AP42 Section: 11.1

Reference Number: 2

Title: Guide For Air Pollution Control Of Hot Mix Asphalt Plants,

Information Series 17, National Asphalt Pavement Association,

Riverdale, MD,

1965.

NATIONAL ASPHALT PAVEMENT ASSOCIATION

Information Series 17

GUIDE for Air Pollution Control of Hot Mix Asphalt Plants

Published by

NATIONAL ASPHALT PAVEMENT ASSOCIATION

6715 Kenilworth Avenue • Riverdale, Maryland

FOREWORD

This guide has been prepared by the National Asphalt Pavement Association as a guide to owners and operators of hot mix asphalt plants in the selection and proper use of equipment to meet the varying degrees of regulatory air pollution control with which they may be faced, now or in the future.

The Association recognizes the over-all air pollution problem and the fact that our industry is a contributor to this problem. The Association, therefore, recommends that all owners and operators of hot mix asphalt plants should establish good housekeeping procedures for maintaining their operations within reasonable air pollution standards. These standards may be established by regulatory agencies or the minimum acceptable in presenting a good public image.

If you desire further specific information, contact the headquarters of NAPA.

Prepared by
RESOURCES RESEARCH, INC.
Falls Church, Virginia

Table of Contents

GUIDE for Air Pollution Control of Hot Mix Asphalt Plants

CHAPTER I

Introduction

The pollution of our atmosphere is a matter of growing concern all over the United States. Reports of deteriorating air quality are to be found almost daily in the press. The classic air pollution episodes of a decade or more ago, such as the Meuse Valley, London, Los Angeles, and Donora, are being joined by reports of existing problems closer to home. Within the past five years, New York and the northeastern seaboard has been plagued by three serious episodes of long duration. Los Angeles is far from solving its problem. The daily newspapers as well as popular magazines have carried extensive reports of air pollution problems. The public is becoming aware and alarmed by what is happening to the air we breathe. Federal, state, and local governments are responding to widespread demands for remedial measures by enacting regulatory standards, codes, and ordinances applicable to all who contribute to the pollution problem. These regulations rapidly are being backed by well-staffed and informed agencies responsible for their enforcement.

Air pollution means different things to different people. As individuals we are aware of the results of polluted air because of possible health hazards, eye irritation, materials damage, nuisances, inconveniences, property devaluation, and esthetic deterioration. There are a number of harmful effects from air pollution on humans and on those objects in the human environment to which man attaches importance. Probably the most important effect of air pollution in general is the physiological effect of various pollutants on men and domestic animals, i.e., damage to their physical health. Closely related to this is the psychological effect on human beings; pollution can create fear and other psychological disorders which are detrimental to the efficiency and mental health of people. Agricultural damage from air pollution is a well-established fact, although there is still much to be learned about the degree of damage to crops and other vegetation occurring as a result of various concentrations and durations of exposure. Material damage is another important harmful effect; this type of damage is that caused to fabrics, paints, metals, and other materials we use. Lastly, reduction in visibility was one of the earliest air pollution effects noted, and it is still readily observed. Reduction in visibility can produce very definite economic losses, e.g., smog-bound airports have caused severe delays in air schedules, rerouting of planes, and sometimes air crashes. The same conditions on expressways in metropolitan areas have caused very severe congestion, delays for thousands of motorists, and many multiple vehicle accidents. *Air pollution, therefore, might be defined as the presence in the outdoor air of substances put there by the acts of man in concentrations and of a duration sufficient to interfere with the comfort, safety, and health* *of many or with the full use and enjoyment of his property.*

All of us contribute to pollution of the atmosphere. When people drive their automobiles, heat their homes, or burn their trash they reduce air quality. As we increase demands for and use of electrical energy, transportation, waste disposal, agricultural products, and manufactured products we contribute to air pollution.

Industry naturally comes in for its share of blame for the steadily increasing load of pollutants in the air, since industrial operations often are accompanied by visual evidence of undesirable emissions of smoke, fumes, and dust. The asphalt paving industry is widely distributed all over the country, with many plants in metropolitan areas which are plagued by serious air pollution from many sources. As might be expected, asphalt plants have not infrequently been the subject of complaints from the public.

The hot-mix asphalt plant is functional rather than decorative. Heating of the component materials and the grading, mixing, and transporting operations naturally produce dust, smoke and fumes. If the plant is located remote from dwellings or commercial developments, emission of these pollutants seldom causes complaints. However, many plants, which formerly were well isolated, have become engulfed by our rapidly spreading suburbs. It is therefore necessary for the plant owner to control the emission of dust and other pollutants, both in the interest of good community relations and to comply with ordinances, codes, and other regulatory measures which may impose penalties or actually shut down operations if not obeyed.

Fortunately, there have been many advances in equipment and knowledge dealing with the control of pollutant emissions in recent years. It is true that the addition of such equipment increases plant investment and operating costs, but there is little doubt that air pollution controls are here to stay. In fact, controls are likely to become much more stringent as the country grows in population and consumes all kinds of fuel at an ever increasing rate. For example, it has been widely predicted that vehicles burning gasoline or diesel fuel will be prohibited in the congested central areas of our large cities within ten to fifteen years. Asphalt plants, as well as other industries using fossil fuels, will be subjected to increasingly severe limitations on their operations.

CHAPTER II

The Hot-Mix Asphalt Plant

2.1 General

All-hot mix asphalt plants incorporate the following processes: conveying proportioned quantities of cold aggregate to a dryer, heating and drying the aggregate, screening and classifying the hot aggregate in hot bins, heating the asphalt, measuring and mixing the aggregate and asphalt in proper proportions, and finally delivering the hot mixture into trucks which haul it to the paving site.

2.2 Types of Plants

Hot-mix plants can be classified according to permanence of location or according to the method of measuring and mixing the hot aggregate and asphalt. Portable plants are designed to be readily dismantled and transported on trailers from one job site to another, whereas permanent (or stationary) plants are set up for efficient operation in a relatively permanent location, usually in a metropolitan area.

With regard to the final mixing process, plants are either of the batch or continuous mix type. Both types of plants have the same pattern of material flow up to the point of measuring the aggregate from the hot bins into the mixer. In the batch type plant, the operator weighs out the correct quantity of aggregate from each hot bin in succession into the mixer. The total batch of aggregate is then dry mixed in the pugmill for a prescribed time, during which time the operator proceeds to accumulate another batch in the weigh hopper. When the dry mix cycle is complete, hot asphalt is added to the mixer by either metering or weighing the correct amount. The hot asphalt may be sprayed or dumped into the pugmill, and upon completion of the proper mixing cycle, the hot-mix asphalt is delivered through a hopper into trucks hauling to the job site. Figure 2-1 shows a typical batch plant and identifies potential sources of air pollutants.

The continuous mix plant transfers a preblended mixture of the dried and graded aggregate from the gradation unit by means of a bucket elevator to the mixer. Dry mixing in the mixer is not required, as it is in the batch plant. The hot asphalt is sprayed on the aggregate as it falls from the top of the elevator into the mixer. The length of the mixing cycle in a continuous mix

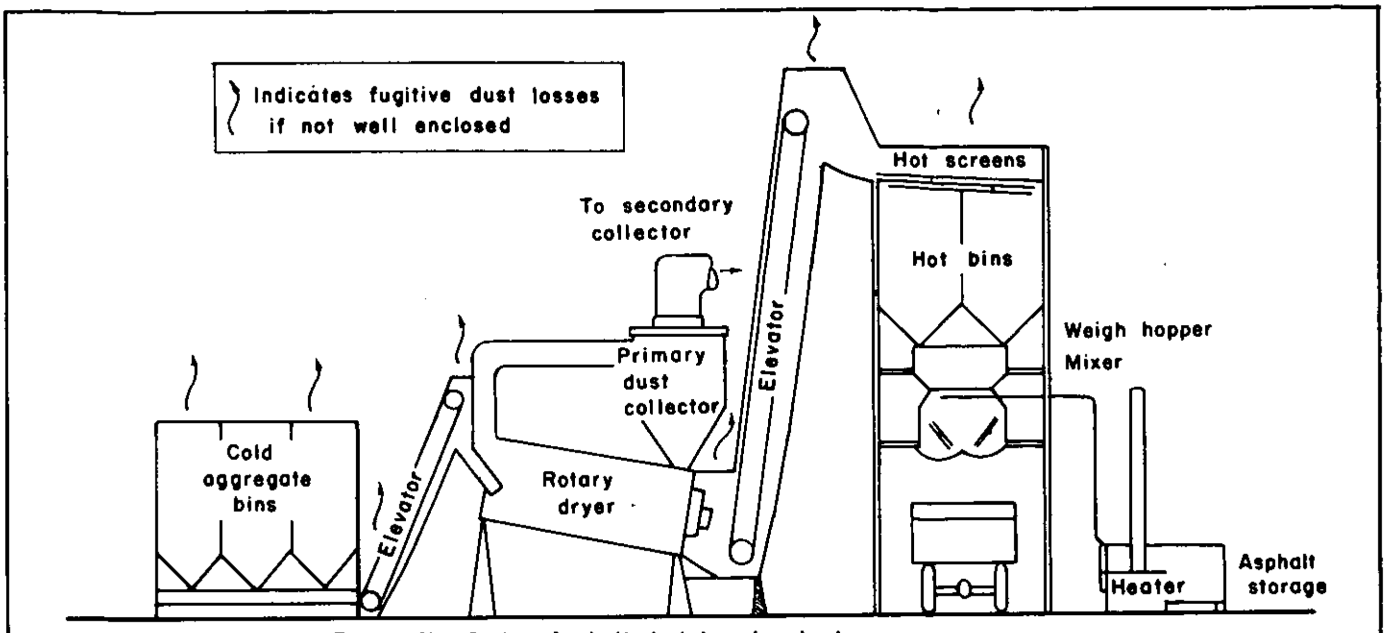

Figure No. 2-1 —Asphalt batch mix plant

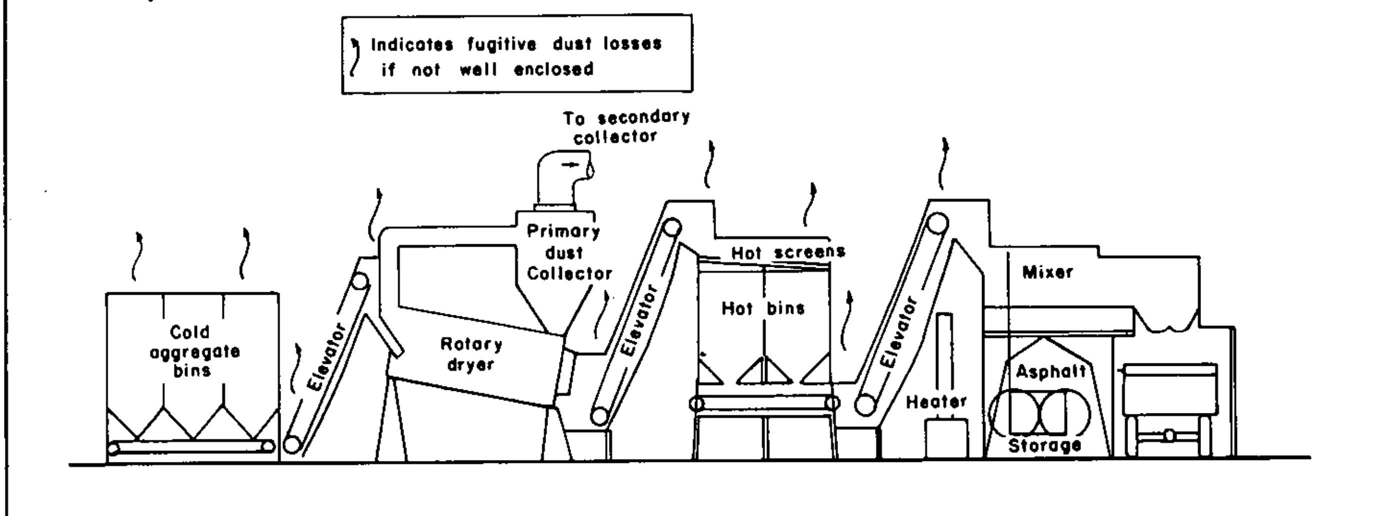

Figure No. 2-2 — Asphalt continuous mix plant.

plant is governed by an adjustable dam at the discharge end of the pugmill; the hot-mix asphalt flows over the dam into the discharge hoppers. Mixing time can be varied without changing the hourly tonnage output by varying the height of the adjustable dam. In Figure 2-2 a typical continuous plant is shown with potential sources of pollutants identified.

2.3 Air Pollutants: Sources and Types

2.31 General

Pollutants released to the air during the operation of an asphalt plant are both gaseous and particulate in nature. There are two types of gaseous pollutants: gases and vapors. A gas is a fluid which at standard temperature and pressure tends to expand indefinitely to fill completely the container in which it is located. It has definite weight but no definite shape or volume. A gas can diffuse and mix readily with other gases. A vapor is a fluid having identical properties of a gas but is liquid or solid at standard temperature and pressure. Particulates are either solid or liquid substances which are classified as to source, method of formation, or size. Their usual classification includes dusts, fumes, mists, fogs, and smokes. Particle size is an important characteristic of particulate matter as it plays a major role in the facility with which a particle can be removed from a gas stream, the length of time it will remain suspended in the ambient air, the distance it will travel, and the degree of retention or passage into the respiratory tract.

The gaseous emissions result from the combustion of fuel in the dryer burner and in the hot oil heater. There is also some release of odorous vapors from the hot asphaltic cement in the mixer and from the trucks hauling the mix from the plant. The particulate pollutants consist of dust, which forms the great bulk of pollutant emission, and smoke from the dryer burner and the hot oil heater.

2.32 Gaseous Pollutants

The combustion of fuel in the plant produces combustion products which vary with the type of fuel and the temperature and efficiency of combustion. The more important pollutants from the standpoint of quantities and toxic effects are carbon monoxide, oxides of sulfur (sulfur dioxide and trioxide), and oxides of nitrogen (nitrogen dioxide and nitric oxide). Of these gaseous pollutants, sulfur dioxide is probably the most troublesome. It is produced when fuel oil containing sulfur is used in the plant. When natural gas is used for fuel, the oxides of sulfur rarely create a problem.

Sulfur dioxide is a colorless gas, which in its pure state is about twice as heavy as air, that causes a choking sensation and respiratory irritation in both animals and humans. In sufficient concentration it can cause death, especially to persons or animals already having some respiratory difficulty. It is also damaging to vegetation growing in the vicinity of a source of sufficient intensity. The gas is formed when sulfur in the fuel combines with oxygen in the combustion air at the combustion temperatures.

Carbon monoxide is also a colorless gas, without odor, which is produced in any combustion device using gas or oil when there is inadequate oxygen to complete the oxidation to carbon dioxide. It is not produced in significant concentration unless the combustion process is very poorly managed; in a properly fired plant the carbon is almost completely converted to carbon dioxide, which is not toxic. It is unlikely that enough would be produced in a hot-mix plant to cause any trouble outside the plant.

The oxides of nitrogen are always formed when air, which is composed principally of nitrogen and oxygen, is heated by a high temperature flame (1500° Fahrenheit or more). Nitrogen dioxide is a colorless gas and is highly irritating to the eyes and lungs of animals and humans. The nitrogen oxides tend to combine with unburned hydrocarbons and other constituents of polluted air to form irritating components of smog when weather conditions favor smog formation.

2.33 Particulate Pollutants

Particulate pollutants involved in asphalt plant operations include stone dust, fly ash, soot, and unburned droplets of fuel oil. Stone dust is caused by the release of dust from the surface of the larger aggregate particles due to the heat and vibration of the dryer and other components of the plant and to some extent to the fracture of aggregate during the drying and screening processes. Its particle size ranges from about 0.1 micron to more than 100 microns. (74 microns = 200 mesh, 44 microns = 325 mesh and 1 micron = 1/25,000 of an inch.)

Fly ash and soot are solid particles formed during the combustion of oil or gas. Fly ash results from certain impurities in fuel oil which create a solid rather than gaseous combustion product. Particle size is about 1 to 100 microns. Fly ash production is related to the type of fuel, being much higher for the heavy residual fuels like Bunker C. Soot consists of unburned particles of carbon, which results from an insufficiency of oxygen to oxidize all of the carbon in the fuel. Careful control of the fuel-air mixture can eliminate soot formation. The particle size range of the basic carbon particles is below 1 micron, but there is an agglomeration of "piling-up" when small particles of soot collide, resulting in fluffy particles which are much larger. Black smoke is essentially very fine soot in suspension, although some fly ash and dust is often present.

Unburned fuel oil droplets may be emitted from the stack or coated on the aggregate in the dryer if the management of combustion is poor. These droplets may range from about 1 to 100 microns. As they are sticky, other contaminants may cling to them upon collision and cause larger particles to build up. The incomplete atomization of the fuel oil, due to a poorly functioning atomizer or insufficient heating of the heavier oils, is basically the cause of this type of pollutant emission.

Dust originating in the aggregate is the major atmospheric pollutant from asphalt plants. The principal source of this dust is the rotary dryer. The primary dust collector is considered as an integral part of the drying system, since the dust collector fan or fans furnish most of the draft that draws the flame and hot gases through the dryer. The fine material collected by the dust collection system is often returned to the mix, unless it is found to be unsuitable and prohibited by the specifications. Other important sources of dust are the vibratory screens, unenclosed bucket elevators, weigh hopper, storage piles and bins, and traffic dust from the yard. Included among the particulate pollutants are soot and unburned particles of fuel in the smoke from the dryer and hot oil heater.

The hourly productive capacity of the dryer can be raised by increasing the heat from the burner and the drum gas velocity. However, the dust carried out of the dryer into the dust collection system increases rapidly with a rise in drum gas velocity. In figure 2-3 may be seen the effect of increasing drum gas velocity on the dust carryout for a typical aggregate. For example, increasing the drum gas velocity by 50% (from 600 feet per minute to 900 feet per minute) can increase the dust carryout by approximately 125%. Above 900 feet per minute the rate of increase is even greater. It will be readily apparent that keeping the drum gas velocity reasonably low tends to minimize the problem of dust removal.

Figure 2-4 shows a fairly typical particle size distribution in the cold aggregate being fed to the dryer and in the dust reaching the dust collector after the drying operation. The particle sizes in this chart, from 1 micron to 100 microns, are the sizes with which dust collection in asphalt plants is most concerned. For comparison with standard screen sizes, minus 200 mesh material is equivalent to minus 74 microns. In the gradation shown, it will be noted that about 5% of the cold aggregate is minus 200 mesh. The dust reaching the primary dust collector is about 70% minus 200 mesh; this is the fraction of greatest interest in air pollution control. Washing of aggregate reduces potential air pollution difficulties by removing a substantial portion of fine dust that would otherwise escape to the atmosphere.

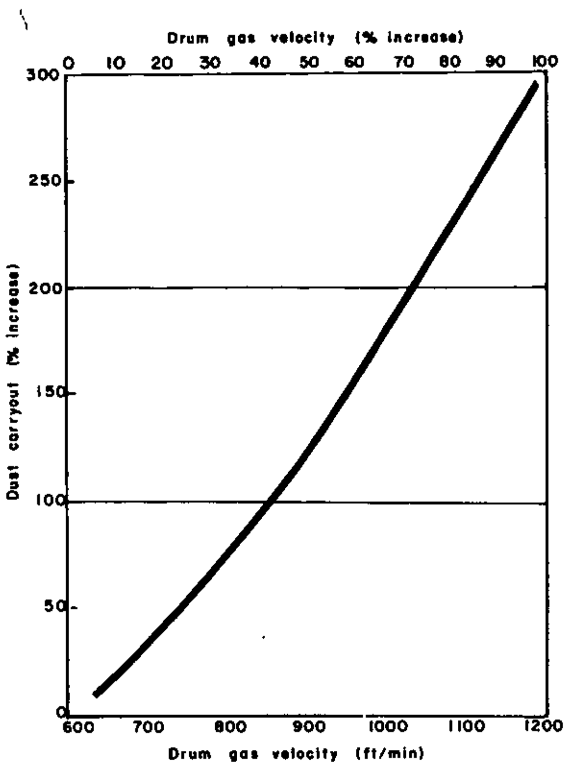

Figure No. 2-3 — Effect of drum gas velocity on dust carryout.

(Barber — Greene Co.)

Particulate contamination is principally a matter of causing "dirty conditions," i.e., the coating of dusty, sooty, and sometimes sticky particles on houses, furniture, curtains and drapes, clothing, skin, vegetation, and many other surfaces where they are objectionable. The smaller particle sizes tend to remain in suspension much longer than the coarser particles and to spread over a much wider area. The heavier particles will be deposited quickly within a half-mile or so of the plant and will cause much more intense soiling of surfaces than the particles of 1 micron size and below,

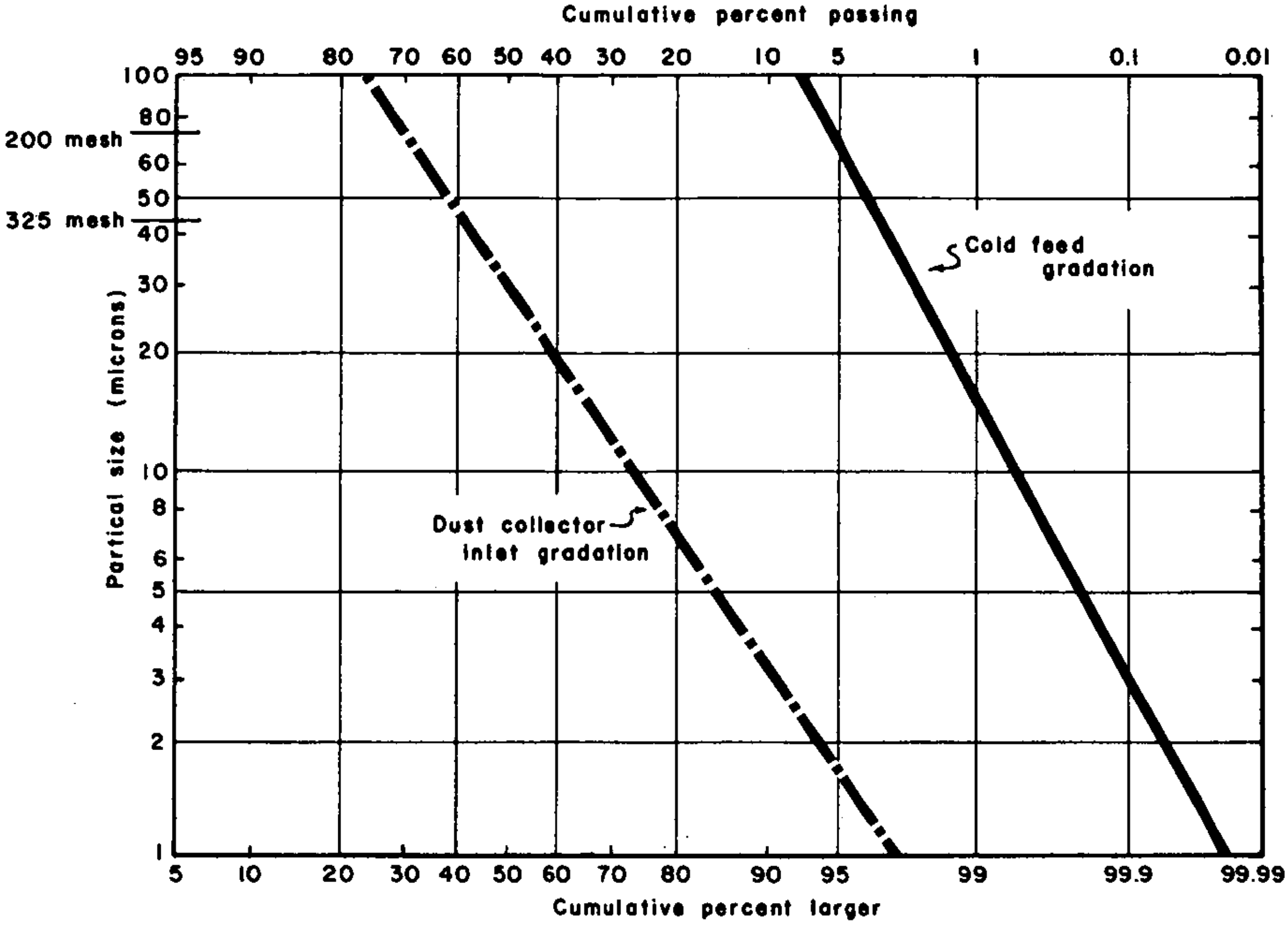

Figure No. 2-4 — Typical cold feed gradation and primary dust collector inlet gradation.

which may drift with the wind for hours and even days. When particulate contamination is heavy, irritation to human and animal respiratory systems may result, and chronic or acute disease may be caused. Fine particles in suspension may cause visibility interference directly or may stimulate the formation of fog by acting as condensation nuclei.

CHAPTER III
Air Pollution Control

3.1 General

The control of emissions from asphalt plants is desirable and necessary from several aspects. Public health authorities at the federal, state, and local levels are requiring increasingly stringent emission standards from industry in order to reduce the health hazards to people breathing the smog and foul air occurring more and more often in many metropolitan areas. Community tolerance of industrial smoke and grime has also become less, due in part to greatly increased publicity given to the detrimental effects of air pollution. Workers in a dusty, grimy plant are likely to be dissatisfied and to seek other employment, and the skilled workers who are the most difficult to replace will probably be the first ones lost. There may be excessive absenteeism and even chronic ill-health among them, under severe conditions. Excessively dusty conditions also have adverse economic effects on plant operations, as the dust tends to reduce the life of many plant components by causing excessive wear on moving parts, and the loss of needed fine material for the mix may often require the addition of expensive mineral fillers.

It is possible to reduce the quantity of dust and other pollutants emitted from the plant to acceptable residuals by the use of control equipment now available and by good maintenance and housekeeping. There is considerable variation in codes regulating asphalt plant emissions. The owner of a plant should be prepared to meet the standards imposed at any location where he is likely to operate.

Economic considerations make it desirable that dust collection be accomplished in several stages. *A primary collector capable of removing about 50 to 75% of the stack dust by weight is considered as the minimum under all operating conditions.* It will be necessary under virtually all urban codes to use one or more types of secondary collectors to obtain an acceptably low dust emission level. *However, the use of secondary collectors in isolated areas where their high dust removal capacity is not required will increase operating costs and depreciation.* Careful control of combustion will reduce the emission of pollutants which are products of combustion, such as soot, unburned oil particles, and carbon monoxide. The use of automatic burner controls on both the dryer and the hot oil heater will tend to keep burner efficiency high, minimizing pollutant output from this source as well as economizing on fuel. Dryer burners using gas are much less prone to combustion problems than those using oil for fuel, but gas is not available at competitive prices at many locations.

3.2 Air Quality Objectives and Regulations

The objectives of air pollution control in asphalt plants are basically the following:

A. To limit the emission of dust and other pollutants to the levels required by codes or ordinances applicable to the plant and locality;

B. To prevent the addition of dust and other pollutants to the air of neighboring communities to such an extent as to cause complaints and *unfavorable public relations;*

C. To provide reasonably comfortable and healthy working conditions for the employees of the plant;

D. To reduce as far as economically feasible the wear on plant equipment from dust generated in the processes and to reclaim useful fine material for the asphalt mix in order to minimize the cost of added mineral fillers.

Obviously, these objectives are not in conflict with each other. In general, compliance with codes in most urban areas will have the effect of accomplishing the other objectives listed. For plants located in isolated areas, the first two objectives may be readily and inexpensively attained, but efforts to economize on control measures by providing the minimum required by regulatory agencies may result in unsatisfactory conditions within the plant area.

Air pollution control codes and regulations affecting asphalt plants frequently use a combination of opacity standards of smoke and dust plumes by visual observation and of measured amounts (by weight) of dust and other particles emitted from the stacks of the plants. The visual method is rather inaccurate in determining how much polluting material is actually reaching the free air, since black smoke tends to appear more dense and opaque to the observer than white dust for a comparable weight of particles per unit volume. However, the standard method now in use for measuring the opacity of the exhaust plume, Ringelmann's Scale for Grading the Den-

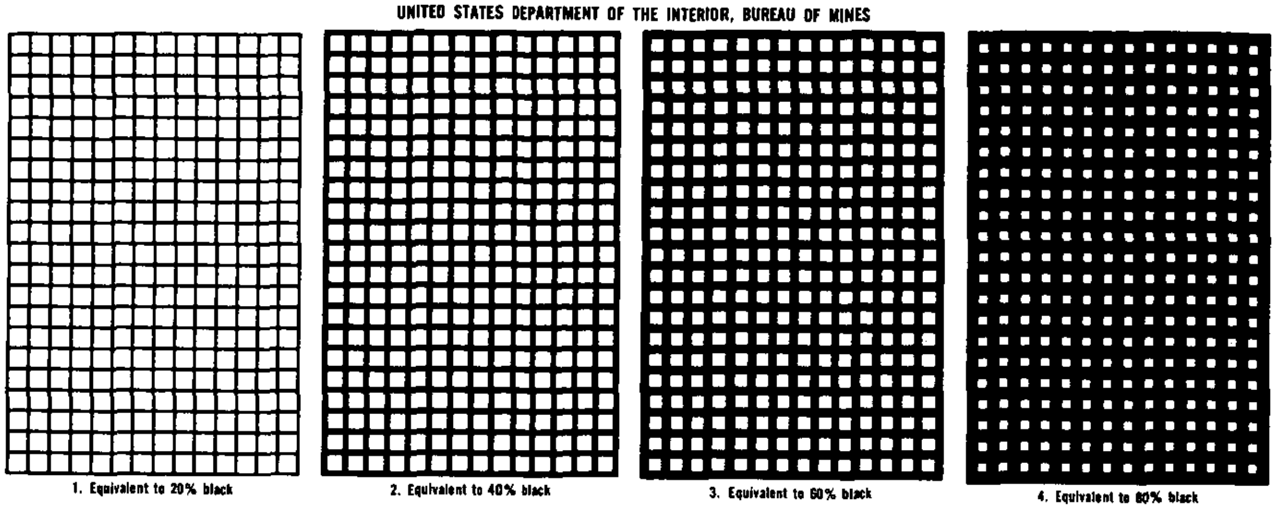

Figure No. 3-1 — Ringelmann Smoke Chart

sity of Smoke, will undoubtedly remain in many codes for some time to come. Ringelmann's Scale is shown in Figure 3-1. A further discussion of its use in controlling air pollution is in Chapter IV.

There is a trend toward more definite and enforceable standards based on the quantity of particulates issuing from the stack. The most common requirement involves setting an upper limit on the weight of the particles that can be emitted per unit weight or unit volume of the carrier gas. Another type of standard relates the quantity of particulates emitted to the process weight of the material in production. Los Angeles County has a sliding scale which limits such emissions to an average of approximately one pound per thousand pounds of process material (i.e., total weight of hot-mix asphalt) under 30 tons per hour, with a ceiling of 40 pounds per hour of particulates above that level of production. Los Angeles County also sets a limit on the stack concentration of 0.4 grain per standard cubic foot of carrier gas. In the State of New Jersey, there is an unusual approach to air pollution due to solid particles. The standards there differentiate between material coarser than 44 microns and that finer than 44 microns. Coarse dust may not be emitted in a concentration which will result in the deposit of more than 200 tons per square mile per year in any area off the premises of the plant. Fine dust is limited to a concentration of 0.615 milligram per cubic meter of air as measured at a point 10 stack lengths downwind from the plant. The trend in other states and metropolitan areas is toward adoption of standards similar to those of Los Angeles County, which is generally considered to be among the more advanced communities in air pollution control. It should be realized that changes in requirements are being made constantly as the people and their elected representatives become more aware of air pollution. *Before a plant is set up in a new location, the operator should determine exactly what requirements are in effect.*

3.3 Pollution Control Measures

3.31 General

For convenience, collection equipment may be divided into two groups: dry collectors and wet collectors. Only dry collectors are suitable for use as primary collectors, if the fines collected are to be returned to the mix, as is usually the case. Most wet collectors use a mist or fine spray of water to wet the dust particles in the exhaust stream, forming a sludge which must be ponded or otherwise disposed of away from the plant.

The approximate collection efficiency of a number of types of dust collectors used in asphalt plants, assuming that the dust is a typical stone dust, is shown in Figure 3-2.

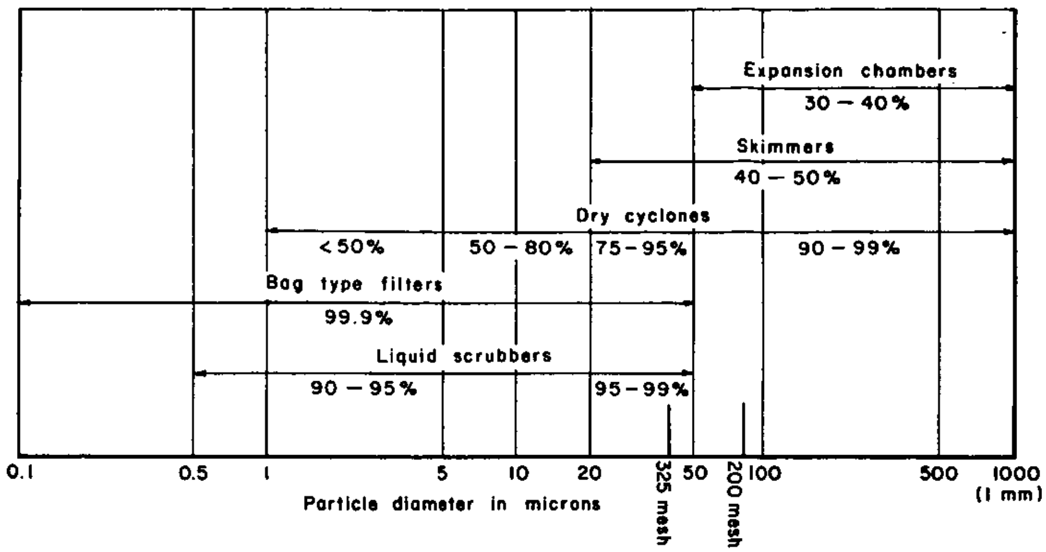

Figure No. 3 - 2 — Approximate efficiency ranges for various types of dust collectors.

3.32 Dry Collectors

Of the many types of dry collectors used in asphalt plants, the expansion chamber is the simplest. This type of collector is designed to cause the fallout of dust from exhaust gases by an abrupt large increase in the cross-sectional area of the exhaust system, with a corresponding drop in the velocity of the gases. When the velocity is reduced to a very low value, the larger particles settle out by the action of gravity. If there is a series of horizontal plates in the chamber, the settling distance is reduced and efficiency is thereby increased, as the time available for settling has an important effect on efficiency of collection.

The skimmer is basically an expansion chamber with the addition of one or more baffles to change the direction of the gas stream, resulting in increased efficiency. The impinging of dust particles on the baffles further reduces their velocity, causing more and smaller dust particles to be deposited from the gas stream. Expansion chambers and skimmers rarely achieve an efficiency of dust removal as great as 50% by weight, which is often inadequate to meet today's standards, even in isolated areas. The smallest particle that can be collected by the usual simple expansion chamber is about 40 microns in diameter. Multiple tray chambers and skimmers can ordinarily collect particles of 15-20 microns diameter or larger. Of course, these devices do not collect *all* of the particles of the given size or larger, but they do collect none smaller than those sizes.

The great majority of primary dust collectors used in asphalt plants are of the type known as cyclones. A cyclone is basically an upright cylinder with a conical bottom, into which the gas stream is introduced near the top through a tangential inlet so that the dust particles are thrown out of the gas stream against the smooth walls of the cyclone and slide down the walls to a discharge chute or collecting screw conveyor. Centrifugal force is the main factor in removing particles from the gas stream; thus, with other conditions the same, a cyclone of smaller diameter will remove a greater weight of particles and particles of smaller size than one having a larger diameter. The gas stream in the process of being cleaned spirals down the wall of the cyclone; upon striking the bottom it reverses direction, moves in a spiral fashion up through the center of the cyclone, and is drawn out through a central duct emerging through the top. The considerable length of travel of the stream in the downward spiral and the reversal of direction at the bottom causes a much higher proportion of small and light particles to fall out of the stream than is the case with the expansion chamber or skimmer. As the partially cleaned dust-laden gas spirals up the center of the cyclone, some of the whirling dust does not enter the outlet pipe. These dust particles either rejoin the gas stream coming into the cyclone, or they may be skimmed off by a device designed to return them directly to the collector at the bottom of the cyclone. As a general rule, the efficiency of a cyclone increases with an increase in the dust loading, gas inlet velocity, length of the cyclone body, or with the ratio of body diameter to gas inlet diameter. Except for the increase in body length, the factors which increase efficiency also increase the pressure drop in the system.

Large diameter cyclones have a number of advantages as primary dust collectors. They are simple in design and relatively inexpensive for the required volume of flow. There is little tendency to clog, and they cause a small pressure drop in the system. The efficiency in dust removal may range from about 60% to 80% by weight, depending on the grain size distribution of the dust and on the diameter and design of the cyclone (Fig. 3-2). A large diameter cyclone may have an efficiency by weight in collection of material greater than 40 microns of 95 to 99%, but its efficiency on material less than 5 microns in diameter will probably be below 50% by weight. Figure 3-3 shows one type of large diameter cyclone, with a bypass channel near the top to shave off some of the fine dust near the top center and return it to the bottom.

Higher efficiency in collection can be obtained by using a somewhat smaller diameter cyclone; this requires increasing the number of units needed to handle the same gas flow as could be handled by a single large cyclone. Medium diameter cyclones (normally about 18 to 30 inch) can be used in groups of 2 to 12 cones as either primary or secondary collectors. Their overall efficiency usually falls in the range of about 80 to 95% by weight. Medium diameter cyclones do not collect much more of the material above 40 microns than large diameter cyclones, but their efficiency below 40 microns is considerably improved. Since 60% or more of the dust by weight may be smaller than 40 microns (See typical distribution in Figure 2-4), this improved efficiency on the smaller particle sizes is significant. A group of six medium diameter cyclones, which is capable of efficient primary dust removal in plants in the 100-200 tons per hour range, is shown in Figure 3-4.

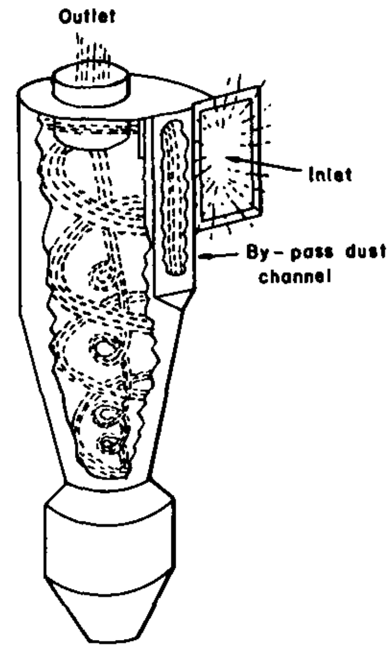

Figure No. 3-3 – Single primary cyclone (Buell engineering Co.)

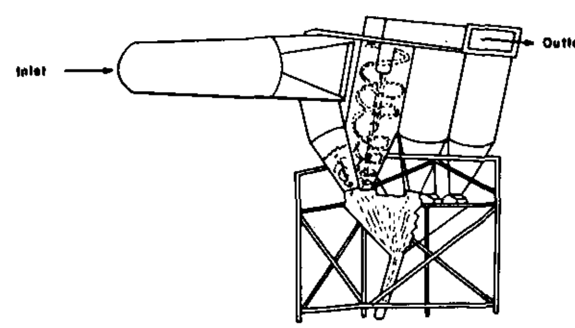

Figure No. 3-4 – Group of six medium cyclones (Barber-Greene Co.)

Multiple tube cyclones, which may include as many as 50 units with a diameter of 6 to 8 inches, have a very high overall efficiency on a weight basis of about 90 to 95%. The high velocity of the spiralling dust stream tends to cause problems of erosion, and if there is fuel oil mist or even a small amount of moisture present, clogging of the tubes may become a problem. Smoothness of the inner walls is of greater importance in small diameter cyclones than in large ones, as the small eddies caused by roughness will tend to re-entrain the smaller dust particles which the smaller diameter units collect more efficiently than the larger ones. Multiple small diameter cyclones rarely are used as primary dust collectors because of the maintenance problems and the high pressure drop, but they do find applications as the secondary collector or as an intermediate collector (dry secondary) before the final wet collector (scrubber), when very high collection efficiency must be obtained.

Two other types of dry dust collectors are the bag type dust arresters using multiple tubular cloth filters and electrostatic precipitators. The multiple tube filter assemblies, usually termed "baghouses," are quite efficient in removing particulate material. They are rather bulky and are much more suitable for permanent plants than for portable ones, although small portable units are made. The actual filter units are made of various fabrics, usually woven of cotton and synthetic blends or all synthetic material, often treated with silicones or other chemicals, and are formed as cylinders or envelopes on a metal frame. Various designs may call for filtering the gas stream from inside the sleeve to outside or may just reverse that direction. Most of the dust layer which builds up on the surface must be removed periodically by shaking the tubes, stripping them by circular moving bands or by other procedures; the removal may be manually or automatically controlled. The tubular sleeves in a baghouse may vary in diameter from 5 to 20 inches and may be as long as 30 feet. The number of bags needed to handle secondary dust collection in a 150 ton per hour asphalt plant may be more than a thousand, and the baghouse may weigh 15 to 20 tons. The collection efficiency of these assemblies will usually be better than 99% by weight, and the minimum particle size removed will be around 0.1 micron or less.

Electrostatic precipitation units do not find much application to asphalt plants, since they have a rather high first cost, have large space requirements, and are most efficient with low dust loadings. There is also a possibility of an explosion hazard if combustible particles reach the precipitator. They can usually achieve 98 to 99% efficiency in the particle size range of 0.1 to 50 microns. They have the advantages of low pressure drop and not particularly high operating costs.

3.33 Wet Collectors

Wet collectors, as used in asphalt plants, constitute either all or a part of a secondary collection system. There are a great number of types of industrial wet collectors available; they are collectively known as "scrubbers." Those in most common use in asphalt plants are in two principal groups:

A. Centrifugal types
B. Impingement types

Centrifugal type scrubbers are in wide use in the asphalt paving industry and generally give good results without serious maintenance problems. They may be single or multiple spray chambers into which the dust-laden gas stream is introduced tangentially. There may be as few as five or as many as sixty spray nozzles in each chamber. There is also at least one type that uses a single large spray nozzle and orifice plate to form a turbulent mist in a contact chamber before the gas stream enters the centrifugal spray tower. Some centrifugal scrubbers have smooth inner walls, while others have fluted walls to provide additional impinging surfaces for the wetted dust particles. There is some removal of any soluble gaseous pollutant by absorption of gas into the mist and fine droplets of spray as the pollutant-carrying gas stream moves through the scrubber. For instance, some of the sulfur dioxide caused by sulfur in the fuel is taken out in this manner by a mist of water alone. If ammonia is added, chemical reactions take place in addition to the physical absorption, resulting in greater removal of sulfur dioxide. Both the gaseous and particulate-carrying water particles form a film of sludge on the walls which flows down to a sump on the bottom and is removed, either continuously or at frequent intervals. One type of centrifugal scrubber is shown in Figure 3-5.

Impingement type scrubbers utilize various systems of baffles in a spray chamber or tower in which the gas stream is forced to travel in S-

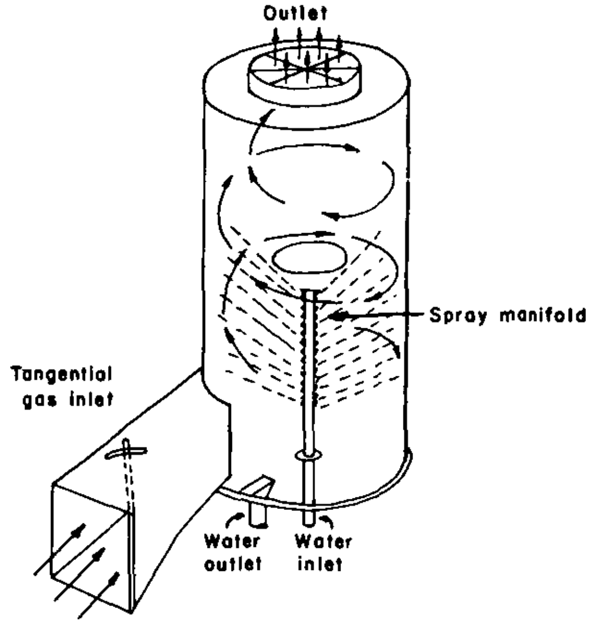

Figure No. 3-5 — Centrifugal spray tower (Chemical Const. Corp.)

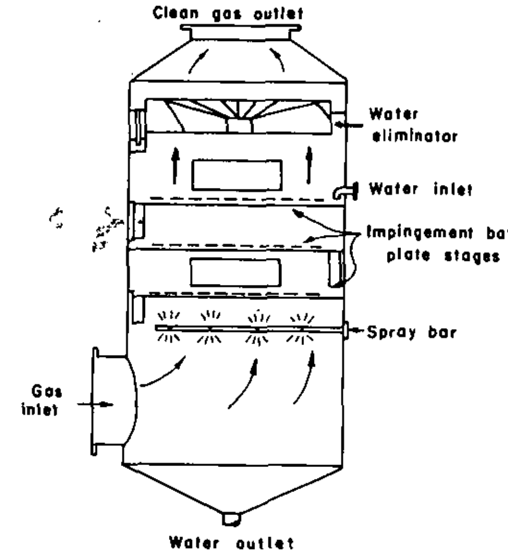

Figure No. 3-6 — Impingement scrubber tower (Peabody Engineering Corp.)

shaped patterns, resulting in impingement of the wetted particles of dust against the baffles and sides of the chamber. In Figure 3-6 the baffle plate tower is especially designed for particulate removal. The incoming gas stream is first humidified by a fine mist from the spray bar just inside the inlet. It then passes upward through perforations in a series of plates, which are covered with a layer of liquid, which is prevented from flowing through the perforations by the jets of up-flowing gas. Small baffles are placed over each perforation to cause the wetted dust particles to impinge upon them and drop into the liquid layer, which gradually moves across the plate and flows down on the walls to a sludge sump, from which it is continuously removed. The flow of water to spray nozzles and plate layers of liquid will vary with different types and designs of impingement scrubbers from 100 to 300 gallons per minute and pressure will vary from 50 to 100 pounds per square inch.

Other scrubbers used to some extent are the dynamic type of scrubber which uses a combination of wetting and mechanical impingement action, and packed towers, which use layers of ceramic shapes, crushed rock, metal mesh, or various types of rings, flooded with water or other scrubbing liquid, through which the gas stream is forced to follow a twisting path. The packed tower is especially useful in absorbing gaseous pollutants and fumes, but clogging can become a problem at dust levels frequently found in secondary inlet streams in asphalt plants.

There are so many variables in the design of scrubbers and in the dust loading from the primary that the efficiencies of wet collectors will show considerable variation. In general, a properly designed and operated combination of primary cyclone and secondary scrubber should have an overall collection efficiency on asphalt dryer dust of better than 95% and may frequently exceed 99% by weight. As a rule of thumb, the more power the collector actually uses, the better efficiency you will receive from the wet collector. This would include the power needed to atomize the wash liquid and the power needed to move the gas stream through the collector.

3.34 Fugitive Dust Collection

Although the dryer is the major source of dust and other pollutants generated in the asphalt plant, there is an appreciable amount of dust given off from other plant components such as the cold aggregate conveyors, bucket elevators, and vibratory hot screens. Dust given off from components other than the dryer is termed "fugitive dust," and it must be collected to the maximum extent feasible if emission standards are to be met.

It is necessary that all moving assemblies handling the cold or heated aggregate be isolated from the free air by a system of hoods, covers, and ducts, with appropriate booster fans when required, and that this fugitive dust collection system be connected to feed into the primary dust collector together with the dryer dust. Fugitive dust will usually amount to about ten percent of the total dust output of the plant. The design of fugitive dust collection systems is highly specialized.

3.35 Improving Combustion Efficiency

Some of the combustion products from the burners of the dryer and the hot oil heater contribute to air pollution, while most are harmless. About 99% of the stack gasses consist of carbon dioxide, nitrogen, and oxygen, which are all nontoxic. However, there are small but often significant amounts of other gases, such as sulfur dioxide and trioxide, nitric and nitrous oxides, aldehydes, and carbon monoxide, which are definitely pollutants. The oxides of nitrogen are formed from atmospheric nitrogen and oxygen upon exposure to a hot flame, and one or both of the oxides of sulfur are formed if sulfur is contained in the fuel. The production of these polluting gases cannot be prevented by improving the efficiency of combustion.

On the other hand, carbon monoxide, smoke, and irritating aldehydes are products of incomplete combustion, and their presence shows that insufficient oxygen is being provided for the flame. Another undesirable constituent of the stack gas is unburned fuel in the form of mist or very small droplets. All of these pollutants indicate waste of fuel and incomplete combustion.

The appearance of the plume issuing from the stack is not necessarily a reliable indicator of the amount of polluting gases and solids. Carbon monoxide is colorless, and relatively large (about 100 microns) particles of fuel or dust moving at high speed may tend to cause little light scattering and thus be almost invisible. However, dark smoke being emitted for an appreciable time after starting up is good reason to question the combustion efficiency.

Gas fired dryers or heaters do not usually present a serious problem. They are carefully designed so that the burners provide complete combustion, and they have to pass rather rigid tests before approval by the American Gas Association. Also the nature of the fuel is such that it can be burned completely with relative ease. Maintaining the burner in a clean condition is usually all that is necessary to keep it at peak efficiency. If acrid odors or eye irritation are noted in the vicinity of the exhaust, aldehydes are present and combustion is not as complete as it should be. In such a case the burner should be adjusted to give a higher air to fuel ratio.

Oil fired equipment can cause difficulty unless all components of the burner and accessories are kept clean and properly adjusted at all times. Fuel oil must be atomized before being burned, and the heavier grades must be preheated before being fed to the atomizer. The degree of preheating must be kept just right, neither too high nor too low for the type of fuel being used. Fuel oil furnished by different refineries may have different characteristics, and adjustments may have to be made if the brand is changed. More frequent checks, adjustments, and maintenance by experienced personnel is usually required with oil fired burners than with gas, as improper combustion may be caused by worn or clogged nozzles, partially plugged air supply, insufficient atomizing pressure, improper preheat temperature for the fuel used, or overloading (firing in excess of the design rate). As with gas burners, acrid odors and eye irritation are signs of incomplete combustion and of increased emission of pollutants.

3.36 Area Dust Control

Even though the asphalt plant equipment is well designed and well maintained, so as to provide a very satisfactory stack exhaust, the effectiveness of its dust collection system is lost if the housekeeping of the plant area is poor. Two principal operations can generate excess dust: (1) handling large quantities of aggregate, and (2) heavy truck traffic on access roads and in the area.

Adequate attention should be given to dust control measures appropriate to the conditions under which the plant is operating. In a permanent plant, paving of all areas subject to traffic by haul trucks in and adjacent to the plant will be a worthwhile investment. Careful attention should also be given to dumping of aggregate to minimize dust emission during this operation. Wetting down the aggregate with a sprinkler or hose just before or during the dumping is helpful in preventing excessive dust; the water added will be less than that of a single brief shower. In portable plant sites, oiling the roads and trafficable areas or running a sprinkling truck around during dry weather will prevent the dust from becoming a nuisance and possibly a pollution control violation. If there are waste dust piles from plant operations, they should be located so as to minimize their disturbance by wind or normal plant operations, until they can be removed from the area. Attention to all these suggested housekeeping activities does not cost much and will pay handsome dividends on an air pollution control inspection.

CHAPTER IV
Meeting Air Pollution Control Objectives

4.1 Methods of Checking Compliance

The basic objective of air pollution control codes and regulations is to obtain air quality in the community which will not be objectionable from a health, comfort, or esthetic standpoint. In almost all cases, however, there are a number of contributors to air pollution in the community, and it is seldom easy to determine the degree to which each is contributing undesirable materials to the overall level. The usual approach has been one of identifying the sources as far as practicable and of prescribing limits to the quantities of air pollutants that each may emit during a given period. If these regulatory emission standards do not result in satisfactory air quality, the standards are reexamined and made more restrictive.

If the appearance of the stack emission is dark or opaque to light, it is frequently subject to an emission opacity regulation. In almost all cases, the standard used is the Ringelmann Chart, a scale for rating the density of smoke. A trained observer, standing on the ground, can rate the appearance of a stack plume to that of a chart having varying degrees of grey. Instruments have also been developed to measure stack appearance but have not had widespread use.

To measure the dust and other solid particles from the stack, a special sampling procedure is required involving the measurement of the gas flow, temperature, sampling rate and pressure. Flow measurements are usually made using a pitot tube (Figure 4.1). Two standard types are available. A detailed description of the use of the pitot tube is given in Appendix II.

Equipment required to obtain a representative sample of dust includes a probe, collecting thimble, impinger bottles, a differential manometer, a dry gas meter and a pump. Figure 4-2 shows a differential manometer and impingers. A number of sampling manuals are available which describe the procedures in detail. The weight of dust is related to the gas volume and is generally described in grains per cubic foot or pounds of dust per 1000 pounds of gas.

Sampling for gaseous contaminants, such as sulfur dioxide, uses generally the same procedure as for dust, except that isokinetic sampling is not required. Collection devices for gases are different from those used for solid particles. Absorption devices such as gas impingers or fritted bubblers are often used to cause a known percentage of the gas molecules to be dissolved in the collecting liquid. Filters are not suitable for gaseous contaminants.

It is beyond the scope of this manual to describe completely all of the techniques used in sampling. Additional information may be obtained on details of sampling procedures and devices from *Air Pollution,* edited by A. C. Stern, Academic, Press, New York, 1962; and from *Method for Determination of Velocity, Volume, Dust and Mist Content of Gases.* Bulletin WP-50, Western Precipitation Corp., Los Angeles, 1956.

4.2 Compliance with Minimum Objectives

In general, the more liberal codes dealing with emission standards for asphalt plants exist in those states and communities where air pollution problems have not yet become acute. There are and will doubtless continue to be different standards for non-urban areas with very low population density and for the urban areas where air pollution is now serious. Even in relatively isolated sections, there are certain control measures regarding plant operation which are either currently required or are likely to be in the near future.

The minimum control measures include combustion control (smoke abatement), primary dust

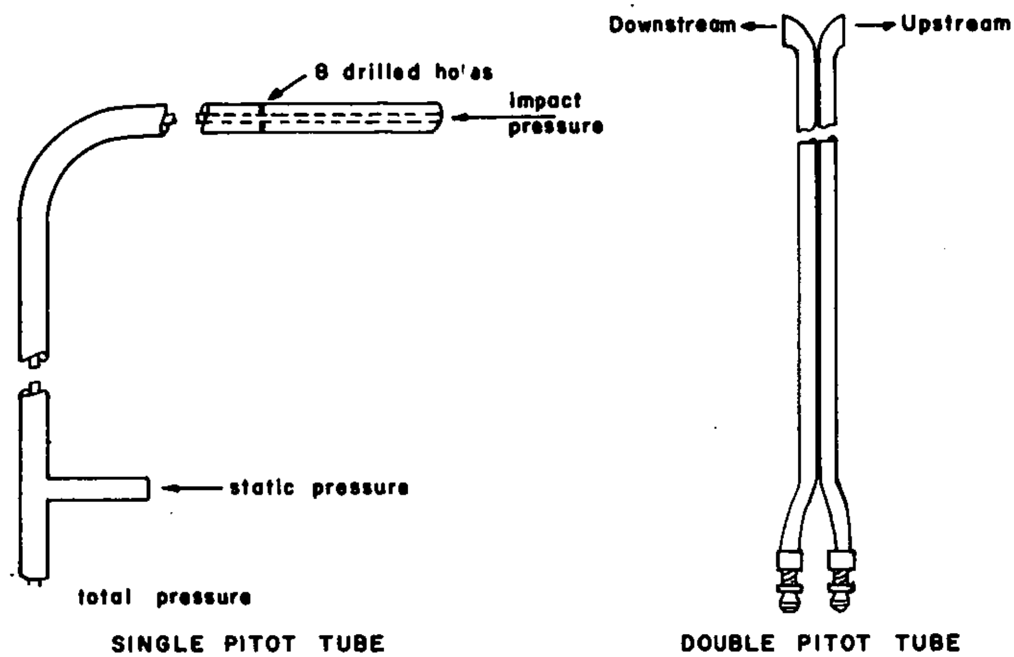

Figure No. 4-1 – Sketches of single and double pitot tubes

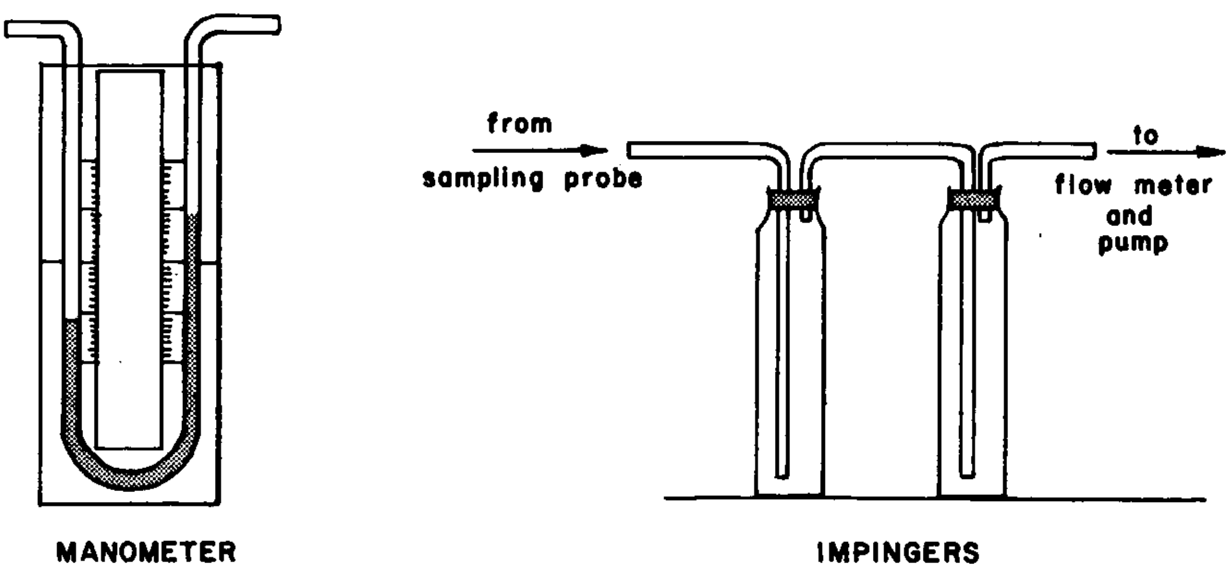

Figure No. 4-2 – Sketches of differential manometer and impingers collection, and measures to safeguard the health of employees. In some states the third type of control measure is covered in industrial health regulations or codes, rather than in those dealing with air pollution control.

4.21 Combustion Control

The combustion of fuel in asphalt plants is involved in two principal operations: drying the aggregate and heating the asphaltic cement before mixing. Fuels used include natural or manufactured gas and several grades of fuel oil. Gas burners may be of the high or the low pressure type. Oil burners may be of the high or the low pressure type. Oil burners are of the low pressure air atomizing type or the high pressure steam atomizing type. Low pressure combination oil and gas burners are being increasingly utilized in portable plants, to provide flexibility in operation when setting up the plant in various locations. The hot oil heater for conditioning the asphalt prior to mixing usually has the same basic type of burner as the rotary dryer.

Gas burners seldom present serious problems in combustion control. It is important that the burner be carefully matched to the pressure of gas available. With high pressure gas burners care must be taken to insure that draft pressure in the dryer or hot oil heater remains in balance with the gas pressure, so that "puff back" at the burner does not occur. It is possible for dark smoke to be created by a gas burner if the air supply to the burner is severely restricted. The design of the equipment is such that this will not happen if routine maintenance takes care of keeping the burner clean and free of obstructions.

Fuel oil is available in grades 1, 2, 4, 5, and 6, the higher numbers having higher viscosity. The composition of these grades is not uniform all over the country, but depends on the kind of crude oil used, economic factors, and techniques of cracking. The lighter oils (with lower numbers) are more highly refined, have reduced sulfur content, and are therefore less likely to cause air pollution problems. Residual fuels such as No. 4 and No. 6 (also known as Bunker C) have a certain amount of solids in dispersion, which may result in fly ash and soot if combustion is not highly efficient. These heavier oils are also higher in sulfur content, as a rule, and this may cause excessive sulfur dioxide concentrations in the stack gases. Heavy oils require preheating for proper atomization of the fuel in the burner.

Since fuel oil must be atomized, the adjustment of burner controls must be watched more carefully than with gas. It is important that the proper grade of fuel oil be used and that the oil not be contaminated. As with gas burners, the draft air must be in balance with the burner air, so that back pressure does not cause "puff back."

Black smoke issuing from the stack is a sign of incomplete combustion and wasted fuel. When the dryer is cold there will be a certain amount of unburned fuel in the exhaust; this cannot be entirely avoided when starting up. In general, state and local codes require that the exhaust from the stack be not darker than Ringelmann No. 2, except that it may be darker than No. 2 but not darker than No. 3 for not more than 4 or 5 minutes in any one hour. To meet this standard, especially with the heavier oils, combustion equipment must be kept clean and well adjusted at all times. If dark smoke is observed at any time other than the initial firing up, adjustments must be made to increase the air-fuel ratio by either decreasing the fuel supply to the burner or increasing the burner or draft air supply.

4.22 Primary Dust Collection

In non-urban areas where asphalt plants may be set up in locations convenient to paving projects but isolated as far as possible from residences, a number of states permit dust collection to be limited to primary collectors such as dry cyclones. Usually no limit is placed on the quantity of dust emitted from the stack in such cases, provided that the plant is located so that not more than one or two residences lie within a one-mile radius from the point of emission. The quantity of dust emitted per hour with only primary collection can be quite large. In a 150 ton per hour plant, it can be expected that 3 to 5 tons per hour of dust, almost all minus 200 mesh (74 microns), will be fed to the inlet of the primary dust collector. A reasonable efficiency for a large single cyclone with a low pressure drop would be about 75%. This would mean that, if an average figure of 4 tons of dust is used, about 3 tons of valuable fines per hour are returned to the aggregate to enter the mixing chamber, while one ton of dust per hour is released to the air. The asphalt plant operator will have little difficulty in meeting requirements such as this, once he has found a plant site which meets the criteria for isolation from residences and yet is accessible to the paving project with haul roads as short as practicable.

4.23 Health and Efficiency of Employees

A high level of dust in the immediate vicinity of the plant equipment creates unpleasant working conditions. It may also cause irritation of the respiratory tract and eyes among the workers, perhaps leading to permanent damage in severe cases. This condition can be helped by the use of goggles and face masks during periods when local winds are inadequate to keep the working areas relatively clear. State health department inspectors would certainly expect such equipment to be available and to be used when dust levels are particularly high. However, wearing protective goggles and masks reduces visibility and may cause lowered efficiency when worn for long periods.

In some cases, either industrial health regulations or air pollution control codes require a definite program of controlling fugitive dust from the elevators, vibratory hot screens, and other locations where exposed aggregate is in motion by installing a system of hoods, covers, and ducts to return this material to the dust collector. Other measures to reduce the dust problem within and near the plant include oiling, using dust-laying chemicals, on sprinkler trucks or roadways and other areas subject to heavy truck traffic. The plant operator may consider lightly wetting down aggregate storage piles in extremely dry weather, both to reduce the dust nuisance and to save valuable fines. Housekeeping actions of the type described above not only keep employee absenteeism and dissatisfaction down but also help to reduce wear and tear on the mechanical moving parts that cannot be dustproofed.

4.3 Compliance with Maximum Objectives

4.31 General

The maximum objectives in air pollution control in effect today are contained in the codes of metropolitan areas where air pollution from many sources is already serious. Los Angeles County, California, and Wayne County, Michigan are two urban areas where agencies have imposed rather stringent restrictions on emission of particulates, as well as emission of toxic gases. In other states and cities, authorities have learned that such restrictions can be met by industry, and they are tending to incorporate the standards used by those most advanced in the field in new codes or regulations being drafted or in revisions to existing control measures.

Los Angeles County has established a sliding scale for the emission of dust and fumes, in which the total weight of the material involved in the industrial process is used as a basis for determining the allowable quantity of the emission. The discharge from all sources in a single plant is limited to approximately 4 pounds per hour per ton of process material at a production of one ton per hour, 2 pounds per hour per ton at a production of 5 tons per hour, with a ceiling of 40 pounds per hour for any process weight of 30 tons per hour or greater. Los Angeles County also has a limit for the permissible concentration of particulates of 0.4 grain per cubic foot of gas at standard conditions. For asphalt plants the process weight emission limits are much more restrictive than the limits on concentration of particulates in stack gas. The opacity standard for stack discharges in Los Angeles County states that no single emission source may discharge any air contaminant as dark as or darker than Ringelmann No. 2 for a period of more than three minutes in any hour.

In Wayne County (Detroit), Michigan, the emission of dusts and fumes in asphalt plants is limited to 0.2 pound of dust per 1000 pounds of exhaust gases or approximately 0.1 grain per standard cubic foot. Furthermore, permits are required for the operation of such plants, and additional housekeeping requirements frequently are imposed as a condition of the permit.

4.32 Particulate Emission Control

In order to reduce the emission of particulates to 40 pounds per hour or less, as the more stringent codes require, it is necessary to use highly efficient collection equipment. While it is possible to use very efficient single stage collectors such as multiple tubular cloth filters (baghouses) or electric precipitation equipment, these units would have to be quite large and expensive to handle the large volume of heavily laden gases generated in the dryer and other components of a hot-mix plant. These types of collectors are not generally suitable for portable plants due to transportability and maintenance problems in the field. There are advantages in a system which uses some form of dry primary collector and one or more secondary collectors, which can reduce the dust load in the primary effluent to the desired concentration.

Experience in Los Angeles County has shown that a dry primary collector followed by one of several types of scrubbers has been able to reduce plant emission below 40 pounds per hour, even in larger plants. In a ten year period from 1948 to 1958, average dust emission in asphalt plants was reduced from about 5 pounds per ton of asphalt produced to about 0.15 pound per ton. This was accomplished by using well-balanced dry primary and wet secondary systems and by careful attention to maintenance.

Two principal types of scrubbers are used in plants in Los Angeles County: multiple centrifugal type spray chambers and baffled spray towers. Both types have proved effective, but the multiple centrifugal type has generally produced a lower stack emission under the same loading and with the same water-gas ratio in the scrubber. Figure 4-3 shows the means performance of the two types under various levels of water-gas ratios. Both types produced 40 pounds per hour or less at water-gas ratios of 5 gallons per thousand cubic feet or less. Gas fired dryers of both types produced less particulate weight per hour than oil fired dryers, which is undoubtedly due to fly ash and some oil particles escaping unburned from the dryer.

Based on the Los Angeles County experience the predicted effect on the stack emission weight of an increasing quantity of minus 200 mesh material in the dryer is shown at a number of levels of water-gas ratio in Figure 4-4. These curves are the expected values for multiple centrifugal type spray towers. The baffled spray towers showed the same basic relationship of total fines to stack emission, but at a somewhat higher emission level. For example, the prediction curves indicate that 10,000 pounds per hour of minus 200 mesh material in the dryer is reduced to 40 pounds per hour in the stack effluent by 4.0 gallons of water per thousand standard cubic feet in the scrubber for the average oil fired dryer, while only 3.0 gallons per thousand cubic feet were sufficient in the gas fired dryer. These curves indicate an expected efficiency overall of better than 99.9% for the system.

In Wayne County, Michigan, the use of wet scrubbers (usually a combination of packed towers with spray) as secondary collectors in asphalt plants throughout the county enables their standard to be met without great difficulty. The county also requires oiling or paving of access roads and traffic areas in and around the plant. Special attention is given to covering aggregate conveyors and transfer points to insure satisfactory operation of the fugitive dust collection system.

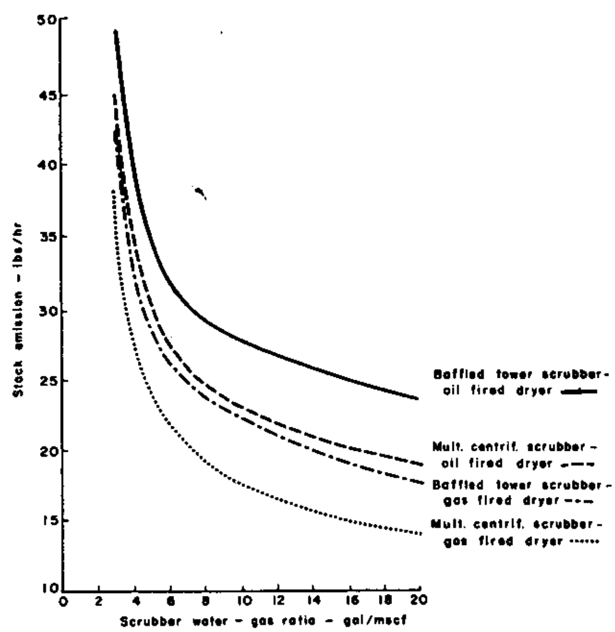

Figure No. 4-3 — Effect of scrubber water - gas ratio on stack emissions. (Aggregate fines in dryer feed 5900 lbs/hr)

(Reprinted with permission from the Journal of APCA, February 1960)

The City of Chicago is developing rather stringent regulations which are applicable to hot-mix asphalt plants. At least one permanent plant uses a baghouse for air pollution control to meet the City's air quality objectives. It reportedly is workvery satisfactorily.

It should not be expected that efficiencies equal to those shown for Los Angeles County would be obtained in all sections of the country, even if identical equipment were used. Many variables affect the efficiency of collectors. The grain size distribution of the minus 200 mesh material and the shape of the dust particles both have an effect on efficiency. For instance, very thin, wafer-like particles are not efficiently collected by most dry primaries, while particles of nearly spherical shape are readily collected by them. As previously mentioned, relatively soft aggregate-like limestone will have a higher percentage of fines than trap rock when crushed. This means that there will be a greater amount of fine dust per ton of production when limestone is used as the aggregate, and a greater quantity of dust will enter the primary, which is less efficient in handling the smaller dust sizes than the larger sizes. With reference to Figure 3-2, it is seen that expansion chambers and skimmers are virtually ineffective

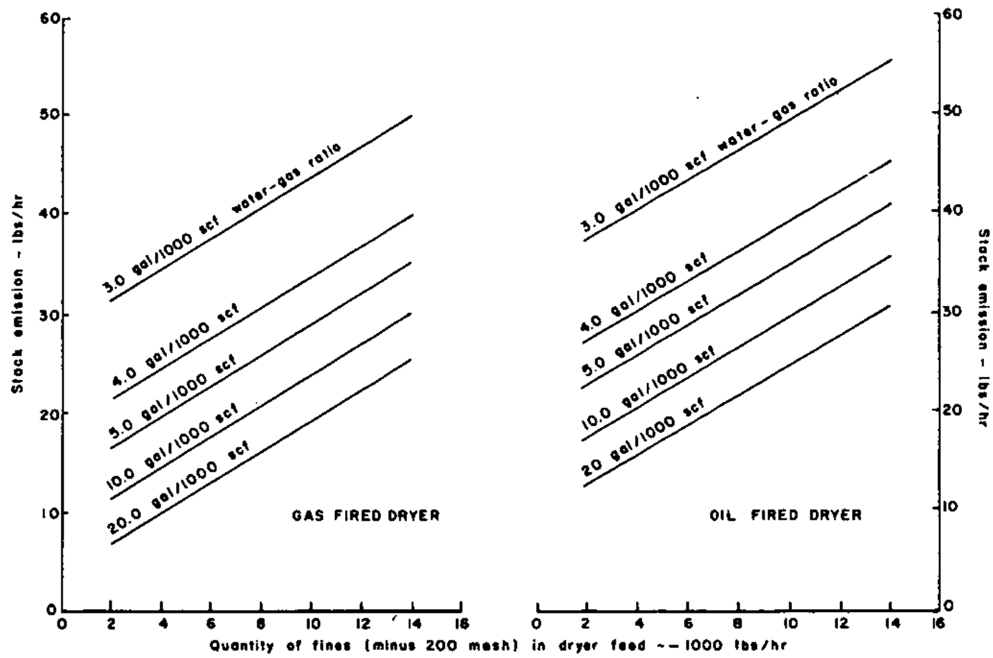

Figure No. 4-4 — Emission prediction curves for multiple centrifugal scrubbers serving asphalt plants (Reprinted with permission from the Journal of APCA, February 1966)

on particles below 50 microns and that dry cyclones drop off rapidly in efficiency of collection on particles below 20 microns.

In Table I there are given some cost ranges, both initial investment costs and power costs, of a number of types of primary and secondary dust collectors. While first cost should certainly be a consideration, the selection of equipment should take into account the factors of maintenance and operation costs. Equipment that is not of rugged design and construction may have such a frequency of breakdown as to be completely uneconomical. Before deciding on any given combination, several reputable manufacturers of dust collection equipment designed for asphalt plant use should be invited to survey the proposed operation and to recommend a collection system that will meet the code requirements of the area.

The plan operator of a stationary hot mix plant in an urban area with highly restrictive air pollution code requirements must of necessity consider the dust collection system as a basic element in overall plant design and operation. He should select a system which will meet the code requirements while permitting maximum efficiency in production with the aggregates known to be available in the area. An important consideration is whether the fines removed by the collection system are suitable, acceptable under most paving specifications, and needed in the final mix. If so, greater efficiency in the dry collector or collectors should be sought than if the collected fines are to be wasted. Greater efficiency in dry dust collection over that of a single, large diameter cyclone can be obtained by adding a secondary dry collector of multiple, small diameter (6 to 8 inch) cyclones or by substituting a group of medium diameter cyclones for the large one, following the dry collection in each case by a final high efficiency secondary such as a spray tower.

As pointed out in Section 2.4, the volume of dust carryout from the dryer is very sensitive to the drum gas velocity. A small increase in velocity of the gas through the dryer will result in a much larger proportionate increase in dust load in the dryer effluent. In an area where there is a stringent code, the dryer used should be adequately large in relation to the overall plant production to allow the drum velocity to be kept low.

Combustion control in a strict air pollution control area is a very important consideration. The discussion of this operational factor in Section 4.21 covers the basic considerations. However, the question of fuel for the burners is especially important in a strict area for two reasons: (1) total particulate emission from the final collector is higher for fuel oil burners, especially for those using the heavier grades, than for gas burners, and (2) emission of sulfur dioxide from combustion sources is subject to strict limitation. The increased particulate emission may be compensated for by increased efficiency of collection, as by increasing the scrubber water-gas ratio, but the emission of sulfur dioxide from the plant is not so easily controlled. Code requirements are often dual, i.e., limiting the sulfur content of the fuel used and the concentration of sulfur oxides in the stack gas. For example, Los Angeles County does not permit the use of a liquid fuel (during the period from May 1 through October 31) having a sulfur content in excess of 0.5 percent by weight, nor does it permit at any time the emission of total sulfur compounds (calculated as sulfur dioxide) in excess of 0.2 percent by volume of the stack gas at point of discharge. In general, the use of gas-fired burners or of low-sulfur grades of fuel oil are the only practical ways to meet these requirements.

TABLE I

Comparative Costs of Dust Collectors

Type	First Cost ($/CFM)	Power Consumption (KW/1000 CFM)	Pressure Drop* (Inches Water)
PRIMARY			
Settling Chamber	0.1	0.1	0.1 - 0.5
Cyclone, Lg. Diam.	0.1 - 0.2	0.1 - 0.5	0.5 - 3.0
Cyclone, Med. Diam.	0.2 - 0.3	0.3 - 0.8	1.0 - 4.0
SECONDARY			
Cyclone, Multiple	0.3 - 0.6	0.5 - 2.0	2.0 - 10.0
Filter, Cloth Tubular	0.3 - 2.0	0.5 - 1.5	2.0 - 6.0
Precipitator, Electric	0.6 - 3.0	0.2 - 0.6	0.1 - 0.5
Scrubber, Spray Tower	0.1 - 0.2	0.1 - 0.2	0.1 - 0.5
Scrubber, Wet Cyclone	0.3 - 1.0	0.6 - 2.0	2.0 - 8.0
Scrubber, Packed Tower	0.3 - 0.6	0.6 - 2.0	0.5 - 10.0

* *Pressure drop is the additional fan power that is needed to maintain the momentum of the gas stream through a dust collector. It is usually measured in inches of water, although other pressure units such as pounds per square inch could be used.*

Measures to safeguard the health and comfort of employees and to maintain good housekeeping in the plant, as discussed in Section 4.23, are of maximum importance in an area subject to strict controls. It can be expected that inspections by enforcement personnel of the regulatory agency will be frequent, thorough, and tough. An effective and well-maintained fugitive dust control system and paving or oiling of heavy traffic areas will be required.

4.4 Disposal of Collected Materials

The quantity of materials collected in an efficient dust collection system of a hot mix plant can be considerable. The total weight of minus 200 mesh material collected in a plant of approximately 150 tons per hour capacity may well run from three to five tons per hour. It is obvious that the more of this material that can be returned to the mix, the smaller will be the problem of disposal. Since the coarser fraction of the dust is usually desirable to give optimum gradation in the mix, collection devices such as screw conveyors or chutes are attached to the bottom of the primary, and in some cases the dry secondary, collectors to deliver these fines to the bucket elevator leading to the hot screens.

The remaining fraction of the fines, which is that removed in the final secondary, is most often discharged as a sludge which creates a disposal problem. The volume of this sludge for an average plant will be on the order of 150-200 gallons per minute, and there may be approximately a ton of solids per hour. For several reasons it is necessary that the sludge be retained in a settling pond of adequate size. The pond should be at least six feet deep and should hold at least two hours discharge of the scrubber. It would be more desirable for the pond to hold an entire day's scrubber discharge. The principal reason for the settling pond is that the authorities will not permit a concentrated sludge of this sort to be discharged either into a sewer system or into a natural stream, because of the severe water pollution aspects of such a discharge. Secondly, some of the water can be re-used in the scrubber, after some clarification has taken place in the settling pond, thus reducing scrubber water costs. The settling pond should be built in such a way that the discharge to sewers or to natural streams is only from the water which has been clarified. Periodic pumping out or otherwise removing the settled sludge is also necessary, since the pond receives some tons of sludge every working day, and the capacity of the pond will be used up quickly unless the settled sludge is cleaned out.

The sludge which is pumped or dredged from the settling pond must be removed from the plant site to an appropriate disposal area. Abandoned quarries, marshes, and other waste land may be available for such use. In some cases, the material may be readily accepted in land fill or reclamation projects. It should be borne in mind that the disposal method used must be one that will avoid contaminating natural water courses, since these are also very sensitive areas, as the public and its servants become more conscious of pollution of our whole environment.

CHAPTER V

SUMMARY

Air pollution today is a more pressing problem than ever before in our history. Federal, state, and local governments are enacting more and more stringent air pollution codes, regulatory standards and ordinances, and there are competent and well-staffed agencies to enforce them.

Hot-Mix asphalt plants have frequently been the subject of complaints from the public and tend to be singled out in the enforcement of regulations. In order to maintain good community relations and to avoid violations of regulatory controls which may lead to penalties or even being shut down, the plant owner has to control the emission of pollutants from his plant by installing equipment and adopting methods of operation which will result in his meeting the established standards.

There have been many advances in equipment and knowledge dealing with the control of pollutant emissions in recent years. The asphalt plant owner will be well-advised to steer clear of homemade equipment or equipment of novel but untested design. Pollution control equipment which has been proved in actual asphalt plant use to be effective, durable, sturdy, and requiring low maintenance will be the best investment in the long run.

Pollutants released from hot-mix plants include both gaseous and particulate types. Gaseous pollutants are mainly combustion products and include oxides of sulfur and of nitrogen, aldehydes, and carbon monoxide, among others. Sulfur dioxide is a possible gaseous pollutant of asphalt plants which is most likely to be a specific subject of regulation.

Particulate pollutants include stone dust from the aggregate used, urburned fuel oil droplets, fly ash, smoke, and soot. Dust is the major atmospheric pollutant emitted by asphalt plants, and the principal source of this dust is the rotary dryer. The weight of dust generated by the dryer will probably be 2 to 3 percent of the total weight of the aggregate.

The objectives of air pollution control in asphalt plants include the following:

A. To limit the emission of dust and other pollutants to the levels required by codes or ordinances applicable to the plant and locality;

B. To prevent the addition of dust and other pollutants to the air of neighboring communities to such an extent as to cause complaints and unfavorable public relations;

C. To provide reasonably comfortable and healthy working conditions for the employees of the plant; and

D. To reduce as far as economically feasible the wear on plant equipment from dust generated in the processes and to reclaim useful fine material for the asphalt mix in order to minimize the cost of added mineral filters.

Air pollution regulatory standards and codes applicable to asphalt plants generally impose limits on opacity (visual density) of the stack exhaust, quantity of dust and other particulates emitted in a unit of time, and concentration of noxious gases in the stack exhaust. They also usually describe the minimum plant housekeeping measures which are acceptable to prevent fugitive dust emission and other nuisances in neighboring areas.

There is considerable variance in air pollution codes and standards in different parts of the country, and regulatory measures are usually much more stringent in metropolitan than in rural areas. Changes in requirements are being made frequently, as pollution becomes more severe in many areas. The asphalt plant owner should be constantly aware of current regulations and the possibility of tightened requirements in the future for the locality of his plant or the area in which he expects to set up a plant.

Pollution control equipment in asphalt plants generally falls into two categories: dry collectors and wet collectors. The primary collector which receives the main dust stream directly from the dryer is almost always a dry collector; it often returns fine material to the asphalt mix. In isolated areas where air pollution controls are minimal, the primary collector may be all that is used. In areas of more stringent requirements, it is necessary to use one or more secondary collectors, either dry or wet.

Dry collectors include expansion chambers, skimmers, cyclones, bag filter assemblies, and electrostatic precipitators. Cyclones are the most widely used primary collectors in the asphalt industry; collectors may be single large diameter cyclones, groups of medium diameter cyclones, or multiple tube cyclones of up to 50 small diameter units. Baghouses and electrostatic precipitators fall into the category of secondary collectors.

Wet collectors use a liquid (usually water) spray or mist to wet most of the dust particles in the gas stream, removing them as a sludge. Such collectors are always used as secondary collectors. They are generally referred to as scrubbers, and the majority of them in use in asphalt plants are either of an impingement or a centrifugal type. Wet collectors are highly effective as final cleaning units; a well-designed combination of dry primary and wet secondary can often remove more than 99% by weight of the dust in the exhaust stream. Average collection efficiency of various types of collectors for several particle size ranges is shown on Figure 3-2.

Pollution control agencies do not ordinarily consider it sufficient to clean the exhaust gas stream from the dryer alone, as there are many sources of dust such as hot vibratory screens, elevators, and transfer points which may release fugitive dust of approximately 10% of the total plant emission. Hoods, covers, and ducts to entrap and convey this dust to the dust collectors are necessary. Such central devices may be furnished by the manufacturer; if not, a competent consultant should be engaged to design an efficient system.

The combustion units in an asphalt plant have an important influence on the air pollution potential of the plant. Dirty, clogged burners and improper air-fuel mixtures can result in excessive output of smoke, soot, fly ash, irritating aldehydes, and carbon monoxide. Gas burners are generally much less troublesome in this respect than oil fired equipment, due to the natural characteristics of the fuel. However, gas may be considerably more expensive than oil in some areas, and it may not even be accessible at the plant site. Continual close attention to the cleanliness and adjustment of the burners and accessory equipment is important.

Compliance by the plant with visual opacity standards for the stack exhaust is usually checked by use of the Ringelmann Chart, shown as Figure 3-1. The emission of polluting gases and dust from the plant is usually checked by sampling the stack gases for a number of sampling periods, of a half hour or more each, during a normal day's operation. Air pollution inspectors are furnished with standard equipment for measuring stack discharges and for collecting representative samples of the pollutants which are being carried in the exhaust. When these samples are taken back to the laboratory and carefully weighed or otherwise measured, the quantities found are related to the measured average discharge of gases. This determines whether the concentration of gas or dust was higher during the sampling period than that permitted by the regulatory standards in the locality.

In isolated locations, regulatory agencies often permit plants to operate with only primary dust collectors and do not regulate the quantity of the dust discharged provided the collector is of approved design and operating in a reasonably effective manner. Similarly, there may be relaxed or perhaps in some areas no restrictions on visual opacity of the stack exhaust or on emission of sulfur dioxide or other gases.

In metropolitan areas where air pollution is widespread and serious, highly restrictive codes require the use of very efficient primary and secondary collectors, effective combustion control, and a high standard of plant housekeeping. Los Angeles County, California, and Wayne County (Detroit), Michigan, are examples of such areas. In localities such as these, local enforcement personnel are trained and equipped to make thorough and efficient inspections for violations of the regulations. The air pollution problem in Los Angeles County has been severe for several decades, and strict enforcement there has caused a phenomenal reduction in industrial emissions. Because of their well-publicized problems and achievements, Los Angeles County is regarded widely as a pacesetter in regulatory standards and as a proving ground for air pollution control devices.

Collecting dust and other particulate matter efficiently is only a part of the total problem; there remains the question of what to do with the large volume of dust or sludge. Naturally, return of suitable fines to the mix is very helpful, but several tons of fines may be removed by wet collectors in the form of sludge and must be stored in a settling pond for clarifying. Water pollution restrictions prevent disposal of sludge to natural drainage systems. Water from which most of the fine particulates have been settled can be re-used in the scrubber or discharged to a stream. The settling pond must have its settled sludge pumped out periodically to a suitable disposal area; otherwise, it would quickly fill up and become useless.

The hot-mix asphalt industry as a whole faces problems of increased cost to meet increasingly high standards of air quality. However, the technical and economic problems are less severe than in many other industries and can be solved without undue difficulty.

CHAPTER VI
Looking to the Future

As the world's population grows explosively, with the inevitable industrial expansion keeping pace, air pollution emergencies on a major scale will begin to occur frequently in many parts of the world, especially in the more "advanced" countries. We must find practical solutions to air pollution from industrial and domestic sources very soon in the United States and other highly developed countries. The technical knowledge which has developed our tremendous industrial society must now be applied to solving the problems of waste disposal resulting from the activities of that society. The use of fossil fuels as energy sources is very likely to be greatly modified within the next decade. New combustion processes or hitherto impractical or unknown ways to release the energy of fuels without fouling the atmosphere will have to be found. Nuclear energy sources, maximum exploitation of hydroelectric potentials, and harnessing of solar energy will provide other means of reducing our reliance on fossil fuels for major energy requirements.

Since the movement of the air respects no political boundaries, present governmental bodies and procedures at the lower levels will not be able to cope with the problem effectively. New administrative machinery is needed and will certainly appear. In addition to municipalities with air pollution codes and regulations, there will be air pollution control districts to deal with air pollution at the lowest level. Regional agencies covering portions of a number of states will supersede state agencies in many cases when dealing with monitoring of air pollution, establishment and revision of standards, and the enforcement of control requirements. The federal government will unquestionably play an increasingly active part in air pollution research and overall coordination and control. International bodies will not likely be long in coming; in the early stages they will probably be joint commissions of two governments, although it is not difficult to imagine an air pollution control agency as a part of the European Common Market.

The asphalt paving industry can expect more rigid control of all aspects of its plant operations as they affect the air pollution picture within the next few years. Plants in the major metropolitan areas will doubtlessly feel the increased pressure before the rural plants. It is probable that emphasis will be placed initially on improving the efficiency of secondary collection systems in order to reduce the emission of particulates to some predetermined level, such as a maximum of 40 pounds per hour for the plant. Gradually, the permissible concentration of dust in the stack exhaust and the maximum quantity which can be discharged from a plant within an hour will be reduced, as the overall air pollution situation becomes more critical. The ducts and hoods of the fugitive dust collection system will be carefully inspected by control authorities to eliminate any losses to the maximum extent possible. Manufacturers of asphalt plant equipment will be required to make improvements in design until the ultimate is reached: a completely sealed plant from rock input to hot-mix asphalt discharge, with a negligible output of dust and noxious gases from the stack. Major improvements are likely to be made in dryer design to reduce the dust loading into the collectors to a very low level. New heat sources to replace the burning of fossil fuels in drying the aggregate and conditioning the asphalt will be developed by the manufacturers.

The cost to industry and the population as a whole of controlling air pollution sources so as to maintain air of acceptable quality will be very great. It is too late to expect any cheap solutions, if such ever were possible. However, solutions will be found and we will accept their expenses as a necessary part of the cost of production and of the general cost of living. The problems of the asphalt industry in meeting the emission standards that will have to be set to keep our air acceptably clean are not so severe as in many other sectors of the economy; there is no doubt that the standards imposed can and will be met.

APPENDIX I

Conversion Factors and Sample Calculations

PRESSURE

MULTIPLY	BY	TO OBTAIN
Pounds per square inch (gage)	27.673	Inches of water at 4°C.
	51.715	Millimeters of Mercury at 0°C.
	70.307	Grams per square centimeter
Inches of water (4°C.)	0.03614	Pounds per square inch (gage)
	25.399	Kilograms per square meter

MASS

MULTIPLY	BY	TO OBTAIN
Grains	0.0029	Ounces (Avoir.)
	0.0648	Grams
Grams	0.0022	Pounds (Avoir.)
	15.432	Grains
Pounds	7000.	Grains
	0.4536	Kilograms

CONCENTRATION
(Liquids and Solid Particles in Gas)

MULTIPLY	BY	TO OBTAIN
Grains per cubic foot	2.2883	Grams per cubic meter
	0.1426	Pounds per 1000 cubic feet
	1.8997	Pounds per 1000 lbs. of air at standard temp. and pressure
Pounds per 1000 cubic feet	16.018	Grams per cubic meter
	7.	Grains per cubic foot
	13.298	Pounds per 1000 lbs. of air (STP)

Standard conditions for gas: 0°C. and 760 mm of mercury

Sample Calculation

If the average stack sampling concentration is reported as 0.4 grains per cubic foot (standard conditions), but the limits given by the code are in other units, this concentration may be converted by applying appropriate conversion factors, thus:

0.4 gr/SCF = 0.4 × 2.2883 = 0.9153 g/cubic meter
0.4 gr/SCF = 0.4 × 0.1426 = 0.057 lbs/1000 cubic feet
0.4 gr/SCF = 0.4 × 1.8997 = 0.760 lbs/1000 lbs. of air (STP)

APPENDIX II

Sampling Procedures

In order to measure the quantity of dust and other solid particles coming from the exhaust stack, a technique called isokinetic sampling is in general use. Isokinetic sampling is that in which the flow of the gas into a sampling probe very closely matches the velocity and direction of the flow in the stack or duct at the point where samples are being taken. This method of sampling the stack gas is necessary for dusts and other particulates since large particles do not follow the same path as small particles when the velocity of gas in the nozzle of the sampling probe is not the same as the velocity of the main gas stream. This causes errors in sample weight collected, which will be on the high side if the probe velocity is lower than that of the mainstream and on the low side if the reverse condition exists, By using equipment and methods which match the velocity as closely as possible, isokinetic sampling is accomplished and errors are minimized.

The first step in sampling a stack is to determine the rate of flow of gas and the distribution of velocity in the stack, so that actual sampling can be done at points most representative of the mean stack concentration and velocity. This is done by taking pitot tube measurements at preselected points across the diameter of the stack and determining from these data the location of the proper sampling points. One type of pitot tube is an instrument consisting of two concentric tubes, one of which measures impact pressure of the gas stream, while the other measures the static pressure. Figure 4-1 shows a single standard pitot tube and a double pitot tube. The double pitot tube or type "S" is used in gas streams carrying a load of particulates which may plug the small static pressure holes on the standard single tube. In the double pitot tube one opening faces toward the source of the stream; the other faces downstream. In both instances the difference between the impact and static pressures is related to velocity. Pitot tubes must be carefully calibrated under flow conditions similar to those in which they will be used. It is necessary to use a pressure measuring instrument, such as a differential manometer, with the pitot tube to obtain the velocity. Also, variations in temperature and humidity affect the density of the gas and thus must be measured and taken into account when computing the velocity of the gas stream.

The sampling apparatus consists of a probe to insert into the gas stream, a collecting device such as impinger, filter, or bubbler, a manometer and thermometer to measure the gas pressure and temperature, a flow meter to measure the total volume passing through the sampler, and a vacuum pump, all connected in the order stated. The probe used in sample collection is usually made up in a local shop to meet the conditions expected to be encountered in the various locations to be sampled. It is threaded to accept the set of nozzles which will be used with it. The selection of the correct nozzle from an isokinetic sampling set of nozzles which are calibrated, having different sizes and flow characteristics, and its installation on the sampling probe results in matching the velocity in the probe nozzle and in the mainstream outside, permitting the collection of a representative sample. In order to compute velocity and total flow, it is necessary to use a differential manometer in connection with the pitot tube or sampling probe. This instrument is a U-shaped tube containing mercury or other liquid of known density, with each leg of the tube mounted on a graduated scale, so that the height of the liquid in each leg may be quickly measured. The difference in the height of the mercury in the two columns bear a direct relationship to the pressure difference applied to the ends of the tube. A sketch of the differential manometer is shown in Figure 4-2. Also shown is a set of two impingers in series, in which dust particles from the probe are caught. Often a final filter is used after impingers to be sure of getting all of the material. When the collected solid particles are weighed, the average dust concentration in the stack can be expressed as weight of dust in each unit volume or each unit weight of the gas stream. For example, the concentration may be given as milligrams per cubic meter at standard temperature and pressure, grains per standard cubic foot, or pounds per thousand pounds of stack gas.

APPENDIX III

List of References with Detailed Information

BOOKS

Air Pollution, Vols. I and II, edited by A. C. Stern, Academic Press, New York, N. Y., 1962. (new edition to be published in 3 volumes in 1967).

Air Pollution, World Health Organization, Columbia University Press, New York, N. Y., 1961.

Air Pollution Control, W. L. Faith, Wiley, New York, N. Y., 1959.

Air Pollution Handbook, P. L. Magill, F. R. Holden, and C. Ackley, McGraw-Hill, New York, N. Y., 1961.

MANUALS

Air Pollution Manual, Part I — Evaluation, American Industrial Hygiene Association, Detroit, Mich., 1960.

Air Pollution Abatement Manual, edited by C. A. Gosline, Manufacturing Chemists Association, Washington, D. C., 1951.

ASTM Standards, Part 23, American Society for Testing and Materials, Philadelphia, Pa., 1966.

Technical Manual No. I, Air Pollution Control Association, Pittsburgh, Pa., 1963.

Technical Manual No. II, Air Pollution Control Association, Pittsburgh, Pa., 1965.

PERIODICALS

Journal of the Air Pollution Control Association, 4400 Fifth Avenue, Pittsburgh, Pennsylvania, 15213 (monthly).

Journal of the American Industrial Hygiene Association, 14125 Prevost, Detroit, Michigan, 48227 (bi-monthly).