). It is not surprising that the drum mix plant is proving increasingly popular in the industry. At present about 2.6 percent of all U.S. plants are estimated to use this process. It is estimated, however, that 30 percent of those put in operation during the last 3 years are of the dryer-drum mix type. It has also been estimated that use of such plants will grow at an accelerated rate, and in the next few years up to 85 percent of all new plants will be dryer-drum mix (Khan and Hughes, 1977; Patankar and Foster, 1978; Moe, 1978).

Because the drying takes place within the same container as the mixing, emissions are partly screened by the curtain of asphalt added so that the particulate loading from the dryer is much lower than that from conventional plants. Further, the emissions from the hot elevators, screens, bins, weigh hopper and mixer, which in conventional plants are conveyed by the scavenger ductwork to the collector, are not present in the drum-mix plant. In the latter type of plant, these elements are replaced by proportioning feed controls that provide all components as input directly to the drum where both drying and mixing take place. The overall inlet loading to the collector of particulates is much lower than the rate from conventional plants, perhaps by one or more orders of magnitude (see Table 6-1).

A possible drawback to the dryer-drum mix plant from an environmental point of view is that the rate of HC emissions may be substantially higher than from conventional plants (Robert et al., 1975). However, one test recently reported in a plant equipped with

TABLE 6-1

ASPHALT CONCRETE
UNCONTROLLED EMISSION FACTORS,
(kilograms of particulates/metric ton asphalt product)

| Source | Value kg/Mg | Value (lb/ton) | Stated | Calculated from Known Loading: Known Parameters | Calculated from Known Loading: Parameters |
|---|---|---|---|---|---|
| EPA-AP 42 | | | | | |
| Conventional | 22.5 | (45) | x | | |
| Dryer-Drum | 4.9 | (9.8) | x | | |
| Air Pollution Engineering Manual | | | | | |
| Test C426 | 23.9 | (47.8) | | x | |
| Test C537 | 15.8 | (31.6) | | x | |
| Kinsey (Plant A) (Dryer-Drum) | 22.8 | (45.6) | | x | |
| Kinsey (Plant B) (Dryer-Drum) | 2.2 | (4.4) | | x | |
| Khan & Hughes (Average) | 2.79 | (5.57) | | x | |
| Standard-Havens (Dryer-Drum) | 6-8 | (12-16) | | | x |
| Khan and Hughes (Dryer-Drum) | 0.1 | (0.20) | x | | |

baghouses showed only traces of HC in dust and condensate (Forsten, 1978). The HC emission rate from dryer-drum plants has not been determined experimentally.

Because the dust particles from the dryer-mixer drum are coated with sticky asphalt, it was formerly considered that the use of fabric filter controls would not be feasible with the drum mix plant (Robert et al., 1975; Kinsey, 1976). However, it has now been found that baghouses can be used with this process. Some 8 percent of dryer-drum mix plants are estimated to use fabric filter collectors (Khan and Foster, 1977). No concern over the feasibility of baghouses for these plants was expressed by the National Asphalt Pavement Association in recent discussions of the asphalt industry (NAPA, 1978).

A new development in dryer-drum mix plants has been reported by one plant manufacturer. The process uses natural draft flow of air with no exhaust fan. Less equipment is required than with conventional drum mix plants. According to the manufacturer, the process also consumes less horsepower and less fuel and no control equipment external to the drum is needed. Although some plants have been installed and a few first test results reported, the significance of this process as a new development in dryer-drum mix technology has not yet been established. An apparent problem is the difference in output particulate loadings expressed as grams/metric ton (pounds/

ton) of product and as milligrams/dry standard cubic meter (grains/dry standard cubic foot). Figures supplied by the manufacturer show that in both cases, output loadings increase with production rate. Because the volumetric flow (as well as the velocity) of exit gas from the drum is much less than from conventional plants, an output of particulates which is relatively low when measured in grams (pounds) per hour or per metric ton (ton) of product may exceed the allowable level when measured as milligrams/dry standard cubic meter (grains/dry standard cubic foot) as required by current NSPS. Manufacturer-supplied data reflecting test results indicate that at a production rate of 82 Mg (90 tons)/hr or less, the emission rate is within current NSPS; whereas, the output of particulate emissions tends to exceed 90 mg/dscm (0.04 gr/dscf) at production rates from 109 to 272 mg (120 to 300 tons)/hr. The resulting rates for all of these production levels when shown in mass of particulates per hour were less, according to the data, than results reported from EPA tests of plants using scrubber or baghouse control systems (Nelson, 1978).

6.2.3 Asphalt Recycling Plants

A process for recycling asphalt paving by crushing up old road beds for direct firing has been recently implemented on an experimental basis. It is estimated that 40 plants using this process have made production runs to up to 12 weeks. These plants operate particularly in the Midwest relaying asphalt to cover potholes.

Although EPA has ruled the plants subject to NSPS and at least two have demonstrated compliance, preliminary indications are that the process may not meet the allowable level of particulate emissions. Partial combustion of the recycled asphalt cement produces a blue smoke reportedly more difficult to control than the mineral dusts of plants using virgin material. Tests have been reported of plants with opacity less than 20 percent, but particulate emissions exceed 90 mg/dscm (0.04 gr/dscf). The plants use approximately 20 to 30 percent virgin material mixed with the recycled asphalt. While considered effective in conservation of energy and reclamation of solid waste, this process involves some pollution penalties (EPA, 1978b; Patankar, 1978).

6.2.4 Hot Water Emulsions

Recently EPA has encouraged the use of hot-water emulsion mixes rather than cutback asphalts. The emission levels that occur during production of hot water emulsions are undetermined. Some potential pollution problems exist in the reported practice of bypassing control equipment partly for safety purposes when a sudden surge of steam carrying particulate emissions occurs as the water is dumped into the pugmill. These emissions are vented directly to the atmosphere. Changes in operating procedures and modifications of control equipment (e.g., to avoid damage of the fabric filters from the surge of steam) may be indicated (EPA, 1978b).

## 6.3 Levels for Particulate Emissions

### 6.3.1 Variables Affecting Compliance

Current NSPS are now being met to a considerable degree and, in some situations, compliance is achieved with the more rigid standard of 68 mg/dscm (0.03 gr/dscf) prevailing in a few states. A natural question is, therefore, whether BTS supports a stricter level for particulate emissions. In analyzing such a possible revision, it is useful to consider some aspects of asphalt concrete plant operations that affect the emission rate achieved.

Current NSPS for particulate emissions from asphalt concrete plants are prescribed in terms of milligrams/dry standard cubic meter (grains/dry standard cubic foot) of exit gas from the stack. Consequently, the efficiency demanded of a control system in order to meet current NSPS depends upon two variables: the quantity of uncontrolled emissions with which the collector must deal (sometimes referred to as the inlet loading to the control system) and the flow rate in dry standard cubic meters/minute (dry standard cubic feet/minute). Neither of these variables is completely subject to operator control.

Asphalt concrete plants are designed to operate at a specific capacity in metric tons (tons) per hour. This capacity is related to the capability of the dryer to handle a given quantity of aggregate at a time. Since approximately 1 minute is required for drying, the hourly output of the plant is rated at 60 times the dryer capacity.

A plant with a 2722 kg (6000-lb) mixer has a capacity of 163 Mg (180 tons)/hr. As the plant works most efficiently at this capacity, it is advantageous to operate at full production level. The exhaust fan is designed to handle a specified volumetric flow of exist gas, which contains not only the combustion products from the heat used in drying but also the moisture removed from the aggregate and any excess air supplied to ensure complete combustion (NAPA, 1977; 1978).

Particulates in the aggregate are carried out in the exit gas from the dryer and are the principal source of particulate emissions from an asphalt concrete plant. Small additions are, of course, provided by the ventline from the screens, weigh hopper, storage, etc. The quantity of particles that become airborne in the dryer and, hence, the inlet loading to the collector vary with the velocity of the exit gas. It has been shown that the increase in particulate loading with gas velocity is nonlinear; for example, a 50 percent increase in exit gas velocity from 3 to 4.5 m/sec (600 to 900 ft/min) will increase the quantity of particulates by from 2 1/4 to about 2 1/2 times (Crim et al., 1971; Robert et al., 1975).

6.3.1.1 Volumetric Flow Rate. The exit gas velocity, sometimes called the velocity index, represents the volumetric flow rate provided by the exhaust fan divided by the cross-sectional area of the dryer. For example, in a dryer 2.44 m (8 ft) in diameter with a flow rate of 1133 acmm (40,000 acfm), the velocity of the exit gas is nearly 4.06 m/sec (800 ft/min). For a different size dryer, the velocity for the same volumetric flow rate would vary as the square of the radius (half the diameter) of the dryer. Since the volumetric flow rate is essentially fixed, so is the exit velocity, or velocity index. It is not normal practice for an asphalt plant to vary the velocity of exit gas. If for any reason a smaller quantity of asphalt is to be produced than the full capacity allows, a damper is applied to reduce the total volumetric flow. The gas exits at essentially the same velocity. Many asphalt plants are provided with automatic dampers to adjust the volumetric flow. Thus, an increase in inlet loading of particulates as a result of change in velocity of the exit gas is not to be expected (NAPA, 1977; 1978).

The translation of actual volume per minute to dry standard volume represents an adjustment for the presence of moisture in the gas and for temperature, since the volume of a gas varies directly with temperature. The volume of exit gas can be computed by the formula

$$\text{dscm} = \text{acm} \times \frac{294.27}{273.16 + T(^{o}C)} \times \frac{100 - \%\ \text{moisture}}{100}$$

$$\text{dscf} = \text{acf} \times \frac{460 + 70}{460 + T(^{o}F)} \times \frac{100 - \%\ \text{moisture}}{100}$$

where T represents temperature of the exit gas in $^{o}C$ ($^{o}F$), and 273.16 (460) is applied in converting the temperature to the absolute (Kelvin) scale. An example of this conversion is shown in Figure 6-1.

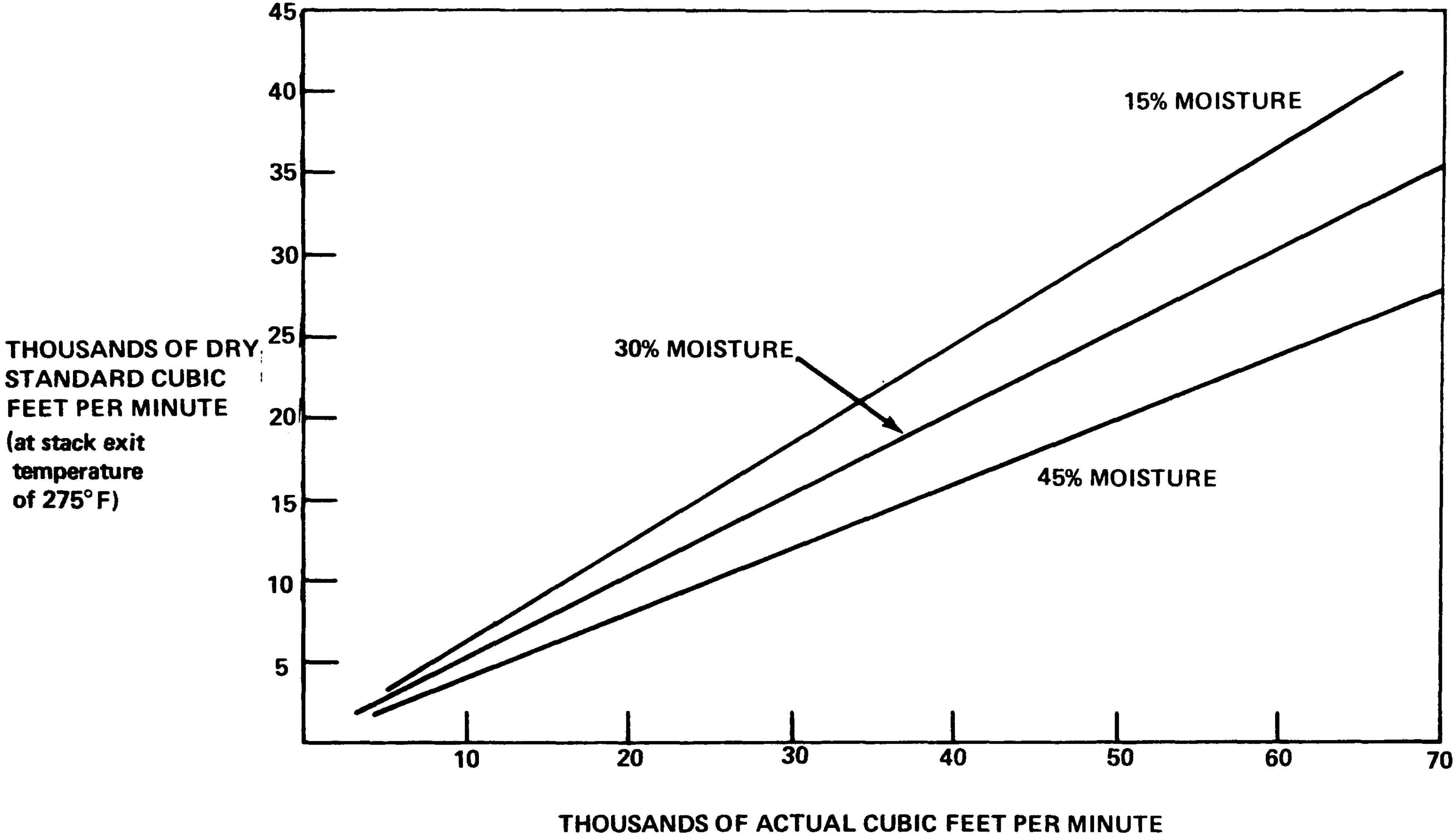
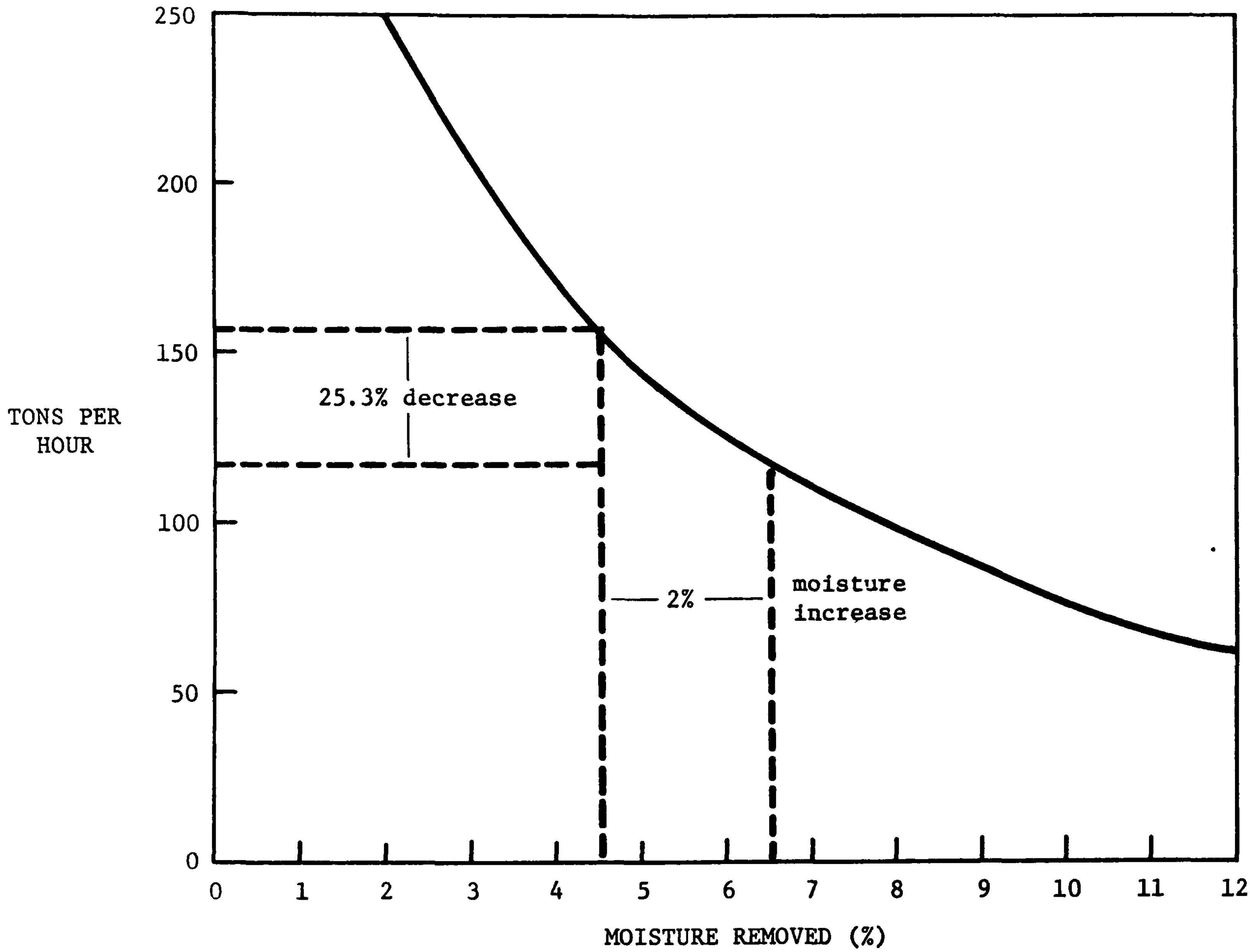



**FIGURE 6-1**
**RELATION BETWEEN ACF AND DSCF**

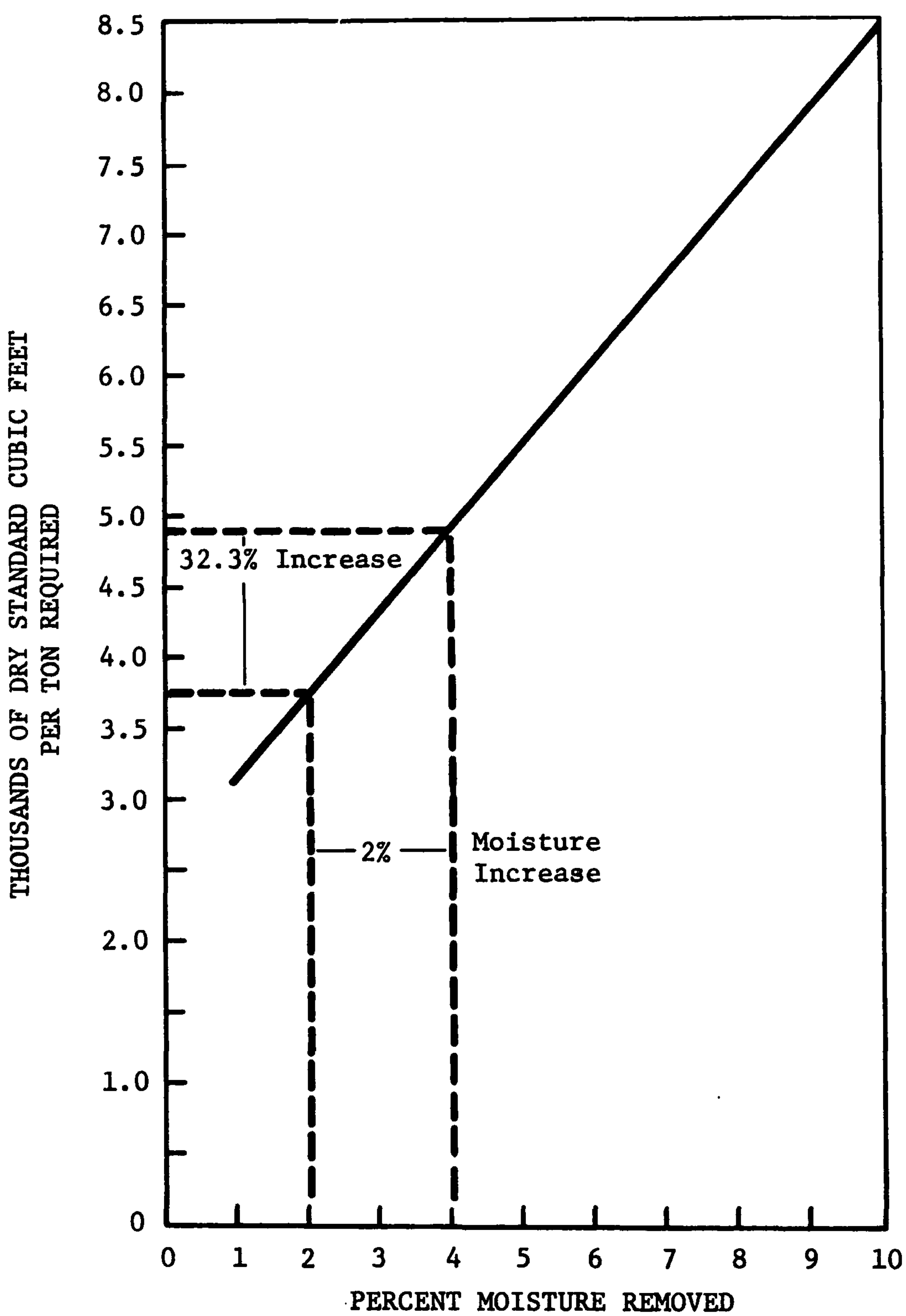
Thus, the flow rate in dry standard volume varies inversely with the percent of moisture in the exit gas; the principal source of moisture is that removed from the aggregate in drying. The percent of moisture by weight in the aggregate translates into a much larger percent of moisture (by volume) in the exit gas, depending particularly upon temperature, type of fuel used, and amount of excess air provided. It is common for the moisture in the aggregate to range from about 4 to 10 percent; whereas the percent of moisture in the exit gas may vary from about 15 to as much as 50 percent. It has been found from experience that the effect of atmospheric humidity is not significant (NAPA, 1977; 1978).

Because the volumetric flow rate is essentially fixed and the moisture in the aggregate may vary, the effect of a high percentage of aggregate moisture is to reduce the capacity at which the plant may operate as shown in Figure 6-2. The result is to require a higher ratio of actual volume per minute to tons of asphalt produced. Simultaneously, the ratio of dry standard volume to actual volume in the volumetric flow will decrease. The increase in both actual volume and dry standard volume required per mass of product as the percent of moisture removed from the aggregate is nearly linear (for a given type of fuel and dryer exhaust gas temperature) and can be approximated quite well by a straight line as shown in Figure 6-3. As a result of these variables, the decrease in production is greater than the decrease in dry standard volume per minute associated with




SOURCE: Barber-Greene Co., 1976.

**FIGURE 6-2**
**TONS PER HOUR CAPACITY AT DIFFERENT MOISTURE CONTENT**
**(FOR SPECIFIC DRYER OPERATING AT CONSTANT TEMPERATURE)**




SOURCE: Barber-Green Co., 1976.

**FIGURE 6-3**
**INCREASE IN DSCF/TON AT DIFFERENT MOISTURE CONTENT**
**(WITH USE OF NO. 2 FUEL OIL, DRYER EXHAUST AT 350°F)**

a given flow rate in actual volume per minute. Thus, as higher moisture in the aggregate reduces the production of asphalt and, hence, the drying of aggregate, the ratio of exit gas in dry standard volume to mass of product tends to increase.

6.3.1.2 Uncontrolled Emission Rate. The inlet loading to the collector, representing the rate at which airborne particles are emitted in the uncontrolled situation, depends on several variables in a way not precisely defined in the literature. The U.S. Environmental Protection Agency (1973a) has published a list of pollutant emission factors in which the uncontrolled emission rate of particulates for asphalt concrete plants is given as 22.5 kg/mg (45 lb/ton) of product. This figure was based on information in the literature for conventional (i.e., other than drum-mix) plants. In fact, the uncontrolled emission rate is reported to vary under unspecified conditions by at least one order of magnitude, as shown in Table 6-1. Regrettably, available data do not permit a determination of flow rate as a function of independent variables.

The nature of the aggregate used in asphalt production affects the inlet loading of particulates to the collector. Available information in the literature indicates that at a given exit gas velocity, essentially a constant percentage of the total weight of the aggregate fines will be airborne from the dryer (Robert et al., 1975; Danielson, 1973). This result would be expected from the physical principles involved, since the tendency of a particle to become airborne depends upon its size and weight in relation to the velocity of the air stream. At typical velocity indices, from about one-half to about three-fourths of the total aggregate fines (particles of -200 mesh size, i.e., those which pass a 200 mesh screen and are less than 74 microns) will be carried out in the exit gas from a dryer. Such particles can be expected to total about three-fourths of the particulate weight in the inlet loading. Thus, an unusually high percentage of fines in the aggregate will result in much heavier inlet particulate loadings than usual. In addition to the percent of fines, the distribution of particles of -200 mesh size can also vary.

6.3.2 Environmental Considerations

6.3.2.1 Particulate Emission Rate in Pounds per Ton. In addressing the environmental effects of current NSPS for particulates from asphalt concrete plants (and the effects of possible changes), it would be useful to have reliable data on the allowable emission rate per unit of product.

To convert from emission in mass per dry standard volume to total mass of particulate output or to output in mass per mass of product from a given plant, it is necessary to know the flow rate of stack gas from the plant in dry standard volume, either overall or as a ratio to production. At various percentages of moisture in the aggregate (by weight) from 2 to 10 and stack gas exit temperature in the range from 135° to 177°C (275° to 350°F), variations in the flow rate range from about 109.24 dscm/Mg (3500 dscf/ton) to about 265.28 dscm/Mg (8500 dscf/ton) (Foster, 1977; NAPA, 1975). On this basis, the particulate emission rate in kilograms/metric ton (pounds/ton) of asphalt corresponding to 90 mg/dscm (0.04 gr/dscf) can be tabulated as follows:

| Stack Gas Flow Rate, dscm/mg (dscf/ton) | Kilograms of Particulate per Metric Ton of Product (lb/ton) |
|---|---|
| 109.24 (3500) | 0.010 (0.020) |
| 124.84 (4000) | 0.012 (0.023) |
| 156.05 (5000) | 0.015 (0.029) |
| 187.26 (6000) | 0.017 (0.034) |
| 218.47 (7000) | 0.020 (0.040) |
| 249.68 (8000) | 0.023 (0.046) |
| 265.29 (8500) | 0.025 (0.049) |

These figures are generally lower by an order of magnitude than most of the factors estimated by EPA (1976) for the output of various control devices. However, the EPA estimates do include a factor of 0.02 kg/mg (0.04 lb/ton) for an orifice-type scrubber and indicate that emission rates an order of magnitude lower can be achieved by baghouses. They are substantially higher than the rates reported for 16 dryer-drum mix plants by Khan and Hughes (1977). They can serve as a reasonable range within which the current NSPS for particulates may be converted to mass per mass of product.

6.3.2.2 Emissions from New Plants. Using the values calculated above, a ceiling on particulate emissions from the 150 new and modified plants estimated to come under NSPS each year can readily be derived. Although the average production of asphalt plants overall was estimated to be 160 Mg (176 tons)/hr (Khan and Hughes, 1977), the trend is clearly towards larger plants (NAPA, 1978; EPA, 1974) so that an average asphalt production rate of 181 to 200 Mg (200 to 220 ton)/hr from plants subject to NSPS is reasonable. On this basis, the output per plant per hour would range from 1.8 kg (4 lb) to nearly 5.0 kg (11 lb). Taking a midpoint in the average rate of 0.015 kg/Mg (0.03 lb/ton)* in order to have a single figure and a production rate of 191 Mg (210 ton)/hr on the average results in a figure of 2.86 kg (6.3 lb)/hr per plant or just under 191 Mg/yr (2.1 tons/yr). The estimated 150 plants becoming subject to NSPS each would then produce a gross total of about 286 Mg (315 tons) of particulate. In one sense, this figure represents a near maximum, because it does not take into account plants with control systems that reduce particulate emissions to levels less than NSPS. On the other hand, inherent in the method of calculating the emission factor is a possible error of as much as $\pm$ 25 percent.

In summary, narrowing the standards to 69 mg/dscm (0.03 gr/dscf) would reduce the ceiling on possible particulate emissions by 25 percent or about 73 Mg (80 tons). Seventy-three Mg (80 tons) is about 0.11 percent of the estimated annual emissions from asphalt plants in 1975 (Khan and Hughes, 1977).

*Such a rate would be quite representative, as it corresponds to a flow rate at about 4 to 5 percent aggregate moisture and a stack gas exit temperature in the 135° to 177°C (275° to 350 °F) range.

6.3.2.3 Other Possible Impacts. While all environmental effects possible from a change in the NSPS for particulates would be very slight, they would not necessarily all be beneficial. As noted in Section 4, if the option of using a venturi scrubber is exercised, the efficiency of the scrubber can be increased by providing more energy (through higher horsepower) so as to increase the pressure drop. The higher efficiency necessary to remove an additional 25 percent of the particulate load would result in a corresponding increase in pressure drop but an increase of about 50 percent (actually 9/16) in energy and, hence, in fuel requirements. When this increase is applied to the estimates of fuel usage and resultant emissions, the effects (which could be avoided by choice of fabric filter as control system) are seen to be as insignificant as the possible gains from reducing particulate emissions. Nevertheless, these effects are negative.

Similarly, an increase in solid waste disposal would be anticipated from stricter particulate emission standards since 25 percent of the particulates not now being captured would be removed. This very small incremental increase in mass would presumably be disposed of as waste. It would not be reasonable to assume any recycling of this additional quantity, when not all fines presently removed are being reused. A change of one quarter in the standard would result in the additional collection of 25 percent of the 286 Mg (315 tons) which would be emitted under current standards. This annual increase in solid waste would be about 72 Mg (79 tons).

### 6.3.3 Effects on the Asphalt Industry

Any change in the particulate standards would clearly affect the asphalt industry in some adverse fashion, the extent of which would be extremely difficult to quantify. New plants gear up to meet a level of 90 mg/dscm (0.04 gr/dscf) (except in states with stricter standards such as Maryland, New Jersey and New York) through installation of control systems with rated efficiencies that are adequate. Many of the devices installed up to now are clearly able to meet stricter standards, but as shown in Section 5, about 25 percent of those that can meet a level of 90 mg/dscm (0.04 gr/dscf) do not meet a level of 68 (0.03). Detailed data are not available for analyzing why some plants have achieved lower mass-loadings. Factors involved are assumed to include type of control system and design parameters, details of installation, and operating and maintenance practice. It would be interesting to know how lower emissions rates correlate with the price of installed equipment and with systems actually representative of BTS.

As a minimum, very strong opposition from the industry to tightening of NSPS at this time would have to be anticipated. Plants would be faced with a higher failure rate (already 20 percent) with the use of control systems considered representative of BTS based on a sample of sufficient size to support valid statistical inference.

However, as already noted in Section 5, test data are not sufficiently detailed to determine how many of the control systems of plants not meeting NSPS actually represent BTS in terms of the conditions under which they were designed, installed or operated. No information has come to the attention of EPA (1978) that indicates any plants equipped with baghouses have had to close down.

The probability of retesting would be increased. The estimate of about 40 percent under present conditions (NAPA, 1978) seems high in contrast with the test sample which showed two retests out of 72. No quantitative information is available on the fate of plants that require retesting, i.e., how many achieve compliance after a given number of tests and how many face indefinite injunction against operating. The average figure of $1848 for each standard Method 5 test supplied by one firm (Snowden, 1978) could be expected to apply to retests. This amount is less than other more general estimates. While this amount represents less than 1 percent of gross annual income to an asphalt plant, retesting can mount up costs and erode the margin out of which annual profits must come. Of course, it is not necessarily true that cost of testing must come out of the profits of a plant for a single year. Such costs logically represent part of the total plant investment. It is also possible that cost of retesting where a control system had failed to meet specifications might be borne partially by the vendor. Adequate data are not available, however, to assess any possible inflationary effect on the price of asphalt products.

## 6.4 Levels for Opacity

EPA regional personnel have noted that most tests of asphalt concrete plants subject to NSPS result in opacity readings within the 20 percent limit and often well below this maximum allowable level. These comments are consistent with the limited amount of detailed data from tests for opacity, as discussed in Section 5. Of the plants in the small test sample, over 80 percent were certified at opacity less than 20 percent. It is possible that in addition to the approximately 25 percent tested at opacity less than 5 percent, other plants may have exhibited a percentage this low if more detailed reporting had been supplied. Under existing regulations, a measurement of simply "less than 20 percent" is adequate.

Opacity is clearly related to the amount of particulate loading in the stack gas. The opacity standard was designed to provide an easy visual means of determining that a plant is operating satisfactorily as evidenced by the transparency of its stack exhaust. Heavy emission of particulates leads to a dense plume, which exhibits a higher percentage of opacity than one relatively free of particulates.

A number of regional personnel have verified that opacity is dominated by the particulate standard. That is, meeting the NSPS level of 90 mg/dscm (0.04 gr/dscf) for particulates implies a very low opacity reading--much lower than the current standard of 20 percent. This judgment is supported by engineering experience. In short, the consensus is that an opacity reading above 5 percent is generally associated with particulate emissions exceeding the NSPS. As noted in Section 5, although the test sample is too small to support definitive inferences, test results are consistent with this view. Opacity readings in the upper range of 0 to 20 percent seem to be associated with excess particulate emissions. Conversely, low emission levels of particulates tend to imply very low opacity percentages. Readings as low as 0 percent opacity were reported in test results from plants for which the particulate mass loading was well below the NSPS level.

Available data for defining the relationship between particulate levels and opacity percentages are not exact. Other factors appear to influence the relationship, including size and color of the particles emitted in the plume and path length of emissions. (Cooper and Rossano, 1971; EPA, 1978).

### 6.5 Fugitive Emission Control

The types of emissions encompassed by the term "fugitive" are variously classified in the literature. In the interests of comprehensive consideration, three types are noted as to nature and source, even though some authorities exclude the first from the category of fugitive emission. The three types discussed are:

- Scavenger or fugitive dust emissions (controlled under NSPS)
- "Open source" emissions
- Miscellaneous emissions.

Scavenger emissions or "fugitive dust emissions" are those that go through the ventline carrying "scavenger air" to the collector from enclosed components of a continuous mix or batch plant. Since the components involved are not represented in a dryer-drum mix plant, scavenger emissions do not occur in a dryer-drum plant. The scavenger air contains dust and gaseous emissions from the following principal sources (Khan and Hughes, 1977; Patankar and Foster, 1978; NAPA, 1975; Robert et al., 1975):

- Hot aggregate elevator
- Vibrating screens
- Hot aggregate storage bins
- Weigh hopper
- Mixer.

Scavenger air may range from about 7 to over 25 percent of the total system gas volume, depending on moisture content in the dryer air (NAPA, 1973). The proportion of emissions in the scavenger air may range around 15 to 25 percent of the total, as shown by relative particulate loadings reported in representative tests (Danielson, 1973). One study estimated the particulate concentration from the mixer alone to be about 2 percent of that from the dryer (Khan and

Hughes, 1977). These scavenger emissions flow through the control system and exit in the stack gas, so that they are controlled under current NSPS. Hence, they are of no further concern in the present context.

"Open source" emissions is a term sometimes applied to those that emanate from stockpiles, cold plant towers, reject chutes, feed bins, loading operations, and truck traffic around the plant. These emissions are not now controlled (Khan and Hughes, 1977; Patankar and Foster, 1978). One estimate is that they may constitute about 10 percent of the total dust output of an asphalt concrete plant (Robert et al., 1975). However, as this estimate also includes emissions from the hot material elevator which are usually vented as part of the scavenger air, the estimate should be reduced.

No quantitative data are available on which to confirm or refine this single estimate. Measuring such fugitive emissions is regarded as difficult if not impossible to achieve. The rate is inevitably affected by weather. It has been estimated that on a dry, windy day, open source emissions may greatly exceed all others from an asphalt concrete storage plant.

Control of open-source emissions appears to be inherent in effective maintenance or good housekeeping practices (Khan and Hughes, 1977). Wetting aggregate stockpiles, as recommended in some reports, may not be in the best interests of an asphalt manufacturer because high moisture content decreases production and degrades efficiency. However, the National Asphalt Pavement Association urges its members to enclose the stockpiles and cold feed bins to prevent dust blowing while simultaneously protecting the aggregate from moisture (NAPA, 1978). Oiling traffic surfaces can reduce particulate emissions but gives rise to small quantities of hydrocarbon emissions.

Miscellaneous emissions occur during finished product discharge to the trucks from the mixer. Particulates from this coated product are extremely low--about 2 percent of the stack concentration. However, gaseous emissions, particularly hydrocarbons (HC), occur at an unknown rate. One study estimates the concentration of HC from the mixer to be less than 3.5 ppm, or about 8 percent of that from the stack. Polycyclic organic material is estimated to be about 0.36 $mg/m^3$, less than 1 percent of the rate in stack emissions (Khan and Hughes, 1977). Because these emissions occur only during the fraction of operational time when the mixer is engaged in discharging its product, emissions on an hourly rate are very low. Other minor sources of miscellaneous emissions include those from handling and storage of raw liquid asphalt and from disposal of mineral fines.

## 6.6 Changes in Tests and Procedures

### 6.6.1 Monitoring Requirements

As a means of ensuring that NSPS are maintained, monitoring requirements are sometimes specified. However, they are not specified in the Code of Federal Regulations for asphalt concrete plants (40 CFR 60).

By its very nature, the asphalt concrete industry appears to be a poor candidate for continuous monitoring. Because of the intermittent operations involved in virtually all plants, monitoring cannot be continuous, but would consist of a sequence of start-and-stop measurement operations maintained over varying periods of time. As previously noted, an asphalt concrete plant operates on the average of 666 hr/yr. Reinstallation, calibration, and all the fine adjustments necessary for accurate monitoring would be necessary.

Several processes have been developed for continuous monitoring of particulate emissions, including photometric detection, use of tape detectors, chemical determination, and beta-ray attenuation (Cooper and Rossano, 1971). None of these was developed for asphalt concrete manufacture. The cost and complexity of these processes makes them ill-suited to an industry where no gain in process control can be expected; thus, they are an additional expense.

Periodic testing for opacity percentage by visual means is a relatively cheap and readily performed operation. It is provided for in current regulations and can be used to indicate whether a soundly designed control system, once installed and determined to meet NSPS requirements, is maintained and operated at the proper level of efficiency. In most instances, even admission to the plant area itself is not required.

### 6.6.2 Production Penalty

The change considered in this subsection relates to a procedure applied in administering compliance. It does not concern emission levels established by NSPS or regulations for monitoring.

It is a common practice in certifying plants as in compliance to limit the production capacity when testing occurs at substantially less than the full production rate. In some regions, the procedure is reportedly to certify the plant at the tested level plus 23 Mg (25 tons)/hr (MITRE Corp., 1978). The plant can then be cited for violating regulations if it attempts to produce at capacity without retesting. This procedure appears to be pursuant to the requirement in 40 CFR 60 that testing be conducted under "representative conditions." If a plant must operate a greater number of hours to produce a given quantity of asphalt, the production cost per unit mass will be raised, since these costs increase directly with the hours of plant operation. Moreover, asphalt plants are designed to operate at a specific production rate that is optimum in terms of efficiency. If required to operate significantly below this rate, reduction in this maximum possible efficiency results in further indirect costs for each unit mass of asphalt produced. Individual plants thus affected are placed at a competitive disadvantage.

Regional EPA officials and others who certify compliance are not unreasonable in attaching a production ceiling. Indeed, the practice can be justified on technical grounds which are complex and somewhat controversial.

Production at less than full capacity is required when the percentage of moisture removed from the aggregate raises the ratio of actual volume per minute per mass of product to a level that would exceed the capacity of the exhaust fan.

Assuming that the efficiency of the collector system and the inlet mass loading per unit mass of aggregate remain somewhat constant for a given type of aggregate, then higher emission rates can be expected if the flow rate of stack gas decreases. Thus, when the plant operates at substantially higher production levels, the same output in mass of particulate per mass of product should result. But in this situation the rate measured will be higher because the increase in production will exceed the increase in flow rate. For example, a plant with a control system operating at 99.9 percent efficiency, which will just meet current NSPS particulate levels at about 187.3 dscm/Mg (6000 dscf/ton) at a given inlet mass loading, will exceed 103 mg/dscm (0.045 gr/dscf) as the flow rate decreases by 12.5 percent to 163.9 dscm/Mg (5250 dscf/ton). Certifying officials have good reason for somewhat limited views of how far compliance has been demonstrated for higher production rates.

Some situations may result in a hardship to the plant operator and achieve no environmental gains. Test measurements may imply that if the plant had been operating at full capacity, all other conditions remaining the same, it would have been in compliance. This situation may occur when a plant is being operated at a production rate which is maximum for the percentage of moisture in the aggregate and is very different from one in which a marginal control system is maneuvered into meeting the NSPS level by adjusting production. By extrapolating the observed results in controlled mass loading and the flow rate to operation at full capacity it may be possible to estimate whether the plant would have met NSPS if operating at a higher rate.

#### 6.6.3 Exemptions for Small Plants

Concern has been expressed by EPA regional personnel that formal testing for particulates places a burden on small plants. The suggestion has been made that these plants be exempted from this requirement (MITRE Corp., 1978).

The direct costs of testing for rate of particulate emissions, which vary from less than \$2000 to as much as \$5000, may be compared with published figures on gross income for asphalt companies. As noted in Section 6.3, testing costs would not necessarily come out of income for a single year. A survey of member companies by the National Asphalt Pavement Association reports results from about 850 plants (not distinguished as to NSPS status) producing $59 \times 10^6$ Mg (65 million tons) (about 22 percent of total national production).

On the basis of this survey, plants producing less than 90,700 Mg (100,000 tons)/year (less than 136 Mg (150 tons)/hour have produced about 9 percent of the total asphalt tonnage; the annual gross income per plant was about $465,000. This figure contrasts with an average of all plants of from about $700,000 to $800,000 per plant. The higher figure represents results based on the survey, whereas the lower figure is derived by dividing the estimated national total of 4500 asphalt plants into the total value of hot mix asphalt (NAPA, 1977).

Thus, it is clear that the burden can weigh inequitably on small plants simply because of their smaller income. In terms of gross income, the costs remain a small fraction for plants of all sizes. A price range of about $2000 to $2500 for test costs represents no more than about 136 Mg 0.5 percent of the gross income for plants in the group producing less than 136 Mg (150 tons)/hour. The distribution of plants by size below 136 Mg (150 tons)/hour is not known; however, it is known that plants of 109 Mg (120 ton)/hr capacity or less now represent about 12 percent of the total. Detailed data on cost margins of asphalt plants are unavailable.

It is not reasonable to consider exempting small plants entirely from NSPS. It can be shown that in the extreme the resulting particulates from all such plants becoming subject to current standards in any one year could exceed the total emissions calculated in Section

6.3 for all new plants, if they meet current NSPS level. Extreme results are derived from the use of the emission factor (EPA, 1973a) of 0.85 kg/Mg (1.7 lb/ton) with use of a cyclone as control device, and from estimates of total production from the plants at issue as slightly under 907,000 Mg (1 million tons) in the first year of operation. The latter production estimate is obtained by the assumption that the fraction of 9 percent of the total mass of asphalt produced by plants with capacities less than 136 Mg (150 tons)/hr applies also to the ratio of new and modified plants (0.0333) to all asphalt plants.

Merely exempting small plants from formal particulate testing, as originally proposed by EPA regional personnel, would have a very small environmental impact. Plants still subject to NSPS would have to be certified on a basis other than formal tests (as provided for in 40 CFR 60). They might be required to satisfy the certifying officials that they had installed a suitable control system, such as a baghouse or wet venturi scrubber, and meet a satisfactory opacity level as determined by visual observation (i.e., equal to or substantially less than the NSPS level of 20 percent). If such plants provide about 9 percent of the annual asphalt production from plants newly subject to NSPS, then at a level of 90 mg/dscm (0.04 gr/dscf) they would be expected to emit about 25.4 Mg (28 tons) of particulates per year. An increase of 10 percent would not exceed 2.7 Mg (3 tons) annually. At a level of success in predicting control system performance that approaches 100 percent, no appreciable increase in particulate emissions would be expected.

It is not certain what the rate of success would be in predicting that a control system will perform satisfactorily and meet the standard for particulates. The failure rate of approximately 20 percent observed in the sample of test results examined in this analysis appears high as an estimate of the frequency of error in certifying a control system as adequate. It must be assumed that assurance would be required on engineering details in design and installation of the system, which would sharply reduce the likelihood of failure from that reflected in the essentially random sample of baghouse and venturi scrubber system in the available test data. On this basis, 20 percent of the mass produced annually by the plants involved would result in somewhat higher emission rates of particulates. If these rates are approximately 1.5 times the rate achieved under full control, then the overall increase of about 10 percent in particulate emissions would be expected.

Comparing the estimates of 10 percent increase in particulate emissions with the estimate of 286 Mg (315 tons) emitted per year by plants newly subject to NSPS indicates that the amount would be approximately 29 Mg (32 tons) annually.

In contrast to these factors favoring exemption of small plants from the particulate test are other offsetting factors. Since only new or modified plants are tested, these tend to be large units. Thus, the number of small units exempt from the test would be relatively small. In addition, the particulate test is the only way to determine independently that the installed control system is operating as designed. In an economic sense the cost of the test can be considered to be one of the necessary costs of plant construction and treated accordingly during planning.

6.6.4 Waiving of Particulate Tests

It has also been suggested by some EPA regional personnel that wherever a plant has properly installed a well designed particulate control system, formal testing could be waived and compliance granted. This idea is appealing, both because of the savings to the asphalt industry and because of the procedural simplification for officials.

These estimates could be considerably refined given comprehensive and detailed data on the performance of venturi scrubbers and baghouses under various conditions and on the emission rates of plants so equipped.

It can be seen, however, that the order of magnitude of the possible increase is extremely small. Even an error of 100 percent in the estimate of 29 Mg (32 tons) per year would still give a figure less than 0.1 percent of the annual estimate of particulates (63,500 Mg/70,000 tons) from the asphalt industry as a whole (Khan and Hughes, 1977).

6.7 Control of Other Pollutants

Other pollutants emitted by asphalt concrete plants are nitrogen oxides ($NO_x$), sulfur dioxide ($SO_2$), hydrocarbons (HC) and carbon monoxide (CO). Estimates of the amount of each emitted annually by all asphalt concrete plants and by the estimated 150 new and modified plants coming under NSPS each year are given in Table 6-2. The amount of these pollutants emitted is very small and does not exceed 454 mg (500 tons) per year for any pollutant. The contribution of the asphalt industry to national emissions in these categories is minute; no pollutant emission reaches as much as 1/10 of 1 percent of national emissions from stationary sources. The fractional percentage of total emissions in the U.S. for any category is even lower--by as much as an order of magnitude.

It may be noted that the fraction of total national emissions resulting from asphalt concrete plants is smaller for the above pollutants--even though they are not expressly controlled--than is true for particulate emissions from asphalt plants, which are controlled. The total of about 63,500 Mg (70,000 tons) of particulates emitted from asphalt plants is about 0.35 percent of all particulate emissions nationwide (about 17.9 million Mg or 19.7 million tons). This percentage is approximately one order of magnitude higher than the percentage of other emissions in the respective national totals (Khan and Hughes, 1977).

TABLE 6-2

CONTRIBUTION OF ASPHALT HOT MIX
INDUSTRY TO NATIONAL EMISSIONS OF OTHER POLLUTANTS

| Pollutant | National Emissions[a] ($10^6$ Mg/yr) | Total Emissions from Stationary Sources[b] ($10^6$ Mg/yr) | Emissions from Hot-Mix Asphalt | | | |
|---|---|---|---|---|---|---|
| | | | $10^6$ Mg/Yr | | Percent Asphalt Plant Emissions | |
| | | | All Plants[a] | New Plants Each Year[d] | Total Sources | Stationary Sources |
| Sulfar Oxides | 29.96 | 29.36 | 0.014 | 0.00045 | 0.05 | 0.05 |
| Nitrogen Oxides | 22.25 | 13.35 | 0.007 | 0.00024 | 0.033 | 0.06 |
| Hydrocarbons | 25.06 | 8.68 | 0.005[c] | 0.00018 | 0.022 | 0.06 |
| Carbon Monoxide | 96.89 | 22.28 | 0.008 | 0.00027 | 0.008 | 0.04 |

[a]Khan and Hughes, 1977.

[b]Estimated from percent of stationary to total, 1972 and 1973 (Khan and Hughes, 1977; EPA, 1976).

[c]As methane equivalent.

[d]Based on EPA estimate of 150 new plants each year or 3.33 percent of total industry.

The stack emission rates of $NO_x$ and $SO_2$ estimated for asphalt concrete plants are far lower than those set by NSPS for these pollutants from acid plants. The rate of less than 0.05 kg/Mg (0.1 lb/ton) for $SO_2$ compares with the 2 kg/Mg (4 lb/ton) set for sulfuric acid plants. Similarly, the rate of 0.25 kg/mg (0.5 lb/ton) for $NO_x$ is a small fraction of the NSPS emission rate of 1.5 kg/mg (3 lb/ton) set for nitric acid plants (Khan and Hughes, 1977; 40 CFR 60). The previously mentioned pollutants--$NO_x$, $SO_2$, HC and CO--are controlled to some degree by the use of scrubbers or fabric filters which wash out or trap impurities. $SO_2$ is also reduced by the use of limestone or dolomite which is estimated to make up 85 percent of all aggregate in asphalt concrete mixes. These substances are widely used catalytically in scrubbers for $SO_2$ reduction.

The emission rate of HC for drum-mix or dryer-drum plants has not been determined experimentally but is believed to be greater than that of conventional (batch or continuous mix) processes (Robert et al., 1975). Therefore, the drum-mix plant should be considered in a somewhat special category as meriting study specifically to determine whether its HC emissions are environmentally significant. This issue is especially important in view of the anticipated growth of the drum-mix process.

## 6.8 Use of Liquefied Asphalt Cutbacks

The suggestion has been raised by EPA regional personnel that the use of "cutbacks" in application of liquefied asphalt be eliminated or sharply reduced (MITRE Corp., 1978). A similar interest has also been expressed by the asphalt industry (NAPA, 1978).

The issue is somewhat tangential to the present review because it is concerned with the application of liquefied asphalt in surfacing operations, rather than with production of asphalt concrete, as specified under current NSPS. The term cutback refers to liquefied products in which the asphalt is cut back or diluted by kerosene or other volatile HC fluids for use as a surfacing material. However, because the issue was raised in the context of the present study and because restriction of cutbacks provides the real opportunity for reducing HC emissions from asphalt products, it is briefly discussed here.

Recent studies by or under contract to EPA have confirmed the significance of cutbacks in surfacing operations as a source of HC emissions (Kirwan and Maday, 1977; Midwest Research Institute, 1978). It is estimated that well over 2 percent of national HC emissions result from cutbacks used in pavements and other surfaces. Cutbacks were found in laboratory tests to emit HC at a peak rate within the first minute of exposure. It was also found both in the laboratory and from field samples that such emissions continue at a diminished rate for long periods. Some samples taken from highways in the Midwest were emitting HC more than 3 years after paving operations were completed. It is in the interests of the asphalt industry to substitute other forms of liquefied asphalt for cutbacks. For example, significant reductions in energy requirements and savings of fuel can result from substituting water-based emulsions. Such alternative products can be generally used, although cutbacks may continue to be required in surfacing operations at temperatures below about 10°C (50° F).

# 7.0 CONCLUSIONS

## 7.1 NSPS for Particulate Emissions

### 7.1.1 Retention of Present Level

Current NSPS of 90 mg/dscm (0.04 gr/dscf) for particulate emissions are being satisfactorily met. No basis exists for relaxing the standards, since more than three-fourths of the plants tested met current NSPS, and there have been no reports of any excessive numbers of failures. The fact that many plants are able to achieve even lower particulate emission rates is evident both from test results and from the fact that standards of 68 mg/dscm (0.03 gr/dscf) have been successfully implemented in a few states. Thus, it would clearly be possible to tighten the standards.

However, it is concluded that no change should be made in current NSPS at the present time for the following reasons.

### 7.1.2 Justification for Retention

- The current standards are sufficiently stringent.

  Current standards are being met, sometimes at levels notably less than 90 mg/dscm (0.04 gr/dscf); however, a significant number of failures have occurred. Nearly one-fifth of the plants equipped with one of the control systems considered representative did not achieve compliance. Two of the plants using fabric filters achieved compliance only after a second test. Of the tests involving plants known to be using either a baghouse or a scrubber of the venturi type, about 25 percent of those achieving compliance would not have achieved the level of 68 mg/dscm (0.03 gr/dscf). This indicates that even the devices counted on to achieve greater particulate control, while succeeding most of the time and sometimes even surpassing present requirements, cannot always be relied upon to meet stricter standards in all situations because of the possibility of faulty equipment design or of inadequate equipment maintenance programs.

- Achieving the standards is subject to variability in the aggregate.

  Variations in the distribution of particles within the fines can result in higher emission rates than usual. The likelihood of test failure from this cause is increased as the standards become more restrictive. Variability in aggregates used has been reported and could be involved in the variability of test results observed. Aggregates used in some parts of the country are known to be particularly high in fines passing 200 mesh screen and in the finer particles much below 74 microns. For example, the sand used in the southeastern U.S. and other types of aggregate are clayey or contain very fine silt (Barber-Greene, 1976; NAPA, 1978). Factors that are not known include the distribution of particle sizes below 20, 10 and 5 microns in particular types of aggregate and the inlet mass loading as a function of aggregate characteristics. The occasional laboratory tests that have been conducted are inconclusive. In some such tests, baghouses have met current standards with little difference regardless of the aggregate used. In other tests, however, variations have occurred in both the inlet loading and the output emission rates (EPA, 1978; University of Texas, 1973).

- Efficiencies required of control systems may already be at the limits of technological capability.

  As noted in Sections 4 and 6, the efficiencies demanded of control systems by current NSPS for particulates are already quite high, both in relation to the rated efficiencies and the theoretical maximum. This fact applies particularly to collectors used with aggregates having a high distribution of small particles, for which rated efficiencies of control devices may be relatively low. Certainly the efficiencies demanded are extremely high if based on the EPA average factor for uncontrolled emissions of 22.5 kg/Mg (45 lb/ton) of product (EPA, 1973a). Actual efficiencies achieved in compliance testing are largely unknown because inlet loadings are seldom measured. To do so would be both difficult and expensive. Test data available during present analysis indicate a practice of scoring efficiencies by comparison of test results with the EPA estimate of 22.5 kg/Mg (45 lb/ton) (using known parameters of production and of flow rate in dry standard volume) (New York State, 1976).

Test results in the sample analyzed indicate that stricter particulate levels could probably be met in most instances through a baghouse combined with a cyclone as primary collector.

- The possible environmental gain would be slight.

  The maximum reduction of about 73 Mg (80 tons) annually for each 23 mg/dscm (0.01 gr/dscf) by which the standard is tightened is a small fraction (about 0.11 percent) of the total annual particulate emissions of asphalt plants at present and is infinitesimal compared with the national level from all sources. The cost and other administrative burden to EPA in promulgating new standards may not presently be justified by environmental benefits.

### 7.1.3 Clarification of Items

An important question is the role of dryer-drum mix plants in the asphalt industry and the performance of control systems installed in such plants. As already noted, it was formerly believed that baghouses could not be used because of the tendency of the sticky, asphalt-coated particles to clog the fabric filters. Although experience in some plants has demonstrated that baghouses can be effective, further information is needed. The remarkable results reported by Khan and Hughes (1977) raise a valid question as to whether different particulate emission levels are required for drum-mix plants in order to ensure that future plants subject to NSPS install BTS. These results are somewhat at variance both with those reported by Patankar and Foster (1978) and with those in the test data supplied by EPA regional personnel. However, the discrepancies imply the need for a study to define what the controlled rate actually is and what levels of particulate emissions would be expected from properly designed and operated venturi scrubbers and baghouses. If the trend toward dryer-drum mix plants approaches the predicted level of 85 percent, it will be particularly important for consideration of future changes in NSPS to know how these plants and their control systems operate in regard to particulate levels.

Also related to a tighter standard is the education of owners to the need for equipment that is well engineered, maintained, and operated. Owners need better guidance on the performance and cost benefits of baghouses vs. scrubbers.

## 7.2 NSPS for Opacity

### 7.2.1 Justification for Retention

Although the results of the relatively small body of data available on opacity tests indicate that it would be feasible to tighten the current standard of less than 20 percent opacity, no significant environmental gain would be achieved. The cost and administrative burden to EPA and other officials both inside and outside of the Federal Government would be unwarranted.

In asphalt concrete plants the opacity standard is essentially dominated by the NSPS for particulate emissions. When a particulate level less than or equal to 90 mg/dscm (0.04 gr/dscf) is met, the opacity is much lower than 20 percent. Tests results are consistent with experienced engineering judgment than an opacity reading of higher than 5 percent will be associated with a plant in which the particulate emissions exceed NSPS. Tightening the opacity standards to require a lower percentage will not in itself reduce pollutants or otherwise aid in protection of the environment. Indeed, a lower percentage for opacity will normally be achieved as the automatic result of an emission rate for particulates of less than or equal to 90 mg/dscm (0.04 gr/dscf).

### 7.2.2 Actual Correlation Between Opacity and Particulate Emissions

The exact correlation between opacity readings and rate of particulate emissions for asphalt concrete plants is unresolved. However, some inference can be drawn from related studies. One such study involved a survey of member companies of the Industrial Gas Cleaning Institute (Stastny, 1973). The member companies were asked to express an opinion as to what emission level would generally produce clear or near clear stacks for 42 industrial applications Unfortunately, asphalt concrete plants were not included in the 42. However, in the rock products category data were given for seven operations which included:

- Dry cement kilns
- Wet cement kilns
- Gypsum
- Alumina

- Alumina
- Lime
- Bauxite
- Magnesium oxide.

The average mass loading for these industries, which would yield no visible emissions (except condensed water vapor), was 84 mg/dscm (0.037 gr/dscf) with actual values ranging from 55 to 110 mg (0.024 to 0.048 gr). If it is assumed that there are significant similarities between these industries and the drying of asphalt aggregates, then the NSPS level of 90 mg/dscm (0.04 gr/dscf) should produce near clear stacks. The overall average for the 42 industries was 76 mg/dscm (0.034 gr/dscf).

It is unlikely that opacity readings alone could ever provide a legal basis on which to certify a plant as in compliance with particulate NSPS. Opacity readings reflect a number of variables in addition to particulate loading (Stastny, 1973). Among these are path length, angle of incidence of the light, moisture content of effluent, weather conditions and process changes. The opacity standard should be set at a level such that the specific features of all plants with BTS fully meeting the NSPS for particulates will be in compliance. On this basis, the opacity level as now set appears to satisfactorily reflect the numerous considerations involved. Existing regulations provide for subsequent opacity readings to be taken on plants where it is suspected that improperly functioning equipment may be causing excess particulate emissions. (EPA 1978a). These considerations reinforce the conclusion already stated that no change in opacity levels is warranted now.

## 7.3 Testing Procedure

### 7.3.1 Waiving of Formal Particulate Testing

7.3.1.1 Small Plants. The cost of formal particulate testing places a disproportionate burden on small plants of less than about 36 Mg /hr (150 tons/hr). These costs could be eliminated at very little expense to the environment; increase in particulate emissions would be from near 0 to about 2.7 Mg (3 tons) per year for plants newly subject to NSPS if these plants were exempt from formal testing but required to be certified on the basis of control system.

On the other hand, there are considerations militating against such a policy. The actual cost of testing is small in relation to net income over the life of the plant. The precedent implied by granting a blanket exemption may be undesirable. There are also procedures providing for the use of alternative methods in certain cases. It is concluded that class exemption of plants of any size is presently unwarranted.

7.3.1.2 Other Plants. All asphalt concrete plants might be certified on the basis of optimal control systems and opacity readings of less than about 5 percent. The result would be substantial savings to the industry and minimal environmental risk. However, there are considerations militating against such a policy, in addition to the difficulty of correlating opacity with particulate emission level. One of these is the difficulty of providing accurate opacity readings from wet plumes such as those that occur with venturi scrubbers. Perhaps more important is the uncertainty of predicting efficiency of even those control systems of the types considered representative of BTS. It is therefore concluded that no effort should be made to implement a certification policy on particulate testing based solely on the presence of one optional control system and an opacity reading of less than 5 percent.

7.3.2 Production Penalty

Attaching a production penalty (i.e., ceiling on maximum production authorized), as now practiced in certifying plants tested at less than capacity, may result in a hardship to some plants. Where moisture is the factor limiting production, any environmental gains expected from this practice are minimal. Therefore, explicit guidelines should be considered to eliminate the possible hardship which may be imposed upon individual operators in the asphalt industry. The crucial question is whether the rate of uncontrolled emissions (i.e., the inlet loading to the control system) remains the same per ton of product under varying degrees of moisture in the aggregate. Presently, there is a lack of experiential data to answer this question. The matter should be thoroughly investigated.

## 7.4 Control of Other Pollutants

### 7.4.1 Pollutants Involved

The other pollutants ($NO_x$, $SO_2$, HC and CO) are emitted by asphalt concrete plants in amounts that are very small when compared with:

1. Total national emissions
2. The rates achieved by controlled industries
3. The rates for particulate emissions even under current NSPS.

No apparent need exists at this time to consider NSPS for emissions of $NO_x$, $SO_2$ or CO from asphalt plants generally or for HC emissions from conventional plants (i.e., batch and continuous mix).

### 7.4.2 HC Rates from Drum Mix Plants

The rates for HC reflect a state of the industry in which dryer-drum mix plants represent less than 3 percent of the total. It is not known to what extent the expected growth up to 85 percent of the total of these plants will have on overall HC emissions, since the rate for such plants is not established. A study to determine the HC emission rates from dryer-drum mix plants is warranted.

### 7.4.3 HC Emissions from Cutbacks

The big source of HC emissions from asphalt is in liquefied asphalt cutbacks. Although this issue is somewhat tangential to the present study, it does represent the most effective way to reduce HC emissions from industrial use of asphalt. Therefore, it is concluded, that work now in progress under EPA aegis should continue toward development of regulations restricting the use of liquefied asphalt cutbacks and promoting the use of emulsions.

### 7.4.4 Emissions from Recycling Plants

It is concluded that determination of particulate emission rates is needed from plants that recycle asphalt concrete. The effectiveness of baghouses and venturi scrubbers under various operating conditions as defined by process parameters should also be determined.

### 7.4.5 Emissions from Hot Water Emulsion Mixes

It is concluded that particulate emissions that occur from use of hot water emulsion mixes in asphalt concrete production should be determined as well as of suitable means to control those with available equipment.

## 8.0 RECOMMENDATIONS

Recommendations to EPA regarding NSPS for asphalt concrete plants fall into two categories: specific changes in the regulations and unresolved issues or areas warranting further investigation. Specific changes involve the development of an enforcement policy covering testing and certification regulations. Further study is needed in regard to the unresolved issues of percent of opacity and level of particulates, R&D of uncontrolled particulate and hydrocarbon emissions from dryer-drum mix plants, standards for cutbacks, and the technology for development and use of improved control devices.

### 8.1 Specific Changes in Regulations

#### 8.1.1 Current Levels of Pollutants

As of this review, no changes in the current levels of standards for pollutants (particulates and opacity) from asphalt concrete plants are recommended. Both standards -- 90 mg/dscm (0.04 gr/dscf) and less than or equal to 20 percent opacity -- should be retained for the present.

#### 8.1.2 NSPS Applied to Emission of Other Pollutants

There is no need for NSPS to be applied to the emission of any other pollutants or to be extended to any other sources from hot-mix asphalt concrete plants; therefore, none should be promulgated at this time.

### 8.1.3 Enforcement Policy

No change is recommended in the requirement to test asphalt plants of all sizes. Development of an enforcement policy regarding the testing and certification of plants as in compliance should be considered. Research and development to define inlet loadings from different degrees of moisture in the aggregate should be carried out to determine whether a change is warranted.

The production penalty (a ceiling on production at some small increment above the production at which tested) should be removed so that all plants can be certified up to production capacity based on the following:

1. Particulate testing at a level less than 90 mg/dscm (0.04 gr/dscf) when operating at a production level that represents full capacity for the percentage of moisture in the aggregate used which can be determined from mathematical tables to correspond to a rate no higher than 90 mg/dscm (0.04 gr/dscf) at the nominal capacity of the plant.

2. Installation of a soundly designed fabric filter or wet scrubber system of the orifice or venturi type.

## 8.2 Areas of Further Investigation

### 8.2.1 Percent of Opacity and Level of Particulates

It is unlikely that a precise correlation between opacity and particulate emissions exists which is precise enough to ever serve as a basis for certifying plants as in compliance based on percentage of opacity alone. However, a more definitive relationship between these two measures in which the effect of other variables (e.g., path length, process changes) are taken into account could improve the use of opacity reading as a surveillance tool to ensure continuing compliance with NSPS for particulates. It is therefore recommended that further study be undertaken by the appropriate organizational units in EPA to meet this objective.

### 8.2.2 Determination of Uncontrolled HC Emissions From Drum Mix Plants

Further development activities are needed to determine the rate of uncontrolled HC emissions from dryer-drum mix asphalt plants as a function of significant variables, such as production rate and exit-gas velocity, in dry standard volume per minute. The basis for promulgating NSPS for HC emissions should be: (1) a finding that the HC emission rate is on the average greater than 4.54 kg (10 lb)/hr/plant (which is 1.25 times the maximum rate permitted under Los Angeles Rule 66 as federally modified) and (2) a growth rate that indicates that dryer-drum mix plants will exceed 50 percent of all new plants by 1982.

### 8.2.3 Technology for Development and Use of Improved Control Devices

Further development activities are needed to develop reliable projections on inlet loading to control devices (i.e., uncontrolled emission rates) for each type of asphalt plant (continuous mix, batch, and dryer-drum mix) as a function of aggregate input. Projections for exit-gas flow rate and projections of distribution of particle size in the uncontrolled emission should also be determined.

These could be used in evaluating expected results of control systems under operating conditions and, hence, become a basis for possible future modification of the particulate emission standards.

In addition, it is recommended that an educational program be considered, either sponsored and organized by EPA or the industry, for the purpose of providing better guidance to owners on need for well engineered, maintained and operated control devices. This program should include detailed information on the performance and cost benefits associated with baghouses and scrubbers.

8.2.4 Control of Particulates from Recycling Plants

Determination should be made of the effectiveness of BTS in controlling particulate emissions from plants which recycle asphalt pavement. If, as some evidence indicates, emissions from these plants exceed NSPS even when equipped with collector systems that adequately control emissions from plants using virgin material, a study should be made of the extent to which recycling conserves energy and alleviates the solid waste disposal problem. Findings in these areas of investigation should be used in considering whether plants recycling asphalt pavement warrant a separate and less stringent standard for particulate emissions.

8.2.5 Control of Emissions from Hot-Water Emulsions

A study should be made of particulate emissions vented to the atmosphere from asphalt concrete plants using hot-water emulsions. This investigation should include particularly the effectiveness of existing equipment to control such emissions during the sudden surge of steam when hot water is added directly to the pugmill. An objective should be to determine what, if any, modifications to operating practice and control technology are necessary if significant emissions are occurring as a result of bypassing the control system.

### 8.2.6 Standards for Cutbacks

Continued study should be made to develop standards on the use of cutbacks in application of liquefied asphalt.

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## TECHNICAL REPORT DATA
*(Please read Instructions on the reverse before completing)*

| | | |
|---|---|---|
| 1. REPORT NO. EPA-450/3-79-014 | 2. | 3. RECIPIENT'S ACCESSION NO. |
| 4. TITLE AND SUBTITLE A Review of Standards of Performance for New Stationary Sources - Asphalt Concrete Plants | | 5. REPORT DATE June 1979 |
| | | 6. PERFORMING ORGANIZATION CODE |
| 7. AUTHOR(S) Kathryn J. Brooks, Edwin L. Keitz, and John Watson | | 8. PERFORMING ORGANIZATION REPORT NO. MTR-7826 |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS Metrek Division of the MITRE Corporation<br>1820 Dolley Madison Boulevard<br>Mc Lean, VA 22102 | | 10. PROGRAM ELEMENT NO. |
| | | 11. CONTRACT/GRANT NO. 68-02-2526 |
| 12. SPONSORING AGENCY NAME AND ADDRESS DAA for Air Quality Planning and Standards<br>Office of Air, Noise, and Radiation<br>U. S. Environmental Protection Agency<br>Research Triangle Park, NC 27711 | | 13. TYPE OF REPORT AND PERIOD COVERED |
| | | 14. SPONSORING AGENCY CODE EPA 200/04 |
| 15. SUPPLEMENTARY NOTES | | |

16. ABSTRACT

This report reviews the current Standards of Performance for New Stationary Sources: Subpart I - Asphalt Concrete Plants. Emphasis is given to the state of control technology, extent to which plants have been able to meet current standards, experience of representatives of industry and of EPA officials involved with testing and compliance, economic costs, environmental and energy considerations, and trends in the asphalt industry. Information used in this report is based upon data available as of June 1978. Recommendations are made for possible modifications and additions to the standard, including future studies needed of unresolved issues.

17. KEY WORDS AND DOCUMENT ANALYSIS

| a. DESCRIPTORS | b. IDENTIFIERS/OPEN ENDED TERMS | c. COSATI Field/Group |
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| 18. DISTRIBUTION STATEMENT Release Unlimited | 19. SECURITY CLASS *(This Report)* Unclassified | 21. NO. OF PAGES 150 |
| | 20. SECURITY CLASS *(This page)* Unclassified | 22. PRICE |

EPA Form 2220-1 (Rev. 4-77) PREVIOUS EDITION IS OBSOLETE