CEMENT KILNS

Compliance Assistance Program
California Environmental Protection Agency
Air Resources Board

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100 INTRODUCTION

101 WHAT THIS MANUAL IS ABOUT

This technical manual addresses the control and reduction of the air pollution which cement kilns could produce. In these pages you can find:

- Descriptions of processes and equipment,
- Regulation requirements for air pollution control,
- Checklists/inspection aids and supporting materials to help you comply.

You can learn about:

- The pollution problems posed by plant operations,
- The air contaminants which could affect your health,
- The rewards of complying with regulations,
- The consequences of violations and how to avoid them.

Aggregates, Asphalt Hot Mix Facilities, and Concrete Batch Plants, although related, are not the main focus of this Cement Kilns manual; our compliance assistance program (CAP) has separate technical manuals devoted to each of these. However, you may wish to consult the complementing quartet of these manuals, along with others such as Baghouses and Electrostatic Precipitators.

102 WHAT ARE CEMENT KILNS?

Basically, a cement kiln is the key piece of equipment, a furnace, in an industrial facility which turns a mixture of calcium carbonate/limestone and shales, clays, and iron ores into a fine, powdery substance called cement. The cement can then be used to bind together sand, gravel, and other ingredients to make the synthetic rock which we call concrete. The general term, "cement kiln" is often used to mean "cement plant." Furthermore, the main focus of this manual is on the portland class of cement, made from limestone, silica, iron, and alumina.

A cement kiln facility quarries, crushes, and grinds the raw materials, measures, proportions, blends, and introduces them into the kiln, where they are heated to a temperature of about 2700 degrees Fahrenheit. The result is hard, cooked pieces of calcium silicates, called clinker, which are then ground with gypsum into a fine, powdered cement and shipped to markets. Detailed explanations are presented in Chapters 2 and 3.
How can cement kilns relate to air quality? In several stages of the processes, opportunities may occur for pollutants to escape or to be propelled into the air. The air quality may be at risk from the time when the source elements are mined from within the earth, crushed, conveyed, stored, mixed into concrete, and until the patio surface is finished. These pollutants are mainly particulates, or dust; the sources and controls are discussed in detail in this manual.

To help educate plant operators and inspectors in proper methods to contain, capture, and control errant particulates, and thus to promote cleaner air, is the main purpose of this manual. We also hope to help plant operators avoid violations, fines, and costly shutdowns.

First, let's look at our California agencies which regulate air pollution:

103 CALIFORNIA AIR RESOURCES BOARD

Air pollution is a serious problem in California. We are pumping tons of polluting material into California air every day from the activities of 29 million residents, 23 million cars, and a myriad of industrial sources large and small. Unfortunately, the air pollution is not blown away by fresh sea breezes from the Pacific Ocean. To the contrary, this air pollution tends to remain in place, due to the dominant atmospheric high pressure, the atmospheric temperature inversions, the terrain barriers and basins, and other factors.

On the other hand, California leads the nation in programs to clean up the air. In 1955, the Bureau of Air Sanitation began identifying the air pollution levels that could endanger public health. Recognizing cars and trucks as a major cause of smog, the State formed the Motor Vehicle Pollution Control Board (MVPCB) in 1960 to regulate tailpipe emissions. California was the first state to adopt vehicle emission standards for hydrocarbons (HC) and carbon monoxide (CO).

In 1967 the MVPCB and the Bureau of Air Sanitation were combined to create the Air Resources Board (ARB). With this merger, the authority to define the health threat of air pollution and to regulate its causes was united into a single organization. Since then the ARB, working with county and regional air pollution control districts, (APCDs) and air quality management districts, (AQMDs) has created one of the world’s most comprehensive air quality cleanup programs. (For simplicity, the term, "air districts" may be used.)

Next came the California EPA. In July, 1991, the California Environmental Protection Agency was formed to bring together, under a single accountable
100 INTRODUCTION

Cabinet level agency, these entities: the Department of Pesticide Regulation, the Department of Toxic Substances Control, the Office of Environmental Health Hazard Assessment, the Integrated Waste Management Board, the State Water Resources Control Board, nine Regional Water Quality Control Boards, and the Air Resources Board. What does the Air Resources Board do?

As the primary statutory authority, the ARB establishes and enforces standards to limit air pollutant emissions from motor vehicles. The ARB does more:

1. Conducts inspections, in cooperation with the air districts to ensure compliance with air pollution regulations by applying consistent and evenhanded enforcement.

2. Develops suggested rules and regulations to assist local air districts in their efforts to improve the air quality.

3. Establishes air quality standards to protect the health of the vulnerable members of our population and to prevent damage to property and crops.

4. Evaluates the effectiveness of pollutant control strategies and programs for vehicles and industry.

5. Monitors air quality throughout the State.

6. Conducts extensive research programs.

The ARB's past efforts and the cooperation of industry and the public have reduced the pollution emitted from vehicles and other large sources. Now and for the future, the ARB aims to continue to enforce present regulations and to further reduce the effects of other, smaller sources of pollution. Continuing to clean up our air requires difficult choices, careful planning, and the support of all Californians.

104 COMPLIANCE ASSISTANCE PROGRAM

Within the Compliance Division, the California Air Resources Board has a Compliance Assistance Program (CAP). The CAP produces innovative publications to provide assistance to industry and regulators for comprehensive, consistent, and accurate compliance inspections. The goal of the CAP is to reduce air pollution by promoting a greater awareness of air quality regulations.

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and by encouraging cooperation between regulators and industry. Toward this goal, the CAP provides industry with information, checklists, and other self-auditing tools to help them know how to stay in compliance.

Enforcement audits of some industrial sources have shown noncompliance rates up to 50 percent. Reducing these rates can bring rewards to everyone.

Based on the idea that emission source operators will comply with air quality regulations if they understand what is required of them, the CAP identifies the requirements and presents them in several alternative formats. These CAP publications can assist industries to monitor their operations and to conduct their own daily inspections, thus increasing their compliance rates and reducing costly violations.

Through the development and distribution of these rule-specific publications, CAP creates a flow of information in a variety of useful forms:

**Handbooks.** Easy-to-read, colorfully illustrated handbooks are developed for the industrial labor force on the production line. Most can be read in 10 minutes, and all contain helpful self-inspection checklists.

**Pamphlets.** Quick-reference pamphlets contain detailed flow charts, checklists, and meaningful diagrams to assist plant supervisors and their inspectors.

**Technical Manuals.** Detailed technical inspection manuals are developed mainly for industry’s environmental managers, ARB inspectors, and local air district inspectors. These contain rule information, process description, and step-by-step procedures for compliance inspections.

### 104.1 FOCUS / TARGET AUDIENCE FOR THIS MANUAL

The primary focus of the Compliance Assistance Program is to improve the knowledge of inspectors and industrial operators about air emissions. In order to reduce noncompliance and excess emissions, both the inspector and the operator need to know what is regulated, why it is regulated, and how compliance is determined.

This technical manual is targeted for corporate and industrial managers and their staffs, including production environmental managers, and for air pollution control district inspectors.
104.2 MANUAL DESIGN

This cement kiln manual is designed to assist you, the inspectors in government and in industry, in assuring that cement plant operations meet the requirements of air pollution control regulations.

This manual complements an existing trio of CAP Manuals. Together, they can form a quartet of reference manuals for your office or your inspection kit: Cement Kilns, Concrete Batch Plants, Aggregates Plants, and Asphalt Hot Mix Facilities. In a musical analogy, since cement is the basis which holds the other products together, it may be called the bass of the quartet, which holds chords together. Concrete Batch, with so many versatile applications, can be the melody, while Aggregates and Asphalt Plants can be woven in as the tenor and baritone. Other CAP manuals and pamphlets, such as Baghouses, and Visual Emissions Evaluations, can provide the percussion and rhythm.

This manual provides both an overview and detailed information, along with references for further details. It is divided into easy-to-use, numbered sections and subsections for your convenience.

Section 100 provides overviews of air pollution problems in California, the formation of the ARB and the Compliance Assistance Program, and the design and purpose of this manual.

Section 200, Category Description, includes a brief overview of the historical events in the development of cements, brief descriptions of plant operations and equipment, and a summary of known air pollutant emissions from cement plants.

Section 300, Process and Control, describes in more detail the various processes used in cement kilns and the controls used to protect our air quality.

Section 400 describes Inspection Procedures for assuring compliance, including checklists, other inspection aids, and guidelines.

Section 500 presents the Legal Requirements of the laws and regulations governing cement kilns.

The Glossary contains a collection of terms used in the manual and the industry.

The Appendices contain supplemental information such as copies of pertinent sections of regulations: Appendix A contains a fugitive dust sample control plan and RACM; B cites Particulate Matter (PM10) emissions determinations.
(EPA Method 5); C contains Visible Emissions Evaluation procedures; D contains a pre-inspection worksheet, a sample inspection checklist, and troubleshooting guidelines for baghouses; E contains similar material for electrostatic precipitators; F contains sample Permits to Operate and an Authority to Construct; G lists references used in producing this manual; H is AP-42 emission factors, and Appendix I is provided as a place for your district rules.

The Index at the end of the manual can help you to find topics.

104.3 MANUAL MAINTENANCE

This manual is a dynamic, living document that relies on your experience and expertise for its changes and improvements. Please read the manual to familiarize yourself with its contents, how it is organized, and how to use it. As you do, please jot down any questions you may have, and highlight anything that is unclear to you. The amendment process starts with you; please use the procedure included here to share your observations and suggestions.

As you identify issues that you think will benefit others, talk with your supervisor and express your concerns. If you want further clarification of a point, call the ARB, Compliance Division, Compliance Assistance Section at (916) 324-7659 or leave a message at 1-800-952-5588. When you believe that the manual should be amended, write down your proposed amendment and send it to:

Air Resources Board
Compliance Division, Compliance Assistance Section
P. O. Box 2815
Sacramento, CA 95812

When we receive your proposed amendment, we will review it, contact others to see how widespread the issue is, and we will respond back to you. For those proposed amendments that need immediate response, a workshop may be scheduled or draft changes will be provided for comment. For those changes that may be less critical, we will wait until we have several before having a workshop or comment period and making the appropriate changes.

Right now, when you first receive this manual, please be sure to fill in the tracking card located near the front page, and promptly mail it to the ARB. Then we can mail you an update for your manual each time there is a change.
100 INTRODUCTION

105 CALIFORNIA CLEAN AIR ACT

The California State Legislature, aware of California's serious air pollution problems and the inability of many areas to meet the State and Federal ambient air quality standards, passed the California Clean Air Act of 1988 (CCAA). The CCAA requires the air pollution control districts to develop control measures to achieve a five percent annual emission reduction of volatile organic compounds (VOCs) in those districts that are designated non-attainment for the State's air quality standard for ozone.

106 AIR POLLUTION HEALTH CONCERNS

This section includes information about California's air pollution health concerns in general, in order to show how emissions from cement kilns may relate to the larger air pollution problem.

Air pollution has caused concerns as a serious problem for the health of the 29 million people of California. To protect human health, the ARB has set standards for air quality. These standards are based on research indicating the concentrations at which pollutants can be harmful, and they include a margin of safety to protect people who are particularly sensitive to air pollution, such as the young, the elderly, and those with allergies or asthma.

Volatile organic compounds are precursors to both ozone, a serious concern, and particulate matter (organic particles with diameters of less than 10 microns, known as PM10, which may be an even more serious concern than ozone). Cement kiln dust (CKD) is mostly particulate matter. Over 90 percent of California's population live in areas of non-attainment for the State ozone and PM10 standards. The following subsections discuss and illustrate VOCs, PM10, ozone, and our ambient air quality standards.

106.1 VOLATILE ORGANIC COMPOUND (VOC) AND PM10

A volatile organic compound (VOC) is a carbon substance which can be a cause of air pollution. VOCs contain at least one atom of carbon, excluding methane, carbon dioxide, and certain other organic compounds determined by the Environmental Protection Agency (EPA) and the ARB to be non-photochemically reactive (primarily halogenated hydrocarbons).

VOCs are known precursors of ozone and PM10. That is, VOC emissions cause the formation of ozone and a smaller amount of PM10. Ozone is formed in the...
lower atmosphere during a series of chemical reactions between volatile organic compounds (VOCs) and nitrogen oxides (NOx) in the presence of sunlight.

PM10 levels are the result of both direct and indirect sources. Direct sources include fuel combustion, dust, and soil erosion by wind. Indirect sources include the chemical reactions of VOCs, nitrogen oxides, sulfur oxides, other chemicals in the air, and condensations of emitted gases in the air. From these reactions, solid and liquid particles form with diameters less than 10 microns.

For the year 1991, the ARB emissions inventory shows that cement kilns in California emitted 1,216 tons per day of particulate matter (PM) and particulate matter less than 10 microns in diameter (PM10).

106.2 STANDARDS FOR OZONE AND PARTICULATE MATTER (PM10)

Ozone is a strong respiratory irritant that can impair the normal function of the lungs, especially during vigorous physical activity. This health effect is particularly acute in children, the elderly, and people with respiratory difficulties. Ozone can also damage some types of vegetation, reducing crop yields.

Particulate matter with equivalent aerodynamic diameters smaller than 10 microns (PM10) can adversely affect our breathing. Small enough to pass through our natural filters, PM10 invaders can be inhaled deeply into the lungs, causing irritation to the respiratory tract. Furthermore, as they invade our lungs, these particles may bring along toxic substances clinging to their surfaces. PM10 can also be an aesthetic nuisance: since it is just large enough to be seen, it scatters light and reduces our atmospheric visibility.

To protect California’s population from the harmful effects of ozone and PM10, federal and State air quality standards have been established for these contaminants, as shown in Table 100.1. The State hourly ozone standard is 0.09 parts per million (ppm) and the federal hourly ozone standard is 0.12 ppm. The State PM10 standard for a 24 hour period is 50 micrograms per cubic meter (μg/m³) and the federal standard is 150 μg/m³, determined over a 24-hour period.
### Table 100.1 Ambient Air Quality Standards

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Averaging Time</th>
<th>State Std.</th>
<th>Federal Std.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ozone</td>
<td>1 hour</td>
<td>0.09 ppm (180 µg/m³)</td>
<td>0.12 ppm (235 µg/m³)</td>
</tr>
<tr>
<td>PM10</td>
<td>Annual Geometric Mean</td>
<td>30 µg/m³</td>
<td>- - -</td>
</tr>
<tr>
<td></td>
<td>24 hours</td>
<td>50 µg/m³</td>
<td>150 µg/m³</td>
</tr>
<tr>
<td></td>
<td>Annual Arithmetic Mean</td>
<td>- - -</td>
<td>50 µg/m³</td>
</tr>
</tbody>
</table>

Today, most of California’s people live in districts which have attained neither of these State standards, neither ozone nor PM10.
This chapter describes the category of Portland cement, the fine powder used to make concrete, including an overview of modern cement manufacturing methods and equipment. First, a look at some of the significant historical events in the development of cement’s ingredients and methods of production.

HISTORICAL HIGHLIGHTS OF DEVELOPMENT

The cement/concrete industry has become an increasingly important and growing sector of commerce and employment in the United States. Modern cement technology has visibly enhanced our quality of life in the forms of highways, bridges, airports, skyscrapers, public housing complexes, bungalows, driveways, patios, swimming pools, and neighborhood basketball courts. The Portland cement we know, however, based on lime, is the result of a long evolution through trial, error, study, and experimentation.

Early forms of cement/concrete were hard and durable, but they bore little resemblance to the product of present technology, with its sophisticated ingredients and innovative methods of application. Although lime is a primary ingredient in the manufacture of modern cements, several builders have used other substances to hold together fragments or solid masses, dating from the time of brick walls in ancient Egypt. These bricks were held together with moist layers of clay from the Nile River. The resulting walls, solid masses of dry clay, have endured in the dry environment, but they would not have done so well in a rainy climate.

The Assyrians and Babylonians used bitumen to hold alabaster slabs and burnt bricks together, and the Egyptians used a material obtained by burning gypsum to create what is now called plaster of Paris. The reason for using gypsum may have been that it could be processed at a lower temperature than that needed for lime, and fuel was scarce. The Greeks used slaked lime (calcium hydroxide) mixed with sand, and the Romans also used it to produce a mortar which was exceedingly hard.

Examples of the tenacity and durability of slaked lime mortars still survive in ancient Roman brickwork. Historians and builders have made in-depth studies to determine how the hardness of this mortar was achieved. Of the various methods and processes used in producing mortar, including the addition of molasses, it has become apparent that, rather than any secret ingredient or method of processing the lime, the essential factor which produced the remarkable hardness was thoroughly mixing and ramming the mortar: craftsmanship!

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Cement Kilns

200 CATEGORY DESCRIPTION

Cementitious Materials: Some materials can temporarily acquire plasticity. During their state of plasticity, they can be pressed, cast, molded, and formed into definite shapes, but then, the materials harden or set, retaining their shape. Here, the term "plastics" usually means organic plastics; those which can hold together fillers or aggregates are called cementitious materials.

Five cementitious materials have been used to develop cement: clays, common limes, hydraulic limes, natural cements, and pozzolana cements. These materials share an important characteristic: they achieve plasticity when mixed with water. When the water is removed, such as by evaporation, sedimentation, or chemical reaction, the plasticity disappears.

Classes of Cements: Although this manual is mostly concerned with today's portland cement, several other classes of cement are described here first, for comparison and contrast:

♦ Clays,
♦ Common limes,
♦ Hydraulic limes,
♦ Natural cements, and
♦ Pozzolana cements.

201.1 CLAYS

Clays may be used alone or mixed with other substances. Clays are formed by the disintegration of minerals containing aluminum, generally kaolin minerals: kaolinite, nacrite, and dickite. However, the composition varies widely, with different proportions of silicon and aluminum, and other metals may also be present, such as magnesium, sodium, and potassium. As a result, different clays have different characteristics, such as plasticity and fusing points.

Clay was easy to use, because it required no preliminary processing. In fact, ancient clays naturally formed molds of plants and animals, providing fossils for sciences. Sun-dried clays are still used for adobe brick in dry climates; warm temperatures dry and harden the clay. However, clays do not harden in water.

201.2 COMMON LIMES

After clays, limes were probably some of the earliest cementitious materials, but common limes do not set under water, and they do require processing. Limes must be heated before water is added. Limes are produced from calcium carbonate, CaCO₃, commonly known as calcite. Some high-calcium limestones
contain magnesium. *Dolomite*, CaMg(CO₃)₂, contains calcium carbonate and magnesium carbonate in equal molecular proportions.

### 201.3 HYDRAULIC LIMES

Hydraulics is a science concerned with water. Unlike clays and common limes, a hydraulic lime can be used to form a hydraulic cementitious material. In other words, the material can set and harden under water and withstand the erosive effects of water. It could be used to construct a dam. The American Society for Testing and Materials (ASTM) C 141-61 defines it:

"An hydraulic hydrated lime is the hydrated, dry cementitious product obtained by calcining a limestone containing silica and alumina to a temperature short of incipient fusion, so as to form sufficient free lime (CaO) to permit hydration, and at the same time leaving unhydrated sufficient calcium silicates to give the dry powder, meeting the requirements herein prescribed, its hydraulic properties." [Calcining amounts to *cooking* the limestone to free the embedded carbon dioxide.]

### 201.4 NATURAL CEMENTS

*Natural* cements are *hydraulic* cementitious materials; they are similar to hydraulic limes. Each raw material contains compounds of silicon, aluminum, and calcium. The only preparation required for the raw materials before calcination is to crush and grind them to a small size. While the main use of hydraulic limes is for mortar, the main use of natural cements is for concrete.

ASTM C 10-54 defines modern natural cement:

"The product obtained by finely pulverizing calcined argillaceous limestone. The temperature of calcination is no higher than is necessary to drive off carbonic acid gas." [CO₂]

**In brief, this is one manufacturing process for natural cement:**

The rock is blasted down from the face of the quarry, crushed into a size suitable for the kiln, loaded into dump trucks, and dumped into a rotary kiln with coal -- a layer of rock and then a layer of coal in a continuous operation. As the charge works its way through the kiln, it becomes calcined, e.g., heated to remove its carbon dioxide (CO₂). When it reaches the end of the kiln, a conveyor takes it to the grinder to be ground into a fine powder, natural cement.
201.5 POZZOLANA CEMENTS

This class of cements was made by the Romans from hydrated lime and finely ground volcanic materials containing aluminum, silicon, sodium, and potassium. Named for a town in Italy, Pozzolana cements were among the very earliest forms of hydraulic cements. Of the six classes addressed here, it is the only one which required two raw material components, as shown in Table 200.1.

Between those ancient cements and the modern product lies a fascinating drama of chemical and mechanical experimentation, abundantly described by a number of authors, some of whom are cited in this manual's references. Skipping on to more recent events, we leave to the reader the pleasure of discovering more of the charm and intrigue enfolded within cement's ancient history.

<table>
<thead>
<tr>
<th>Class of Cement</th>
<th>Number of Materials Required</th>
<th>Steps Required to Produce it</th>
<th>Main Compounds Which Produce Characteristics</th>
<th>Is it Hydraulic?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clays</td>
<td>1</td>
<td>None</td>
<td>Aluminum Silicates</td>
<td>No</td>
</tr>
<tr>
<td>Common Limes</td>
<td>1</td>
<td>Calcinate</td>
<td>Calcium Hydroxide</td>
<td>No</td>
</tr>
<tr>
<td>Hydraulic Limes</td>
<td>1</td>
<td>Calcinate</td>
<td>Calcium Hydroxide, Silicates</td>
<td>Yes</td>
</tr>
<tr>
<td>Natural Cements</td>
<td>1</td>
<td>Calcinate and Grind</td>
<td>Silicates</td>
<td>Yes</td>
</tr>
<tr>
<td>Pozzolana Cements</td>
<td>2</td>
<td>Calcinate Limestone, Mix with Finely Ground Pozzolana</td>
<td>Silicates</td>
<td>Yes</td>
</tr>
<tr>
<td>Portland Cements</td>
<td>1*</td>
<td>Grind, Blend with Raw Materials, Produce Clinker, Grind Clinker</td>
<td>Silicates, Aluminates</td>
<td>Yes</td>
</tr>
</tbody>
</table>

* Generally, four components are used to produce modern portland cement: limestone, silica, iron, and alumina.
202 LATER EVENTS LEADING TO PORTLAND CEMENT

For the last hundred years, the main type of cement used in the United States has been Portland cement. It is a hydraulic cement, meaning that it withstands the effects of water. Its name may have originated from a comment made by an eighteenth century engineer, John Smeaton. In rebuilding a lighthouse which had been heavily damaged by the pounding saltwater waves of the ocean, Smeaton said he developed a cement which "... would equal the best merchantable Portland Stone in solidity and durability ..." (Its color was similar to the limestone on the Isle of Portland.)

Then, in 1824, after persistent efforts and experimental refinements of many other construction pioneers, Joseph Aspdin first patented a material which he named "Portland Cement." (As a rule, the name is no longer capitalized.)

Using Aspdin's design from England, depicted in Figure 200.1, David Saylor built a kiln in this country. It was a vertical, domed kiln for burning bricks formed from powdered limestone and clay. He ground the burned brick clinker into a powder, portland cement, which won an award at the Centennial Exposition in Philadelphia in 1876. By 1890 there were seventeen cement plants in the United States, producing over 330,000 barrels per year. One barrel of cement equaled four 94-lb bags, or 376 pounds net; we now measure production in tons.

Equipment. During the nineteenth century, there was little mechanization of cement plants. The old vertical kiln was fuel efficient, but it required a lot of manual labor. In developing a continuous operation requiring less labor, engineers tried both horizontal and vertical models.

Then, Frederick Ransome developed a successful rotary model abroad, and the Atlas Cement Company used it in Pennsylvania in 1899. It was only 25 feet long and 5 feet in diameter, and it rotated on a horizontal axis. Thomas Edison later patented one measuring 150 feet long and 8 feet in diameter, and subsequent kilns were even larger. Figure 200.2 shows a kiln near Victorville, measuring 450 feet by 16 feet. Fueled by coal, oil, and natural gas, these continuous operation rotary kilns revolutionized cement production in the United States.

Equipment for crushing and grinding the kilned clinker into powdery cement also evolved. For example, the Gates crusher and the Griffin mill were not only efficient and dependable, but they also made a fine, uniform product.
Developments in the United States. After the invention of *portland* cement, many years passed before the industry became important in the United States. The first U. S. production was in 1875. From 1875 through 1879, the total production was only 82 thousand barrels, but the annual production increased to 42 thousand barrels in 1880, 176 million in 1928, and 182 million in 1942. In modern measure, *tons*, 182 million barrels is approximately 34 million *tons*.

As a summary up to that point, Table 200.2 lists some of the important events in developing the cement industry. Each of these has had a significant impact on plant design, manufacturing processes, development, or use of the product. Some of the dates are approximate.
Figure 200.2 A Long Dry Cement Kiln Near Victorville
Table 200.2 Some Notable Events In The Cement Industry

<table>
<thead>
<tr>
<th>Year</th>
<th>Event Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before history</td>
<td>The first use of clays.</td>
</tr>
<tr>
<td>Before history</td>
<td>The first use of common limes.</td>
</tr>
<tr>
<td>1756</td>
<td>Smeaton’s development of hydraulic lime, and the Eddystone lighthouse.</td>
</tr>
<tr>
<td>1818</td>
<td>The first natural cement manufactured in the United States.</td>
</tr>
<tr>
<td>1824</td>
<td>Aspdin’s patent for portland cement.</td>
</tr>
<tr>
<td>1868</td>
<td>The first reinforced concrete.</td>
</tr>
<tr>
<td>1873</td>
<td>Invention of the rotary kiln.</td>
</tr>
<tr>
<td>1875</td>
<td>The first portland cement manufactured in the United States.</td>
</tr>
<tr>
<td>1880</td>
<td>The first use of the barrel pulverizer, the prototype of the tube mill.</td>
</tr>
<tr>
<td>1886</td>
<td>The first rotary kiln made in America.</td>
</tr>
<tr>
<td>1887</td>
<td>The discovery of tricalcium silicate by Le Chatelier.</td>
</tr>
<tr>
<td>1891</td>
<td>The first concrete highway, built in Bellafontaine, Ohio.</td>
</tr>
<tr>
<td>1898</td>
<td>The first waste heat boiler.</td>
</tr>
<tr>
<td>1902</td>
<td>Organization of the Association of Portland Cement Manufacturers.</td>
</tr>
<tr>
<td>1903</td>
<td>The construction of an eighteen story reinforced concrete building in Cincinnati.</td>
</tr>
<tr>
<td>1905</td>
<td>Organization of the National Association of Cement Users, which later became the American Concrete Institute.</td>
</tr>
<tr>
<td>1905</td>
<td>The first use in the industry of the Bates valve bag and packing machine.</td>
</tr>
<tr>
<td>1911</td>
<td>Application of the Cottrell precipitator to cement manufacturing.</td>
</tr>
<tr>
<td>1920</td>
<td>Invention of the Fuller-Kinyon pump.</td>
</tr>
<tr>
<td>1935</td>
<td>The first soil-cement secondary road.</td>
</tr>
</tbody>
</table>

Recognition and Development of Potential. Since 1942, the industry has advanced mainly through the continued development of techniques and the use of computers. Furthermore, as cement was manufactured with greater uniformity and reliably met standardized specifications, planners, architects, contractors, and builders began to see its enormous potential. As a result, the building industry was revolutionized. As of the year 1993, the latest complete data available, California had 13 cement kiln facilities and produced approximately 10 million tons of cement.
200 CATEGORY DESCRIPTION
Cement Kilns

203 BASIC CEMENT PLANT PROCESSES

The portland cement manufacturing processes and methods of controlling air pollutants are discussed in detail in the next chapter, but here is an overview of the basic processes.

203.1 SELECTION OF RAW MATERIALS

Portland cement generally contains four chemical elements: calcium, silicon, aluminum, and iron, usually in the form of oxides. The iron and aluminum are only a small percentage of the total mix. In selecting the raw materials, these factors are considered:

- Composition
- Uniformity
- Physical characteristics
- Overburden
- Quantity
- Location, topography
- Transportation
- Unit cost

Composition: The requirements for raw materials for clinker are these:

- The essential elements must be present.
- Proportioning the materials within desired limits must be possible.
- The amount of nonessential elements present is not excessive.

Uniformity: If a raw material is not fairly uniform, it may require excessive extra analyses and mixing operations; perhaps a better source could be located.

Physical Characteristics: Some important physical characteristics of the raw materials are grindability, homogeneity, and the uniformity of its hardness. Special considerations may also apply:

- If its hardness varies, does it tend to segregate after it is ground?
- If it is to be blasted in a quarry or mine, does it shatter easily?

Overburden: The amount of overburden, or waste material, and its physical characteristics may make the use of a raw material impractical.

Quantity: The supply of the primary raw materials must be adequate for the planned annual production and the number of years of operation. Primary materials are those which form over 85 percent of the clinker weight, mainly limestone and silica. Secondary materials form less than 15 percent.

Location, Topography, and Transportation Methods: These interdependent factors in determining plant location can affect the unit cost of the product.
203.2 LAYOUT AND WORKFLOW OF A CEMENT FACILITY

Each plant is unique, but two main types of dry process plants predominate:

- Preheater / precalciner kilns, as pictured in Figure 200.3 and described in Figure 200.4, and
- Long dry kilns, as pictured in Figure 200.5.

Typically, but with differences at individual plants, the process goes like this: The basic raw materials, limestone (CaCO₃) and silica (SiO₂), are mined at an adjoining or nearby quarry, loaded onto huge, 85-ton dump trucks (for example), and hauled to a primary crusher. After the material is crushed to pieces of approximately 8 inches in diameter, it is moved by covered conveyor belts to secondary and tertiary cone crushers, which reduce it to about 2 inch and then half-inch marble sized pieces.

Next, the marble sized raw materials go to the pre-blending pile. In the facility shown in Figure 200.3, the pile is inside a huge pre-blending dome at the right edge of the picture. The dome protects the materials from wind erosion. In a pre-blending station, the primary materials (limestone and sometimes shales) are mixed and blended. The blended material is further mixed with iron, clay, and/or bauxite, which are stored in silos, on its way to a grinding mill, where it is converted into powder. In this particular facility, the mill is a 5,400 horsepower ball mill, using tumbling steel balls to reduce the marbles to powder. Figure 200.3, a composite photo, shows a typical preheater / precalciner plant, and Figure 200.4 shows the basic process.

An essential key to the efficiency and success of preheater / precalciner plants is the pre-heat tower near the mouth of the kiln. In Figure 200.3, the tower is in the center of the picture. The kiln is fired from the opposite end, and the combustion heat of 2,700 degrees Fahrenheit travels through the kiln to the mouth, where the valuable heat energy is captured and used to preheat the raw materials to 1,500 degrees. The feed is thus precalcined (the carbon dioxide is driven off) before it is introduced into the kiln.

[The text continues, entrained in sequence with the figures.]
Figure 200.3 A Preheater / Precalciner Plant Near Victorville
1. Raw materials of limestone, clay, iron, and alumina are fed in at the upper end of the slightly inclined and rotating kiln. Tires and certain wastes used as supplemental fuels may be introduced here.

2. Fossil fuels, coal, oil, or natural gas, and solvent-type fuels, if used, are introduced into the kiln here.

3. In the burning zone, the flame reaches 3,500 degrees Fahrenheit. The raw materials average 2,450 degrees. Here, tires undergo a chemical reaction, oxidizing their organic compounds. Inorganic steel belts oxidize and bond with raw materials, forming nodules of "clinker."

4. Marble-sized clinker leaves the kiln and enters a cooling chamber. Ultimately, cooled clinker is mixed with a bit of gypsum and ground into portland cement.

5. Hot combustion gases move up the kiln against the flow of the tumbling raw materials. Exhaust fans draw the gases into the pre-heater, where the heat is used to raise the temperature of the raw materials to about 1,500 degrees.

6. Powdered limestone, a primary component of the raw feed mix, chemically scrubs the hot gases as they pass through the pre-heater, helping to neutralize the acid gases.

7. A dust collection system, such as a baghouse, traps kiln dust, which is then either fed back into the kiln as a raw material, recycled in other processes, or disposed of.

8. Carbon dioxide, nitrogen, and water vapor comprise most of a kiln's emissions. Other emissions are detailed in this chapter.

Figure 200.4 Workflow of Processes to Make Portland Cement
In contrast to preheater/precalciner kilns, long dry kilns such as that in Figure 200.5 do not use preheaters. The five vertical tubes collect and cool the kiln dust before it enters the baghouse in order to prevent burning out the bags.

In both types of kiln processes, however, as chemical reactions occur within the kiln to produce clinker, chemists continuously monitor and analyze the accuracy of the blend. Using X-ray fluorescence and computerized mechanization such as that shown inset in Figure 200.5, they make adjustments as necessary. Then, after a hot journey through the kiln, the clinker is cooled and conveyed to a grinder which reduces it to a fine powder, portland cement.
Next, gypsum is added, to make concrete workable, i.e., when the cement is mixed with sand and gravel to produce concrete, the gypsum delays the setting time. Then, some of the cement may be packaged, as shown in Figure 200.6, and the rest is stored in bulk to await shipping. For bulk shipping, the most common methods are by rail and in the pneumatically loaded and recognizable truck-trailers such as that shown in Figure 200.7.
204 FUELING THE FIRE

Cement plants use conventional solids, liquids, and gases for fuel, usually coal, oil, and natural gas. A few plants also use selected waste materials to supplement their main fuel, wastes such as scrap rubber tires, waste solvents, and sludges remaining from recycling solvents.

204.1 CONVENTIONAL FUELS

The solid fuels used in cement facilities are usually coals, such as the low-sulfur product mined at Sunnyside, Utah. Some plants have used petroleum coke or small amounts of anthracite and coke, ground up and mixed with bituminous coal. The liquid fuels are petroleum products, and the gaseous fuels are usually natural gas.

At most plants, fuels cost more than any other materials, and only occasionally does a site have nearby coal deposits. Consequently, most fuels are bought from available market supplies and shipped in, often by rail.

Fuel storage: Cement facilities usually keep a reserve stock of fuels in order to maintain production in spite of any transportation disruptions, but stockpiling has some disadvantages. The coal stockpile should have good drainage, and all nearby vegetation must be removed. Coals from two sources should not be mixed, because of their different characteristics. When coal is stored, it is important to consider these factors:

- The possibility of fires in stockpiles,
- The gradual loss of heat content by oxidation, and
- Contamination of the coal during handling.

Reserve oil stocks may also present disadvantages, such as the need to provide large storage tanks, since the consumption is high. Furthermore, thick oil may need to be heated during cool weather.

Gaseous fuels, while not normally stockpiled in reserve, may still be diminished or interrupted from time to time, so some plants may substitute coal or oil during emergencies.

Fuel choice: The selection of fuel for a cement plant may depend on the types of fuels available in the vicinity, the plant equipment, and the relative cost of each type. There are advantages and disadvantages peculiar to each type.
Coal is used at many plants because it is available and broadly distributed throughout geographical areas. By net heat energy, coal may have somewhat higher thermal efficiency than gas. However, while oil and gas may be burned as they are received, coal must be crushed, finely ground, and sometimes dried. Coal is also subject to considerations of uniformity and its level of contents of heat energy, ash, and sulfur.

On a net heat energy per unit cost basis, some operators have chosen oil. Kiln fuel control may be easier with oil than with coal, and in cases when the color of the cement may be significant, oil may affect the color less than does coal.

Natural gas may be a very desirable fuel for cement plants, depending on its quality, quantity, and price, because of its relative ease of handling and ease of controlling the rate of fueling the kiln. However, since the gas flame burns faster and hotter than coal, for example, it may produce larger quantities of NOX (oxides of nitrogen).

204.2 SUPPLEMENTAL FUELS

A few cement plants supplement their main fuel with permitted, measured amounts of selected waste materials such as used rubber tires, waste solvents, and the sludges remaining from solvent recycling. Burning these wastes has raised questions from people who are concerned about the effects on the environment. However, since kilns provide controlled burning at temperatures above 2,700 degrees Fahrenheit, perhaps burning some wastes in kilns can be a welcome solution to some of our difficult and expensive disposal problems.

Disposing of these wastes has posed the problems of storage, handling, transportation, and sometimes landfill considerations. Each year, for example, California generates an estimated 2,500,000 tires for disposal. Unmanaged or illegally stockpiled, these scrap tires can pose environmental and health risks.
Alternative "disposal" methods for rubber tires have caused these problems:

- Tires can be a habitat for vermin and they may contain puddles of casual water for mosquitos and other pests.

- Tires have often been irresponsibly dumped in rivers, streams, and other remote property, for convenience and to avoid a $2 disposal fee.

- Stacks of tires can pose a serious fire hazard. Tires buried in a central California landfill recently caught fire. The fire was difficult to quench, and it produced thick, black smoke for about 10 days.

Furthermore, disposing of tires in landfills can be an energy waste. According to studies by Southdown, Inc., "The average passenger radial tire contains over 50 percent pure rubber polymer and synthetic fibers, which means each tire is packed with energy potential -- about 15,000 Btu per pound, compared to about 10,000 Btu per pound of coal." Other sources estimate that the heat energy of coal is about 12,000 Btu per pound, while tires can produce about 1.2 times as much, or 14,400 Btu.

The Southdown cement plant, near Victorville, was one of the first plants in California to use tires as a fuel supplement. Their staff found a suitable ratio of tires to natural fuel and developed methods of handling the tires. In 1991, they performed a test comparing kiln emissions with and without tire burning. As shown in Table 200.3, the results were favorable. Plant emissions, for example, contained less nitrogen oxide (NOX) with tires as a fuel supplement than without. One witness who watched a tire enter the kiln exclaimed, "Within a few feet of the entry, the tire was completely vaporized!" The steel belts from radial tires become chemically locked into the cement, to augment the purchased iron, an essential ingredient of cement.

Southdown ultimately determined that burning tires was not economically feasible for their plant. Other plants, however, such as the Mitsubishi Cement Company, continue to use tires to supplement low-sulfur coal. They have installed an automated system for loading the tires and conveying them into the kiln at a measured rate, as shown in Figures 200.8 and 200.9.
### Table 200.3 Burning Tires: a Test Demonstration

Cement Kiln Emissions, Using Tires for Supplemental Fuel
Victorville, CA, April '91

<table>
<thead>
<tr>
<th>Compound Measured</th>
<th>Coal Only</th>
<th>Coal and Tires</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sulfur Dioxide, ppm</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Oxides of Nitrogen, ppm</td>
<td>435</td>
<td>336</td>
</tr>
<tr>
<td>Carbon Monoxide, ppm</td>
<td>980</td>
<td>770</td>
</tr>
<tr>
<td>Total Hydrocarbons, ppm</td>
<td>12.5</td>
<td>8.6</td>
</tr>
</tbody>
</table>

### Stipulations for Burning Wastes

**What kinds of wastes may be suitable for burning as supplemental fuels?**

There are two main stipulations:

- The waste must contain a significant amount of potential energy to augment the primary fuel.

- The waste must not contain RCRA (Resource Recovery and Conservation Act) regulated substances which could produce toxic emissions, e.g., metals such as antimony, arsenic, barium, beryllium, cadmium, or hexavalent chromium, etc., *unless* the kiln complies with the detailed requirements imposed by the EPA Boilers and Industrial Furnaces rule.
Figure 200.8 Used Tires for Disposal as Supplemental Fuel

Figure 200.9 Tires Are Conveyed into the Kiln at a Measured Rate.

Oct 1996
205 CEMENT KILNS AND AIR QUALITY

How can cement kilns affect our air quality? In most stages of the processes, opportunities can occur for pollutants to escape or to be propelled into the air. Pollutants may escape from the time the source elements are mined from within the earth, crushed, conveyed, mixed, fired in the kiln, ground into powder, stored, and until the final product is shipped.

The pollutants from cement kiln facilities are mainly particulates and products of combustion. Some of the particulates emitted are of smaller diameter than 10 microns; these are called PM10. Operators are very aware of cement kiln dust, (CKD) not only because it could pollute the air, but also because it is product. In years past, CKD was often present throughout most plants, but with modern equipment and controls, now CKD occurs mostly at the feed end of the kiln, where nearly all cement plants in California capture and recycle it. Details of sources and controls are presented in Chapter 3.

The ARB’s Emissions Inventory Branch lists the emissions for each California cement kiln facility. The total emissions by classifications for the year 1993, the latest year for which data analysis is complete and available, are listed below:

- Total organic gases (TOG) 450.5 tons/year
- Total carbon monoxide (COT) 4,759.2 tons/year
- Oxides of nitrogen (NOX) 15,043.0 tons/year
- Oxides of sulfur (SOX) 1,535.4 tons/year
- Particulate matter (PM) 6,810.6 tons/year

(This data is reviewed and discussed in more detail in Chapter 3.)
This chapter describes the processes used in cement kiln operations, some of the equipment used, and the control methods used to limit air pollutant emissions. Most of the emissions occur wherever materials are handled or transported.

301 PROCESSES IN BRIEF

With reference to a typical plant layout shown in Figures 300.1a, 300.1b, and 300.2 on the next three pages, this is briefly how portland cement is made: Shale or clay and a calcareous material (a substance containing calcium carbonate or lime) are quarried, crushed, carefully proportioned, mixed, ground to a fine powder, and then cooked at about 2,700 °F.

For mixing and grinding, either a wet process or a dry process may be used, but it is essential that the mixture be correctly proportioned, finely ground, and thoroughly intermixed. California cement kilns have used the wet process in the past, but most or all have converted to the dry process, because evaporating extra moisture in the kiln requires more heat energy.

Next, iron and aluminum are added, and the mixture is fed into a slightly inclined kiln which rotates about its nearly horizontal axis. As the mixture makes its way slowly toward the low end of the kiln, it is heated to the sintering point -- a temperature at which the mass becomes shaped and partly fused, but below the melting point. The water and carbon dioxide are removed before the mass becomes hot enough to form clinker. As the mass becomes hotter, chemical reactions take place within the mixture, forming new compounds. Some of these compounds melt to partially fuse the mass.

The resulting clinker is then dropped into a cooler or conveyed to a clinker pile to be cooled, sometimes with a water spray. When cool, the clinker is mixed with a small amount of gypsum, and the mixture is ground to a very fine powder, portland cement, which is used to make concrete. The gypsum allows the concrete to remain workable for a longer time before it sets.

The finely ground cement, which must conform to certain standard specifications of composition, fineness, strength, and other physical properties, is conveyed to silos, where it is stored until it is shipped. It is usually shipped in bulk by special trucks, or by rail, but may also be packaged in bags of 94 pounds net, 4 of which constitute a barrel of 376 pounds net. Barrels used to be the common unit of measure, but now we use tons. Processes are described in more detail after the layout figures on the next few pages.
This is a fairly typical preheater / precalciner plant, except that most plants finish-grind their own clinker.
Figure 300.1b Workflow and Process
Figure 300.2 A Preheater / Precalcer Cement Kiln Facility
302 PROCESSES IN DETAIL

In this section we present details of these cement plant processes:
(Please see Figures 300.3 and 300.4.)

- Quarrying Operations
- Preliminary Grinding and Mixing
- Kilning / Clinkering, and
- Finish / Fine Grinding
- Storing, Packaging, and Shipping

302.1 QUARRYING OPERATIONS

While safety is an essential consideration throughout the cement plant, and hard hats are always required outside of vehicles and offices, the quarry may require even more vigilance. In this open pit mine, tons of material are drilled, blasted, scooped, loaded, and dumped. In blasting,

- Peripheral personnel must be aware and protected,
- Radio transmissions must be restricted to prevent premature ignition,
- The plume and its debris must be safely contained, and
- The plume must remain within plant boundaries. (Check the wind first.)

Heavy equipment abounds. Huge loaders, and dump trucks standing 18 feet tall weighing 85 tons, carry their 85 tons of rock quickly along unpaved roads to the preliminary crusher mills. If the mined raw material is dry, then personnel must take precautions to prevent dust from escaping into the air. The roads may need to be sprayed so that vehicles will not raise dust into the air. Often, covered conveyors are used instead of trucks to move the raw materials to be processed. Covers may be required by the conditions of the permitted equipment.

302.2 PRELIMINARY GRINDING AND MIXING

Preparing the Raw Mix: In preparing the raw mix, the goals are that:

- The raw materials are combined in the desired proportions,
- They are blended as completely as practicable, and
- They are ground to an optimum size so that the ratio of surface area to weight will allow the chemical reactions in the kiln to reach equilibrium.

The two main raw materials, limestone and shale, and usually iron and alumina, are combined along the way. They are carefully proportioned; it is crucial to obtain the desired ratios. The raw mix may be so finely ground that 85 per cent of it will pass through a 200-mesh sieve, where each opening is about .003 inch. In the past, both wet and dry processes have been used to prepare the mix.
Blasting is conducted with great care. Most blasts produce much smaller plumes of rock and dust.

Figure 300.3 Quarrying and Crushing Cement Materials
(Blasting is Inset)
Figure 300.4 A Limestone Quarry With Heavy Equipment
Wet Process is Older

The Wet Process is the older of the two methods. The amount of water needed for the wet process depends on the physical and chemical properties of the raw materials. For example, the water for limestone-clay slurries may be about 50 per cent, while limestone-shale slurries may require less. In any event, all of the water added to prepare the kiln feed has to be removed eventually, and that can require expensive fuel consumption.

Similar types of mills and operations are used in both the dry and wet processes. However, in the wet process, there may be more options to the sequence of operations, depending upon the physical characteristics of the raw materials as they are received at the plant.

After crushing, the material is dumped into huge bins, from which the chemist blends the correct proportions. The components of the feed are measured, and small adjustments may be made to the amounts of shale or limestone in order to provide a constant and optimum mixture to be fed into the kiln. As the feed approaches the kiln, waste heat from the kiln entrance is usually used to pre-heat the feed to a temperature of about 1500 degrees Fahrenheit.

Dry Process

In the dry process, raw materials may be dried before entering the preliminary mills, but the heat generated by the friction of preliminary grinding may be sufficient, and waste heat from the kiln may also be used for drying the material.

Preliminary blending of the raw materials may be accomplished in the quarry by a huge frontloader, as depicted in Figure 300.4. For example, one scoop of stripping and two of rock may be loaded into the 85-ton transport trucks such as the one also depicted in Figure 300.4. The proper proportions may also be blended later, when the material is conveyed to the crushers, where it is reduced to the size of marbles. For this dry process, the material is ground and pulverized without adding water, and the finely crushed rock may be dried before it is pulverized.

Wet or Dry Process? Each facility does only one process, not both, and switching back and forth is not practical. For the dry process, most of the water content of the mix must be removed early in the preparations. For the wet process, the mix has a large percentage of water when it enters the kiln. However, it requires less heat energy to remove the moisture at the beginning of the dry method than to remove the water for the wet method during the kilning process. Consequently, taking into account the following considerations, most California kilns currently use the dry method.
Wet or Dry? Five Factors Which May Affect the Choice:

- Water content of the raw materials
- Water supply at the plant
- Cost of fuel
- Dust collection
- Uniformity of the product

**Water Content of the Raw Materials:** If the primary materials are wet when received at the plant, then the wet process may be suggested. Wet materials include marl, granulated blast furnace slag, and some clays. If the materials contain only surface water, then adding large quantities of water to be removed later may not be fuel efficient.

**Water Supply:** Many plants are located in dry areas of the state.

**Cost of Fuel:** Relatively expensive fuel favors the dry process, because dry feed requires less fuel to heat and maintain the kiln at 2,700 degrees Fahrenheit. However, burning hazardous wastes to augment the usual fuels, coal or gas, may lower the cost of fuel, making the wet process more viable.

**Dust Collection:** Less dust may be expected from the wet process than from the dry process, requiring less dust control equipment.

**Uniformity:** A total weight of about 600 pounds of dry raw materials is required to produce a 376-pound barrel of clinker. It may seem that the slurry for wet-process cement would be more uniform than the dry-process materials. However, dry mix can be weighed after preliminary grinding, allowing accuracy of mix ratios in order to produce dry process cement which is uniform enough for any commercial use.

### 302.3 KILNING / CLINKERING

The kiln, such as that shown in Figure 300.5, may have more functions than any other piece of equipment in a cement plant. The kiln serves as:

- A chamber for the combustion of fuel,
- A flue for gases and vapors,
- A conveyor for solids,
- A heat exchanger and dryer,
- A calciner (It drives off calcium carbonate),
- A mixer for the raw feed, and
- A host for chemically transforming the feed into clinker.
Clinker + gypsum conveyed to grinding mill

Figure 300.5 Long Dry Kiln Operations
Since it has so many functions, the kiln may not produce optimum results for any one function, so compromises or additions may be made in favor of one or more of the others. For example, the first two do not require rotation, and as a conveyor, the kiln need not be so elaborate. The last function, of course, is the essential and nearly final goal in producing portland cement.

302.4 FINISH / FINE GRINDING

By the process already shown in Figure 300.5, the finish or fine grinding of marble-sized clinker is accomplished by a heavy duty device such as shown in Figure 300.6, a 4,500 horsepower steel ball mill. In this rotating, drum-like device with inwardly protruding feet, the clinker is lifted and dropped by the feet, while steel balls pummel and mash it into a fine powder. The fine grinding is not always completed at the kiln site. At least one plant sends the clinker marbles to a plant which specializes in finish or fine grinding, packaging, and shipping.
302.5 STORING, PACKAGING, AND SHIPPING

The fine, powdered cement must be kept captive; it is the valuable end product of a long and exacting process, but it is also a potential air pollutant. It is usually pneumatically pumped through valves, ducts, and tubes from one host to another, i.e., from mill to silo to bulk truck to concrete batch plant storage to concrete mix, etc. It is essential to assure that the connections do not leak.

303 POSSIBLE SOURCES OF EMISSIONS

The ARB’s emissions inventory separately lists emissions for each California cement plant. As introduced in the previous chapter, the total emissions by classification for the year 1993, the latest year for which data analysis is complete and available, are listed below:

- Total organic gases (TOG) 450.5 tons/year
- Total carbon monoxide (COT) 4,759.2 tons/year
- Oxides of nitrogen (NOX) 15,043.0 tons/year
- Oxides of sulfur (SOX) 1,535.4 tons/year
- Particulate matter (PM) 6,810.6 tons/year

(This data was mentioned briefly in Chapter 2.)

Where do these emissions come from? The types of pollutants emitted from each plant depend on its peripheral operations and components, assorted machinery, internal combustion engines, and motor vehicles. Basically, most opportunities for pollutants to escape into the air occur at the mouth of the kiln, at points where materials are handled or transferred from one place or carrier to another, and where control equipment is not operating properly.

Fugitive dust can come from quarrying, crushing, and grinding operations. Oxides of nitrogen can come from combustion sources, the amount depending on the type of fuel, the burning temperature, and other variables. The Emission Factors are included in Appendix G, AP-42, but they are approximations, and specific cases may vary.

From a constructive point of view, the many possible sources of pollution at cement facilities could be called, “Opportunities to Prevent Air Pollution.”
Through conscientious use of procedures and controls, pollution may be prevented at each of these opportunities:

- The mouth of the kiln,
- Elevators, and conveyor belts,
- Filters / dust collectors throughout the plant,
- Roadways in plants and entries to public roads, and
- Loading / transportation points.

### 304 CONTROL OF AIR POLLUTION

The cement industry has already attained significant reductions in their air emissions throughout the years, as new technology became available. We can continue to control air pollutants from cement facilities throughout California by complying with the rules and regulations, by using control devices as appropriate, and by implementing frequent, effective maintenance and housekeeping practices.

### 304.1 RULES AND REGULATIONS FOR CONTROL

Rules, regulations, and the permitting process are designed to control emissions from plants by setting limits and requiring specific operating conditions. These regulations are stringent, and they vary from one district to another, but they generally include:

- **Visible emissions** - not greater than 20% opacity or higher than a Ringelmann 1; *State* law does permit no greater than 40% / Ringelmann 2.

- **Fugitive dust** - dust usually cannot cross property line.

- **Breakdown** - must report breakdowns within one hour.

- **Nuisance** - must not emit pollutants which cause injury, detriment, nuisance, or annoyance to any considerable number of persons or to the public, or which endanger the comfort, repose, health, or safety of any such persons or the public, or which cause, or have a natural tendency to cause, injury or damage to business or property.

- **Permit to Construct** - to construct or modify, must have this permit.

- **Permit to Operate** - must operate under the conditions listed on the permit.

- **Regular maintenance** - can help assure compliance with air pollution regulations, avoid breakdowns, and maintain production efficiency.
304.2 METHODS OF CONTROL

One of the primary elements of maintenance is thorough cleaning. Most control devices used at cement plants collect and/or suppress dust which is predominantly particulate matter.

Cement kiln dust, known as CKD, has been a problem throughout the plant in years past, particularly wherever materials were handled or transported. Today, dust collectors are used in most areas, with devices based on inertia, filtration, sedimentation, or electrical precipitation. The dust is usually either a raw resource or a valuable product, portland cement, so it can be added to one of the raw materials or to the raw mix, or perhaps it can be fed directly into the kiln.

Collection devices include electrostatic precipitators and baghouses. CAP has technical manuals for both, checklists and operating tips from which are provided in the Appendix of this manual. Various designs of these devices can attain collection efficiencies as high as 99%. The many variables which determine their efficiencies include design, bag material, particle size, flow rate, etc. Table 300.1 shows typical emission sources and control measures.

<table>
<thead>
<tr>
<th>Source</th>
<th>Control Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blasting</td>
<td>Water / chemical suppressants</td>
</tr>
<tr>
<td>Crushing</td>
<td>Water sprays</td>
</tr>
<tr>
<td>Overburden</td>
<td>Water sprays</td>
</tr>
<tr>
<td>Fuel deliveries</td>
<td>Covered coal cars or train enclosure</td>
</tr>
<tr>
<td>Coal storage and handling</td>
<td>Covered storage</td>
</tr>
<tr>
<td>Preheater</td>
<td>Baghouses</td>
</tr>
<tr>
<td>Kiln</td>
<td>Baghouses</td>
</tr>
<tr>
<td>Cement transfer / shipping</td>
<td>Pneumatic ducts with sealed valves</td>
</tr>
<tr>
<td>Cement screws</td>
<td>Seals and socks</td>
</tr>
<tr>
<td>Conveyors</td>
<td>Cover, vent, capture, suppress, spray</td>
</tr>
<tr>
<td>Yard and road dust</td>
<td>Wash, sweep, pave, spray, landscape</td>
</tr>
<tr>
<td>Public roads (trackout)</td>
<td>Clean truck tires and rails at departure</td>
</tr>
<tr>
<td>Stockpiles (ground)</td>
<td>Water sprays, windbreaks, covers, structured storage, trapdoor access</td>
</tr>
</tbody>
</table>
How to do an Inspection. This chapter, written primarily for the regulatory inspector, can be an excellent source of information about conducting facility self-inspections. It can guide you through a complete compliance inspection of a cement facility. It discusses procedures for pre-inspection, post-inspection, sampling, and inspector safety. Guidelines and checklist materials are provided here. When you use your checklists, you may find rewards: Your inspections will be more effective, and you will save time as you are more aware of these aspects of your inspection:

- What to look for,
- What questions to ask,
- How to locate unpermitted cement equipment, and
- How to conduct, complete, and document your inspection.

The standards and policies you need to determine compliance with each requirement will depend on your specific district rule and implementation strategy. You may place a copy of your district rule and your inspection aids in the appendix provided for it.

First, follow the pre-inspection procedures. Review the source files and applicable rules, learn what equipment you may need, what information to exchange with the facility manager, and what to check for on the Permit to Operate.

Then, proceed with a complete compliance inspection, including cement plant equipment, operations, and administrative requirements.

Finally, the post-inspection procedures provide guidance on how to determine compliance rates, calculate excess emissions, and assure follow-up.

Your objectives as you inspect a cement kiln are to assure compliance with:

- State and federal regulations,
- District regulations,
- Authority to Construct / modify and
- Permits to Operate.

District regulations which are generally associated with concrete batch plants include those concerning fugitive dust, visible emissions, particulate matter,
breakdowns, nuisance, and Permits to Operate, specifying conditions under which the equipment and facility must operate (such as hours of operation, production rate, etc.). An extensive baghouse inspection checklist and associated information are included in Appendix D.

401 PRE-INSPECTION PROCEDURES

Before you visit the site, your preparations are essential. Some of the general guidelines and steps to follow are discussed here:

File Review. In the District source file, check all the information available about the plant, including:

1. Equipment lists
2. Permit applications
3. Permits approved
4. Conditions for each permitted unit
5. Previous inspection reports
6. Reports of Violation (note rule sections and equipment)
7. Enforcement action taken
8. Complaints
9. Variance history
10. Abatement orders
11. Source test date
12. Breakdown report
13. Authority to Construct

You may enhance the tenor of the pre-inspection meeting by completing some portions of the inspection documentation before arriving at the facility. If your district has specific checklists or forms, use them.

Regulation Review. Review any references to specific rules which may be noted in the source files, assuring that you are familiar with each standard and exemption for each applicable rule. Discuss the legal requirements with experienced personnel and review any policies your district may have. Assure that you receive consistent interpretations on how to apply requirements of the rules.
Equipment Check. Assemble all appropriate equipment for the inspection, such as:

1. Vision and hearing protection
2. Safety shoes, hard hat, and gloves
3. Identification cards and business cards
4. Sampling supplies, if samples may be required: cans, labels, pens, seals, wipes, and container to carry cans
5. Forms for inspection and chain of custody
6. Specialized equipment such as a visible emissions evaluation kit, including provisions for determining temperature, dewpoint, and wind
7. Camera and film

Pre-entry and Entry.

1. Look at the plant from the outside. Do you smell any odors or see any emissions? Note the size and layout of the facility. Identify and prioritize potential problem areas to inspect first if your time is running short.

2. Enter the facility through the normal public access.

3. Present your business credentials.

4. Request to see the contact person mentioned in the files, such as the plant manager or a supervisor of environment, production, or maintenance.

Be prepared to cite and provide copies of these sections of the California Health & Safety Code (HSC) in case the source representative may not be familiar with your district’s authority:

- 41510: Right of Entry
- 42303: Information Required

Know your district’s policy for refused entry.
Pre-inspection Meeting. Before you begin your inspection, meet with the source representative to obtain operating information. State the purpose of your inspection and identify the equipment which you will inspect.

During this meeting, obtain information including:

1. Name, complete address, and ownership of the plant
2. Contact name, title, and phone number
3. Operating season, schedule, and production rate
4. All fuels used and sulfur contents (for permitted tanks)
5. Date of last breakdown
6. A copy of the annual inventory reports as required by the district permit
7. Any unfinished district business such as variances, Authority to Construct, and breakdown correction reports.

Discuss sample collection and any required safety procedures, and request copies you need, such as production records and material safety data sheets (MSDS).

Check Permits. Request to see a copy of each permit for the facility - permits should be posted - and check that they are current and valid. Check existing permit conditions and ask if any changes to the operation have been made which are not reflected in the permits.

402 FACILITY INSPECTION PROCEDURES

Begin the inspection of the facility, keeping in mind throughout, these six points of inspection:

- Capture / Point of Contaminant Generation
- Transport
- Air Mover
- Instrumentation
- Subsystem
- Control Device

In order to assure that you do not overlook any equipment or operations, you may wish to conduct your inspection in the same order as the production process, from quarrying to shipping. As you proceed, ask yourself questions about each phase and aspect of the facility to help you determine compliance with your district’s regulations and permit conditions.
Most districts have developed an inspection form tailored for their own regulations and permit conditions. Write the answers on the inspection form.

If your district does not have a tailored inspection form, the questions in the following sections may help you to develop a source specific inspection form pertinent to the regulations and permit conditions for facilities in your district. Sample inspection guides are included in Appendix D.

Compliance with Regulations. Check compliance with the regulations commonly associated with concrete batch plants, including the requirements related to visible emissions, fugitive dust, and particulate matter. (Compliance Assistance technical manuals are also available for Aggregates, Hot Mix Asphalt Facilities, and Baghouses.)

1. Visible Emissions (VE) Checklist (A CAP VE handbook is available.)

   a. VE from the facility - Do you see any which violate opacity or Ringelmann limits for your district?

   b. Emission points - Check all possible points.

In order to perform a visible emissions evaluation, you must be certified. For information on becoming certified, contact the ARB at 800-952-5588. If you do evaluate VE, be sure to follow the prescribed procedures. Use a stop watch or one with a second hand, and remember to determine the relative humidity. An evaluation form, along with techniques for making and recording smoke evaluations from stationary sources is included with EPA Method 9, located in Appendix C. Further details about VE observations are provided in the ARB’s VE certification course and in the CAP handbook.

2. Fugitive Dust Checklist (A CAP handbook is also available.)

   a. Dust, outside - Do you see any coming from the plant?

   b. Property line - Where is it? Does any dust travel past the line?

   c. Dust, inside - Precautions adequate to minimize dust? Do trucks track cement onto road / yard area? Paved roads or wet roads Speed limits for vehicles Wind breaks: screens, walls, bushes/ trees Stockpiles covered or watered Conveyors covered or watered Program of control or watering
d. Cement - Are filters / collectors for silos / bins used effectively?

e. Public roads (Trackout) - Precautions to prevent depositing product?
Is dust removed from trucks before they enter public roads? If tracks occur, promptly removed?

f. Wind - Write down the present speed and direction:

Take three wind readings at 15-minute intervals with Dwyer gauge, or get wind data from nearest air monitoring station or a wind instrument located at the site.

3. Particulate Matter Checklist

- Visible emissions - Violation of limits?
- Control equipment - Condition OK and operating properly?
- Production rate - Changed since last inspection? By how much?

Permit to Operate - Compliance. The permit issued by your district will list the conditions which must be met in order to comply with your district’s air pollution requirements. Determine whether the plant complies with its permit.

If the plant does not have a permit, or if the permit is not current and posted properly, or if the conditions are not met, issue a Notice of Violation or take other action consistent with your district’s policies.

Permit Checklist

a. Permit - Current and properly posted for equipment such as silos, bin vent filters, mixers, and scales? (Some districts issue permits for combinations of equipment; others issue individual permits.)

b. Equipment - Accurately listed? Substituted, added, or modified without Permit to Operate / Authority to Construct?

c. Equipment - In good working condition?

d. Operating conditions - As specified by the permit?
Be sure to check all conveyors and transfer points, including valves and ducts. For Maintenance and Self-inspection, managers may regularly address the items listed below to help maintain equipment in good working condition. As you check each piece of equipment, use a checklist.

1. Raw Materials Conveyors Checklist
   a. Raw material
   b. Conveyor covers
   c. Discharge chutes
   d. Collector discharge valves
   e. Lube joints and gear boxes

2. Loading Stations
   a. Pneumatic valves
   b. Filters / collectors

3. Ductwork
   a. Material buildup
   b. Deterioration
   c. Fugitive leaks
   d. Dustpiles
4. **Baghouse** Figure 400.1 is a photo of a baghouse with a continuous emissions monitor, (CEM) and Figure 400.2 is a diagram showing bag cleaning methods. Here is a short baghouse inspection checklist. A more extensive example is in Appendix D, and a CAP baghouse technical manual is also available.

   a. Pressure system: positive, or negative?
   b. Write down the pressure drop across the baghouse.
   c. Write down the inlet and outlet temperatures.
   d. Any fugitive leaks from housing?
   e. What type of cleaning system is used?
   f. How often are the bags cleaned?
   g. Are there visible emissions during cleaning?
   h. Is compressed air pressure for cleaning adequate?
   i. How are bags checked? How often are they checked/changed?

5. **Plant Towers**

   a. Are there fugitive leaks from the housing?
   b. Any holes, cracks, or signs of corrosion?
   c. Overflow chutes: Any discharge onto the ground?

6. **Fan**

   a. Location:
   b. Type of fan:
   c. Motor horsepower:
   d. Pressure drop across the fan:
   e. Excessive vibration or noise?
   f. Visible emissions from the fan?

7. **Storage Bins**

   a. Are there emissions from the storage bins?
   b. How many bins are there? Of what capacity?

8. **Recycling System**

   a. What materials are recycled?
   b. What percent of the mix is from recycled materials?
   c. Is waste material contained, or tracked away or carried to waterways?

After collecting all of the information that you need to determine compliance with regulations and permit conditions, you are ready to begin the post-inspection phase of the inspection.
Sonic Vibration  Horizontal  Vertical

Clean gas  Backwash air

Figure 400.2 Baghouse and Cleaning Methods
400 INSPECTIONS

403 POST-INSPECTION PROCEDURES

Before leaving the facility,

1. Determine whether the plant is in compliance.

2. Inform the plant representative of the inspection results: If appropriate, issue a Notice of Violation (NOV), advise of additional concerns, and indicate whether more information or investigation is needed.

3. Document sample collections, any unresolved concerns, and requests for additional information.

Follow up on all violations, consistent with your district’s policy, to ensure that the facility is brought into compliance. Using your district’s format, prepare a report for your district’s files. The report may include or refer to the following items, some of which may already be in your district’s file for that facility. They may need to be updated, however.

- A written description of the facility and processes.
- A plan diagram showing the location of equipment and emission points.
- A process diagram: materials, flow rates, temperatures, pressures, etc.
- A statement indicating compliance or violation for each emission point.
- Recommendations, if any, such as a source test or an engineering evaluation for emissions regulated by rules other than the opacity rule.
- Assessment of fugitive emissions and other potential impacts.

If you take any samples, then follow your district’s chain of custody policy.
Review ARB Safety Manual

Safety Tips and Reminders

404 INSPECTOR SAFETY

YOUR safety in the industrial environment is important to everyone! Please refer to the ARB safety manual and observe the safety policies and procedures of your district and of the facility that you inspect. Ask the plant representative about any particular precautions for his or her plant.

Your usual safety equipment includes: hard hat, safety glasses, ear plugs, safety shoes, and gloves. Take these with you on all inspections.

Here are some specific hazards and cautions which you may want to consider: (Many of these have been learned from experience.)

1. Dust can be particularly hazardous. Besides being a threat to lungs and eyes, dust can cause poor visibility, leading to accidents around trucks, front-end loaders, and other moving equipment near stockpiles or bins.

2. Noise is not only harmful to hearing, but it can also distract you from avoiding moving equipment or other dangers. Some noises may have special significance: backup horns and blast warning whistles.

3. Conveyor belts transporting aggregates demand your constant awareness. Pulleys, belts, and sprocket-and-chain drive mechanisms can quickly capture your loose clothing.

4. Good housekeeping (neatness) is helpful to minimize these hazards:
   - Protruding pipes, hoses or other obstacles
   - Wet surfaces
   - High voltage lines and loose wires or lines
   - Field connections
   - Frayed insulation
   - Improperly grounded electrical equipment
   - Dust on ground / floor which may cause slipping

5. Stockpiles. Standing on the stockpiles or on the bunkers over feeder gate openings can be dangerous. People have been pulled down into the material and buried alive so quickly that they could not escape.
6. **Goggles and faceshield** are safeguards for prevention, to be donned in advance, whenever appropriate. Shirt collars and cuffs can be closed, and your boot tops can be covered by your pantlegs.

7. **Climbing on or in** any part of the facility requires extreme caution. Ladders, stairways, and handrails need to be secure. Before going near an enclosure or heavy machinery, you may want to assure that the power to operate it is locked off so that no one else can inadvertently turn it on.

8. Entering an enclosure may be neither appropriate nor allowed. Check with your district. **If you enter an enclosure, you will want to assure that:**

   - The power which operates the equipment is locked off,
   - You have a confined space entry permit if required, and that
   - You meet requirements of CAL-OSHA and General Industry Safety Orders.

9. **Truck traffic.** As you enter and leave the plant, you may see traffic signs and directions; these signs are posted to enhance your safety. You may be a visitor in a foreign land, but you know that vehicles will be working around loading zones. You may find it helpful to establish **eye contact** with the driver before crossing his or her path.

10. **Loaders** move fast. They scurry about and scoot everywhere, along pathways which are not well defined. They can appear unexpectedly, often backing up unpredictably. Their drivers have blind spots, and you may not hear a backup alarm.
In this chapter we address air quality legal requirements for cement kilns, beginning with district requirements and ending with pertinent verbatim sections of the California Health and Safety Code (HSC). Other environmental regulations also apply to noise, water, and hazardous materials, but they are not the main focus of this manual.

INTRODUCTION

The California Legislature passes laws, called statutes, that authorize Executive Branch agencies such as the Air Resources Board (ARB) to implement these statutes by adopting and enforcing regulations. The ARB directly regulates air pollutant emissions from motor vehicles and some other sources. However, most industrial emission sources are regulated principally by the local Air Pollution Control Districts and Air Quality Management Districts. Cement kilns are also regulated by other agencies, including the Department of Toxic Substances Control (DTSC) and the Office of Environmental Health Hazard Assessment (OEHHA).

501 DISTRICT REQUIREMENTS

Each local air district within the state has its own legal requirements based on its own special needs. These requirements vary from one district to another due to the nature of the particular air quality problems and the source types within the districts.

To assure compliance, the inspector is to collect and apply the rules for his or her local district. Appendix I is provided as a collection place for you to put the rules for your district. All districts have requirements in the following areas, each of which is discussed here, some in detail:

- Authority to Construct (including modifications)
- Permit to Operate
- Visible Emissions
- Particulate Matter Emissions
- Fugitive Dust Emissions
- Nuisances
- Breakdown and Variances
501.1 AUTHORITY TO CONSTRUCT AND PERMIT TO OPERATE

The districts use these two documents to permit the construction and operation of facilities and equipment which could cause air pollutant emissions. These documents also specify conditions for the construction and operation.

Specified Conditions for Permits to Operate. Under the authority of the California Health and Safety Code (HSC), and in order to comply with the California State Implementation Plan where applicable, the districts may issue conditions, other than the applicable general emissions limitations, for the operation of equipment and components of facilities. These conditions are stated in the Permit to Operate (PO), and often include such items as these: operating hours, throughput, materials type and quantity, and emissions limits.

Maintenance Program. The Permit to Operate stipulates that the equipment must be properly maintained and kept in good operating condition. The facility manager may also be directed to develop a maintenance program for the equipment listed in the Permit in order to preclude a violation of the California Health and Safety Code and applicable district rules and regulations.

Monitoring and Recordkeeping. Documentation of key operating parameters may be required in some Permits to Operate. The records may take the form of handwritten logbooks, completed preprinted forms, strip or circular recording charts from continuous recording readouts, or a computerized database. Computer records may do more than merely archive monitored operating parameters; they may also help to analyze problems.

Rule Violations. In the event that any equipment violates district rules and regulations, many districts require the facility manager to stop operating the pertinent equipment and proceed as necessary to end the violation. The facility manager must notify the district of any upset conditions, breakdown or scheduled maintenance which causes emissions in excess of limits established by the district. A variance allowing a facility to temporarily pollute while it works towards compliance may be allowed by the local air district hearing board if legal requirements are met.

Facility Inspection. The facility owner may be required to submit a periodic inspection report. The report may include the amount of emissions produced, operating conditions, calibration of monitoring instruments, and whether or not the operating conditions complied with the Permit to Operate or were within the manufacturer’s specifications. Data from the report can be used for the emissions inventory and to validate the accuracy of monitoring records.
Maintenance Logs. Permit conditions may require records of maintenance performed, including the time, date, types of problems and their resolutions, and the names of persons doing the work. These records must be retained for specified periods of time, typically three years, and they must be made available to the air pollution control district upon request.

Manuals for Operation and Maintenance. Some Permits require operators to obtain and be familiar with an Operations and Maintenance Manual (O&M) prepared specifically for their facility. The manufacturer may have prepared most of this information. These manuals typically include:

1. General information about the facility design and equipment.
2. Plans describing procedures and operating parameters.
3. Plans describing preventive maintenance schedules, inspection and repair programs, and the recommended spare parts inventory.
4. Emergency procedures for fires, gas leaks, power losses, waste spills, etc.
5. MSDS information.

Many permits require that the equipment be operated in accordance with manufacturer’s instructions, unless the instructions conflict with district rules or permit conditions. The manufacturer instructions and procedures, along with the Operating Permit, typically must be posted on the control panel or other equipment, and must be readily visible or available to the operator.

501.2 VISIBLE EMISSIONS (VE)

Each of the air pollution control districts in California has a visible emissions limitation rule. Although the texts of these rules vary, they provide that:

“... no person shall discharge into the atmosphere from any source whatsoever any contaminant, other than uncombined water vapor, for a period or periods aggregating more than three minutes in any one hour which is:

(a) As dark or darker in shade as that designated as No. 1 (or 20% opacity) on the Ringelmann Chart, as published by the United States Bureau of Mines, [Some districts use Ringelmann No. 2 or 40% opacity.]

(b) Or of such opacity as to obscure an observer’s view to a degree equal to or greater than does smoke described in subdivision (a).”
### Ringelmann System

The state standard for visible emissions (Section 41701, California Health and Safety Code) is No. 2 on the Ringelmann Chart, or 40% opacity.

Appendix C contains detailed descriptions for evaluating visible emissions and how to become certified to do so. The Ringelmann system is used to determine whether emissions of smoke are within the limits or standards which are set by statutes and ordinances and defined by the Ringelmann Chart. In this system, smoke density in a plume is compared with a series of graduated shades of gray, as judged by the inspector. EPA Reference Method 9 is also provided in Appendix C.

The Compliance Division of the ARB conducts a “Fundamentals of Enforcement” class four times a year to train and certify government and industry personnel to perform these evaluations. The certification is valid for a period of six months, after which recertification is available.

**Calculating the results of visible emissions evaluations:** For HSC applications, the inspector counts all of the 15-second readings for which the opacity was observed to exceed the Ringelmann limit. A total of more than 12 readings, over **three minutes** in a one hour period constitutes a violation. By contrast, for federal applications of EPA Reference Method 9 (NSPS applications), opacity exceedance is determined by **averaging** any 24 consecutive readings taken by the inspector at 15-second intervals (six minutes). If the average exceeds the standard, the facility is in violation.

### 501.3 Particulate Matter Emission Limits

Air pollution control districts have general rules which apply to any source operation which emits or may emit dust, fumes, or suspended particulate matter. Some rules specify limits by concentration, in grains per cubic foot, for example; other rules specify weight of emissions per unit of production. Most districts have both limits. To determine the concentrations of particulate emissions at facilities would require source testing, using EPA Method 5, which is contained in Appendix B.

### 501.4 Fugitive Dust Emissions

Fugitive dust regulations prevent or limit the amount of dust which could escape into the ambient air. In most cement kilns, dust is not ordinarily a problem, but
without adequate controls it could emanate from some locations, e.g., at the points of movement, supply or storage.

501.5 NUISANCE

District rules based on Section 41700, HSC, protect the public’s health and welfare from the discharge of air contaminants which constitute a public nuisance. This concept includes protection from injury, detriment, and annoyances such as odors from emissions.

501.6 EQUIPMENT BREAKDOWN PROVISIONS

Each district has an equipment breakdown rule for reasonable malfunctions. For stated conditions, the rule gives some protection from enforcement actions when certain equipment fails and prevents compliance with air pollution regulations. Industrial managers may want to keep a copy of the breakdown rule at the worksite and assure that personnel know their responsibilities in the event of an equipment malfunction.

In order to qualify for district breakdown provisions, a malfunction must meet the conditions specified by the district. These conditions are typical:

- The breakdown is a result of a failure that was unforeseeable,
- The breakdown is not the result of neglect or disregard of any air pollution control law, rule, or regulation,
- It is not intentional or the result of negligence,
- It is not the result of improper maintenance,
- It does not constitute a nuisance, and
- It is not an abnormally chronic breakdown of the same equipment.

District rules also list a number of procedures which must be followed in reporting the breakdown in a timely manner to the district. If the breakdown is not reported to the district within the allowed time period, as stated in the rule, a separate violation occurs, for which enforcement action is appropriate.
When a breakdown is reported to the district it is recorded in the district’s breakdown log. Sources must provide the district with this information:

1. The source’s name and location and the source contact’s name and telephone number,

2. The specific equipment affected by the breakdown,

3. The specific equipment that failed,

4. The date and time that the breakdown occurred,

5. The date and time that the breakdown is being reported to the district, and

6. The remedy proposed by the source.

Upon receipt of a breakdown report, the district performs an on-site investigation of the malfunctioning equipment to determine whether it meets the prescribed breakdown conditions. If the inspector determines that a valid breakdown condition does not exist, he or she may initiate enforcement action. This could lead to fines, abatement orders, and injunctions against further operations.

Filing a breakdown report which is false, or claiming that a malfunction is a breakdown, may constitute a violation. The burden of proof is on the source to provide sufficient information to show that a breakdown did occur. Otherwise, the source is subject to appropriate enforcement action.

A source with a breakdown must take immediate steps to correct the malfunction as quickly as possible. If a source finds that repairs cannot be completed within the district’s allowable duration for a breakdown, the source may file for an emergency variance in order to avoid enforcement action. The allowable duration is usually 24 hours for continuous processes which cannot be shut down immediately, but all other equipment may be operated only to the end of the cycle.
After a breakdown has been repaired, and within a specified time limit, district rules require sources to submit written details to the air pollution control officer:

- Proof of the source’s return to compliance, including the date and time that the breakdown was corrected,
- The duration of excessive emissions,
- An estimate of the quantity of excess emissions,
- A statement of the cause of the occurrence, and
- The corrective measures to be taken to prevent recurrences.

The district log will also include the following information, some of which may be entered as the case progresses:

1. A confirmation that the breakdown is allowable under district rules,
2. The name of the district investigator,
3. The initial inspection file number,
4. The compliance confirmation inspection file number,
5. The date that the breakdown correction report was filed by the source, and
6. An indication of whether or not a variance was requested.

501.7 VARIANCES

A facility operator may petition for a variance in either of these situations:

1. Pollution control equipment has broken down and meets the criteria for breakdown condition under district rules, but the operator finds that it will take longer to repair the breakdown than provided for under the district breakdown rule. In such a case, the operator may wish to apply for an emergency variance. If good cause is shown, applications for emergency variances may be approved quickly: the chairman of a district hearing board or any designated member may issue an emergency variance without a notice and hearing.

2. A source is out of compliance, either by its own determination or by that of other inspectors, or expects to soon be out of compliance with some air pollution control district rule or regulation, or with Section 41701 of the HSC.
In either of these two situations the operator may want to apply for a variance in an attempt to obtain a shield from enforcement action during the temporary period of noncompliance. The decision and the impetus to file for a variance belongs to the source operator.

An application for either a short variance (90 days maximum) or a regular variance (1 year maximum, unless a schedule for progress is included) also asks for an interim variance (up to 90 days or until the next Hearing Board meeting, whichever comes first). It is the source’s responsibility to estimate the length of variance needed and to apply for the appropriate one.

The approval authority for variances is the district Hearing Board rather than the air pollution control officer or his or her staff. A favorable decision is usually more likely if the source provides ample information in the application.

Although each district has its own rules for variances, the district rules are based on the HSC. Some of the pertinent sections are included at the end of this chapter. It would be helpful for district inspectors as well as source operators to be familiar with the local district variance requirements.

The law (HSC) says that:

1. Sources are not allowed to operate in violation of ARB or district requirements without a variance, even if the source is working towards a solution to the problem. Under HSC Section 42400.2, if a source continues to operate in violation of district rules, it may be subject to a fine of $25,000 per day, or up to one year in the county jail, or both. Under HSC Section 42400.3, for willful and intentional violations, the penalty can be $50,000 per day, or up to one year in the county jail, or both.

In general, penalties specified for criminal offenses may include jail time, and penalties for civil offenses do not. Also, fines can be imposed as separate offenses for each day of violation. Please consult the Health and Safety Code.

2. A variance will not be granted unless the Hearing Board makes all of the findings listed in HSC, Section 42352.

Verbatim sections of the Health and Safety Code begin on the next page.
The following sections of the California Health And Safety Code have been selected for verbatim presentation here, after this list. These HSC sections are the basis for air pollution control laws, including the authority of districts to adopt and enforce regulations, to perform inspections, and to issue permits with conditions. For specific situations, you may wish to consult the complete HSC.

39000 Legislative Findings - Environment
39001 Legislative Findings - Agency Coordination
39002 Local and State Agency Responsibilities
39003 ARB Responsibilities
40000 Local / State Responsibilities
40001 Adoption and Enforcement of Rules and Regulations
40702 Adoption of Rules and Regulations
41509 No Limitation on Power to Abate Nuisance
41510 Right of Entry With Inspection Warrant
41700 No Person Shall Discharge Pollutants
41701 Opacity Standards - No Emissions Shall Exceed Ringelmann 2...
42300 District Permit System
42301 Permit Issuance - Requirements
42301.6 Permit Approval: Powers and Duties of Air Pollution Control Officer
42301.7 Air Contaminants, Threatened Release
42303 Information Disclosure - Air Contaminant Discharge
42303.5 False Statements in Permit Applications
42304 Permit Suspension (Failure to Supply Information)
42352 Variance - Findings Required for Issuance
42400 Penalties, Criminal - Misdemeanor, $1,000/Day and/or Six Months Jail
42400.1 Penalties, Criminal - Negligence, $15,000/Day and/or Nine Months Jail
42400.2 Penalties, Criminal - Knowingly, $25,000/Day and/or One Year Jail
42400.3 Penalties, Criminal - Willfully . . . $50,000/Day and/or One Year Jail
42401 Penalties, Civil - Violating Order of Abatement $25,000/Day
42402 Penalties, Civil - Violations . . . $1,000/Day
42402.1 Penalties, Civil - Negligence, $15,000/Day
42402.2 Penalties, Civil - Knowingly, $25,000/Day
42402.3 Penalties, Civil - Willfully . . . $50,000/Day
42402.5 Penalties, Civil - Administrative, $500/Each Violation
42403 Penalties, Civil - Relevant Circumstances
42404.5 Statute of Limitations for Civil Actions
42450 Orders of Abatement, District Board: Authority, Notice, Hearing
503 INTRODUCTION, CA HEALTH AND SAFETY CODE

The California Legislature passes laws, called statutes, that authorize Executive branch agencies (such as the Air Resources Board) to implement laws, through regulations, pursuant to the directives of the statutes.

The following relevant California HSC references are included verbatim to provide you with the basis for California Air Pollution Control Laws. The paragraph numbers are the HSC Section numbers in numerical order:

39000 LEGISLATIVE FINDINGS - ENVIRONMENT

The Legislature finds and declares that the people of the State of California have a primary interest in the quality of the physical environment in which they live, and that this physical environment is being degraded by the waste and refuse of civilization polluting the atmosphere, thereby creating a situation which is detrimental to the health, safety, welfare, and sense of well-being of the people of California.

39001 LEGISLATIVE FINDINGS - AGENCY COORDINATION

The Legislature, therefore, declares that this public interest shall be safeguarded by an intensive, coordinated state, regional, and local effort to protect and enhance the ambient air quality of the state. Since air pollution knows no political boundaries, the Legislature declares that a regional approach to the problem should be encouraged whenever possible and, to this end, the state is divided into air basins. The state should provide incentives for such regional strategies, respecting, when necessary, existing political boundaries.

39002 LOCAL AND STATE AGENCY RESPONSIBILITIES

Local and regional authorities have the primary responsibility for control of air pollution from all sources other than vehicular sources. The control of vehicular sources, except as otherwise provided in this division, shall be the responsibility of the State Air Resources Board. Except as otherwise provided in this division, including, but not limited to, Sections 41809, 41810, and 41904, local and regional authorities may establish stricter standards than those set by law or by the state board for nonvehicular sources. However, the state board shall, after holding public hearings as required in this division, undertake control activities
in any area wherein it determines that the local or regional authority has failed to meet the responsibilities given to it by this division or by any other provision of law.

39003 ARB RESPONSIBILITIES

The State Air Resources Board is the state agency charged with coordinating efforts to attain and maintain ambient air quality standards, to conduct research into the causes of and solution to air pollution, and to systematically attack the serious problem caused by motor vehicles, which is the major source of air pollution in many areas of the state.

40000 LOCAL / STATE RESPONSIBILITIES

The Legislature finds and declares that local and regional authorities have the primary responsibility for control of air pollution from all sources, other than emissions from motor vehicles. The control of emissions from motor vehicles, except as otherwise provided in this division, shall be the responsibility of the state board.

40001 ADOPTION & ENFORCEMENT OF RULES / REGULATIONS

(a) Subject to the powers and duties of the state board, the districts shall adopt and enforce rules and regulations to achieve and maintain the state and federal ambient air quality standards in all areas affected by emission sources under their jurisdiction, and shall enforce all applicable provisions of state and federal law.

(b) The rules and regulations may, and at the request of the state board shall, provide for the prevention and abatement of air pollution episodes which, at intervals, cause discomfort or health risks to, or damage to property of, a significant number of persons or class of persons.

(c) Prior to adopting any rule or regulation to reduce criteria pollutants, a district shall determine that there is a problem that the proposed rule or regulation will alleviate and that the rule or regulation will promote the attainment or maintenance of state or federal ambient air quality standards.

40702 ADOPTION OF RULES AND REGULATIONS

A district shall adopt rules and regulations and do such acts as may be necessary or proper to execute the powers and duties granted to, and imposed upon, the
district by this division and other statutory provisions. No order, rule, or regulation of any district shall, however, specify the design of equipment, type of construction, or particular method to be used in reducing the release of air contaminants from railroad locomotives.

41509 NO LIMITATION ON POWER TO ABATE NUISANCE

No provision of this division, or of any order, rule, or regulation of the state board or of any district, is a limitation on:

(a) The power of any local or regional authority to declare, prohibit, or abate nuisances.

(b) The power of the Attorney General, at the request of a local or regional authority, the state board, or upon his own motion, to bring an action in the name of the people of the State of California to enjoin any pollution or nuisance.

(c) The power of a state agency in the enforcement or administration of any provision of law which it is specifically permitted or required to enforce or administer.

(d) The right of any person to maintain at any time any appropriate action for relief against any private nuisance.

41510 RIGHT OF ENTRY WITH INSPECTION WARRANT

For the purpose of enforcing or administering any state or local law, order, regulation, or rule relating to air pollution, the executive officer of the state board or any air pollution control officer having jurisdiction, or an authorized representative of such officer, upon presentation of his credentials or, if necessary under the circumstances, after obtaining an inspection warrant pursuant to Title 13 (commencing with Section 1822.50), Part 3 of the Code of Civil Procedure, shall have the right of entry to any premises on which an air pollution emission source is located for the purpose of inspecting such source, including securing samples of emissions therefrom, or any records required to be maintained in connection therewith by the state board or any district.
500 LEGAL REQUIREMENTS

41700 NO PERSON SHALL DISCHARGE POLLUTANTS

Except as otherwise provided in Section 41705, no person shall discharge from any source whatsoever such quantities of air contaminants or other material which cause injury, detriment, nuisance, or annoyance to any considerable number of persons or to the public, or which endanger the comfort, repose, health, or safety of any such persons or the public, or which cause, or have a natural tendency to cause, injury or damage to business or property.

41701 OPACITY STANDARDS - NO EMISSIONS SHALL EXCEED RINGELMANN 2

Except as otherwise provided in Section 41704, or Article 2 (commencing with Section 41800) of this chapter other than Section 41812, or Article 2 (commencing with Section 42350) of Chapter 4, no person shall discharge into the atmosphere from any source whatsoever any air contaminant, other than uncombined water vapor, for a period or periods aggregating more than three minutes in any one hour which is:

(a) As dark or darker in shade as that designated as No. 2 on the Ringelmann Chart, as published by the United States Bureau of Mines, or

(b) Of such opacity as to obscure an observer’s view to a degree equal to or greater than does smoke described in subdivision (a).

42300 DISTRICT PERMIT SYSTEM

(a) Every district board may establish, by regulation, a permit system that requires, except as otherwise provided in Section 42310, that before any person builds, erects, alters, replaces, operates, or uses any article, machine, equipment, or other contrivance which may cause the issuance of air contaminants, the person obtain a permit to do so from the air pollution control officer of the district.

(b) The regulations may provide that a permit shall be valid only for a specified period. However, the expiration date of any permit shall be extended upon completion of the annual review required pursuant to subdivision (c) of Section 42301 and payment of the fees required pursuant to Section 42311, unless the air pollution control officer or the hearing board has initiated action to suspend or revoke the permit pursuant to Section 42304, 42307, or 42390, that action has resulted in a final determination by the officer or the board to suspend or revoke the permit, and all appeals have been exhausted or the time for appeals from that final determination has been exhausted.
(c) The annual extension of a permit’s expiration date pursuant to subdivision (b) does not constitute permit issuance, renewal, reopening, amendment, or any other action subject to the requirements specified in Title V.

42301 PERMIT ISSUANCE - REQUIREMENTS

A permit system established pursuant to Section 42300 shall do all of the following:

(a) Ensure that the article, machine, equipment, or contrivance for which the permit was issued does not prevent or interfere with the attainment or maintenance of any applicable air quality standard.

(b) Prohibit the issuance of a permit unless the air pollution control officer is satisfied, on the basis of criteria adopted by the district board, that the article, machine, equipment, or contrivance will comply with all of the following:

(1) All applicable orders, rules, and regulations of the district and of the state board.
(2) All applicable provisions of this division.

(c) Prohibit the issuance of a permit to a Title V source if the Administrator of the Environmental Protection Agency objects to its issuance in a timely manner as provided in Title V. This subdivision is not intended to provide any authority to the Environmental Protection Agency to object to the issuance of a permit other than that authority expressly granted by Title V.

(d) Provide that the air pollution control officer may issue to a Title V source a permit to operate or use if the owner or operator of the Title V source presents a variance exempting the owner or operator from Section 41701, any rule or regulation of the district, or any permit condition imposed pursuant to this section, or presents an abatement order that has the effect of a variance and that meets all of the requirements of this part pertaining to variances, and the requirements for the issuance of permits to operate are otherwise satisfied. The terms and conditions of any variance or abatement order may be incorporated into the permit as a compliance schedule, to the extent required by Title V.

(e) Require, upon annual renewal, that each permit be reviewed to determine that the permit conditions are adequate to ensure compliance with, and the enforceability of, district rules and regulations applicable to the article, machine,
equipment, or contrivance for which the permit was issued which were in effect at the time the permit was issued or modified, or which have subsequently been adopted and made retroactively applicable to an existing article, machine, equipment, or contrivance, by the district board and, if the permit conditions are not consistent, require that the permit be revised to specify the permit conditions in accordance with all applicable rules and regulations.

(f) Provide for the reissuance or transfer of a permit to a new owner or operator of an article, machine, equipment, or contrivance. An application for transfer of ownership only, or change in operator only, of any article, machine, equipment, or contrivance which had a valid permit to operate within the two-year period immediately preceding the application is a temporary permit to operate. Issuance of the final permit to operate shall be conditional upon a determination by the district that the criteria specified in subdivisions (b) and (e) are met, if the permit was not surrendered as a condition to receiving emission reduction credits pursuant to banking or permitting rules of the district. However, under no circumstances shall the criteria specify that a change of ownership or operator alone is a basis for requiring more stringent emission controls or operating conditions than would otherwise apply to the article, machine, equipment, or contrivance.

42301.6 PERMIT APPROVAL: POWERS AND DUTIES OF AIR POLLUTION CONTROL OFFICER

(a) Prior to approving an application for a permit to construct or modify a source which emits hazardous air emissions, which source is located within 1,000 feet from the outer boundary of a schoolsite, the air pollution control officer shall prepare a public notice in which the proposed project or modification for which the application for a permit is made is fully described. The notice may be prepared whether or not the material is or would be subject to subdivision (a) of Section 25536, if the air pollution control officer determines and the administering agency concurs that hazardous air emissions of the material may result from an air release, as defined by Section 44303. The notice may be combined with any other notice on the project or permit which is required by law.

(b) The air pollution control officer shall, at the permit applicant’s expense, distribute or mail the public notice to the parents or guardians of children enrolled in any school that is located within one-quarter mile of the source and to each address within a radius of 1,000 feet of the proposed new or modified source at least 30 days prior to the date final action on the application is to be
taken by the officer. The officer shall review and consider all comments received during the 30 days after the notice is distributed, and shall include written responses to the comments in the permit application file prior to taking final action on the application.

(1) Notwithstanding Section 49073 of the Education Code, or any other provision of law, the information necessary to mail notices required by this section shall be made available by the school district to the air pollution control officer.

(2) Nothing in this subdivision precludes, at the discretion of the air pollution control officer and with permission of the school, the distribution of the notices to the children to be given to their parents or guardians.

(c) Notwithstanding subdivision (b), an air pollution control officer may require the applicant to distribute the notice if the district had such a rule in effect prior to January 1, 1989.

(d) The requirements for public notice pursuant to subdivision (b) or a district rule in effect prior to January 1, 1989, are fulfilled if the air pollution control officer or applicant responsible for giving the notice makes a good faith effort to follow the procedures prescribed by law for giving the notice, and, in these circumstances, failure of any person to receive the notice shall not affect the validity of any permit subsequently issued by the officer.

(e) Nothing in this section shall be deemed to limit any existing authority of any district.

(f) An applicant for a permit shall certify whether the proposed source or modification is located within 1,000 feet of a schoolsite. Misrepresentation of this fact may result in the denial of a permit.

(g) The notice requirements of this section shall not apply if the air pollution control officer determines that the application to construct or modify a source will result in a reduction or equivalent amount of air contaminants, as defined in Section 39013, or which are hazardous air emissions.

(h) As used in this section:
(1) "Hazardous air emissions" means emissions into the ambient air of air contaminants which have been identified as a toxic air contaminant by the state board or by the air pollution control officer for the jurisdiction in which the project is located. As determined by the air pollution control officer, hazardous air emissions also means emissions into the ambient air from any substances identified in subdivisions (a) to (f), inclusive, of Section 44321 of the Health and Safety Code.

(2) "Acutely hazardous material" means any material defined pursuant to subdivision (a) of Section 25532.

42301.7 AIR CONTAMINANTS - THREATENED RELEASE

(a) If the air pollution control officer determines there is a reasonably foreseeable threat of a release of an air contaminant from a source within 1,000 feet of the boundary of a school that would result in a violation of Section 41700 and impact persons at the school, the officer shall, within 24 hours, notify the administering agency and the fire department having jurisdiction over the school.

(b) The administering agency may, in responding to a reasonably foreseeable threat of a release, do any of the following:

(1) Review the facility's risk management and prevention plan prepared pursuant to Section 25534 to determine whether the program should be modified, and, if so, require submission of appropriate modifications. Notwithstanding any other provision of law, the administering agency may order modification and implementation of a revised risk management and prevention plan at the earliest feasible date.

(2) If the facility has not filed a risk management and prevention plan with the administering agency, require the preparation and submission of a plan to the administering agency pursuant to Section 25534. Notwithstanding any other provision of law, the administering agency may require the filing of a risk management and prevention plan and its implementation at the earliest feasible date.

(c) The air pollution control officer may, in responding to a reasonably foreseeable threat of a release, do any of the following:

(1) If necessary, issue an immediate order to prevent the release or mitigate the reasonably foreseeable threat of a release in violation of Section 41700 pending a hearing pursuant to Section 42450 when there is a substantial probability of an injury to persons at a school resulting from a release that makes it
Prevent, Reduce, Mitigate Injury

reasonably necessary to take immediate action to prevent, reduce, or mitigate that injury. The officer may not issue such an order unless there is written concurrence to issue the order by a representative of the administering agency.

(2) Apply to the district board for issuance of an order for abatement pursuant to Section 42450.

(d) Nothing in this section limits any existing authority of any district.

42303 INFORMATION DISCLOSURE - AIR CONTAMINANT DISCHARGE

An air pollution control officer, at any time, may require from an applicant for, or the holder of, any permit provided for by the regulations of the district board, such information, analyses, plans, or specifications which will disclose the nature, extent, quantity, or degree of air contaminants which are, or may be, discharged by the source for which the permit was issued or applied.

42303.5 FALSE STATEMENTS IN PERMIT APPLICATIONS

No person shall knowingly make any false statement in any application for a permit, or in any information, analyses, plans, or specifications submitted in conjunction with the application or at the request of the air pollution control officer.

42304 PERMIT SUSPENSION (FAILURE TO SUPPLY INFORMATION)

If, within a reasonable time, the holder of any permit issued by a district board willfully fails and refuses to furnish the information, analyses, plans, or specifications requested by the district air pollution control officer, such officer may suspend the permit. Such officer shall serve notice in writing of such suspension and the reasons therefor on the permittee.

42352 VARIANCE - FINDINGS REQUIRED FOR ISSUANCE

(a) No variance shall be granted unless the hearing board makes all of the following findings:

(1) That the petitioner for a variance is, or will be, in violation of Section 41701 or of any rule, regulation, or order of the district.

(2) That, due to conditions beyond the reasonable control of the petitioner, requiring compliance would result in either (A) an arbitrary or unreasonable
tak[ing of property, or (D) the practical closing and elimination of a lawful

business. In making those findings where the petitioner is a public agency, the

hearing board shall consider whether or not requiring immediate compliance

would impose an unreasonable burden upon an essential public service. For

purposes of this paragraph, “essential public service” means a prison, detention

facility, police or firefighting facility, school, health care facility, landfill gas

control or processing facility, sewage treatment works, or water delivery opera-
tion, if owned and operated by a public agency.

(3) That the closing or taking would be without a corresponding benefit in

reducing air contaminants.

(4) That the applicant for the variance has given consideration to
curtailing operations of the source in lieu of obtaining a variance.

(5) During the period the variance is in effect, that the applicant will

reduce excess emissions to the maximum extent feasible.

(6) During the period the variance is in effect, that the applicant will

monitor or otherwise quantify emission levels from the source, if requested to do
so by the district, and report these emission levels to the district pursuant to a
schedule established by the district.

(b) As used in this section, “public agency” means any state agency, board, or
commission, any county, city and county, city, regional agency, public district,
or other political subdivision. [Further stipulations of Subsection 42352.5 are
not included in this technical manual.]

42400 PENALTIES, CRIMINAL - MISDEMEANOR

(a) Except as otherwise provided in Section 42400.1, 42400.2, or 42400.3, any

person who violates this part, or any rule, regulation, permit, or order of the state
board or of a district, including a district hearing board, adopted pursuant to Part
1 (commencing with Section 39000) to Part 4 (commencing with Section
41500), inclusive, is guilty of a misdemeanor and is subject to a fine of not more
than one thousand dollars ($1,000) or imprisonment in the county jail for not
more than six months, or both.

(b) If a violation under subdivision (a) with regard to the failure to operate a
vapor recovery system on a gasoline cargo tank is directly caused by the actions
of an employee under the supervision of, or of any independent contractor
working for, any person subject to this part, the employee or independent con-
tactor, as the case may be, causing the violation is guilty of a misdemeanor and
is punishable as provided in subdivision (a). That liability shall not extend to

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the person employing the employee or retaining the independent contractor, unless that person is separately guilty of an action that violates this part.

(c) The recovery of civil penalties pursuant to Section 42402, 42402.1, 42402.2, or 42402.3 precludes prosecution pursuant to this section for the same offense. When a district refers a violation to a prosecuting agency, the filing of a criminal complaint is grounds requiring the dismissal of any civil action brought pursuant to this article for the same offense.

(d) Each day during any portion of which a violation of subdivision (a) occurs is a separate offense.

42400.1 PENALTIES, CRIMINAL - NEGLIGENCE

(a) Any person who negligently emits an air contaminant in violation of any provision of this part or any rule, regulation, permit, or order of the state board or of a district pertaining to emission regulations or limitations is guilty of a misdemeanor and is subject to a fine of not more than fifteen thousand dollars ($15,000) or imprisonment in the county jail for not more than nine months, or both.

(b) Any person who owns or operates any source of air contaminants in violation of Section 41700 which causes actual injury, as defined in paragraph (2) of subdivision (d) of Section 42400.2, to the health or safety of a considerable number of persons or the public is guilty of a misdemeanor and is punishable as provided in subdivision (a).

(c) Each day during any portion of which a violation occurs is a separate offense.

(d) The recovery of civil penalties pursuant to Section 42402, 42402.1, 42402.2, or 42402.3 precludes prosecution pursuant to this section for the same offense. When a district refers a violation to a prosecuting agency, the filing of a criminal complaint is grounds requiring the dismissal of any civil action brought pursuant to this article for the same offense.
500 LEGAL REQUIREMENTS

42400.2 PENALTIES, CRIMINAL - KNOWINGLY, DOCUMENT FALSIFICATION / FAILURE TO TAKE CORRECTIVE ACTION

(a) Any person who emits an air contaminant in violation of any provision of this part, or any order, rule, regulation, or permit of the state board or of a district pertaining to emission regulations or limitations, and who knew of the emission and failed to take corrective action within a reasonable period of time under the circumstances, is guilty of a misdemeanor and is subject to a fine of not more than twenty-five thousand dollars ($25,000) or imprisonment in the county jail for not more than one year, or both.

(b) For purposes of this section, “corrective action” means the termination of the emission violation or the grant of a variance from the applicable order, rule, regulation, or permit pursuant to Article 2 (commencing with Section 42350). If a district regulation regarding process upsets or equipment breakdowns would allow continued operation of equipment which is emitting air contaminants in excess of allowable limits, compliance with that regulation is deemed to be corrective action.

(c) Any person who, knowingly and with intent to deceive, falsifies any document required to be kept pursuant to any provision of this part, or any rule, regulation, permit, or order of the state board or of a district, is guilty of a misdemeanor and is punishable as provided in subdivision (a).

(d) (1) Any person who owns or operates any source of air contaminants in violation of Section 41700 which causes actual injury to the health or safety of a considerable number of persons or the public, and who knew of the emission and failed to take corrective action within a reasonable period of time under the circumstances, is guilty of a misdemeanor and is punishable as provided in subdivision (a).

(2) As used in this subdivision, “actual injury” means any physical injury which, in the opinion of a licensed physician and surgeon, requires medical treatment involving more than a physical examination.

(e) Each day during any portion of which a violation occurs constitutes a separate offense.

(f) The recovery of civil penalties pursuant to Section 42402, 42402.1, 42402.2, or 42402.3 precludes prosecution pursuant to this section for the same offense. When a district refers a violation to a prosecuting agency, the filing of
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500 LEGAL REQUIREMENTS

- Criminal
  - Willfully
    - A criminal complaint is grounds requiring the dismissal of any civil action brought pursuant to this article for the same offense.

42400.3 PENALTIES, CRIMINAL - WILLFULLY, INTENTIONALLY

(a) Any person who willfully and intentionally emits an air contaminant in violation of any provision of this part or any rule, regulation, permit, or order of the state board or of a district, pertaining to emission regulations or limitations is guilty of a misdemeanor and is subject to a fine of not more than fifty thousand dollars ($50,000) or imprisonment in the county jail for not more than one year, or both.

(b) The recovery of civil penalties pursuant to Section 42402, 42402.1, 42402.2, or 42402.3 precludes prosecution pursuant to this section for the same offense. When a district refers a violation to a prosecuting agency, the filing of a criminal complaint is grounds requiring the dismissal of any civil action brought pursuant to this article for the same offense.

(c) Each day during any portion of which a violation occurs constitutes a separate offense.

42401 PENALTIES, CIVIL - VIOLATING ORDER OF ABATEMENT

Any person who intentionally or negligently violates any order of abatement issued by a district pursuant to Section 42450, by a hearing board pursuant to Section 42451, or by the state board pursuant to Section 41505 is liable for a civil penalty of not more than twenty-five thousand dollars ($25,000) for each day in which the violation occurs.

42402 PENALTIES, CIVIL - GENERAL VIOLATIONS

(a) Except as otherwise provided in subdivision (b) or in Section 42402.1, 42402.2, or 42402.3, any person who violates this part, any order issued pursuant to Section 42316, or any rule, regulation, permit, or order of a district, including a district hearing board, or of the state board issued pursuant to Part 1 (commencing with Section 39000) to Part 4 (commencing with Section 41500), inclusive, is strictly liable for a civil penalty of not more than one thousand dollars ($1,000).
(b) (1) Any person who violates any provision of this part, any order issued pursuant to Section 42316, or any rule, regulation, permit, or order of a district, including a district hearing board, or of the state board issued pursuant to Part 1 (commencing with Section 39000) to Part 4 (commencing with Section 41500), inclusive, is strictly liable for a civil penalty of not more than ten thousand dollars ($10,000).

(2) Where a civil penalty in excess of one thousand dollars ($1,000) for each day in which the violation occurs is sought, there is no liability under this subdivision if the person accused of the violation alleges by affirmative defense and establishes that the violation was caused by an act which was not the result of intentional or negligent conduct. In a district in which a Title V permit program has been fully approved, this paragraph shall not apply to a violation of federally enforceable requirements that occurs at a Title V source.

(c) Each day during any portion of which a violation occurs is a separate offense.

42402.1 PENALTIES, CIVIL - NEGLIGENCE OR ACTUAL INJURY

(a) Any person who negligently emits an air contaminant in violation of this part or any rule, regulation, permit, or order of the state board or of a district pertaining to emission regulations or limitations is liable for a civil penalty of not more than fifteen thousand dollars ($15,000).

(b) Any person who owns or operates any source of air contaminants in violation of Section 41700 which causes actual injury, as defined in paragraph (2) of subdivision (d) of Section 42400.2, to the health or safety of a considerable number of persons or the public is liable for a civil penalty as provided in subdivision (a).

(c) Each day during any portion of which a violation occurs is a separate offense.

42402.2 PENALTIES, CIVIL - KNOWINGLY, DOCUMENT FALSIFICATION, FAILURE TO TAKE CORRECTIVE ACTION

(a) Any person who emits an air contaminant in violation of any provision of this part, or any order, rule, regulation, or permit of the state board or of a district pertaining to emission regulations or limitations, and who knew of the emission and failed to take corrective action, as defined in subdivision (b) of Section 42400.2, within a reasonable period of time under the circumstances, is liable for a civil penalty, of not more than twenty five thousand dollars ($25,000).
(b) Any person who, knowingly and with intent to deceive, falsifies any document required to be kept pursuant to any provision of this part, or any rule, regulation, permit, or order of the state board or of a district, is subject to the same civil penalty as provided in subdivision (a).

(c) Any person who owns or operates any source of air contaminants in violation of Section 41700 which causes actual injury, as defined in paragraph (2) of subdivision (d) of Section 42400.2, to the health or safety of a considerable number of persons or the public, and who knew of the emission and failed to take corrective action, as defined in subdivision (b) of Section 42400.2, within a reasonable period of time under the circumstances, is subject to a civil penalty as provided in subdivision (a).

(d) Each day during any portion of which a violation occurs is a separate offense.

42402.3 PENALTIES, CIVIL - WILLFULLY AND INTENTIONALLY

(a) Any person who willfully and intentionally emits an air contaminant in violation of this part or any rule, regulation, permit, or order of the state board, or of a district, pertaining to emission regulations or limitations, is liable for a civil penalty of not more than fifty thousand dollars ($50,000).

(b) Each day during any portion of which a violation occurs is a separate offense.

42402.5 PENALTIES, CIVIL - ADMINISTRATIVE

In addition to any civil and criminal penalties prescribed under this article, a district may impose administrative civil penalties for a violation of this part, or any order, permit, rule, or regulation of the state board or of a district, including a district hearing board, adopted pursuant to Part 1 (commencing with Section 39000) to Part 4 (commencing with Section 41500), inclusive, if the district board has adopted rules and regulations specifying procedures for the imposition and amounts of these penalties. No administrative civil penalty levied pursuant to this section may exceed five hundred dollars ($500) for each violation. However, nothing in this section is intended to restrict the authority of a district to negotiate mutual settlements under any other penalty provisions of law which exceeds five hundred dollars ($500).
42403 PENALTIES, CIVIL - RELEVANT CIRCUMSTANCES

(a) The civil penalties prescribed in Sections 39674, 42401, 42402, 42402.1, 42402.2, and 42402.3 shall be assessed and recovered in a civil action brought in the name of the people of the State of California by the Attorney General, by any district attorney, or by the attorney for any district in which the violation occurs in any court of competent jurisdiction.

(b) In determining the amount assessed, the court, or in reaching any settlement, the district, shall take into consideration all relevant circumstances, including, but not limited to, the following:

(1) The extent of harm caused by the violation.
(2) The nature and persistence of the violation.
(3) The length of time over which the violation occurs.
(4) The frequency of past violations.
(5) The record of maintenance.
(6) The unproven or innovative nature of the control equipment.
(7) Any action taken by the defendant, including the nature, extent, and time of response of the cleanup and construction undertaken, to mitigate the violation.
(8) The financial burden to the defendant.

42404.5 STATUTE OF LIMITATIONS FOR CIVIL ACTIONS

Any limitation of time applicable to actions brought pursuant to Section 42403 shall not commence to run until the offense has been discovered, or could reasonably have been discovered.

42450 ORDERS OF ABATEMENT, DISTRICT BOARD: AUTHORITY, NOTICE AND HEARING

The district board may, after notice and a hearing, issue an order for abatement whenever it finds that any person is constructing or operating any article, machine, equipment, or other contrivance without a permit required by this part, or is in violation of Section 41700 or 41701 or of any order, rule, or regulation prohibiting or limiting the discharge of air contaminants into the air.

In holding such a hearing, the district board shall be vested with all the powers and duties of the hearing board. Notice shall be given, and the hearing shall be held, pursuant to Chapter 8 (commencing with Section 40800) of Part 3.
ACFM - Actual cubic feet per minute.

Anemometer - An instrument for measuring the velocity of air or gas.

Atmospheric Pressure - The pressure of the atmosphere as measured by means of the barometer at a location specified.

APCD - An acronym for Air Pollution Control District, but used coincidentally in other contexts, including the cement kiln vocabulary, to mean Air Pollution Control Device - such as a baghouse used to capture cement particulates.


Backwash - A method of cleaning baghouse fabric in which direction of air flow is reversed, accompanied by flexing of the fabric and breaking of the dust cake. Also known as backpressure, re-pressure, collapse-clean, etc.

Baghouse - A device containing a fabric filter medium in the shape of a bag, sleeve, envelope, cartridge or pocket, for the purpose of removing particulate entrained in a gas stream.

Barrel - Formerly, a customary measurement of a quantity of cement. One barrel was equal to 376 pounds net weight, or 4 bags of 94 pounds each.

BIF - Boilers and Industrial Furnaces Rule.

Bleed - Particles of dust or fumes that leak through the bag.

Bridge - Material blockage across an opening such as a hopper outlet.

Burnability - An index or factor which indicates the ease of burning a given clinker. Higher numbers indicate harder to burn.

Cake - The dust layer developed on the surface of the baghouse filter medium during the filtration process.

Calcine, Calcination - A process used in producing cement; to change to calx or powder by heating to a high temperature, but below the melting point; to burn to ashes or powder; or to oxidize at high temperature. In the kiln, at about 2200
degrees F and rising, the process in which carbon dioxide is liberated from the carbonates of the raw materials.

**Cement** - A substance which can bind together other dissimilar materials. *Portland* cement is the product kilned from the raw materials limestone and shale or clay which contains alumina, iron oxide, and traces of other substances. Gypsum and other materials may also be added near the end of the process.

**Cementitious Material** - A substance of moldable plasticity that may be used to bind together one or more other materials, known as fillers or aggregates.

**Cement Kiln Dust (CKD)** - Dust, fine particulates including PM10, formed in kilning processes.


**CKD** - Cement Kiln Dust.

**Clinker** - The incombustible residue, fused into an irregular lump, that remains after the combustion of fuel and cement's raw materials. The clinker is then finely ground into powdery cement.

**Coefficient of Haze** - A measure of light transmitted through a filter soiled with ambient air. Coefficient of haze units are in terms of 100 times the optical density as determined by transmittance.

**Collection Efficiency** - Percentage of emissions collected by a control device.

**Combustion** - A chemical change, esp. oxidation, accompanied by the production of heat and light.

**Comminuted** - Reduced in size.

**Compound** - A pure, homogeneous substance consisting of atoms or ions of two or more different elements in definite proportions.

**Concentration** - Amount of dust in a volume of gas. Usually expressed in terms of grains/cu ft, lb/1000 lb. of gas, ppm, mg/cu m. or lb/million Btu.

**Condensation** - The process of changing a vapor into liquid, usually by cooling.
Contaminate - To make impure or corrupt by contact or mixture.

Corrosion - Deterioration or physical degradation due to chemical action.

Decomposition - Breaking down into components.

Density - The ratio of the mass of a substance to the volume. The mass of a unit volume of a substance.

Diameter, Aerodynamic - The diameter of a sphere of unit density having the same terminal settling velocity as a particle in question, regardless of its geometric size, shape, and true density.

Dust - Solid particles less than 100 microns created from larger particles. Particles thus formed are not usually called dust unless they are larger than about 1 micron in diameter.

Electrostatic Filter - Filter using electrostatic charge effects to enhance the capture of particles.

Disintegration - The process of separating into components.

Electrostatic Precipitator - An air pollution control device which uses an electric charge to collect particulates.

Emissions - Particulates and chemicals leaving a process which enter the ambient air.

Evaporation - The change of state from a liquid to a vapor.

Filter cake - The accumulation of dust on a baghouse bag. It often assists in the filtration process. Also, see Cake.

Fossil Fuels - Fuels such as oil and coal, formed from ancient plants and animals under heat and pressure.

Fines - Particulate matter less than 1 micron in diameter.

Fluxing - Removing oxides or preventing their formation.
**Fugitive Emissions** - Nonstack emissions which may be caused by leaks, faulty operations, or poor housekeeping.

**Fume** - Fine particles dispersed in air or gases, formed by condensation, sublimation or chemical reaction. Particles are usually less than one micron in size.

**Fusing** - The liquid or melted state induced by heat.

**Gas** - A formless state of matter like air, which completely occupies a contained space.

**Gypsum** - Calcium sulfate dihydrate, an ingredient of cement which controls the rate of setting.

**Grain** - A unit of weight equivalent to 1/7000 of a pound, or 65 milligrams.

**Hazardous Wastes** - Left-over materials which are no longer commercially usable and which are either listed as hazardous by the U. S. EPA, or which meet any of the four characteristics used by the EPA to define hazardous wastes: Toxicity, Reactivity, Ignitability, and Corrosivity. Disposal of these materials can pose a problem, but their use as a supplemental fuel for kilns can be a productive solution.

**Haze** - A state of atmospheric obscuration due to the presence of fine, solid and/or liquid particles in stable suspension.

**Hopper** - A temporary storage enclosure, such as at the top of a recycler or at the bottom of a baghouse to catch dust.

**Humidity, Absolute** - The weight of water vapor carried by a unit weight of dry air or gas. Pounds or grains of water vapor per pound of dry air.

**Humidity, Relative** - The ratio of the water vapor in a gas to the amount of water vapor that the gas is capable of carrying at the same temperature.

**Hydraulic** - Ability to set and harden under water, i.e. Portland Cement.

**Inch of Water** - A unit of pressure equal to the pressure exerted by a column of liquid water one inch high at a standard temperature. The standard temperature is normally taken as 70°F. One inch of water at 70°F = 5.196 lb per sq. ft.
**Inclination** - A slant. Kilns are inclined about 4 degrees from the horizontal.

**Lime** - Calcium oxide, CaO, also called burnt lime, calx, quicklime, or caustic lime. It is formed in the calcining zone of a kiln.

**Limestone** - Calcium carbonate, CaCO₃.

**Maximum Exposed Individual (MEI)** - A hypothetical person who receives the most exposure possible to a hazardous substance, including all possible sources and pathways, 24 hours every day.

**NESHAPs** - National Emission Standards for Hazardous Air Pollutants

**Net Gas-to-Cloth Ratio** - The total baghouse inlet gas volume divided by the area of on-stream filter media. When one cell is off stream for cleaning, its area is deducted from the total available cloth area in calculating the net ratio. Net gas-to-cloth ratio = Total Inlet Gas Volumetric Flow/On Stream Cloth Area.

**Opacity** - The light attenuation of a stack plume. A perfectly clear plume (100% light transmission) has zero opacity. A plume that transmits no light at all has 100% opacity.

**Particle** - A small discrete mass of solid or liquid matter such as dust, fume, mist, smoke, and fog.

**Particulate Matter** - Any dispersed matter, solid or liquid, in which the individual particles or agglomerates may range from 0.002 micron up to 500 microns. Particle lifetimes in the suspended state range from a few seconds to several months. Additional terms used to describe particulate matter may include dust, fly ash, smoke, soot, droplets, mist, fog, and fumes.

**Plasticity** - Ability to be shaped, as in modeling clay.

**PM₁₀** - Particulate matter less than 10 microns in diameter.

**Potash** - Any of several compounds containing potassium.

**PPM** - Parts per million.
GLOSSARY

Pressure Drop - Resistance to gas flow, such as pressure differential across one bag, across a baghouse, or across an entire system. Units are usually inches of water.

Pressure, Gauge - Pressure measured from atmospheric pressure as a base. Gauge pressure may be indicated by a manometer which has one leg connected to the pressure source and the other exposed to atmospheric pressure.

Pressure Loss - Pressure required to overcome the resistance to gas flow in a system that includes the resistance of straight runs of pipe, entrances to headers, bends, elbows, orifice losses, and pressure drop through gas cleaning devices.

Pressure, Static - The pressure exerted in all directions by a fluid at rest. For a fluid in motion, it is measured in a direction normal to the direction of flow.

Pulse Cycle - The interval of time between one cleaning cycle pulsing of a row of bags and the next pulsing of the same row.

Pulse Jet - Generic name given to all pulsing baghouse collectors. Gas flow is from the outside of the bags to the inside of the bags.

RCRA - Resource Recovery and Conservation Act -- Restrictions on burning certain substances which could produce toxic emissions.

Retrofit - The addition of a baghouse system to an existing process.

SCFM - Specific cubic feet per minute.

Screen #s - A #4 has 4 openings per square inch of approximately 1/4-inch each.

Screw - Mechanical device for moving material, may have replaceable shoes to take the brunt of abrasive wear.

Shale - A fossil rock composed of laminated, claylike, fine-grained sediments.

Slaked Lime - Calcium hydroxide, Ca(OH)₂.

Slaking - Exothermic reaction of water with lime to make slaked lime, Ca(OH)₂.

Smoke - Small gas-borne particles usually resulting from incomplete combustion. Such particles consist predominantly of carbon and other combustible material and are present in sufficient quantity to be observable independently of other solids.
**GLOSSARY**

**Sonic Cleaning** - Sonic energy from air-powered horns produces shock waves which enhance dust removal from fabrics in baghouses.

**Stilling Chamber** - Headbox before conveyor tunnel, to allow dust to settle.

**Volatile** - Able to evaporate readily at normal temperatures and pressures.

**Temperature, Dewpoint** - The temperature at which the condensation of water vapor begins, at a given humidity and pressure, as the temperature is reduced. The temperature corresponding to saturation (100 % relative humidity).

**Temperature, Dry-Bulb** - The temperature of a gas or mixture of gases indicated by an accurate thermometer after correction for radiation.

**Temperature Scales** - The sizes of the degrees on Centigrade (Celsius) and Fahrenheit scales were determined by choosing 100 increments between the freezing point and melting point of water for Centigrade, and 180 increments for Fahrenheit. A Fahrenheit degree is therefore the smaller: 100/180, or 5/9 of a Centigrade degree. The Fahrenheit scale is usually used for ambient air. The Rankine scale, also called Fahrenheit absolute, labels the lowest attainable temperature as zero, exactly 459.67 degrees below Fahrenheit's zero. To convert Fahrenheit to Rankine (R), add 459.67 (or 460) degrees.

**Temperature, Wet-Bulb** - A measure of the amount of water vapor in the air, indicated by a wet bulb psychrometer.

**Transmissometer** - An instrument for measuring the visibility. A light of known intensity is beamed through a portion of the atmosphere to a receiver which measures how much of the original light penetrates any obstructions to visibility. Also called telephotometer, transmittance meter, hazemeter, or smoke density indicator.

**TSCA** - Toxics Substances Control Act.

**U. S. EPA** - United States Environmental Protection Agency.
APPENDIX A

Cement Kilns

-- SAMPLE --

FUGITIVE DUST CONTROL PLAN
AND
RACM

July 1996
In order for District staff to consider an application for approval of a fugitive dust emission control plan, the activity must describe existing fugitive dust sources based on the criteria previously presented. The activity must also describe the "reasonably available dust control measures" applied to each of the identified fugitive dust sources. District staff will then review the fugitive dust emission control plan application resulting in either 1) approval, 2) conditional approval, or 3) denial. In the case of a conditional approval District staff will recommend additional control measures which are necessary for the plan to be considered acceptable. In the case of a denial District Staff considers the information to be lacking or inaccurate and would require particulate matter monitoring.

PART 1. GENERAL INFORMATION

Name of Owner: E. Z. Nedust (Pacific Aggregate Company)

Name of Operator: R. U. Shoor

Phone number: (714) 555-1212 Auxiliary phone number: (213) 555-1212

Complete address of site or assessor parcel number if no address is available:

123 West Street
Riverside, California, 92501
(one half mile north of the intersection of South and North Streets)

Type of Activity: Sand and Gravel (Aggregate) Production
(construction project, aggregate processing, cement manufacturing, etc.)

Scale of operation: ( 40 ) acres/ ( 15,000 ) cubic yards maximum throughput.

(Note: Only operations with a disturbed surface area in excess of 100 acres or with a maximum throughput in excess of 10,000 cubic yards are subject to the particulate matter monitoring requirements of Rule 403)
**PART 2 SOURCES OF FUGITIVE DUST**

In the space provided below, please number and describe all sources of fugitive dust at your facility based on the sources described on pages listed in the Reasonably Available Control Measures section of this document. You may wish to provide mapping if you believe it necessary to understand the characteristics of the site.

<table>
<thead>
<tr>
<th>No.</th>
<th>Description of Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Unpaved roads - Site has 2 miles of unpaved roads which are used by dump trucks, heavy and light duty trucks and passenger cars. Roads are approximately 20 feet wide. Average daily traffic levels range from 50 to 100 vehicle trips per day.</td>
</tr>
<tr>
<td>2</td>
<td>Storage piles - Bulk material is brought to the site and stored prior to processing. Once the material has been processed, it is again stored prior to commercial sale. In total, approximately 800 tons of material can be stored at any one time. The storage piles are conical and have an average height of 15 feet.</td>
</tr>
<tr>
<td>3</td>
<td>Paved road track out - Haul vehicles which exit the site have the potential to track material out on to West Street. On average 300 vehicles exit the site per work day.</td>
</tr>
<tr>
<td>4</td>
<td>Earth moving - The bulk material stored on site is moved around the site for processing and sale. This involves use of front end loaders and other heavy machinery.</td>
</tr>
<tr>
<td>5</td>
<td>Disturbed surface areas - The entire site has been disturbed from its natural condition in one way or another due to changing business practices.</td>
</tr>
</tbody>
</table>
PART 3 DUST CONTROL ACTIONS

Reasonably Available Control Measures

*In the space provided please describe all dust control measures which are being used at your site. Please correspond the control measure descriptions with the numbering previously provided. If you believe that any control measures are not feasible or if they would conflict with other regulations please describe the justification in the space provided.*

<table>
<thead>
<tr>
<th>No.</th>
<th>Measure Used</th>
<th>Description or Justification</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Paving</td>
<td>The area between the wheel washer and the site entry/exit has been paved with concrete. This area doesn't need street sweeping due to its short length (100 feet) and because vehicles which travel on its surface have been essentially cleaned from the wheel washer system. It is periodically hosed down if material gets tracked onto it.</td>
</tr>
<tr>
<td>1</td>
<td>Chem. Stab.</td>
<td>Unpaved roads are treated at the first of the month with a solution of 5 parts water to 1 part magnesium chloride.</td>
</tr>
<tr>
<td>1</td>
<td>Watering</td>
<td>In the spring and summer months the unpaved roads are treated with watering trucks at a frequency of 4 times per work day. In the fall and winter months the unpaved roads are treated with watering trucks at a frequency of 2 times per work day. We have two watering trucks on site at all times for this purpose.</td>
</tr>
<tr>
<td>1</td>
<td>Reduce speeds</td>
<td>All unpaved roadways on the site have a maximum speed limit of 15 miles per hour.</td>
</tr>
<tr>
<td>2</td>
<td>Wet suppression</td>
<td>The plant has both &quot;wet sand&quot; and &quot;dry sand&quot; operations. The dry sand processing area has a spray bar system comprised of 10 spray bars, one over each dry sand storage pile in excess of ten feet tall. These spray bar systems are turned on for one half hour, once in the morning and once in the afternoon and as needed during windy conditions. The wet sand portion of the plant is not treated with spray bars or other watering methods because the material has a high moisture content as a result of the treatment process.</td>
</tr>
<tr>
<td>2</td>
<td>Loadin/loadout</td>
<td>All loadin/loadout procedures are oriented towards the downwind portion of the storage piles.</td>
</tr>
<tr>
<td>3</td>
<td>Wheel washers</td>
<td>A wheel washer system is located 100 feet from the entry/exit to the site off of West Street. The system cleans wheels and provides moisture to the top of haul vehicles thereby increasing the stability of the bulk</td>
</tr>
</tbody>
</table>
material being hauled. At the end of the work day an inspection of West Street is made to determine if material has been tracked out from haul vehicles. If material has been tracked out it is removed and returned to the site.

<table>
<thead>
<tr>
<th>No.</th>
<th>Activity</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Watering</td>
<td>Water is applied to the bulk material prior to movement as needed based on visible emissions.</td>
</tr>
<tr>
<td>4</td>
<td>Wind fencing</td>
<td>Urban development borders the eastern portion of the site. We have installed wind fencing in conjunction with our existing security fencing in order to reduce wind speeds at the site and to prevent wind blown material from leaving the site.</td>
</tr>
<tr>
<td>5</td>
<td>Revegetation/Watering</td>
<td>We have seeded disturbed surface areas which are no longer used with native, drought tolerant grasses. This seeding was followed by watering which aided in the growth of the ground cover as well as providing a thin crust over the surface. Results have been favorable with approximately 75 percent of the abandoned disturbed surface area covered with vegetation.</td>
</tr>
<tr>
<td>5</td>
<td>Wind fencing</td>
<td>See No. 4 above.</td>
</tr>
</tbody>
</table>
PART 4 CERTIFICATION

I certify that the information contained in this fugitive dust emission control plan is true and correct and that all control measures are being implemented at the site in the manner set forth herein.

E. Z. Norcutt 9/1/92
Signature of Owner (Date)

I have read the conditions of this fugitive dust emission control plan and the owner has authorized the implementation of all of its provisions.

L. M. Sharr 5/1/92
Signature of Operator (Date)
(If not the same as owner)

As stated in Proposed Amended Rule 403, failure to implement the fugitive dust control measures in the manner described in this fugitive dust emission control plan is a violation of Rule 403.

FOR AQMD USE ONLY
Based on all of the information contained in this fugitive dust emission control plan it is:

Approved
Conditionally-approved
Denied

Signature of District Exemption Request Reviewer (Date)

*The following are the conditions of approval of the Plan

*The following are the reasons for denial of the Plan
REASONABLY AVAILABLE CONTROL MEASURES

As specified by subparagraph (e)(3) of Rule 403, any person seeking approval of a fugitive dust emissions control plan must demonstrate to the satisfaction of the District that the given activity is employing all reasonably available fugitive dust control measures. The District has prepared the attached guidelines for demonstrating implementation of all reasonably available fugitive dust control measures. These guidelines were developed based on the U. S. Environmental Protection Agency's reference document entitled, "Control of Open Fugitive Dust Sources," Midwest Research Institute, September 1988.
REASONABLY AVAILABLE CONTROL MEASURES

The left column contains the sources of fugitive dust which are intended for emission control under District Rule 403. The two right columns contain an inventory and description of reasonably available fugitive dust control measures for each of the sources. Please use this information as a guide when preparing a fugitive dust emission control plan.

<table>
<thead>
<tr>
<th>Source</th>
<th>Reasonably Available Control Measures</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unpaved Roads</td>
<td>Paving</td>
<td>(1) Best choice</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2) Requires street sweeping/cleaning if subject to material accumulation</td>
</tr>
<tr>
<td>Chemical Stabilization</td>
<td></td>
<td>(1) Second best choice</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2) Vendors can supply information as to application methods and concentrations</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(3) Not recommended for high volume, heavy traffic use</td>
</tr>
<tr>
<td>Watering</td>
<td></td>
<td>(1) In sufficient quantities to keep surface moist</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2) Required application frequency will vary according to soil type, weather conditions, and vehicular use</td>
</tr>
<tr>
<td>Reducing speed limits</td>
<td></td>
<td>(1) 15 mile per hour maximum</td>
</tr>
<tr>
<td>Reducing vehicle trips</td>
<td></td>
<td>(1) Access restriction or redirecting traffic to paved roads in order to reduce vehicle trips by a minimum of 60 percent</td>
</tr>
<tr>
<td>Storage Piles</td>
<td>Wind sheltering</td>
<td>(1) Best choice, enclosed silos</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2) Alternate choice, three sided barriers equal to height of material with no more than 50 percent porosity</td>
</tr>
<tr>
<td>Wet suppression</td>
<td></td>
<td>(1) Application methods include: spray bars, hoses and trucks</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2) Frequency of application will vary on site specific conditions</td>
</tr>
<tr>
<td>Chemical suppression</td>
<td></td>
<td>(1) Best for use on storage piles subject to infrequent disturbances</td>
</tr>
<tr>
<td>Altering loadin/loadout procedures</td>
<td></td>
<td>(1) Confin e loadin/loadout procedures to leeward (downwind) side of the material</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2) Most effective when used in conjunction with wind sheltering</td>
</tr>
<tr>
<td>Coverings</td>
<td></td>
<td>(1) Tarps, plastic, or other material can be used as temporary coverings</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2) When used, these should be anchored to prevent wind from removing coverings</td>
</tr>
<tr>
<td>Paved Road Track-out</td>
<td>Wheel washers</td>
<td>(1) Should be placed where vehicles exit unpaved areas onto paved areas</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2) System can be adjusted to spray entire vehicle, including stored bulk material in haul vehicles</td>
</tr>
<tr>
<td>Sweep/clean roadways</td>
<td></td>
<td>(1) Either sweeping or water flushing may be used</td>
</tr>
<tr>
<td>Cover haul vehicles</td>
<td></td>
<td>(1) Entire surface area should be covered once vehicle is full</td>
</tr>
<tr>
<td>Source</td>
<td>Reasonably Available Control Measures</td>
<td>Comments</td>
</tr>
<tr>
<td>----------------</td>
<td>--------------------------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Paved Road Track-out</td>
<td>Bedliners in haul vehicles</td>
<td>(1) When feasible, use in bottom dumping haul vehicles</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Land Clearing/Earth-moving</td>
<td>Watering</td>
<td>(1) Application of water by means of truck, hoses and/or sprinklers prior to any land clearing or earth movement will increase the moisture content thereby increasing stability of material</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2) Once the initial land clearing/earth movement activities are complete, a second round of watering can generate a thin crust which stabilizes the disturbed surface areas provided that it is not disturbed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(3) Security fencing can be used to prevent unwanted future disturbances of sites where a surface crust has been created</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(4) May be used in conjunction with other measures</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(5) Establish as quickly as possible when active operations have ceased</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(6) Use of drought tolerant, native vegetation is encouraged</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(7) Should be used in conjunction with other measures</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(8) Vendors can supply information on methods for application and required concentrations</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(9) Chemical stabilization is the best choice for areas where active operations have ceased</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(10) Wind fencing should be placed where vehicles exit unpaved areas on to paved areas</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(11) Watering should be used in conjunction with other measures</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(12) Wheel washers should be placed where vehicles exit unpaved areas on to paved areas</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(13) Bulk material in haul vehicles should be covered by wheel washers</td>
</tr>
</tbody>
</table>

9-3
Application for Earth Moving Permit, Demolition & Dust Control Plan

Applicant:  □ Owner/Operator/Leasee  □ General/Prime Contractor  □ Developer

Legal Business Name: ________________________________________________________________

Address: __________________________________________________________________________

City/State/Zip: ______________________________________________________________________

Phone: ___________________________ Fax: ___________________________

Primary Contact Person: _______________________________________________________________

Title ___________________________ Pager/Mobile ___________ Onsite Phone ________ Offsite Phone ______

Property Owner/General Contractor _____________________________________________________

Phone ___________________________ Contact Person __________________________ Title ________

Project Location/Street Address __________________________________________________________________________

Nearest Major Intersection: __________________________________________________________________________

Legal Description (from Phoenix Metropolitan Map Book): Township __________ Range __________ Section __________

Size of Project in Acres (include staging and stockpile areas): __________________________ Project Start Date: __________

Fee Schedule:

<table>
<thead>
<tr>
<th>Total Surface Area Disturbed</th>
<th>Fee</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1 to less than one acre</td>
<td>$65.00</td>
</tr>
<tr>
<td>One to less than five acres</td>
<td>$110.00</td>
</tr>
<tr>
<td>Five acres or greater</td>
<td>$8.00 per acre plus $80.00</td>
</tr>
</tbody>
</table>

Brief description of the project: _____________________________________________________________

Type of Project (mark all applicable codes):

□ Residential (RD)  □ Commercial/Industrial (CD)  □ Road Work (RC)  □ Temporary Storage/Yard (TS)
□ Trenching (TR)  □ Site Preparation/Land Dev (SP)  □ Weed Control (WC)  □ Demolition (DE)

For renovation or demolition activities the following information is required:

Is asbestos present? □ Yes □ No AHERA Determination made by __________________________ Date __________

Has 10 Day NESHAP Notification been submitted? □ Yes □ No Copy of 10 Day Notification attached? □ Yes □ No Start Date: __________

In accordance with Rule 310, Section 401.2, a plot plan is required. Provide a plot plan sketch on 8 1/2 in. by 11 in. paper which includes the total area to be disturbed. Indicate sources of fugitive dust emissions on the plot plan, including delivery, transport, and storage areas. Be sure to include linear dimensions in feet on plot plan. Pursuant to Rule 310, Section 303, a dust control plan is required with any earthmoving application.

Additional measures and comments may be attached to this form. Pursuant to Rule 310, Section 503, records of actual implementation or application of these measures must be maintained daily and kept on site and made available upon request by the Control Officer or designee. The records must be retained for at least 3 years by the permittee.

1/26/96
DUST CONTROL PLAN

Choose at least one measure as a primary RACM (Reasonably Available Control Measure) per category. Unless designated, any other control measure in the category will be considered a contingency or back-up control measure. You may prepare your own plan to submit by following the guidelines in Rule 310, Section 401.

Earthmoving / Demolition (ie., trenching, rough grading, final grading, landscaping, material handling)

- Conduct watering as necessary to prevent visible emissions
- Prewet site
- Cease operations (contingency only, cannot be used as a primary RACM)

Disturbed surface areas

- On the last day of active operations and when active operations will not occur for not more than fifteen days:
  - Apply chemical stabilizers. Reapply as necessary to maintain stabilization.
  - Apply water to all unstabilized disturbed areas 3 times per day
  - Install wind fences/screens
  - Construct berms
- Within 8 months of the last day of active operations:
  - Pave the affected area
  - Physical stabilization with gravel/recycled asphalt
  - Physical stabilization with vegetation

Unpaved roads

- Stabilize with gravel/recycled asphalt
- Apply chemical stabilizers to all unpaved road surfaces in sufficient quantity and frequency to maintain a stabilized surface
- Water all roads used for any vehicular traffic as needed to control emissions
- Water all roads used for any vehicular traffic at least once daily and restrict vehicle speeds to 15 miles per hour

Open storage piles

- Apply chemical stabilizers
- Apply water to the surface area of all open storage piles on a daily basis, when there is evidence of wind driven fugitive dust
- Install temporary coverings/enclosures

Access points

- Install a stabilized construction entrance/gravel pad (Required for all access points on sites of 5 acres or more)
- Install a wheel washer
- Limit, restrict, reroute motor vehicle access
- Vacuum/ Wet broom daily

Hauling

- X Haul trucks carrying bulk materials must be tarped

Describe available water supply, distance from worksite, method of application, & water storage:

____________________________________________________________________________________

____________________________________________________________________________________

I certify that I am familiar with the operations presented in this application and agree to conduct all operations related to the worksite in compliance with the above dust control plan, Rule 310, any permit conditions and all applicable environmental regulations.

Signature of Responsible Official

Print Name & Title

(The responsible official is an officer or designated signer from the company named as applicant. If a designated signer is used, a written designation signed by an officer shall be on file with this office.)
Particulate Matter (PM 10) Emissions Determinations

(EPA Method 5)
METHOD 5
DETERMINATION OF PARTICULATE EMISSIONS
FROM STATIONARY SOURCES

1. Principle and Applicability

1.1 Principle. Particulate matter is withdrawn isokinetically from the source and collected on a
glass fiber filter maintained at a temperature in the range of 120±14°C (248±25°F) or such
other temperature as specified by an applicable subpart of the standards or approved by
Administrator, U.S. Environmental Protection Agency, for a particular application. The particulate
mass, which includes any material that condenses at or above the filtration temperature, is
determined gravimetrically after removal of uncombined water.

1.2 Applicability. This method is applicable for the determination of particulate emissions from
stationary sources.

2. Apparatus

2.1 Sampling Train. A schematic of the sampling train used in this method is shown in Figure 5-1.
Complete construction details are given in APTD-0581 (Citation 2 in Bibliography); commercial
models of this train are also available. For changes from APTD-0581 and for allowable modifications
of the train shown in Figure 5-1, see the following subsections. The operating and maintenance
procedures for the sampling train are described in APTD-0576 (Citation 3 in Bibliography). Since
correct usage is important in obtaining valid results, all users should read APTD-0576 and adopt the
operating and maintenance procedures outlined in it, unless otherwise specified herein. The sampling
train consists of the following components:

2.1.1 Probe Nozzle. Stainless steel (316) or glass with sharp, tapered leading edge. The angle of
taper shall be ≤30° and the taper shall be on the outside to preserve a constant internal diameter.
The probe nozzle shall be of the button-hook or elbow design, unless otherwise specified by the
Administrator. If made of stainless steel, the nozzle shall be constructed from seamless tubing; other
materials of construction may be used, subject to the approval of the Administrator. A range of
nozzle sizes suitable for isokinetic sampling should be available, e.g., 0.32 to 1.27 cm (1/8 to 1/2
in.) or larger if higher volume sampling trains are used inside diameter (ID) nozzles in increments
of 0.16 cm (1/16 in.). Each nozzle shall be calibrated according to the procedures outlined in
Section 5.

2.1.2 Probe Liner. Borosilicate or quartz glass tubing with a heating system capable of
maintaining a gas temperature at the exit end during sampling of 120±14°C (248±25°F), or such
other temperature as specified by an applicable subpart of the standards or approved by the
Administrator for a particular application. (The tester may opt to operate the equipment at a
temperature lower than that specified.) Since the actual temperature at the outlet of the probe is not
usually monitored during sampling, probes constructed according to APTD-0581 and utilizing the
calibration curves of APTD-0576 (or calibrated according to the procedure outlined in APTD-0576)
will be considered acceptable. Either borosilicate or quartz glass probe liners may be used for stack
temperatures up to about 480°C (900°F); quartz liners shall be used for temperatures between 480
and 900°C (900 and 1,650°F). Both types of liners may be used at higher temperatures than
specified for short periods of time, subject to the approval of the Administrator. The softening
temperature for borosilicate is 820°C (1508°F), and for quartz it is 1500°C (2,732°F).

Whenever practical, every effort should be made to use borosilicate or quartz glass probe liners. Alternatively, metal liners (e.g., 316 stainless steel, Incoloy 825,2 or other corrosion resistant metals) made of seamless tubing may be used, subject to the approval of the Administrator.

2.1.3 Pitot Tube. Type S, as described in Section 2.1 of Method 2, or other device approved by the Administrator. The pitot tube shall be attached to the probe (as shown in Figure 5-1) to allow constant monitoring of the stack gas velocity. The impact (high pressure) opening plane of the pitot tube shall be even with or above the nozzle entry plane (see Method 2, Figure 2-6b) during sampling. The Type S pitot tube assembly shall have a known coefficient, determined as outlined in Section 4 of Method 2.

2.1.4 Differential Pressure Gauge. Inclined manometer or equivalent device (two), as described in Section 2.2 of Method 2. One manometer shall be used or velocity head (ARHO) readings, and the other, for orifice differential pressure readings.

2.1.5 Filter Holder. Borosilicate glass, with a glass frit filter support and a silicone rubber gasket. Other materials of construction (e.g., stainless steel, Teflon, Viton) may be used, subject to approval of the Administrator. The holder design shall provide a positive seal against leakage from the outside or around the filter. The holder shall be attached immediately at the outlet of the probe (or cyclone, if used).

2.1.6 Filter Heating System. Any heating system capable of maintaining a temperature around the filter holder during sampling of 120±14°C (248±25°F), or such other temperature as specified by an applicable subpart of the standards or approved by the Administrator for a particular application. Alternatively, the tester may opt to operate the equipment at a temperature lower than that specified. A temperature gauge capable of measuring temperature to within 3°C (5.4°F) shall be installed so that the temperature around the filter holder can be regulated and monitored during sampling. Heating systems other than the one shown in APTD-0581 may be used.

2.1.7 Condenser. The following system shall be used to determine the stack gas moisture content: Four impingers connected in series with leak-free ground glass fittings or any similar leak-free non-contaminating fittings. The first, third, and fourth impingers shall be of the Greenburg-Smith design, modified by replacing the tip with 1.3 cm (1/2 in.) ID glass tube extending to about 1.3 cm (1/2 in.) from the bottom of the flask. The second impinger shall be of the Greenburg-Smith design with the standard tip. Modifications (e.g., using flexible connections between the impingers, using materials other than glass, or using flexible vacuum lines to connect the filter holder to the condenser) may be used, subject to the approval of the Administrator.

The first and second impingers shall contain known quantities of water (Section 4.1.3), the third shall be empty, and the fourth shall contain a known weight of silica gel, or equivalent desiccant. A thermometer, capable of measuring temperature to within 1°C (2°F) shall be placed at the outlet of the fourth impinger for monitoring purposes. Alternatively, any system that cools the sample gas stream and allows measurement of the water condensed and moisture leaving the condenser, each to within 1 ml or 1 g may be used, subject to the approval of the Administrator. Acceptable means are to measure the condensed water either gravimetrically or volumetrically and to measure the moisture leaving the condenser by: (1) monitoring the temperature and pressure at the exit of the condenser and using Dalton's law of partial pressures; or (2) passing the sample gas stream through a tared silica gel (or equivalent desiccant) trap with exit gases kept below 20°C (68°F) and determining the weight gain. If means other than silica gel are used to determine the amount of
moisture leaving the condenser, it is recommended that silica gel (or equivalent) still be used between the condenser system and pump to prevent moisture condensation in the pump and metering devices and to avoid the need to make corrections for moisture in the metered volume.

Note: If a determination of the particulate matter collected in the impingers is desired in addition to moisture content, the impinger system described above shall be used, without modification. Individual States or control agencies requiring this information shall be contacted as to the sample recovery and analysis of the impinger contents.

2.1.8 Metering System. Vacuum gauge, leak-free pump, thermometers capable of measuring temperature to within 3°C (5.4°F), dry gas meter capable of measuring volume to within 2 percent, and related equipment, as shown in Figure 5-1. Other metering systems capable of maintaining sampling rates within 10 percent of isokinetic and of determining sample volumes to within 2 percent may be used, subject to the approval of the Administrator. When the metering system is used in conjunction with a pitot tube, the system shall enable checks of isokinetic rates. Sampling trains utilizing metering systems designed for higher flow rates than that described in APTD-0581 or APDT-0576 may be used provided that the specifications of this method are met.

2.1.9 Barometer. Mercury aneroid, or other barometer capable of measuring atmospheric pressure to within 2.5 mm Hg (0.1 in. Hg). In many cases the barometric reading may be obtained from a nearby National Weather Service station, in which case the station value (which is the absolute barometric pressure) shall be requested and an adjustment for elevation differences between the weather station and sampling point shall be applied at a rate of minus 2.5 mm Hg (0.1 in. Hg) per 30 m (100 ft) elevation increase or vice versa for elevation decrease.

2.1.10 Gas Density Determination Equipment. Temperature sensor and pressure gauge, as described in Sections 2.3 and 2.4 of Method 2, and gas analyzer, if necessary, as described in Method 3. The temperature sensor shall, preferably, be permanently attached to the pitot tube or sampling probe in a fixed configuration, such that the tip of the sensor extends beyond the leading edge of the probe sheath and does not touch any metal. Alternatively, the sensor may be attached just prior to use in the field. Note, however, that if the temperature sensor is attached in the field, the sensor must be placed in an interference-free arrangement with respect to the Type S pitot tube openings (see Method 2, Figure 2-7). As a second alternative, if a difference of not more than 1 percent in the average velocity measurement is to be introduced, the temperature gauge need not be attached to the probe or pitot tube. (This alternative is subject to the approval of the Administrator.)

2.2 Sample Recovery. The following items are needed.

2.2.1 Probe-Liner and Probe-Nozzle Brushes. Nylon bristle brushes with stainless steel wire handles. The probe brush shall have extensions (at least as long as the probe) of stainless steel, Nylon, Teflon, or similarly inert material. The brushes shall be properly sized and shaped to brush out the probe liner and nozzle.

2.2.2 Wash Bottles-Two. Glass wash bottles are recommended; polyethylene wash bottles may be used at the option of the tester. It is recommended that acetone not be stored in polyethylene bottles for longer than a month.

2.2.3 Glass Sample Storage Containers. Chemically resistant, borosilicate glass bottles, for acetone washes, 500 ml or 1000 ml. Screw cap liners shall either be rubber-backed Teflon or shall be constructed so as to be leak-free and resistant to chemical attack by acetone. (Narrow mouth glass bottles have been found to be less prone to leakage.) Alternatively, polyethylene bottles may be used.

2.2.4 Petri Dishes. For filter samples, glass or polyethylene, unless otherwise specified by the
2.2.5 Graduated Cylinder and/or Balance. To measure condensed water to within 1 ml or 1 g. Graduated cylinders shall have subdivisions no greater than 2 ml. Most laboratory balances are capable of weighing to the nearest 0.5 g or less. Any of these balances is suitable or use here and in Section 2.3.4.

2.2.6 Plastic Storage Containers. Air-tight containers to store silica gel.

2.2.7 Funnel and Rubber Policeman. To aid in transfer of silica gel to container; not necessary if silica gel is weighed in the field.

2.2.8 Funnel. Glass or polyethylene, to aid in sample recovery.

2.3 Analysis. For analysis, the following equipment is needed:

2.3.1 Glass Weighing Dishes.

2.3.2 Desiccator.

2.3.3 Analytical Balance. To measure to within 0.1 mg.

2.3.4 Balance. To measure to within 0.5 g.

2.3.5 Beakers. 250 ml.

2.3.6 Hygrometer. To measure the relative humidity of the laboratory environment.

2.3.7 Temperature Gauge. To measure the temperature of the laboratory environment.

3. Reagents

3.1 Sampling. The reagents used in sampling are as follows:

3.1.1 Filters. Glass fiber filters, without organic binder, exhibiting at least 99.95 percent efficiency (<0.05 percent penetration) on 0.3 micron dioctyl phthalate smoke particles. The filter efficiency test shall be conducted in accordance with ASTM Standard Method D2986-71 (Reapproved 1978) (incorporated by reference-see § 60.17). Test data from the supplier’s quality control program are sufficient for this purpose. In sources containing SO2 or S03, the filter material must be of a type that is unreactive to SO2 or SO3. Citation 10 in Bibliography, may be used to select the appropriate filter.

3.1.2 Silica Gel. Indicating type, 6 to 16 mesh. If previously used, dry at 175° C (350° F) for 2 hours. New silica gel may be used as received. Alternatively, other types of desiccants (equivalent or better) may be used, subject to the approval of the Administrator.

3.1.3 Water. When analysis of the material caught in the impingers is required, deionized distilled water shall be used. Run blanks prior to field use to eliminate a high blank on test samples.

3.1.4 Crushed Ice.

3.1.5 Stopcock Grease. Acetone-insoluble, heat-stable silicone grease. This is not necessary if screw-on connectors with Teflon sleeves, or similar, are used. Alternatively, other types of stopcock grease may be used, subject to the approval of the Administrator.

3.2 Sample Recovery. Acetone-reagent grade, <0.001 percent residue, in glass bottles-is required. Acetone from metal containers generally has a high residue blank and should not be used. Sometimes, suppliers transfer acetone to glass bottles from metal containers; thus, acetone blanks shall be run prior to field use and only acetone with low blank values (<0.001 percent) shall be used. In no case shall a blank value of greater than 0.001 percent of the weight of acetone used be subtracted from the sample weight.

3.3 Analysis. Two reagents are required for the analysis:

3.3.1 Acetone. Same as 3.2.

3.3.2 Desiccant. Anhydrous calcium sulfate, indicating type. Alternatively, other types of desiccants may be used, subject to the approval of the Administrator.
4. Procedure

4.1 Sampling. The complexity of this method is such that, in order to obtain reliable results, testers should be trained and experienced with the test procedures.

4.1.1 Pretest Preparation. It is suggested that sampling equipment be maintained according to the procedure described in APTD-0576. Weigh several 200 to 300 g portions of silica gel in air-tight containers to the nearest 0.5 g. Record the total weight of the silica gel plus container, on each container. As an alternative, the silica gel need not be preweighed, but may be weighed directly in the impinger or sampling holder just prior to train assembly. Check filters visually against light for irregularities and flaws or pinhole leaks. Label filters of the proper diameter on the back side near the edge using numbering machine ink. As an alternative, label the shipping containers (glass or plastic petri dishes) and keep the filters in these containers at all times except during sampling and weighing. Desiccate the filters at 20±5.6°C (68±10°F) and ambient pressure for at least 24 hours and weigh at intervals of at least 6 hours to a constant weight, i.e., 0.5 mg change from previous weighing; record results to the nearest 0.1 mg.

During each weighing the filter must not be exposed to the laboratory atmosphere for a period greater than 2 minutes and a relative humidity above 50 percent. Alternatively (unless otherwise specified by the Administrator), the filters may be oven dried at 105°C (220°F) for 2 to 3 hours, desiccated for 2 hours, and weighed. Procedures other than those described, which account for relative humidity effects, may be used, subject to the approval of the Administrator.

4.1.2 Preliminary Determinations. Select the sampling site and the minimum number of sampling points according to Method 1 or as specified by the Administrator. Determine the stack pressure, temperature, and the range of velocity heads using Method 2; it is recommended that a leak-check of the pitot lines (see Method 2, Section 3.1) be performed.

Determine the moisture content using Approximation Method 4 or its alternatives for the purpose of making isokinetic sampling rate settings. Determine the stack gas dry molecular weight, as described in Method 2, Section 3.6; if integrated Method 3 sampling is used for molecular weight determination, the integrated bag sample shall be taken simultaneously with, and for the same total length of time as, the particulate sample run. Select a nozzle size based on the range of velocity heads, such that it is not necessary to change the nozzle size in order to maintain isokinetic sampling rates. During the run, do not change the nozzle size.

Ensure that the proper differential pressure gauge is chosen for the range of velocity heads encountered (see Section 2.2 of Method 2). Select a suitable probe liner and probe length such that all traverse points can be sampled. For large stacks, consider sampling from opposite sides of the stack to reduce the length of probes. Select a total sampling time greater than or equal to the minimum total sampling time specified in the test procedures for the specific industry such that (1) the sampling time per point is not less than 2 min (or some greater time interval as specified by the Administrator), and (2) the sample volume taken (corrected to standard conditions) will exceed the required minimum total gas sample volume.

The latter is based on an approximate average sampling rate. It is recommended that the number of minutes sampled at each point be an integer or an integer plus one-half minute, in order to avoid timekeeping errors. The sampling time at each point shall be the same. In some circumstances, e.g., batch cycles, it may be necessary to sample for shorter times at the traverse points and to obtain smaller gas sample volumes. In these cases, the Administrator's approval must first be obtained.
4.1.3 Preparation of Collection Train. During preparation and assembly of the sampling train, keep all openings where contamination can occur covered until just prior to assembly or until sampling is about to begin. Place 100 ml of water in each of the first two impingers, leave the third impinger empty, and transfer approximately 200 to 300 g of preweighed silica gel from its container to the fourth impinger. More silica gel may be used, but care should be taken to ensure that it is not entrained and carried out from the impinger during sampling. Place the container in a clean place for later use in the sample recovery. Alternatively, the weight of the silica gel plus impinger may be determined to the nearest 0.5 g and recorded. Using a tweezer or clean disposable surgical gloves, place a labeled (identified) and weighed filter in the filter holder. Be sure that the filter is properly centered and the gasket properly placed so as to prevent the sample gas stream from circumventing the filter. Check the filter for tears after assembly is completed. When glass liners are used, install the selected nozzle using a Viton A O-ring when stack temperatures are less than 260°C (500°F) and an asbestos string gasket when temperatures are higher. See APTD-0576 for details. Other connecting systems using either 3/16 stainless steel or Teflon ferrules may be used. When metal liners are used, install the nozzle as above or by a leak-free direct mechanical connection.

Mark the probe with heat resistant tape or by some other method to denote the proper distance into the stack or duct for each sampling point.

Set up the train as in Figure 5-1, using (if necessary) a very light coat of silicone grease on all ground glass joints, greasing only the outer portion (see APTD-0576) to avoid possibility of contamination by the silicone grease. Subject to the approval of the Administrator, a glass cyclone may be used between the probe and filter holder when the total particulate catch is expected to exceed 100 mg or when water droplets are present in the stack gas. Place crushed ice around the impingers.

4.1.4 Leak-Check Procedures.

4.1.4.1 Pretest Leak-Check. A pretest leak-check is recommended, but not required. If the tester opts to conduct the pretest leak-check, the following procedure shall be used. After the sampling train has been assembled, turn on and set the filter and probe heating systems at the desired operating temperatures. Allow time for the temperatures to stabilize. If a Viton A O-ring or other leak-free connection is used in assembling the probe nozzle to the probe liner, leak-check the train at the sampling site by plugging the nozzle and pulling a 380 mm Hg (15 in. Hg) vacuum. Note: A lower vacuum may be used, provided that it is not exceeded during the test. If an asbestos string is used, do not connect the probe to the train during the leak-check. Instead, leak-check the train by first plugging the inlet to the filter holder (cyclone, if applicable) and pulling a 380 mm Hg (15 in. Hg) vacuum (see Note immediately above). Then connect the probe to the train and leak-check at about 25 mm Hg (1 in. Hg) vacuum; alternatively, the probe may be leak-checked with the rest of the sampling train, in one step, at 380 mm Hg (15 in. Hg) vacuum. Leakage rates in excess of 4 percent of the average sampling rate or 0.00057 m3/min (0.02 cfm), whichever is less, are unacceptable.

The following leak-check instructions for the sampling train described in APTD-0576 and APTD-0581 may be helpful. Start the pump with bypass valve fully open and coarse adjust valve, completely closed. Partially open the coarse adjust valve and slowly close the bypass valve until the desired vacuum is reached. Do not reverse direction of bypass valve; this will cause water to back up into the filter holder. If the desired vacuum is exceeded, either leak-check at this higher vacuum or end the leak-check as shown below and start over. When the leak-check is completed, first slowly remove the plug from the inlet to the probe, filter holder, or cyclone (if applicable) and immediately turn off the vacuum pump. This
prevents the water in the impingers from being forced backward into the filter holder and silica gel from being entrained backward into the third impinger.

4.1.4.2 Leak-Checks During Sample Run. If, during the sampling run, a component (e.g., filter assembly or impinger) change becomes necessary, a leak-check shall be conducted immediately before the change is made. The leak-check shall be done according to the procedure outlined in Section 4.1.4.1 above, except that it shall be done at a vacuum equal to or greater than the maximum value recorded up to that point in the test. If the leakage rate is found to be no greater than 0.00057 m$^3$/min (0.02 cfm) or 4 percent of the average sampling rate (whichever is less), the results are acceptable, and no correction will need to be applied to the total volume of dry gas metered; if, however, a higher leakage rate is obtained, the tester shall either record the leakage rate and plan to correct the sample volume as shown in Section 6.3 of this method, or shall void the sampling run. Immediately after component changes, leak-checks are optional; if such leak-checks are done, the procedure outlined in Section 4.1.4.1 above shall be used.

4.1.4.3 Post-test Leak-Check. A leak-check is mandatory at the conclusion of each sampling run. The leak-check shall be done in accordance with the procedures outlined in Section 4.1.4.1, except that it shall be conducted at a vacuum equal to or greater than the maximum value reached during the sampling run. If the leakage rate is found to be no greater than 0.00057 m$^3$/min (0.02 cfm) or 4 percent of the average sampling rate (whichever is less), the results are acceptable, and no correction need be applied to the total volume of dry gas metered. If, however, a higher leakage rate is obtained, the tester shall either record the leakage rate and correct the sample volume as shown in Section 6.3 of this method, or shall void the sampling run.

4.1.5 Particulate Train Operation. During the sampling run, maintain an isokinetic sampling rate (within 10 percent of true isokinetic unless otherwise specified by the Administrator) and a temperature around the filter of 120±14°C (248±25°F), or such other temperature as specified by an applicable subpart of the standards or approved by the Administrator. For each run, record the data required on a data sheet such as the one shown in Figure 5-2. Be sure to record the initial dry gas meter reading. Record the dry gas meter readings at the beginning and end of each sampling time increment, when changes in flow rates are made, before and after each leak-check, and when sampling is halted. Take other readings required by Figure 5-2 at least once at each sample point during each time increment and additional readings when significant changes (20 percent variation in velocity head readings) necessitate additional adjustments in flow rate.

Level and zero the manometer. Because the manometer level and zero may drift due to vibrations and temperature changes, make periodic checks during the traverse. Clean the portholes prior to the test run to minimize the chance of sampling deposited material. To begin sampling, remove the nozzle cap, verify that the filter and probe heating systems are up to temperature, and that the pitot tube and probe are properly positioned. Position the nozzle at the first traverse point with the tip pointing directly into the gas stream. Immediately start the pump and adjust the flow to isokinetic conditions. Nomographs are available, which aid in the rapid adjustment of the isokinetic sampling rate without excessive computations.

These nomographs are designed for use when the Type S pitot tube coefficient is 0.85±0.02, and the stack gas equivalent density (dry molecular weight) is equal to 29±4. APTD-0576 details the procedure for using the nomographs. If $C_p$ and $M_d$ are outside the above stated ranges do not use the nomographs unless appropriate steps (see Citation 7 in Bibliography) are taken to compensate for the deviations.
<table>
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<th>Clock Time</th>
<th>Dry Gas Meter, CF</th>
<th>Pitot H₂O in H₂O</th>
<th>Orifice H₂O in H₂O</th>
<th>Impinger Temp. °F</th>
<th>Filter Box Temp. °F</th>
<th>Stack Temp. °F</th>
<th>Pump Vacuum in. Hg</th>
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When the stack is under significant negative pressure (height of impinger stem), take care to close the coarse adjust valve before inserting the probe into the stack to prevent water from backing into the filter holder. If necessary, the pump may be turned on with the coarse adjust valve closed.

When the probe is in position, block off the openings around the probe and porthole to prevent unrepresentative dilution of the gas stream. Traverse the stack cross-section, as required by Method 1 or as specified by the Administrator, being careful not to bump the probe nozzle into the stack walls when sampling near the walls or when removing or inserting the probe through the portholes; this minimizes the chance of extracting deposited material.

During the test run, make periodic adjustments to keep the temperature around the filter holder at the proper level; add more ice and, if necessary, salt to maintain a temperature of less than 20°C (68°F) at the condenser/silica gel outlet. Also, periodically check the level and zero of the manometer. If the pressure drop across the filter becomes too high, making isokinetic sampling difficult to maintain, the filter may be replaced in the midst of a sample run. It is recommended that another complete filter assembly be used rather than attempting to change the filter itself. Before a new filter assembly is installed, conduct a leak-check (see Section 4.1.4.2). The total particulate weight shall include the summation of all filter assembly catches.

A single train shall be used for the entire sample run, except in cases where simultaneous sampling is required in two or more separate ducts or at two or more different locations within the same duct, or, in cases where equipment failure necessitates a change of trains. In all other situations, the use of two or more trains will be subject to the approval of the Administrator. Note that when two or more trains are used, separate analyses of the front-half and (if applicable) impinger catches from each train shall be performed, unless identical nozzle sizes were used on all trains, in which case, the front-half catches from the individual trains may be combined (as may the impinger catches) and one analysis of front-half catch and one analysis of impinger catch may be performed. Consult with the Administrator for details concerning the calculation of results when two or more trains are used.

At the end of the sample run, turn off the coarse adjust valve, remove the probe and nozzle from the stack, turn off the pump, record the final dry gas meter reading, and conduct a post-test leak-check, as outlined in Section 4.1.4.3. Also, leak-check the pitot lines as described in Method 2, Section 3.1; the lines must pass this leak-check, in order to validate the velocity head data.

4.1.6 Calculation of Percent Isokinetic. Calculate percent isokinetic (see Calculations, Section 6) to determine whether the run was valid or another test run should be made. If there was difficulty in maintaining isokinetic rates due to source conditions, consult with the Administrator for possible variance on the isokinetic rates.

4.2 Sample Recovery. Proper cleanup procedure begins as soon as the probe is removed from the stack at the end of the sampling period. Allow the probe to cool. When the probe can be safely handled, wipe off all external particulate matter near the tip of the probe nozzle and place a cap over it to prevent losing or gaining particulate matter. Do not cap off the probe tip tightly while the sampling train is cooling down as this would create a vacuum in the filter holder, thus drawing water from the impingers into the filter holder.

Before moving the sample train to the cleanup site, remove the probe from the sample train, wipe off the silicone grease, and cap the open outlet of the probe. Be careful not to lose any condensate that might be present. Wipe off the silicone grease from the filter inlet where the probe was fastened.
and cap it. Remove the umbilical cord from the last impinger and cap the impinger. If a flexible line
is used between the first impinger or condenser and the filter holder, disconnect the line at the filter
holder and let any condensed water or liquid drain into the impingers or condenser. After wiping off
the silicone grease, cap off the filter holder outlet and impinger inlet. Either ground-glass stoppers,
plastic caps, or serum caps may be used to close these openings. Transfer the probe and filter-
impinger assembly to the cleanup area. This area should be clean and protected from the wind
so that the chances of contaminating or losing the sample will be minimized. Save a portion of the
acetone used for cleanup as a blank. Take 200 ml of this acetone directly from the wash bottle being
used and place it in a glass sample container labeled "acetone blank." Inspect the train prior to and
during disassembly and note any abnormal conditions.

Treat the samples as follows: Container No. 1. Carefully remove the filter from the filter holder
and place it in its identified petri dish container. Use a pair of tweezers and/or clean disposable
surgical gloves to handle the filter. If it is necessary to fold the filter, do so such that the particulate
cake is inside the fold. Carefully transfer to the petri dish any particulate matter and/or filter fibers
which adhere to the filter holder gasket, by using a dry Nylon bristle brush and/or a sharp-edged
blade. Seal the container. Container No. 2. Taking care to see that dust on the outside of the probe
or other exterior surfaces does not get into the sample, quantitatively recover particulate matter or
any condensate from the probe nozzle, probe fitting, probe liner, and front half of the filter holder by
washing these components with acetone and placing the wash in a glass container.

Distilled water may be used instead of acetone when approved by the Administrator and shall be
used when specified by the Administrator; in these cases, save a water blank and follow the
Administrator's directions on analysis. Perform the acetone rinses as follows: Carefully remove the
probe nozzle and clean the inside surface by rinsing with acetone from a wash bottle and brushing
with a Nylon bristle brush. Brush until the acetone rinse shows no visible particles, after which
make a final rinse of the inside surface with acetone. Brush and rinse the inside parts of the
Swagelok fitting with acetone in a similar way until no visible particles remain. Rinse the probe
liner with acetone by tilting and rotating the probe while squirting acetone into its upper end so that
all inside surfaces will be wetted with acetone.

Let the acetone drain from the lower end into the sample container. A funnel (glass or polyethylene)
may be used to aid on transferring liquid washes to the container. Follow the acetone rinse with a
probe brush. Hold the probe in an inclined position, squirt acetone into the upper end as the probe
brush is being pushed with a twisting action through the probe; hold a sample container underneath
the lower end of the probe, and catch any acetone and particulate matter which is brushed from the
probe. Run the brush through the probe three times or more until no visible particulate matter is
carried out with the acetone or until none remains in the probe liner on visual inspection. With
stainless steel or other metal probes, run the brush through in the above prescribed manner at least
six times since metal probes have small crevices in which particulate matter can be entrapped. Rinse
the brush with acetone, and quantitatively collect these washings in the sample container. After the
brushing, make a final acetone rinse of the probe as described above.

It is recommended that two people clean the probe to minimize sample losses. Between sampling
runs, keep brushes clean and protected from contaminations. After ensuring that all joints have
been wiped clean of silicone grease, clean the inside of the front half of the filter holder by rubbing
the surfaces with a Nylon bristle brush and rinsing with acetone. Rinse each surface three times or
more if needed to remove visible particulate. Make a final rinse of the brush and filter holder.
Carefully rinse out the glass cyclone, also (if applicable). After all acetone washings and particulate matter have been collected in the sample container, tighten the lid on the sample container so that acetone will not leak out when it is shipped to the laboratory. Mark the height of the fluid level to determine whether or not leakage occurred during transport. Label the container to clearly identify its contents.

Container No. 3. Note the color of the indicating silica gel to determine if it has been completely spent and make a notation of its condition. Transfer the silica gel from the fourth impinger to its original container and seal. A funnel may make it easier to pour the silica gel without spilling. A rubber policeman may be used as an aid in removing the silica gel from the impinger. It is not necessary to remove the small amount of dust particles that may adhere to the impinger wall and are difficult to remove. Since the gain in weight is to be used for moisture calculations, do not use any water or other liquids to transfer the silica gel. If a balance is available in the field, follow the procedure for container No. 3 in Section 4.3. Impinger Water. Treat the impingers as follows; Make a notation of any color or film in the liquid catch. Measure the liquid which is in the first three impingers to within ±1 ml by using a graduated cylinder or by weighing it to within ±0.5 g by using a balance (if one is available). Record the volume or weight of liquid present. This information is required to calculate the moisture content of the effluent gas.

Discard the liquid after measuring and recording the volume or weight, unless analysis of the impinger catch is required (see Note, Section 2.1.7). If a different type of condenser is used, measure the amount of moisture condensed either volumetrically or gravimetrically. Whenever possible, containers should be shipped in such a way that they remain upright at all times.

4.3 Analysis. Record the data required on a sheet such as the one shown in Figure 5-3. Handle each sample container as follows:

Container No. 1. Leave the contents in the shipping container or transfer the filter and any loose particulate from the sample container to a tared glass weighing dish. Desiccate for 24 hours in a desiccator containing anhydrous calcium sulfate. Weigh to a constant weight and report the results to the nearest 0.1 mg. For purposes of this Section, 4.3, the term "constant weight" means a difference of no more than 0.5 mg or 1 percent of total weight less tare weight, whichever is greater, between two consecutive weighings, with no less than 6 hours of desiccation time between weighings. Alternatively, the sample may be oven dried at 105°C (220°F) for 2 to 3 hours, cooled in the desiccator, and weighed to a constant weight, unless otherwise specified by the Administrator. The tester may also opt to oven dry the sample at 105°C (220°F) for 2 to 3 hours, weigh the sample, and use this weight as a final weight.

Container No. 2. Note the level of liquid in the container and confirm on the analysis sheet whether or not leakage occurred during transport. If a noticeable amount of leakage has occurred, either void the sample or use methods, subject to the approval of the Administrator, to correct the final results. Measure the liquid in this container either volumetrically to ±1 ml or gravimetrically to ±0.5 g. Transfer the contents to a tared 250-ml beaker and evaporate to dryness at ambient temperature and pressure. Desiccate for 24 hours and weigh to a constant weight. Report the results to the nearest 0.1 mg. Container No. 3. Weigh the spent silica gel (or silica gel plus impinger) to the nearest 0.5 g using a balance. This step may be conducted in the field. "Acetone Blank" Container. Measure acetone in this container either volumetrically or gravimetrically. Transfer the acetone to a tared 250-ml beaker and evaporate to dryness at ambient temperature and pressure. Desiccate for 24 hours and weigh to a constant weight. Report the results to the nearest 0.1 mg.
Note: At the option of the tester, the contents of Container No. 2 as well as the acetone blank container may be evaporated at temperatures higher than ambient. If evaporation is done at an elevated temperature, the temperature must be below the boiling point of the solvent; also, to prevent "bumping," the evaporation process must be closely supervised, and the contents of the beaker must be swirled occasionally to maintain an even temperature. Use extreme care, as acetone is highly flammable and has a low flash point.

4.4 Quality Control Procedures. The following quality control procedures are suggested to check the volume metering system calibration values at the field test site prior to sample collection. These procedures are optional for the tester.

4.4.1 Meter Orifice Check. Using the calibration data obtained during the calibration procedure described in Section 5.3, determine the $\Delta H@$ for the metering system orifice. The $\Delta H@$ is the orifice pressure differential in units of in. H2O that correlates to 0.75 cfm of air at 528°C and 29.92 in. Hg. The $\Delta H@$ is calculated as follows:

$$\Delta H@ = 0.0319 \frac{Tm}{Pbar} \frac{\Theta Y2 V2m}{\sqrt{\Theta Y2 V2m}}$$

Eq. 5-9

Where:

- $\Delta H@$=Average pressure differential across the orifice meter, in. H2O.
- Tm=Absolute average dry gas meter temperature, °R.
- Pbar=Barometric pressure, in. Hg.
- $\Theta$=Total sampling time, min.
- $Y$=Dry gas meter calibration factor, dimensionless.
- $V_m$=Volume of gas sample as measured by dry gas meter, dcf.

0.0319=$(0.0567$ in. Hg/°R) x $(0.75$ cfm)².

Before beginning the field test (a set of three runs usually constitutes a field test), operate the metering system (i.e., pump, volume meter, and orifice) at the $\Delta H@$ pressure differential for 10 minutes. Record the volume collected, the dry gas meter temperature, and the barometric pressure. Calculate a dry gas meter calibration check value, $Y_c$, as follows:

$$Y_c = \frac{10}{V_m} \left[ 0.0319 \frac{Tm}{Pbar} \right]^{1/2}$$

Eq. 5-10

Where:

- $Y_c$=Dry gas meter calibration check value, dimensionless.
- 10=10 minutes of run time.

Compare the $Y_c$ value with the dry gas meter calibration factor $Y$ to determine that:

$$0.97Y < Y_c < 1.03Y$$

If the $Y_c$ value is not within this range, the volume metering system should be investigated before beginning the test.
4.4.2 Calibrated Critical Orifice. A calibrated critical orifice, calibrated against a wet test meter or spirometer and designed to be inserted at the inlet of the sampling meter box may be used as a quality control check by following the procedure of Section 7.2.

5. Calibration

5.1 Probe Nozzle. Probe nozzles shall be calibrated before their initial use in the field. Using a micrometer, measure the inside diameter of the nozzle to the nearest 0.025 mm (0.001 in.). Make three separate measurements using different diameters each time, and obtain the average of the measurements. The difference between the high and low numbers shall not exceed 0.1 mm (0.004 in.). When nozzles become nicked, dented, or corroded, they shall be reshaped, sharpened, and recalibrated before use. Each nozzle shall be permanently and uniquely identified.

5.2 Pitot Tube. The Type S pitot tube assembly shall be calibrated according to the procedure outlined in Section 4 of Method 2.

5.3 Metering System.

5.3.1 Calibration Prior to Use. Before its initial use in the field, the metering system shall be calibrated as follows: Connect the metering system inlet to the outlet of a wet test meter that is accurate to within 1 percent. Refer to Figure 5.5. The wet test meter should have a capacity of 30 liters/rev (1 ft³/rev). A spirometer of 400 liters (14 ft³) or more capacity, or equivalent, may be used for this calibration, although a wet test meter is usually more practical. The wet test meter should be periodically calibrated with a spirometer or a liquid displacement meter to ensure the accuracy of the wet test meter.

Spirometers or wet test meters of other sizes may be used, provided that the specified accuracies of the procedure are maintained. Run the metering system pump for about 15 minutes with the orifice manometer indicating a median reading as expected in field use to allow the pump to warm up and to permit the interior surface of the wet test meter to be thoroughly wetted. Then, at each of a minimum of three orifice manometer settings, pass an exact quantity of gas through the wet test meter and note the gas volume indicated by the dry gas meter. Also note the barometric pressure, and the temperatures of the wet test meter, the inlet of the dry gas meter, and the outlet of the dry gas meter. Select the highest and lowest orifice settings to bracket the expected field operating range of the orifice. Use a minimum volume of 0.15 m³ (5 cf) at all orifice settings. Record all the data on a form similar to Figure 5.6, and calculate \( Y \), the dry gas meter calibration factor, and \( \Delta H@ \), the orifice calibration factor, at each orifice setting as shown on Figure 5.6. Allowable tolerances for individual \( Y \) and \( \Delta H@ \) values are given in Figure 5.6. Use the average of the \( Y \) values in the calculations in Section 6.

Before calibrating the metering system, it is suggested that a leak-check be conducted. For metering systems having diaphragm pumps, the normal leak-check procedure will not detect leakages within the pump. For these cases the following leak-check procedure is suggested: make a 10-minute calibration run at 0.00057 m³/min (0.02 cfm); at the end of the run, take the difference of the measured wet test meter and dry gas meter volumes; divide the difference by 10, to get the leak rate. The leak rate should not exceed 0.00057 m³/min (0.02 cfm).
5.3.2 Calibration After Use. After each field use, the calibration of the metering system shall be checked by performing three calibration runs at a single, intermediate orifice setting (based on the previous field test), with the vacuum set at the maximum value reached during the test series. To adjust the vacuum, insert a valve between the wet test meter and the inlet of the metering system. Calculate the average value of the dry gas meter calibration factor. If the value has changed by more than 5 percent, recalibrate the meter over the full range of orifice settings, as previously detailed.

Alternative procedures, e.g., rechecking the orifice meter coefficient may be used, subject to the approval of the Administrator.

5.3.3 Acceptable Variation in Calibration. If the dry gas meter coefficient values obtained before and after a test series differ by more than 5 percent, the test series shall either be voided, or calculations for the test series shall be performed using whichever meter coefficient value (i.e., before or after) gives the lower value of total sample volume.

5.4 Probe Heater Calibration. The probe heating system shall be calibrated before its initial use in the field. Use a heat source to generate air heated to selected temperatures that approximate those expected to occur in the sources to be sampled. Pass this air through the probe at a typical simple flow rate while measuring the probe inlet and outlet temperatures at various probe heater settings. For each air temperature generated, construct a graph of probe heating system setting versus probe outlet temperature. The procedure outlined in APTD-0576 can also be used. Probes constructed according to APTD-0581 need not be calibrated if the calibration curves in APTD-0576 are used. Also, probes with outlet temperature monitoring capabilities do not require calibration.

5.5 Temperature Gauges. Use the procedure in Section 4.3 of Method 2 to calibrate in-stack temperature gauges. Dial thermometers, such as are used for the dry gas meter and condenser outlet, shall be calibrated against mercury-in-glass thermometers.

5.6 Leak Check of Metering System Shown in Figure 5-1. That portion of the sampling train from the pump to the orifice meter should be leak checked prior to initial use and after each shipment. Leakage after the pump will result in less volume being recorded than is actually sampled. The following procedure is suggested (see Figure 5-4): Close the main valve on the meter box. Insert a one-hole rubber stopper with rubber tubing attached into the orifice exhaust pipe. Disconnect and vent the low side of the orifice manometer. Close off the low side orifice tap. Pressurize the system to 13 to 18 cm (5 to 7 in.) water column by blowing into the rubber tubing. Pinch off the tubing and observe the manometer for one minute. A loss of pressure on the manometer indicates a leak in the meter box; leaks, if present, must be corrected.

5.7 Barometer. Calibrate against a mercury barometer.

6. Calculations
Carry out calculations, retaining at least one extra decimal figure beyond that of the acquired data. Round off figures after the final calculation. Other forms of the equations may be used as long as they give equivalent results.

6.1 Nomenclature.
An=Cross-sectional area of nozzle, m² (ft²).
Bws=Water vapor in the gas stream, proportion by volume.
Ca=Acetone blank residue concentration, mg/mg.
Cs=Concentration of particulate matter in stack gas, dry basis, corrected to standard conditions, g/dscm (g/dscf).
I=Percent of isokinetic sampling.
La=Maximum acceptable leakage rate for either a pretest leak check or for a leak check following a component change; equal to 0.00057 m³/min (0.02 cfm) or 4 percent of the average sampling rate, whichever is less.
Li=Individual leakage rate observed during the leak check conducted prior to the "ith" component change (i=1, 2, 3,...n), m³/min (cfm).
Lp=Leakage rate observed during the post-test leak check, m³/min (cfm).
ma=Mass of residue of acetone after evaporation, mg.
mn=Total amount of particulate matter collected, mg.
Mw=Molecular weight of water, 18.0 g/g-mole (18.0 lb/lb-mole).
Pbar=Barometric pressure at the sampling site, mm Hg (in. Hg).
Ps=Absolute stack gas pressure, mm Hg (in. Hg).
Pstd=Standard absolute pressure, 760 mm Hg (29.92 in. Hg).
R=Ideal gas constant, 0.06236 mm Hg-m³/°K-g-mole (21.85 in. Hg-ft³/°R-lb-mole).
Tm=Absolute average dry gas meter temperature (see Figure 5-2), °K (°R).
Ts=Absolute average stack gas temperature (see Figure 5-2), °K (°R).
Tstd=Standard absolute temperature, 293° K (528° R).
Va=Volume of acetone blank, ml.
Vaw=Volume of acetone used in wash, ml.
Vic=Total volume of liquid collected in impingers and silica gel (see Figure 5-3), ml.
Vm=Volume of gas sample as measured by dry gas meter, dcm (dscf).
Vm(std)=Volume of gas sample measured by the dry gas meter, corrected to standard conditions, dcm (dscf).
Vw(std)=Volume of water vapor in the gas sample, corrected to standard conditions, scm (scf).
vs=Stack gas velocity, calculated by Method 2, Equation 2-9, using data obtained from Method 5, m/sec (ft/sec).
Wa=Weight of residue in acetone wash, mg.
Y=Dry gas meter calibration factor.
AH=Average pressure differential across the orifice meter (see Figure 5-2), mm H₂O (in. H₂O).
RHOa=Density of acetone, mg/ml (see label on bottle).
RHOw=Density of water, 0.9982 g/ml (0.002201 lb/ml).
O=Total sampling time, min.
O₁=Sampling time interval, from the beginning of a run until the first component change, min.
Oᵢ=Sampling time interval, between two successive component changes, beginning with the interval between the first and second changes, min.
Oₚ=Sampling time interval, from the final (nth) component change until the end of the sampling run, min.
13.6=Specific gravity of mercury.
60=Sec/min.
100=Conversion to percent.

6.2 Average Dry Gas Meter Temperature and Average Orifice Pressure Drop. See data sheet (Figure 5-2).
6.3 Dry Gas Volume. Correct the sample volume measured by the dry gas meter to standard conditions (20° C, 760 mm Hg or 68° F, 29.92 in. Hg) by using Equation 5-1.

\[
V_{m(\text{std})} = V_m \frac{Y}{T_m} \left( \frac{P_{\text{bar}} + \Delta H / 13.6}{P_{\text{std}}} \right)
\]

\[
= K_1 V_m \frac{Y}{T_m} \left( \frac{P_{\text{bar}} + \Delta H / 13.6}{P_{\text{std}}} \right)
\]

Equation 5-1

Where:

\[K_1=0.3858 \text{ °K/mm Hg for metric units}\]
\[=17.64 \text{ °R/in. Hg for English units}\]

Note: Equation 5-1 can be used as written unless the leakage rate observed during any of the mandatory leak checks (i.e., the post-test leak check or leak checks conducted prior to component changes) exceeds \(L_a\). If \(L_p\) or \(i\) exceeds \(L_a\), Equation 5-1 must be modified as follows:

(a) Case I. No component changes made during sampling run.
In this case, replace \(V_m\) in Equation 5-1 with the expression:

\[
[V_m - (L_p - L_a)\theta]
\]

(b) Case II. One or more component changes made during the sampling run. In this case, replace \(V_m\) in Equation 5-1 by the expression:

\[
V_m - (L_1 - L_a)\theta_1 - \sum_{l=2}^{n} (L_l - L_a)\theta_l - (L_p - L_a)\theta_p
\]

and substitute only for those leakage rates (\(L_i\) or \(L_p\)) which exceed \(L_a\).

6.4 Volume of Water Vapor.

\[
V_{w(\text{std})} = \frac{V_{lc} \ R H_{\text{Ow}} \ R \ T_{\text{std}}}{M_w \ P_{\text{std}}} = K_2 V_{lc}
\]

Eq. 5-2

Where:

\[K_2=0.001333 \text{ m}^3/\text{ml for metric units}=0.04707 \text{ ft}^3/\text{ml for English units}\]
6.5 Moisture Content.

\[
Bws = \frac{V_w (\text{std})}{V_m (\text{std}) + V_w (\text{std})}
\]

Eq. 5-3

Note: In saturated or water droplet-laden gas streams, two calculations of the moisture content of the stack gas shall be made, one from the impinger analysis (Equation 5-3), and a second from the assumption of saturated conditions. The lower of the two values of Bws shall be considered correct. The procedure for determining the moisture content based upon assumption of saturated conditions is given in the Note of Section 1.2 of Method 4. For the purposes of this method, the average stack gas temperature from Figure 5-2 may be used to make this determination, provided that the accuracy of the in-stack temperature sensor is ±1°C (±2°F).

6.6 Acetone Blank Concentration.

\[
Ca = \frac{ma}{Va \ RHOa}
\]

Eq. 5-4

6.7 Acetone Wash Blank.

\[
Wa = Ca \ Vaw \ RHOa
\]

Eq. 5-5

6.8 Total Particulate Weight. Determine the total particulate catch from the sum of the weights obtained from Containers 1 and 2 less the acetone blank (see Figure 5-3).

Note: Refer to Section 4.1.5 to assist in calculation of results involving two or more filter assemblies or two or more sampling trains.

6.9 Particulate Concentration.

\[
c_s = (0.001 \ g/mg) \ (mn/V_m (\text{std}))
\]

Eq. 5-6
6.10 Conversion Factors:

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</tr>
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<td>g/ft³........</td>
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<td>35.31</td>
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6.11 Isokinetic Variation.

6.11.1 Calculation From Raw Data.

\[
I = \frac{100 \cdot T_s \cdot k_3 V_{lc} + (V_m \cdot Y/T_m) \cdot (P_{bar} + GI/13.6)}{60 \cdot \Theta V_s P_s \cdot \Theta P_u}
\]

Eq. 5-7

Where:
\( k_3 = 0.003454 \text{ mm Hg-m}^3/\text{ml-}^\circ \text{K for metric units.} = 0.002669\text{-in. Hg-ft}^3/\text{ml-}^\circ \text{R for English units.} \)

6.11.2 Calculation From Intermediate Values.

\[
I = \frac{100 \cdot T_s \cdot V_{m(\text{std})} \cdot P_{\text{std}}}{60 \cdot V_{\text{std}} \cdot \Theta \cdot P_s \cdot (1-Bw_s)}
\]

\[
= \frac{K_4 \cdot T_s \cdot V_{m(\text{std})}}{P_s \cdot \Theta \cdot (1-Bw_s)}
\]

Eq. 5-8

Where:
\( K_4 = 4.320 \text{ for metric units=0.09450 for English units.} \)

6.12 Acceptable Results. If 90 percent \( \leq I \leq 110 \) percent, the results are acceptable. If the particulate results are low in comparison to the standard, and I is over 110 percent or less than 90 percent, the Administrator may accept the results. Citation 4 in the bibliography section can be used to make acceptability judgments. If I is judged to be unacceptable, reject the particulate results and repeat the test.
6.13 Stack Gas Velocity and Volumetric Flow Rate. Calculate the average stack gas velocity and volumetric flow rate, if needed, using data obtained in this method and the equations in Sections 5.2 and 5.3 of Method 2.

7. Alternative Procedures

7.1 Dry Gas Meter as a Calibration Standard. A dry gas meter may be used as a calibration standard for volume measurements in place of the wet test meter specified in Section 5.3, provided that it is calibrated initially and recalibrated periodically as follows:

7.1.1 Standard Dry Gas Meter Calibration.

7.1.1.1 The dry gas meter to be calibrated and used as a secondary reference meter should be of high quality and have an appropriately sized capacity, e.g., 3 liters/rev (0.1 ft³/rev). A spirometer (400 liters or more capacity), or equivalent, may be used for this calibration, although a wet test meter is usually more practical. The wet test meter should have a capacity of 30 liters/rev (1 ft³/rev) and capable of measuring volume to within ±1.0 percent; wet test meters should be checked against a spirometer or a liquid displacement meter to ensure the accuracy of the wet test meter. Spirometers or wet test meters of other sizes may be used, provided that the specified accuracies of the procedure are maintained.

7.1.1.2 Set up the components as shown in Figure 5.7. A spirometer, or equivalent, may be used in place of the wet test meter in the system. Run the pump for at least 5 minutes at a flow rate of about 10 liters/min (0.35 cfm) to condition the interior surface of the wet test meter. The pressure drop indicated by the manometer at the inlet side of the dry gas meter should be minimized [no greater than 100 mm H₂O (4 in. H₂O) at a flow rate of 30 liters/min (1 cfm)]. This can be accomplished by using large diameter tubing connections and straight pipe fittings.

7.1.1.3 Collect the data as shown in the example data sheet (see Figure 5-8). Make triplicate runs at each of the flow rates and at no less than five different flow rates. The range of flow rates should be between 10 and 34 liters/min (0.35 and 1.2 cfm) or over the expected operating range.

7.1.1.4 Calculate flow rate, Q, for each run using the wet test meter gas volume, Vw, and the run time, Θ. Calculate the dry gas meter coefficient, Yds, for each run. These calculations are as follows:

\[
Q = \frac{P_{\text{bar}} \times V_{\text{w}}}{(t_{\text{w}}+t_{\text{std}}) \times \Theta}
\]

\[
Y_{\text{ds}} = \frac{V_{\text{w}} \times (t_{\text{ds}}+t_{\text{std}}) \times P_{\text{bar}}}{V_{\text{ds}} \times (t_{\text{w}}+t_{\text{std}}) \times (P_{\text{bar}}+\Delta p/13.6)}
\]

Where:

- \(K_l = 0.3858\) for international system of units (SI); \(17.64\) for English units.
- \(V_{\text{w}}\) = Wet test meter volume, liters (ft³).
Vds=Dry gas meter volume, liters (ft³).
tds=Average dry gas meter temperature, °C (°F).
tstd=273°C for SI units; 460°F for English units.
tw=Average wet test meter temperature, °C (°F).
Pbar=Barometric pressure, mm Hg (in. Hg).
Δp=Dry gas meter inlet differential pressure, mm H₂O (in. H₂O).
Θ=Run time, min.

7.1.1.5 Compare the three Yds values at each of the flow rates and determine the maximum and minimum values. The difference between the maximum and minimum values at each flow rate should be no greater than 0.030. Extra sets of triplicate runs may be made in order to complete this requirement. In addition, the meter coefficients should be between 0.95 and 1.05. If these specifications cannot be met in three sets of successive triplicate runs, the meter is not suitable as a calibration standard and should not be used as such. If these specifications are met, average the three Yds values at each flow rate resulting in five average meter coefficients, Yds.

7.1.1.6 Prepare a curve of meter coefficient, Yds, versus flow rate, Q, for the dry gas meter. This curve shall be used as a reference when the meter is used to calibrate other dry gas meters and to determine whether recalibration is required.

7.1.2 Standard Dry Gas Meter Recalibration.

7.1.2.1 Recalibrate the standard dry gas meter against a wet test meter or spirometer annually or after every 200 hours of operation, whichever comes first. This requirement is valid provided the standard dry gas meter is kept in a laboratory and, if transported, cared for as any other laboratory instrument. Abuse to the standard meter may cause a change in the calibration and will require more frequent recalibrations.

7.1.2.2 As an alternative to full recalibration, a two-point calibration check may be made. Follow the same procedure and equipment arrangement as for a full recalibration, but run the meter at only two flow rates [suggested rates are 14 and 28 liters/min (0.5 and 1.0 cfm)]. Calculate the meter coefficients for these two points, and compare the values with the meter calibration curve. If the two coefficients are within ±1.5 percent of the calibration curve values at the same flow rates, the meter need not be recalibrated until the next date for a recalibration check.

7.2 Critical Orifices As Calibration Standards. Critical orifices may be used as calibration standards in place of the wet test meter specified in Section 5.3, provided that they are selected, calibrated, and used as follows:

7.2.1 Section of Critical Orifices.

7.2.1.1 The procedure that follows describes the use of hypodermic needles or stainless steel needle tubings which have been found suitable for use as critical orifices. Other materials and critical orifice designs may be used provided the orifices act as true critical orifices; i.e., a critical vacuum can be obtained, as described in Section 7.2.2.2.3. Select five critical orifices that are appropriately sized to cover the range of flow rates between 10 and 34 liters/min or the expected operating range. Two of the critical orifices should bracket the expected operating range.

A minimum of three critical orifices will be needed to calibrate a Method 5 dry gas meter (DGM); the other two critical orifices can serve as spares and provide better selection for bracketing the range of operating flow rates. The needle sizes and tubing lengths shown below give the following approximate flow rates:
<table>
<thead>
<tr>
<th>Gauge/cm</th>
<th>Flow rate (liters/min)</th>
<th>Gauge/cm</th>
<th>Flow rate (liters/min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12/7.6</td>
<td>32.56</td>
<td>14/2.5</td>
<td>19.54</td>
</tr>
<tr>
<td>12/10.2</td>
<td>30.02</td>
<td>14/5.1</td>
<td>17.27</td>
</tr>
<tr>
<td>13/2.5</td>
<td>25.77</td>
<td>14/7.6</td>
<td>16.14</td>
</tr>
<tr>
<td>13/5.1</td>
<td>23.50</td>
<td>15/3.2</td>
<td>14.16</td>
</tr>
<tr>
<td>13/7.6</td>
<td>22.37</td>
<td>15/7.6</td>
<td>11.61</td>
</tr>
<tr>
<td>13/10.2</td>
<td>20.67</td>
<td>15/10.2</td>
<td>10.48</td>
</tr>
</tbody>
</table>

7.2.1.2 These needles can be adapted to a Method 5 type sampling train as follows: Insert a serum bottle stopper, 13- by 20-mm sleeve type, into a 1/2-inch Swagelok quick connect. Insert the needle into the stopper as shown in Figure 5-9.

[ Part 60, page 756. Figure 5-9. ]

7.2.2 Critical Orifice Calibration. The procedure described in this section uses the Method 5 meter box configuration with a DGM as described in Section 2.1.8 to calibrate the critical orifices. Other schemes may be used, subject to the approval of the Administrator.

7.2.2.1 Calibration of Meter Box. The critical orifices must be calibrated in the same configuration as they will be used; i.e., there should be no connections to the inlet of the orifice.

7.2.2.1.1 Before calibrating the meter box, leak check the system as follows: Fully open the coarse adjust valve, and completely close the by-pass valve. Plug the inlet. Then turn on the pump, and determine whether there is any leakage. The leakage rate shall be zero; i.e., no detectable movement of the DGM dial shall be seen for 1 minute.

7.2.2.1.2 Check also for leakages in that portion of the sampling train between the pump and the orifice meter. See Section 5.6 for the procedure; make any corrections, if necessary. If leakage is detected, check for cracked gaskets, loose fittings, worn O-rings, etc., and make the necessary repairs.

7.2.2.1.3 After determining that the meter box is leakless, calibrate the meter box according to the procedure given in Section 5.3. Make sure that the wet test meter meets the requirements stated in Section 7.1.1.1. Check the water level in the wet test meter. Record the DGM calibration factor, $Y$.

7.2.2.2 Calibration of Critical Orifices. Set up the apparatus as shown in Figure 5-10.

[ Part 60, page 757. Figure 5-10. ]

7.2.2.2.1 Allow a warm-up time of 15 minutes. This step is important to equilibrate the temperature conditions through the DGM.

7.2.2.2.2 Leak check the system as in Section 7.2.2.1.1. The leakage rate shall be zero.

7.2.2.2.3 Before calibrating the critical orifice, determine its suitability and the appropriate operating vacuum as follows: Turn on the pump, fully open the coarse adjust valve, and adjust the by-pass valve to give a vacuum reading corresponding to about half of atmospheric pressure. Observe the meter box orifice manometer reading, $H$. Slowly increase the vacuum reading until a stable reading is obtained on the meter box orifice manometer. Record the critical vacuum for each orifice. Orifices that do not reach a critical value shall not be used.
7.2.2.2.4 Obtain the barometric pressure using a barometer as described in Section 2.1.9. Record the barometric pressure, Pbar, in mm Hg (in. Hg).

7.2.2.2.5 Conduct duplicate runs at a vacuum of 25 to 50 mm Hg (1 to 2 in. Hg) above the critical vacuum. The runs shall be at least 5 minutes each. The DGM volume readings shall be in increments of 0.00283 m³ (0.1 ft³) or in increments of complete revolutions of the DGM. As a guideline, the times should not differ by more than 3.0 seconds (this includes allowance for changes in the DGM temperatures) to achieve ±0.5 percent in K'. Record the information listed in Figure 5-11.

7.2.2.2.6 Calculate K' using Equation 5-9.

\[
K' = \frac{K1VmY \cdot (Pbar + \frac{1}{13.6})} {\sqrt{Tamb}} \quad \text{Eq. 5-9}
\]

Where:

\[
K' = \text{Critical orifice coefficient,} \quad \frac{(m^3)(K)^{1/2}}{(\text{mm. Hg})(\text{min})} \left[ \frac{(ft^3)(^\circ R)^{1/2}}{(\text{in. Hg})(\text{min})} \right]
\]

Tamb = Absolute ambient temperature, °K (°R).

Average the K' values. The individual K' values should not differ by more than ±0.5 percent from the average.

7.2.3 Using the Critical Orifices as Calibration Standards.

7.2.3.1 Record the barometric pressure.
<table>
<thead>
<tr>
<th>Date</th>
<th>Train ID</th>
<th>DGM cal. factor</th>
<th>Critical orifice ID</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Run number</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry gas meter</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Final reading | m³ (ft³) | |
| Initial reading | m³ (ft³) | |
| Difference, Vm | m³ (ft³) | |
| Inlet/Outlet temperatures: | | |
| Initial | °C (°F) | / |
| Final | °C (°F) | / |
| Avg. Temperature, tm | °C (°F) | |
| Time, Θ | min/sec | / |
| Orifice man. rdg., *H | mm (in.) H₂O | |
| Bar. pressure, Pbar | mm (in.) Hg | |
| Ambient temperature, tamb | °C (°F) | |
| Pump vacuum | mm (in.) Hg | |
| K' factor | | |
| Average | | |

Figure 5-11. Data sheet for determining K' factor.

7.2.3.2 Calibrate the metering system according to the procedure outlined in Sections 7.2.2.2.1 to 7.2.2.2.5. Record the information listed in Figure 5.12.

7.2.3.3 Calculate the standard volumes of air passed through the DGM and the critical orifices, and calculate the DGM calibration factor, Y, using the equations below:

\[ V_{m(\text{std})} = \frac{K_1 V_m}{T_m} \]  
Eq. 5-10

\[ V_{cr(\text{std})} = \frac{P_{bar}\Theta}{\sqrt{T_{amb}}} \]  
Eq. 5-11

\[ Y = \frac{V_{cr(\text{std})}}{V_{m(\text{std})}} \]  
Eq. 5-12

where:

- \( V_{cr(\text{std})} \) = Volume of gas sample passed through the critical orifice, corrected to standard conditions, dsm³ (dscf).

- \( K_1 = 0.3858 \, °K/\text{mm Hg} \) for metric units = 17.64 °R/in. Hg for English units.
7.2.3.4 Average the DGM calibration values for each of the flow rates. The calibration factor, Y, at each of the flow rates should not differ by more than ±2 percent from the average.

7.2.3.5 To determine the need for recalibrating the critical orifices, compare the DGM Y factors obtained from two adjacent orifices each time a DGM is calibrated; for example, when checking 13/2.5, use orifices 12/10.2 and 13/5.1. If any critical orifice yields a DGM Y factor differing by more than 2 percent from the others, recalibrate the critical orifice according to Section 7.2.2.2.

<table>
<thead>
<tr>
<th>Date</th>
<th>Train ID</th>
<th>Critical orifice ID</th>
<th>Critical orifice K' factor</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Dry gas meter</th>
<th>Run number</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>

| Final reading | m3 (ft3) |       |  |
| Initial reading | m3 (ft3) |       |  |
| Difference, Vm | m3 (ft3) |       |  |
| Inlet/outlet temperatures: |       |  |  |
| Initial | °C (°F) | / | / |
| Final | °C (°F) | / | / |
| Avg. Temperature, tm | °C (°F) |       |  |
| Time, Θ | min/sec | / | / |
| Orifice man. rdg., *H | mm (in.) H2O |       |  |
| Bar. pressure, Pbar | mm (in.) Hg |       |  |
| Ambient temperature, tamb | °C (°F) |       |  |
| Pump vacuum | mm (in.) Hg |       |  |
| Vm(std) | m3 (ft3) |       |  |
| Vcr(std) | m3 (ft3) |       |  |
| DGM cal. factor, Y |       |  |  |

Figure 5-12. Data sheet for determining DGM Y factor.
**FIGURE 5-3-ANALYTICAL DATA**

<table>
<thead>
<tr>
<th>Container number</th>
<th>Weight of particulate collected, mg</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Final weight</td>
</tr>
<tr>
<td>1............</td>
<td></td>
</tr>
<tr>
<td>2............</td>
<td></td>
</tr>
<tr>
<td>Total............</td>
<td></td>
</tr>
<tr>
<td>Less acetone blank</td>
<td></td>
</tr>
<tr>
<td>Weight of particulate matter</td>
<td></td>
</tr>
</tbody>
</table>

**Volume of liquid water collected**

<table>
<thead>
<tr>
<th></th>
<th>Volume of liquid water collected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impinger volume, ml</td>
<td>Silica gel weight, g</td>
</tr>
<tr>
<td>Final....................</td>
<td></td>
</tr>
<tr>
<td>Initial..................</td>
<td></td>
</tr>
<tr>
<td>Liquid collected..........</td>
<td></td>
</tr>
<tr>
<td>Total volume collected</td>
<td>g* ml</td>
</tr>
</tbody>
</table>

*Convert weight of water to volume by dividing total weight increase by density of water (1 g/ml).

\[
\frac{\text{Increase, g}}{(1 \text{ g/ml})} = \text{Volume water, ml}
\]
8. Bibliography


APPENDIX C

Visual Emissions Evaluations
Including
Ringelmann Procedures
and
Method 9
Division 26, Part 4, Chapter 3, Article 1, Section 41701 of the Health and Safety code of the State of California states:
"...no person shall discharge into the atmosphere from any source whatsoever any air contaminant, other than uncombined water vapor, for a period or periods aggregating more than three minutes in any one hour which is:

(a) As dark or darker in shade as that designated as No. 2 on the Ringelmann Chart, as published by the United States Bureau of Mines, or

(b) Of such opacity as to obscure an observer's view to a degree equal to or greater than does smoke described in subdivision (a).

Ringelmann Chart

The Ringelmann Chart was one of the first tools used to measure emissions to the atmosphere (see attachment). It was developed by Maximilian Ringelmann in the late 1800's and has been used by almost every industrial nation ever since. The Ringelmann Chart is thoroughly covered in the Bureau of Mines Information Circular No. IC8333 (May 1967).

The Ringelmann Smoke Chart, giving shades of gray by which the density of columns of smoke rising from stacks may be compared, was developed by Professor Maximilian Ringelmann of Paris. Ringelmann, born in 1861, was professor of agricultural engineering at l'Institute Agronomique and Director de la Station d'Essais de Machines in Paris in 1888, and held those positions for many years thereafter.

The chart apparently was introduced into the United States by William Kent in an article published in Engineering News November 11, 1897, with a comment that he had learned of it in a private communication from a Bryan Donkin of London. It was said to have come into somewhat extensive use in Europe by that time. In 1899, Rent proposed that it be accepted as the standard measure of smoke density in the standard code for power plant testing that was being formulated by the American Society of Mechanical Engineers.

The Ringelmann Chart was used by the engineers or the Technologic Branch of the U.S. Geological Survey (which later formed the nucleus of the present Bureau of Mines) in their studies of smokeless combustion beginning at St. Louis in 1904. By 1910 the Ringelmann Chart had been recognized officially in the smoke ordinance for Boston passed by the Massachusetts Legislature.
The chart is now used as a device for determining whether emissions of smoke are within established limits or standards of permissibility (statutes and ordinances) expressed with reference to the chart. It is widely used by law-enforcement or compliance officers in jurisdictions that have adopted standards based upon the chart.

**Description and Method of Preparing the Chart**

The Ringelmann system is a scheme whereby graduated shades of gray, varying by five equal steps between white and black, may be accurately reproduced by means of a rectangular grid of black lines of definite width and spacing on a white background. Professor Ringelmann established the following rule for reproducing the chart:

- **Card 0** - All white.
- **Card 1** - Black lines 1 mm thick, 10 mm apart, leaving white spaces 9 mm square.
- **Card 2** - Lines 2.3 mm thick, spaces 7.7 mm square.
- **Card 3** - Lines 3.7 mm thick, spaces 6.3 mm square.
- **Card 4** - Lines 5.5 mm thick, spaces 4.5 mm square.
- **Card 5** - All black.

The chart, as distributed by the Bureau of Mines, provides the shades of Cards 1, 2, 3, and 4 on a single sheet, which are known as Ringelmann No. 1, 2, 3, and 4, respectively. Additional copies of the chart may be obtained free by applying to the Publications Distribution Branch, Bureau of Mines, 4800 Forbes Avenue, Pittsburgh, Pennsylvania, 15213.

**Use of Chart**

Many municipal, State, and federal regulations prescribe smoke density limits based on the Ringelmann Smoke Chart, as published by the Bureau of Mines. Although the chart was not originally designed for regulatory purposes, it is presently used for this purpose in many jurisdictions where the results obtained are accepted as legal evidence.

While the chart still serves a useful purpose, it should be remembered that the data obtained by its use is empirical in nature and has definite limitations. The apparent darkness or opacity of a stack plume depends upon the concentration of the particulate matter in the effluent, the size of the particulate, the depth of the smoke column being viewed, natural lighting conditions (such as the direction of the sun relative to the observer), and the color of the particles. Since unburned carbon is a principal coloring material in a smoke column from a furnace using coal or oil, the relative shade is a function of the combustion efficiency.
While the Ringelmann Smoke Chart has many limitations, it gives good practical results in the hands of well-trained operators. However, it is questionable whether results should be expressed in fractional units because of variations in physical conditions and in the judgement of the observers.

To use, the chart is supported at eye level in line with the stack, at such a distance from the observer that the lines on the chart merge into shades of gray. The observer glances from the smoke to the chart and notes the number of the chart most nearly corresponding with the shade of the smoke. The observer then records this number with the time of observation. A clear stack is recorded as No. 0, and 100 percent black smoke as No. 5.

Equivalent Opacity

Because the Ringelmann Chart is only useful in evaluating black or gray emissions, a principle of equivalent opacity was developed later which makes possible the application of the Ringelmann principle to other colors of smoke.

One of the first appearances of this concept was in the air pollution control ordinances of the County of Los Angeles in 1945. In 1947 the Health and Safety Code of the State of California was amended to provide for the establishment of country-wide air pollution control districts. As already stated one section of this act limits visible emissions for a given period of time, not only to Ringelmann No. 2 shade of gray but also any visible emission of such opacity as to obscure an observers view to a degree equal to or greater than Ringelmann No. 2 Opacity simply means the degree to which transmitted light is obscured. Thus it is mandatory for any air pollution control district in California formed under this law to use the equivalent opacity concept.

Below is the relationship between Ringelmann number and opacity.

<table>
<thead>
<tr>
<th>Ringelmann Number</th>
<th>Opacity Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>20</td>
</tr>
<tr>
<td>2</td>
<td>40</td>
</tr>
<tr>
<td>3</td>
<td>60</td>
</tr>
<tr>
<td>4</td>
<td>80</td>
</tr>
<tr>
<td>5</td>
<td>100</td>
</tr>
</tbody>
</table>
Advantages

Some of the advantages of the use of visible emission control regulations by air pollution control districts are:

1. The validity of using the Ringelmann Chart and equivalent opacity concept has been established in the field of air pollution control legislation and the courts.

2. Observers can be trained in a relatively short time (24 to 32 hours) and it is not necessary that they have an extensive technical background.

3. No expensive equipment is required.

4. One person can make many observations per day.

5. Violators can be cited without resorting to expensive time consuming source testing.

6. Questionable emissions can be located and the actual emissions then determined by source tests.

7. It is usually not possible to quantify the reduction in total air pollution by the control of visible emissions. However, it is reasonable to assume that there will be a reduction in the discharge of dusts, gases, and mists to the atmosphere.

8. Control can be achieved for those operations not readily suitable to regular source testing methods. Examples are teepee burners for lumber mill waste, dust and other leakage from process equipment, visible automobile and aircraft exhaust, and bulk loading or unloading of dusty materials such as grains, ores, coal, etc.
AIDS FOR VISIBLE EMISSION EVALUATION

A number of smoke reading aids have been developed to assist in evaluating the density of visible emissions. These aids include smoke charts, tinted glass or film comparators, telephotometers, transmissometers, photography and laser techniques.

**Smoke Charts**

The various smoke charts that have been developed work in the Ringelmann principle, comparing shades of gray printed on paper, with the source emissions. They are simply smaller, hand held Ringelmann charts, and can be used to evaluate shades of gray or black only.

**Comparators**

The comparators that have been developed include the smokescope, smoke tintometer and umbrascope. The umbrascope and tintometer use tinted glass for comparison. The smokescope uses a film disc mounted in a device resembling a set of binoculars. The smoke is viewed through an eyepiece of the smokescope and matched to the smoke density shown in the other eyepiece. This device is said to minimize the problems with variations in ambient lighting and those resulting when the observer must refocus his eyes from the chart to the source. One disadvantage of this device is that the film discs represent only Ringelmann number 2 and number 3.

A film strip comprised of films of densities 20, 40, 60, and 80 percent transmission, has been developed by the Public Health Service and is identified as a smoke inspection guide. The inspector views the source emission through the film strip and matches it as closely as possible with one of the densities on the guide.

White smoke comparators might be developed consisting of small cells containing liquid suspensions of fine opaque particles of different concentrations and sizes.

**Telephotometers**

A telephotometer is used to measure the intensity of light from a source. Telephotometers can be used to evaluate the transmittance of plume, even when light scattering from other sources is present.
One type of telephotometer can be used to measure the transmittance of a plume by measuring the luminance (candles/square meter) difference between a pair of contrasting targets through the plume (B'1-B'2) and clear of the plume (B1-B2). The transmittance is calculated from the relationship:

\[ T = \frac{B'1-B'2}{B1-B2} \]

A second type of telephotometer requires only two measurements to obtain the plume transmittance. The instrument is calibrated by measuring the background luminance clear of the plume. The luminance of the same background through the plume is then measured. The transmittance of the plume is displayed in the telephotometer. This type of telephotometer must be frequently recalibrated to correct for changes in the background luminance.

A hand held device similar to a telephotometer has been developed for determining plume transmittance by viewing a light source through the plume. The light source must be several orders of magnitude brighter than the surroundings. During the day, the sun is normally used; at night a bright artificial light source is used. Plume transmittance is indicated from the luminance difference of the light source viewed through the plume and viewed clear of the plume.

There are some problems in using this device. The device will not work if the day is even slightly overcast. In test comparison with an in-stack transmissometer, the opacities measured by this device did not correlate well with those measured with the transmissometer.

**Photography**

Photography can be used to evaluate plume transmittance by placing filters alongside of the camera film plane so that a calibration scale is superimposed on the negative. The camera is oriented to position the filters in the negative. The camera is oriented to position the filters in the brightest part of the scene when taking the photograph. A calibration curve is obtained from the filter image on the photograph negative. The negative density of the filter image is plotted against the known filter density (see figure 1). Then by measuring the densities, on the negative, of contrasting targets through and clear the curve. A densitometer was used to measure negative densities. The transmittance of the plume is then determined by the same relationship used for the telephotometer.
Laser Techniques

From Appendix A of 40 CFR Part 60, Alternate Method 1 to Reference Method 9 of Federal Register:

"Lidar, an acronym for Light Detection and Ranging, was first applied to meteorological monitoring in 1963. Since that time lidar has been developed as a measurement technique for plume opacity, and today is approved as an alternate to Reference Method 9 which employs visible emission observers.

Lidar contains its own unique light source (a laser transmitter which enables a short pulse of light) which enables it to measure the opacity of stationary source emissions during both day-and nighttime ambient lighting conditions. The optical receiver within the lidar collects the laser light backscatters (reflected) from the atmospheric aerosols before and beyond the visible plume as well as those from the aerosols (particulates) within the plume. The receiver's detector converts the backscatter optical signal into an electronic signal. Plume opacity is calculated from the backscatter signal data obtained from just before and beyond the plume."

Backscatter is defined as the scattering of laser light in a direction opposite to that of the incident laser beam due to reflection from particulate along the beam's atmospheric path which may include a smoke plume.

Capabilities

The lidar unit includes an automatic horizontal stepping function, enabling it to make a horizontal scan across the emission points of known sources of pollution. Scans of this type have revealed additional source of visible emissions at night.

The lidar is additionally capable through vertical scanning, of drawing cross sectional views of particular plumes. Several years ago, Stanford Research Institute conducted a study at the Rancho Seco Nuclear Generating Station in which the lidar drew cross sections of a plume created by a large smoke generator. The experiment attempted to show where radioactive materials would touch ground in the event of an accidental release at the plant.

When directed skyward, the lidar can also measure the height of the inversion layer. With the truck in motion, the unit can be fired by an odometer triggered mechanism and the lidar can map plume dispersion and inversion layer heights.
Advantages of Lidar

1. Versatility of function
2. Precision of opacity readings
3. Useful for calibrating in-stack transmissometers
4. Need not comply with all visible opacity reading constraints applicable to subjective evaluation as enumerated by the Environmental Protection Agency Method 9.
5. Readings can be made at night.
6. Mobile
7. Readings can be made from many kilometers away.

Disadvantages of the Lidar

1. The plume must be at a range of at least 50 meters or three consecutive pick intervals (whichever is greater) from the lidar's transmitter/receiver convergence distance along the line of sight. Pick interval is defined as the time or range intervals in the lidar backscatter signal whose minimum average amplitude is used to calculate opacity.
2. Requires clear air behind the plume.
3. Potential eye damage if beam is viewed directly even from a considerable distance.
4. Unable to quantitatively distinguish between water droplets and particulate matter.
5. Cost estimates in excess of $100,000.
6. Cost estimates for maintenance/operation are yet undermined.

Transmissometers

Many permanently installed, in-stack devices are commercially available to continuously monitor and record emission transmittance. Some are designed to set off an alarm to warn operating personnel when transmittance reaches a preset level. Others indicate the transmittance on a meter or record it on strip paper.

Most of these devices use either a light source photocell combination to measure the transmission of light through the plume or remove a sample of plume and measure the transmission through this sample. One problem with the light source-photocell system is that both the light source and photocell deteriorate and require frequent recalibration. If the light transmissions of a sample is measured, it is frequently difficult, especially under varying conditions, to obtain a representative sample.

The bolometer is another device available that uses the same general principal as the light source-photocell. This device measures the resistance change across a filament which is proportional to the light that is transmitted through the emission.

According to the manufacturer the main advantage of the bolometer over the light
source-photocell system is that the bolometer components do not age as rapidly. The device thus does not require as frequent recalibration.

Other systems are now available that include automatic recalibration features and sophisticated optical system for more accurate results.

**Starlight Scope**

One tool which the Air Resources Board staff has been using recently for opacity observation during hours of darkness is the "Starlight Scope".

This instrument was developed for military purposes and is now available commercially. Starlight Scopes are available for loan for law enforcement purposes. Districts wishing to borrow a Starlight Scope may contact the Compliance Division of the Air Resources Board. This Division will coordinate the arrangements for the loan. Air pollution control personnel wishing to use the Starlight Scope for visible emissions evaluations must, of course, become certified in its use.

The Starlight Scope combines the capability of a telescope to magnify an image with the electronic capability to amplify available light. Because of its weight, and to minimize vibration, the effects of which are magnified, it is recommended that the scope be mounted on a tripod. Adaptors are available which enables a videotape camera to be attached to the scope for a historical record of visible emissions.

Although the scope incorporates an automatic shutter closing mechanism designed to protect the viewer from eye damage, caution should still be exercised. The amplification of ambient or artificial light of even moderate brightness may be harmful to the eye of the observer.
CONSTRUCTION AND OPERATION 
OF 
SMOKE GENERATOR 

In order to train personnel to read smoke, it is necessary to have a unit which will produce both black and white smoke and an instrument to measure the transmission of light through this smoke (see attached Figures). For this purpose the smoke generator was developed. The smoke generator that the Air Resources Board is currently using is mounted on a trailer for portability. This unit includes the following systems:

**WHITE SMOKE SYSTEM**

White smoke is created by vaporizing fuel oil in the exhaust pipe of a small gasoline engine. Smoke density is varied by adjusting the feed rate of the fuel oil. This system is capable of producing equivalent opacities ranging from zero to one hundred percent.

![White Smoke Generating Equipment Diagram]
BLACK SMOKE SYSTEM

Black smoke is created by burning toluene in an insulated, twelve cubic foot stainless steel combustion chamber. Incomplete combustion is accomplished by not introducing sufficient excess air. Density of the smoke is varied by adjusting the toluene flow rate. A secondary chamber is provided for further gas cooling. An induced-draft fan provides adequate plume exit velocity. This system is capable of producing black smoke ranging from zero to Ringelmann number five rating.
The transmissometer consists of mainly a light source and photocell combination. The light source is aimed at the receiving photocell and through the smoke plume being produced. The percent opacity is indicated by both an opacity meter and display on a strip chart recorder which has been calibrated for values of zero to Ringelmann number five and equivalent opacity. The light to photocell path is approximately four feet in length, but only one foot (diameter of the smoke stack) is exposed to the smoke. The remaining three feet are continually flushed with ambient air to prevent smoke build-up. The apparatus is calibrated using neutral density filters.
Visible Emission Evaluation Training Form

A sample "Visible Emission Evaluation Training Form" is included. A similar form will be used to make 50 successive readings of smoke from the smoke generator. Half of the readings will be on black or gray smoke. The other half will be on white smoke. Black or gray smoke is to be recorded in Ringelmann numbers to the nearest one-quarter unit. White smoke is to be recorded in percent opacity to the nearest five percent.

The training form is filled out similar to the attached sample, with appropriate information included at the top. After each 25 readings have been made, the observer's readings are compared with readings from the transmissometer. To qualify as a visible emission evaluator, two conditions must be met. First, no single reading may deviate by an amount greater than 3/4 Ringelmann number of 15 percent opacity. Second, the average deviation must not exceed 7.5 percent for each set of 25 readings. Qualification is based on 50 consecutive readings: half of which are black or gray, and half of which are white.

When these requirements have been met the following entries should be made:

1. Sign the form
2. Wind and sky conditions
3. Box-in statistical conditions

Reading Techniques

1. Black smoke is read in densities and recorded in the appropriate Ringelmann numbers and fractions (one-quarter increments).

2. Other colored emission are read in opacities and recorded in percentages (five percent increments).

3. Opacities are related to corresponding densities on the Ringelmann Chart in the following manner.

4. The observer should be positioned at a distance sufficient to provide a clear view of the emissions, generally at least three stack heights but not more than one quarter mile distance.

5. The light source (sun) should be oriented within a 140 degree sector to the observer's back during daylight hours.
6. The light source may be behind the plume during hours of darkness (transmitted light).

7. Readings should be made approximately at right angles to wind direction.

8. Observations should be made at the point of greatest opacity in that portion of the plume where condensed water vapor is not present.

**Recording Techniques (field observations)**

1. All appropriate information should be recorded in the appropriate space on the reporting form (see attached Visible Emissions-Field Evaluation Form).

2. Observations times may be noted in terms of minutes and quarter minutes.

3. Record all emission during observation, showing reading and duration in consecutive order.

4. Total only that time exceeding the Ringelmann number or opacity specified in the standard.

5. Color of visible emissions should be recorded as seen and as it changes.

6. A Notice of Violation should not be issued unless the duration of smoke exceeding the standard was substantially greater than the duration specified in the standard. For example, if the duration in the standard is three minutes a violation should not be issued. A violation should only be issued if four or more minutes of violation has been reported.

7. Any hour means any consecutive 60 minute period.

8. Photographs should be taken before or after but not during observation.

9. The same general rules apply to reading emissions from moving sources.

**Reading Techniques Specifically Applicable to Abrasive Blasting**

On September 22, 1974, air pollution standards specifically applicable to abrasive blasting operations went into effect throughout California. The standards specify that applicable visible emission regulations for abrasive blasting must be evaluated in accordance
with the following evaluation techniques:

(a) Emission shall be read in opacities and recorded in percentages.

(b) The light source should be at the rear of observer during daylight hours.

(c) The light source should be behind the emission during hours of darkness.

(d) Observer position should be approximately right angles to wind direction, and at a distance no less than twice the height of the source but not more than one-quarter of a mile from the base of the source.

(e) Emissions from unconfined blasting shall be read at the densest point of the emission after a major portion of the spent abrasive has fallen out, at a point 25 feet from the source; provided, however, the emission may be read from a greater distance if the observer reasonably determines that the greater distance will not significantly affect the reading.

(f) Where the presence of uncombined water is the only reason for a failure to meet the limitations of the visible emissions standard that standard shall not apply. The burden of proof which establishes that the standard should not apply shall be upon the person seeking to some within its provision.

(g) Emissions from unconfined blasting employing multiple nozzles shall be judged as single source unless it can be demonstrated by the owner or operator that each nozzle evaluated separately, meets the emission and performance standards provided for in this subchapter.

(h) Emissions from confined blasting shall be read at the densest point after the air contaminant leaves the enclosure.
Ringelmann's Scale for Grading the Density of Smoke

Example
Visible Emission Evaluation
**VISIBLE EMISSION EVALUATION TRAINING FORM**

The sample of the "Visible Emission Evaluation Training Form" is included on the next page. A similar form will be used for making 50 successive readings of smoke from the smoke generator. Half of the readings will be on black or gray smoke. The other half will be on white smoke. Black or gray smoke is to be recorded in Ringelmann numbers to the nearest one-quarter unit. White smoke is to be recorded in percent opacity to the nearest five percent.

**USE OF THE TRAINING FORM**

Then use of a Visible Emission Evaluation (VEE) Training Form for VEE certification and recertification is to make certain that smoke readers certified by the California Air Resources Board (CARB) conform to the United States Environmental Agency's Method 9 Guidelines and the CARB rules. To use this form, make certain that all lines are completed. When taking opacity certification readings, circle the number that you determine the opacity to be, always making sure that you are on the correct line. If you would like to change your reading, draw a horizontal line across the circle, and then draw a circle around your new reading.

When correcting the certification sheet, as the correct opacity reading is announced, draw a diagonal line through the true reading. From the true reading, count the number of readings up to and including your circled reading, and write that number on the right hand side of the sheet. Remember that a number four is equivalent to twenty percent opacity, which is out if the certification limit.

If each number on the right hand side of the sheet is three or less, add all twenty five readings and write your total in the "Total" block. If any number is four or more, or if the total is thirty-eight or more, discard your sheet and start your readings on a new sheet. If the total is thirty-seven or less, multiply the total by decimal point two. This will give you your correct percentage of error. Then continue the above procedure for twenty-five consecutive readings. To certify as a smoke reader, both your black and white percentages of error are at or below seven point four percent, complete your form and turn it in to your instructor.
# STATE OF CALIFORNIA - AIR RESOURCES BOARD

## VISIBLE EMISSION EVALUATION TRAINING FORM

**NAME:** JoAnne Doe  
**DATE:** 1-5-95

**AFFILIATION:** Air Resources Board

**BUSINESS ADDRESS:** 2020 X Street, Sacramento, Ca

**CITY:** Sacramento  
**STATE:** CA  
**ZIP CODE:** 95612  
**TELEPHONE:** (916) 323-1168

### DISTANCE & DIRECTION TO STACK

- **Distance:** 75'  
- **Direction:** SE

### SKY CONDITIONS

<table>
<thead>
<tr>
<th>Wind Speed MPH</th>
<th>With Sunglasses</th>
</tr>
</thead>
<tbody>
<tr>
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<td>YES</td>
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I hereby acknowledge that the readings below are my own.

### RUN NO. 1W

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<tbody>
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<td>YES</td>
</tr>
</tbody>
</table>

## Sky Conditions

- Clear

## Distance & Direction to Stack

- 75' SE

## Signature

JoAnne Doe

## Business Address

2020 X Street, Sacramento, CA 95612

## Business Address Zip Code

95612

## Business Address Telephone

(916) 323-1168

## Distance & Direction to Stack

- 75' SE

## Signature

JoAnne Doe

## Wind Speed MPH

- 0-5

---

**BLACK TOTAL:** 0  
**WHITE TOTAL:** 17  
**TOTAL:** 17
VISIBLE EMISSION READING

TESTING INFORMATION

1. USE PEN ONLY (BLACK INK PREFERRED)

2. CIRCLE ONE ANSWER PER LINE TO INDICATE THE OPACITY OR RINGELMANN NUMBER THAT YOU HAVE CHOSEN.

   EXAMPLE:
   01 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100

3. IF THERE IS AN ERROR OR YOU NEED TO CHANGE YOUR ANSWER, DRAW A HORIZONTAL LINE (-) OVER THE WRONG ANSWER AND CIRCLE THE CORRECT ONE.

   EXAMPLE:
   01 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100

4. CALCULATE YOUR DEVIATION FOR EACH SET OF 25 READINGS (WHITE OR BLACK SMOKE).

   EXAMPLE:
   11 01 05 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100

   LEGEND: 0 = READER'S CIRCLED ANSWER
   / = CORRECT ANSWER AS ANNOUNCED BY GENERATOR OPERATOR

   BLACK TOTAL 1 white TOTAL 2

   * TOTAL # OF DEVIATIONS FOR THE SET OF 25 READINGS (WHITE OR BLACK)
   ** TOTAL AVG. DEVIATION FOR THE SET OF 25 READINGS (WHITE OR BLACK)

5. TOTAL AVERAGE DEVIATION CANNOT EXCEED 7.5 FOR A SET OF 25 READINGS (WHITE OR BLACK)

6. TOTAL DEVIATION CANNOT EXCEED 37 FOR A SET OF 25 READINGS (WHITE OR BLACK)

7. NO SINGLE READING IS ALLOWED A DEVIATION OF 20% OR MORE

8. DO NOT STARE AT THE PLUME
# VISIBLE EMISSION EVALUATION TRAINING FORM

**STATE OF CALIFORNIA - AIR RESOURCES BOARD**

**NAME:**

**DATE:**

**AFFILIATION:**

**BUSINESS ADDRESS:**

**CITY:**

**STATE:**

**ZIP CODE:**

**TELEPHONE:** ( )

**DISTANCE & DIRECTION TO STACK**

**WIND SPEED MPH**

**SKY CONDITIONS**

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Section 3.12
Method 9—Visible Determination of the Opacity of Emissions from Stationary Sources

Outline

Section | Documentation | Number of Pages
--- | --- | ---
Summary | 3.12.0 | 2
Method Highlights | 3.12.0 | 2
Method Description | 3.12.1 | 6
1. Certification and Training of Observers | 3.12.2 | 2
2. Procurement of Apparatus and Supplies | 3.12.3 | 2
3. Preobservation Operations | 3.12.4 | 18
4. On-Site Field Observations | 3.12.5 | 2
5. Postobservation Operations | 3.12.6 | 7
6. Calculations | 3.12.7 | 2
7. Auditing Procedures | 3.12.8 | 5
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Summary

Many stationary sources discharge plume-shaped visible emissions into the atmosphere. Method 9 (EPA Reference Method) is used to determine the opacity of this plume by qualified observers. The method includes procedures for the training and certification of observers and procedures to be used by these observers in the field to determine plume opacity. This section of the Quality Assurance (QA) Handbook primarily concerns procedures used by the observers. Only Section 3.12.1 reviews the training and certification procedures, which are described in Reference 1.

The appearance of a plume as viewed by an observer depends upon a number of variables, some of which may be controllable and some of which may not be controllable in the field. Variables which can be controlled to an extent to which they no longer exert a significant influence upon plume appearance include: angle of the observer with respect to the plume; angle of the observer with respect to the sun; point of observation of attached and detached steam plumes; and angle of the observer with respect to a plume emitted from a rectangular stack with a large length to width ratio. The
method includes specific criteria applicable to these variables. Other variables which may not be controllable in the field are luminescence and color contrast between the plume and the background against which the plume is viewed. These variables exert an influence upon the appearance of a plume as viewed by an observer, and can affect the ability of the observer to accurately assign opacity values to the observed plume. Research studies of plume opacity have demonstrated that a plume is most visible and presents the greatest apparent opacity when viewed against a contrasting background. It follows from this, and is confirmed by field trials, that the opacity of a plume, viewed under conditions where a contrasting background is present can be assigned with the greatest degree of accuracy. However, the potential for a positive error is also the greatest when a plume is viewed under such contrasting conditions. Under conditions presenting a less contrasting background, the apparent opacity of a plume is less and approaches zero as the color and luminescence contrast decrease toward zero. As a result, significant negative bias and negative errors can be made when a plume is viewed under less contrasting conditions. A negative bias decreases rather than increases the possibility that a plant operator will be cited for a violation of opacity standards due to observer error.

Method 9 is applicable for the determination of the opacity of emissions from stationary sources pursuant to 60.11(b). Studies have been undertaken to determine the magnitude of positive errors that qualified observers can make while reading plumes under contrasting conditions and using the procedures specified in Method 9. The results of these studies, which involve a total of 769 sets of 25 readings each, are as follows:

1. In the case of black plumes, 100 percent of the sets were read with positive error of less than 7.5 percent opacity; 99 percent were read with a positive error of less than 5 percent opacity.
2. In the case of white plumes, 99 percent of the sets were read with a positive error (higher values) of less than 7.5 percent opacity; 95 percent were read with a positive error of less than 5 percent opacity.

The positive observational error associated with an average of twenty-five readings is therefore established. The accuracy of the method must be taken into account when determining possible violations of applicable opacity standards. 

**Note:** Proper application of Method 9 by control agency personnel in determining the compliance status of sources subject to opacity standards often involves a number of administrative and technical procedural steps not specifically addressed in the Federal Register method. Experience has shown these steps are necessary to lay a proper foundation for any subsequent enforcement action. To clearly delineate items that are EPA procedural policy and requirements of the Method 9 from additional quality assurance procedures, a wording scheme was developed. All of Sections 3.12.1, 3.12.2, 3.12.3, 3.12.6, and 3.12.7 are suggested quality assurance procedures except where noted as EPA policy or Federal Register citings. Section 3.12.4 notes EPA requirements with directive statements using words such as shall, should, and must OAP procedures are noted either with suggestive statements using words such as recommended, suggested, and beneficial or by stating that the entire subsection is recommended. The use of these OAP procedures should provide a more consistent program, improved observer effectiveness and efficiency, and improved data documentation.

**Method Highlights**

Section 3.12.1 briefly reviews the quality assurance procedures to be used in the observer training and certification procedures described in detail in Reference 1. The remaining sections describe the field procedures. Section 3.12.10 provides blank data forms recommended for use by the observer and other personnel, as required. Partially completed forms are included in Sections 3.12.1 through 3.12.7 of the Method Description. Each form in Section 3.12.10 has a subtitle (e.g., Method 9: Figure 2.1) to allow easy reference to the corresponding completed form.

The following paragraphs present a brief discussion of the contents of this section of the OA Handbook:

1. **Certification and Training of Observers** The primary purpose of this section is to provide a brief summary of the certification and training procedures described in Reference 1. It includes a definition and a brief history of opacity, and it discusses observer training procedures and certification and recertification of observers.

2. **Procurement of Apparatus and Supplies** Section 3.12.2 presents specifications criteria and design features to the procurement of useful equipment that would provide good quality visible emissions data. The following are some recommended equipment items that not specifically required by Method 9: watch, compass, range finder, Abney level or clinometer, sling psychrometer, binoculars, camera, safety equipment, clipboard, and accessories. Table 2.1 summarizes the quality assurance aspects of equipment procurement.

3. **Preobservation Operations** Section 3.12.3 summarizes the preobservation activities: gathering facility information, providing prior notification, establishing protocol, and performing equipment checks. Table 3.1 summarizes these procedures.

4. **On-Site Field Observations** Section 3.12.4 contains detailed procedures for determining the visible emissions (VE). This section not only includes the recommended procedures for performing the perimeter survey, plant entry, and VE determination; it also contains a subsection on special observation problems. This subsection explains how to take VE readings under less than ideal conditions (e.g., when the observer position is restricted). The main feature of this section is the presentation of detailed instructions on how to complete the recommended VE data form, and examples of completed forms.

5. **Postobservation Operations** Section 3.12.5 presents a brief discussion concerning the data reporting procedures, data summary, data validation, and equipment check. Section 3.12.6 contains a discussion of the calculations required for completing the data forms and reports. It also includes procedures for calculating the path length through the plume and for predicting steam plume formation by use of a psychrometric chart and pertinent measurements.

6. **Auditing Procedures** Section 3.12.7 recommends performance and system audits for use with field VE determinations. The two performance
audits are an audit by senior observer/supervisor and a data calculation audit. A system audit is suggested, along with a Method 9 checklist, as shown in Figure 7.1. Table 7.1 summarizes the quality assurance activities for audits.

7. References and Bibliography
Sections 3.12.8 and 3.12.9 contain the Method 9 and suggested references and bibliography.

8. Data Forms Section 3.12.10 provides blank data forms which can be taken from the QA Handbook for field use or serve as the basis of a revised form to be used by the Agency. Partially completed forms are included in the corresponding section of the QA Handbook.
1.0 Certification and Training of Observers

The purpose of this section is to summarize the content of the OA manual for VE training programs. Since the observer must be properly certified or a qualified VE reader in order to have his/her opacity reading accepted, it is important that he/she fully understand this phase of his/her training.

1.1 Definition and Brief History of Opacity

The VE evaluation system evolved from the concept developed by Maximilian Ringelmann in the late 1800's, in which a chart with calibrated black grids on a white background was used to measure black smoke emissions from coal-fired boilers. The Ringelmann Chart was adopted by the U.S. Bureau of Mines in the early 1900's and was used extensively in efforts to assess and control emissions. In the early 1950's, the Ringelmann concept was expanded to other colors of smoke by the introduction of the concept of "equivalent opacity."

The Federal government has discontinued the use of Ringelmann numbers in EPA Method 9 procedures for New Source Performance Standards (NSPS). Current procedures are based solely on opacity. Although some State regulations still specify the use of the Ringelmann Chart to evaluate black and gray plumes, the general trend is toward reading all emissions in percent opacity.

In practice, the evaluation of opacity by the human eye is a complex phenomenon and is not completely understood. However, it is well documented that visible emissions can be assessed accurately and with good reproducibility by properly trained/certified observers. The relationships between light transmittance, plume opacity, Ringelmann number, and optical density are presented in Table 1.1. A literal definition of plume opacity is the degree to which the transmission of light is reduced or the degree to which visibility of a background as viewed through the diameter of a plume is reduced. In terms of physical optics, opacity is dependent upon transmittance (I/Io) through the plume, where Io is the incident light flux and I is the light flux leaving the plume along the same light path. Percent opacity is defined as follows:

Percent opacity = (1 - I/Io) x 100.

Many factors influence plume opacity readings: particle density, particle refractive index, particle size distribution, particle color, plume background, path length, distance and relative elevation to stack exit, sun angle, and lighting conditions. Particle size is particularly significant; particles decrease light transmission by both scattering and direct absorption. Thus, particles with diameters approximately equal to the wavelength of visible light (0.4 to 0.7 µm) have the greatest scattering effect and cause the highest opacity.

1.2 Training of Observer

Field inspectors and observers are required to maintain their opacity evaluation skills by periodically participating in a rigorous VE certification program. Accordingly, EPA's Stationary Source Compliance Division (SSCD) and Environmental Monitoring Systems Laboratory (EMSL) have provided the OA training document to individuals who conduct VE training and certification programs. This section summarizes the training program.

1.2.1 Frequency of Training Sessions

Certification schools should be scheduled at least twice per year since Method 9 requires a semiannual recertification. It is highly recommended that training be an integral part of the certification program. A spring/fall schedule is preferable because of weather considerations. Certifying previous graduates while the smoke school is in session is more efficient and less costly than scheduling a separate session.

1.2.2 Classroom Training

The training is accomplished most effectively by holding an intensive 1- or 2-day classroom lecture/discussion session. Although this training is not required, it is highly recommended for the following reasons:

1. Increases the VE observer's knowledge and confidence for the day-to-day field practice and application.
2. Reduces training time required to achieve certification.
3. Trains the smoke reader in the proper recording and presentation of data that will withstand the rigors of litigation and strengthens an agency's compliance and enforcement program.
4. Provides a forum for the periodic exchange of technical ideas and information.

Some states require classroom training for initial certification only. It is recommended, however, that observers attend the classroom training at 3-year intervals to review proper field observation techniques and method changes and to participate in the exchange of ideas and new information.

1.2.3 Lecture Material

Example lecture material for a thorough training program is presented in Section 3.1 and Appendix A of Reference 1. A typical six-lecture classroom training program consists of the following:

Lecture 1—Background, principles, and theory of opacity.
Lecture 2—Sources of VE's, presented by someone thoroughly familiar with source conditions, related particle characteristics, and opacity reading procedures and problems.
Lecture 3—Proper procedures for conducting field observations under a variety of conditions.

Table 1.1. Comparison of Light Extinction Terms

<table>
<thead>
<tr>
<th>Light transmission, %</th>
<th>Optical density units</th>
<th>Plume opacity, %</th>
<th>Ringelmann number</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>N/A*</td>
<td>100</td>
<td>5</td>
</tr>
<tr>
<td>20</td>
<td>0.70</td>
<td>80</td>
<td>4</td>
</tr>
<tr>
<td>40</td>
<td>0.40</td>
<td>60</td>
<td>3</td>
</tr>
<tr>
<td>60</td>
<td>0.22</td>
<td>40</td>
<td>2</td>
</tr>
<tr>
<td>80</td>
<td>0.10</td>
<td>20</td>
<td>1</td>
</tr>
<tr>
<td>100</td>
<td>0.00</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

*N/A = not applicable.
Lecture 4—Influence and impact of meteorology on plume behavior.
Lecture 5—Legal aspects of VE and opacity measurements.
Lecture 6—Actual observation/testing procedures.

1.2.4 Training Equipment — An integral part of the training program is the design and operation of the smoke generator and its associated transmissometer, as specified in Method 9 (reproduced in Section 3.12.1). Such a program is essential because proper observer certification cannot take place without the proper equipment. Section 4 of Reference 1 presents performance specifications and operating procedures for smoke generators which, if followed under a good QA program, will ensure nationwide uniformity and consistency with Method 9 criteria.

The design and operation of the smoke generator has evolved significantly since the mid-1960’s. The basic components of the smoke generator now include:

1. Black and white smoke generating units,
2. Fan and stack,
3. Transmissometer system, and
4. Control panel and strip chart recorder.

Table 1.2 lists the design and performance specifications for the smoke generator. It must generate smoke with an opacity range of 0 to 100 percent and be sufficiently accurate to allow the operator to control and stabilize the opacity of the smoke. It is recommended that the generator also achieve and hold opacities in 5 percent increments at ±2 percent for a minimum of 5 s.

White smoke is produced by dispensing, at regulated rates, No. 2 fuel oil into the propane-heated vaporization chamber. The opacity varies in proportion to the volume of fuel oil vaporized and is regulated by adjusting the flow of fuel oil. Black smoke is produced by the incomplete combustion of toluene in the double-wall combustion chamber. The toluene flowrate is also controlled by valves and flowmeters.

1.2.5 Equipment Calibration Procedures — Detailed calibration procedures are included in a QA procedures manual for VE training programs.1 The generator transmissometers must be calibrated every six months or after each repair. The National Bureau of Standards (NBS) traceable standards (optical filters) for linearity response are available from Quality Assurance Division, Environmental Monitoring Systems Laboratory, U.S. EPA, Research Triangle Park, North Carolina 27711. It is strongly recommended that the calibration be performed before and after each certification course to ascertain whether any significant drift or deviation has occurred during the training period. The “zero and span” check must be repeated before and after each test run. If the drift exceeds 1 percent opacity after a typical 30-min test run, the instrument must be corrected to 0 and 100 percent of scale before resuming the testing.

All of the smoke generator performance verification procedures (e.g., repair and maintenance work, spectral response checks, calibration check, and response time checks) should be documented in writing and dated; a bound logbook is highly recommended. These records become part of the permanent files on the VE training program.

1.2.6 Setup, Operating, and Shutdown Procedures — Detailed procedures and a parts list are given in Section 4.4 of Reference 1.

1.2.7 Storage and Maintenance of the Smoke Generator — Proper storage and maintenance procedures are essential for smoke generators to increase their useful operating life and to provide reliability.

1.2.8 Common Problems, Hazards, and Corrective Actions — The generator has hot surfaces that can cause serious burns. It is recommended that attendees be advised to stay away from the generator during training and test runs. It is also recommended that gas and fuel lines be correctly checked for leaks prior to each use of the generator to prevent fire and explosive hazards to the operator and nearby attendees.

Occasional breakdowns or malfunctions of the generator usually occur at the most inopportune times. The problem must be diagnosed and repaired expeditiously to provide the proper training and maintain the interest of the course attendees. Some common malfunctions are listed in Section 4 of the QA training manual.1

1.3 Certification of Observer

This section summarizes the certification part of the training program. The first part of the certification program is to acclimate the trainees to the smoke generator. The following procedure is recommended. Both black and white plumes are produced at certain levels, and during this production, the opacity values are announced. After some standards exposure, four plumes are presented to the trainee for evaluation. The correct values of the four plumes are announced to provide the trainee with immediate feedback. The majority of the trainees should be ready to take the test after a few sets. Certification runs are made in blocks of 50 readings (25 black smoke and 25 white smoke). The trainees who successfully meet the criteria receive a letter of certification and a copy of their qualification form. The school retains the original of the qualification form for a minimum of three years, to be available for any legal proceedings that might occur. According to Method 9, certification is valid for a period of only six months. Neither certification or recertification procedures require the observer to attend the lecture program; however, it is recommended that the observer attend the series during initial certification and thereafter every three years. It is also recommended that all persons unable to pass after 10 qualification runs be provided additional training before allowing qualification runs to be made.

Test forms vary greatly because of the specific needs and experiences of each agency. Figure 1.1 illustrates one suggested form. The form should be printed on two-copy paper, the original for the official file and the carbon copy for the trainee to grade after each certification run. The test
<table>
<thead>
<tr>
<th>Reading number</th>
<th>Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>4</td>
<td>15</td>
</tr>
<tr>
<td>5</td>
<td>20</td>
</tr>
<tr>
<td>6</td>
<td>25</td>
</tr>
<tr>
<td>7</td>
<td>30</td>
</tr>
<tr>
<td>8</td>
<td>35</td>
</tr>
<tr>
<td>9</td>
<td>40</td>
</tr>
<tr>
<td>10</td>
<td>45</td>
</tr>
<tr>
<td>11</td>
<td>50</td>
</tr>
<tr>
<td>12</td>
<td>55</td>
</tr>
<tr>
<td>13</td>
<td>60</td>
</tr>
<tr>
<td>14</td>
<td>65</td>
</tr>
<tr>
<td>15</td>
<td>70</td>
</tr>
<tr>
<td>16</td>
<td>75</td>
</tr>
<tr>
<td>17</td>
<td>80</td>
</tr>
<tr>
<td>18</td>
<td>85</td>
</tr>
<tr>
<td>19</td>
<td>90</td>
</tr>
<tr>
<td>20</td>
<td>95</td>
</tr>
<tr>
<td>21</td>
<td>100</td>
</tr>
</tbody>
</table>

Figure 1.1. Sample certification test form
form must be filled in completely. Certification requires that both of the following criteria be satisfied:

1. No reading may be in error by more than 15 percent opacity.
2. The average (absolute) error must not exceed 7.5 percent for either set of 25 white or 25 black smoke readings. The certification runs may be repeated as often as necessary. However, it is recommended that all persons who have not passed after ten certification runs be given additional training prior to conducting additional certification runs.

The detailed testing and grading procedures required to ensure a valid test are outlined in Section 5 of the QA training manual.1 The Agency should maintain a bound logbook, arranged by training session, for at least three years, as evidence that the observer has been certified as a qualified VE evaluator by a recognized smoke training and certification group. Each trainee who successfully meets the Method 9 criteria receives a letter of certification and a copy of his/her qualification form. This letter includes the date of expiration.

1.4 Recertification

Method 9 requires an individual to be recertified every six months.

1.5 In-the-Field Training

After the observer's initial certification, it is recommended that a senior observer accompany the new observer on a field observation trip and that both individuals simultaneously record (using the same time piece) their opacity readings as a QA check (see Section 3.12.7). A comparison of these readings will indicate any problems the new observer might have in conducting observations under field conditions. A significant discrepancy between the readings of the two observers, in individual or average values, indicates the need for further in-field training and continuance of the senior observer (not necessarily the same one) QA check. After satisfactory checks have been made on two consecutive field observations, the new observer can confidently conduct inspections without a senior observer. The suggested standard for a satisfactory check for 6-min (minimum) of consecutive readings is:

1. No difference in individual readings should exceed 20 percent.
2. The difference of the average value between observers should not exceed 10 percent.

1.6 Smoke School Certification Quality Assurance Program

It is recommended that any government agency planning to develop a smoke school certification program obtain a copy of the "Recommended Quality Assurance Techniques and Procedures for Visible Emission Training Programs." Table 1.3 contains an activity matrix for certification and training of observers.
### Table 3. Activity Matrix for Certification and Training of Observers

<table>
<thead>
<tr>
<th>Activity</th>
<th>Acceptance limits</th>
<th>Frequency and method of measurement</th>
<th>Action if requirements are not met</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classroom training of observer</td>
<td>Classroom training per Ref. 1</td>
<td>Initially and every 3 years</td>
<td>Review training procedures per Ref. 1</td>
</tr>
<tr>
<td>Smoke generator</td>
<td>Should be able to generate smoke with an opacity range of 0 to 100%; hold opacities ±2% for at least 5 s</td>
<td>Before each certification test run; use method in Ref. 1</td>
<td>Adjust and make repeat check of operation</td>
</tr>
<tr>
<td>Setup, operating, and shutdown procedures</td>
<td>Adherence to procedures in Ref. 1</td>
<td>Each test run</td>
<td>Review procedures</td>
</tr>
<tr>
<td>Storage and maintenance Transmissometer</td>
<td>As above</td>
<td>As above</td>
<td>As above</td>
</tr>
<tr>
<td>Design and performance specifications</td>
<td>Specifications in Table 1.2</td>
<td>Upon receipt, repair, and at 6-mo intervals use method in Ref. 1</td>
<td>Adjust and repeat specifications until acceptance limits are met</td>
</tr>
<tr>
<td>Calibration</td>
<td>±3% opacity maximum</td>
<td>Every 6 mo or after repair, before and after each certification course is recommended; use method in Ref. 1</td>
<td>Adjust and recalibrate until acceptance limits are met</td>
</tr>
<tr>
<td>Zero and span</td>
<td>Opacity drift &lt;1% after a typical 30-min test run</td>
<td>As above</td>
<td>Instruments must be corrected to 0 and 100% before testing is resumed</td>
</tr>
<tr>
<td>Certification of observer</td>
<td>No reading must be in error by more than 15% and average absolute error must not exceed 7.5% for either white or black smoke readings</td>
<td>Take smoke reading test until a successful test has been completed</td>
<td>Retake test until successful completion</td>
</tr>
<tr>
<td>Recertification</td>
<td>As above</td>
<td>Every 6 mo take a smoke reading test until a successful test has been completed</td>
<td>As above</td>
</tr>
<tr>
<td>In-the-field training</td>
<td>No reading in error by more than 20% difference and average absolute error should not exceed 10% difference during the field observation</td>
<td>Checks are made on the first two field observations subsequent to the initial certification; comparison is made between new certified observer and an experienced observer</td>
<td>Continue comparisons until acceptance limits are met during two field observations</td>
</tr>
</tbody>
</table>
2.0 Procurement of Apparatus and Supplies

Method 9 does not specifically require any equipment or supplies. Therefore, this entire section includes quality assurance procedures that are recommended to assist the observer in documenting data. Nevertheless, this section provides specifications criteria or design features, as applicable, to aid in the selection of equipment that may be useful in collecting VE data. Procedures and limits for acceptance checks are also provided. During the procurement of equipment and supplies, it is suggested that a procurement log (Figure 2.1) be used to record the descriptive title of the equipment, the identification number (if applicable), and results of any acceptance checks.

Table 2.1 at the end of this section contains a summary of the quality assurance activities for procurement and acceptance of apparatus and supplies.

2.1 Stopwatch
A watch is used to time the 15-second intervals between opacity readings. The watch should provide a continuous display of time to the nearest second.

2.2 Compass
A compass is useful for determining the direction of the emission point from the spot where the VE observer stands and for determining the wind direction at the source. For accurate magnetic readings, the compass should be jewel-mounted and liquid-filled to dampen the needle swing; map reading compasses are excellent for this purpose.

2.3 Range Finder
A range finder is used to measure the observer's distance from the emission point and should be capable of determining distances to 1000 meters with an accuracy of ±10 percent. The accuracy of the range finder should be checked upon receipt and periodically thereafter with targets at known distances of approximately 500 meters and 1000 meters.

<table>
<thead>
<tr>
<th>Item description</th>
<th>Quantity</th>
<th>Purchase order number</th>
<th>Vendor</th>
<th>DateOrdered</th>
<th>Received</th>
<th>Cost</th>
<th>Disposition</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stopwatch</td>
<td>2</td>
<td>75096</td>
<td>Fisher Scientific</td>
<td>5/1/83</td>
<td>5/14/83</td>
<td>$52.94</td>
<td>checked-ready</td>
<td>to use.</td>
</tr>
</tbody>
</table>

Figure 2.1. Example of a procurement log.
2.4 Abney Level or Clineometer

An Abney level is a device for determining the vertical viewing angle. For visible emission observation purposes, it should measure within 5 degrees. The accuracy should be tested by placing the level flat on a table that has been previously leveled with a referring level and checking it at a 45° angle by placing it on a 45° inclined plane constructed on the plane as the hypotenuse of a right triangle with equal base and height.

2.5 Sling Psychrometer

The sling psychrometer is used in cases where it is suspected that the atmospheric conditions will promote the formation of a steam plume (see Subsection 6.3). The psychrometer should consist of two thermometers, accurate to 1/2°C, mounted on a sturdy assembly whereby the thermometers may be swung rapidly in the air. One thermometer should be fitted with a wettable cotton wick tube on the bulb. Thermometer accuracy at atmospheric conditions will promote cases where it is suspected that the thermometers may be swung rapidly.

2.6 Binoculars

It is recommended that the observer obtain binoculars preferably with a magnification of at least 8 x 50 or 10 x 50. The binoculars should have color-corrected coated lenses and a rectilinear field of view. Color correction can be checked by viewing a black and white pattern such as a Ringelmann card at a distance greater than 50 ft; no color rings or bands should be evident, only black and white. The rectilinear field of view can be tested by viewing a brick wall at a distance greater than 50 ft. There should be no distortion of the brick pattern as the field of view is changed. The binoculars are helpful for identifying stacks, searching the area for emissions and aid in characterizing behavior and composition of plume.

2.7 Camera and Accessories

A camera is often used in VE observations to document the emissions before and after the actual opacity determination. A 35-mm camera with through-the-lens light metering is recommended for this purpose. Useful accessories include a "macro" lens or a 250-mm to 350-mm telephoto lens, and a 6-dioptr closeup lens (for photographing logbook and evidence of particulate deposition). A photo logbook is necessary for proper documentation, and the observer should always be sure to purchase enough fresh color negative film (ASA 100 recommended) for his/her purposes.

2.8 Clipboard and Accessories

For documenting the visible emission observation, the observer should have a 10 in. x 12 in. masonite or metal clipboard, several black ball-point pens (medium point), a large rubber band, and a sufficient number of visible emission observation forms.

2.9 Safety Equipment

The following safety equipment, which should be approved by the Occupational Safety and Health Association (OSHA), is recommended for the VE observer:

- Hard hat in high-visibility yellow or orange
- Safety glasses, goggles, or eye shields
- Ear protectors
- Safety shoes (steel-toed for general industrial use)

Specially insulated safety shoes are necessary in certain areas, such as the top of coke ovens.

| Table 2.1. Activity Matrix for Procurement of Recommended Equipment and Supplies |
|---------------------------------------------|-------------|------------------|---------------------|
| Equipment                  | Acceptance limits | Frequency and method of measurement | Action if requirements are not met |
| Watch                      | Continuous display | Check upon receipt | Return to supplier |
| Compass 10° resolution     | Magnetic with 45° | Check upon receipt | Return to supplier |
| Range finder 10° resolution| Accuracy of 1/2° over distances to 1000 m | Check upon receipt and quarterly with targets at known distances of about 500 m and 1000 m | Adjust or return to supplier |
| Sling psychrometer 1/2° resolution | Accuracy of 1/2° over distances to 1000 m | Check at O°C and 45° | Same as above |
| Binoculars 8 x 50 or 10 x 50 | Magnification of 8 x 50 or 10 x 50 | Check upon receipt by viewing selected objects | Return to supplier |
| Camera 35-mm camera        | 35-mm camera with through-the-lens light metering | Check quality of photos on receipt and after processing film | Return to supplier for repair |
| Clipboard/accessories/forms| 10 in. by 12 in. clip board: black ball-point pens; VE observation forms | Check supplies periodically | Replenish supplies |
| Safety equipment           | Hardhat—yellow or orange, safety glasses and shoes, ear protectors | Check supply of safety equipment periodically | Maintain equipment availability |
3.0 Preobservation Operations

The following procedures are not required by Method 9 but are recommended in order to provide more consistent data collection and better data documentation and verification of representative plume viewing conditions. Not all procedures are needed for every observation.

Before making on-site VE determinations, the observer should gather the necessary facility data, provide prior notifications when applicable, establish an observation protocol, and check for availability of supplies and properly maintained equipment. Table 3.1 at the end of this section summarizes the quality assurance activities for preobservation operations.

3.1 Gather Facility Information

The observer should be thoroughly familiar with the source facility, operation, emissions, and applicable regulations. In preparation for the on-site visit, the observer should review the Agency's information (in the official source file) on the source in question.

The observer should:

1. Determine the pertinent people to be contacted.
2. Become familiar with the processes and operations at the facility and identify those facilities to be observed.
3. Review the permit conditions, requirements, and recent applications.
4. Determine applicable emission regulations.
5. Identify all operating air pollution control equipment, emission points, and types and quantities of emissions.
6. Review history of previous inspections, source test results, and complaints.
7. Check the file to become familiar with (or review) plant layout and possible observation sites.
8. Determine normal production and operation rates.
9. Identify unique problems and conditions that may be encountered (e.g., steam plume).
10. Discuss with attorney if case development is expected.
11. Obtain a copy of the facility map with labeled emission points, profile drawings, and photographs, if available. A facility map is very helpful during inspection and should be a required item for every Agency source file. The map makes it easier for the observer to identify point sources and activities, and it may be used to mark any emission points that have been added or modified.
12. If an operating permit exists, obtain a copy because it may contain the VE limits for each point source and any special operating requirements.
13. Determine the status of the source with respect to any variance or exemption from the Agency's rules and regulations. Observation may not be required if the source has a variance or is exempt from the regulations.
15. Use references such as facility maps and previous inspection reports to determine if the viewing position is restricted because of buildings or natural barriers. If the viewing position requires observations to be taken at a particular time of day (morning or evening) because of sun angle, consider this when planning the inspection.
16. Determine the possibility of water vapor in the plume condensing (see Section 3.12.6). This determination may prevent a wasted trip to the facility on days when a persistent water droplet plume is anticipated because of adverse ambient conditions.

Note: If the observer is not familiar with the type of facility or operation, he/she should consult available reference material and inspection manuals on the source category.

3.2 Prior Notification

The usual procedure is to make the VE determination without prior notification unless the plant must be entered first to obtain a good view of the emission point of interest. However, this procedure is not always possible, especially in remote locations, when operations are intermittent, or when specific personnel must be present or contacted. Determining VE for compliance with State Implementation Plan (SIP) or NSPS opacity regulations requires on-site observations during conditions of typical or normal maximum operations. If the facility is notified of the time of this evaluation, some operating conditions may be altered. If this situation appears likely, it is EPA's policy not to give prior notification. EPA is obligated to notify State/local agencies of inspections and generally prefers to invite the applicable agency to participate. The observer should notify the affected facility and control agencies as soon as practical following any official opacity readings.

3.3 Establish Observation Protocol

Based on information collected under Section 3.1 and any prior experience with the source, an observation protocol should be established. First, the observer should determine whether one, two, or more observers will be required. For example, two observers may be required to simultaneously make the VE determination and gather other on-site data (e.g., take photographs, draw a new modified facility map if one is not available from the plant or gather other needed plant information). In certain situations where the VE observations must be correlated to process operation, the second person will closely monitor the process activity and record the exact time of the operating modes of interest. Only one observer will make the VE determination unless an observer audit is being conducted. In this case, the designated observer is the one being audited.

The applicability of Method 9 (and hence the method of observation) should be determined. If Method 9 is not applicable, see Section 3.12.4, Special Problems.

A written checklist regarding an expected walk-through of the plant including questions to ask plant officials may be helpful.

3.4 Perform Equipment Checks for On-Site Use

Be sure that the necessary equipment and supplies are available for making the VE determination and documenting the results. All equipment should be visually checked for damage and satisfactory operation before each VE determination field trip.
<table>
<thead>
<tr>
<th>Activity</th>
<th>Acceptance limits</th>
<th>Frequency and method of measurement</th>
<th>Action if requirements are not met</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gather facility information</td>
<td>Obtain necessary facility data, Subsec 3.1</td>
<td>Check for completeness of data</td>
<td>Obtain missing data before on-site visit, if possible</td>
</tr>
<tr>
<td>Make prior notification</td>
<td>Make VE determination without prior notification except as stated in Subsec 3.2: EPA should notify State/local agencies and invite participation</td>
<td>Check the protocol for notification before each on-site visit and revise the protocol as necessary</td>
<td>Make required notifications</td>
</tr>
<tr>
<td>Establish protocol</td>
<td>Prepare observation protocol, Subsec 3.3</td>
<td>Check before on-site visit</td>
<td>Complete or prepare protocol as required</td>
</tr>
<tr>
<td>Perform equipment check</td>
<td>All equipment/supplies available and in satisfactory working order</td>
<td>Same as above</td>
<td>Replace or adjust equipment</td>
</tr>
</tbody>
</table>
4.0 On-Site Field Observations

This section describes field observation procedures, including perimeter survey, plant entry, VE determination, and special observation problems. The latter subsection supplements the subsection on VE determination by providing some information on how to take VE readings when unfavorable field conditions prevent the use of the procedure described in Subsection 4.3 (e.g., when the emissions are intermittent or the observer position is restricted). The QA activities are summarized in Table 4.2 at the end of this section.

4.1 Perimeter Survey

Before and after the VE determination, it is strongly recommended that the observer make a perimeter survey of the area surrounding (1) the point of observation and (2) the emission point on which the determination is being made. Such a survey also may be made during the VE determination, if warranted.

A perimeter survey can be useful in determining the presence of other factors that could affect the opacity readings. For example, the representativeness of the VE readings for a given emission point could be questioned unless data is available to show that the observer excluded emissions related to material stockpiling, open burning, and ambient condensed water vapor in adjoining areas of the plant. It is vital that the observer be aware as much as possible of extenuating conditions. The perimeter survey is made to document these conditions. Common sense should be used in determining the need and extent of the survey; in some cases (e.g., a single 350-foot stack) a perimeter survey is not vital.

Perimeter surveys can be made from either outside or inside the plant property, or both. This decision would depend on whether the VE observations are made from inside or outside of the plant, whether the observer actually gains entry to the plant premises, and whether the plant is sufficiently visible from outside the premises to make a reasonable survey. It is suggested that during the survey the observer should note such factors as:

1. Other stacks and emission points whose visible emissions might interfere with opacity readings.
2. Fugitive emissions that result from product or waste storage piles and material handling and may interfere with observations.
3. Fugitive emissions that result from unpaved road travel and may interfere with observations.
4. Water vapor emissions from sludge or cooling ponds.
5. Open burning.
6. Any unusual activities on or around plant premises that could result in nonrepresentative emissions or interfere with opacity readings.

If deemed useful by the observer, photographs may be taken to document extenuating conditions (see discussion of confidentiality and the use of cameras in Subsection 4.2.7).

4.2 Plant Entry

The following discussion presents the recommended plant entry procedures. The VE readings themselves should not be affected by a change in these procedures. However, the usefulness of the readings in showing a possible violation of the applicable standards may be compromised by not following agency procedures for entering plants. Depending on the location of emission points at the plant and the availability of observation points in the area surrounding a facility, the VE observer may not have to gain entry to the plant premises prior to making VE observations. It may be preferable to gain access after taking readings to check on plant process control equipment operating conditions or to complete a perimeter survey. Figure 4.1 is an example entry checklist that can be used to assist the observer in organizing the information that could be used at the time of plant entry.

To maintain a good working relationship with plant officials and, most importantly, to comply with the Clean Air Act and avoid any legal conflict with trespass laws or the company’s right to privacy and due process of law under the U.S. Constitution, the observer must follow certain procedures in gaining entry to the plant’s private premises. In most cases, consent to enter (or the absence of express denial to enter) is granted by the owner or company official. Figure 4.1 lists the pertinent section of the Clean Air Act on facility entry as well as information on confidentiality of process information. It is recommended that the inspector have a copy of this information available in case questions are raised by source representatives.

4.2.1 Entry Point — It is recommended that the plant premises be entered through the main gate or through the entrance designated by the company officials in response to prior notification. The observer’s arrival will usually occur during normal working hours unless conditions contributing to excess opacity levels are noted at certain times other than normal working hours. If only a guard is present at the entrance, it is desirable for the observer to present the appropriate credentials and to suggest that the guard’s supervisor be contacted for the name of a responsible company official. The observer would then ask to speak with the official, who may be the owner, operator, or agent in charge (including the environmental engineer).

4.2.2 Credentials — After courteously introducing himself/herself to the company official, the observer should briefly describe the purpose of the visit and present the appropriate credentials confirming that he/she is a lawful representative of the agency. Such credentials will naturally differ depending upon the agency represented, but it is recommended that they include at least the observer’s photograph, signature, physical description (age, height, weight, color of hair and eyes), and the authority for plant entry. Agencies issue credentials in several forms, including letters, badges, ID cards, or folding wallets.

4.2.3 Purpose of Visit — When first meeting with a company official, the observer needs to be prepared to state succinctly the purpose of the visit, including the reason for the VE determination. Space is provided in the recommended form (Figure 4.1) to specify the exact purpose of the visit, and the observer can refer to this when talking with the company official.
Source name and address
DRI - HARD PORTLAND CEMENT
2 MILES E. OF RT. 1 ON
STATE RD. 1836
ROCKY HILLS, NJ 08916

Observer  JUDY A. SMITH
Agency  U.S. EPA
Region II
Date of VE observation  5/5/82

Previous company contact (if applicable)  GEORGE C. MEARS

Title  OWNER

Purpose of visit  EPA AUDIT INSPECTION AND VE OBSERVATION; REGIONAL OFFICE INSPECTS 10% OF MAJOR SOURCES IN NJ EVERY YEAR

Emission points at which VE observations to be conducted
01 GRINDER 3-05-007-02
02 DRYERS #1 AND #2 3-05-007-02

Authority for entry (see reverse side)

Plant safety requirements
☒ Hardhat
☒ Safety glasses
☒ Side shields (on glasses)
☐ Goggles
☒ Hearing protection EARMUFFS IN MARKED AREAS; PROVIDED BY PLANT
Specify
☒ Safety shoes (steel-toed)
☐ Insulated shoes
☐ Gloves
☐ Coveralls
☒ Dust mask suggested
☒ Respirator(s)
Specify
☒ Other
Specify

Company official contacted (on this visit)  STANLEY C. GRAY
Title  ENVIRONMENTAL ENGINEER

Figure 4.1. Visible emission observer’s plant entry checklist.
Authority for Plant Entry: Clean Air Act, Section 114

(a)(2) the Administrator or his authorized representative upon presentation of his credentials -

(A) shall have a right of entry to, upon or through any premises of such person or in which any records required to be maintained under paragraph (1) of this section are located, and

(B) may at reasonable times have access to, and copy of any records, inspect any monitoring equipment or methods required under paragraph (1), and sample any emissions which such person is required to sample under paragraph (1).

(b)(1) Each State may develop and submit to the Administrator a procedure for carrying out this section in such State. If the Administrator finds the State procedure is adequate, he may delegate to such State any authority he has to carry out this section.

(2) Nothing in this subsection shall prohibit the Administrator from carrying out this section in a State.

(c) Any records, reports or information obtained under subsection (a) shall be available to the public except that upon a showing satisfactory to the Administrator by any person that records, reports, or information, or particular part thereof, (other than emission data) to which the Administrator has access under this section if made public would divulge methods or processes entitled to protection as trade secrets of such person, the Administrator shall consider such record, report, or information or particular portion thereof confidential in accordance with the purposes of Section 1905 of Title 18 of the United States

Confidential Information: Clean Air Act, Section 114 (see above) 41 Federal Register 36902, September 1, 1976

If you believe that any of the information required to be submitted pursuant to this request is entitled to be treated as confidential, you may assert a claim of business confidentiality, covering all or any part of the information, by placing on (or attaching to) the information a cover sheet, stamped or typed legend, or other suitable notice, employing language such as "trade secret," "proprietary," or "company confidential." Allegedly confidential portions of otherwise nonconfidential information should be clearly identified. If you desire confidential treatment only until the occurrence of a certain event; the notice should so state. Information so covered by a claim will be disclosed by EPA only to the extent, and through the procedures, set forth at 40 CFR. Part 2. Subpart B (41 Federal Register 36902, September 1, 1976.)

If no confidentiality claim accompanies this information when it is received by EPA, it may be made available to the public by EPA without further notice to you.

Figure 4.1. Reverse side of form. (Continued)

The principal purpose for an observer's visit to a plant will probably fall into one of three categories: (1) a determination is being made pursuant to a neutral administrative scheme* to verify compliance with an applicable SIP or NSPS, (2) a determination is being made because some evidence of an opacity violation already exists, or (3) an unscheduled determination has just been made from an area off the plant property. The statement of purpose should state clearly what has prompted the visit.

At this time, the observer also should provide the company official with a copy of the opacity readings and ask that person to sign an acknowledgment of receipt of any VE readings made previous to entry. In lieu of the above, the agency should provide a copy within a reasonable time.

4.2.4 Visitor's Agreements, Release of Liability (Waivers) — The observer should not sign a visitor's agreement, release of liability (waiver), hold-harmless agreement, or any other agreement that purports to release the company from tort liability. Signing this type of release form may waive the rights of the observer and his/her employer compensation in event of personal injury or damages; the precise effect of signing an advance release of liability for negligence depends upon the laws of the state in which it is signed. If the plant official denies entry for refusal to sign a release form, the observer should proceed as described in the section on entry refusal.

4.2.5 Section 114 — Section 114 of the Clean Air Act addresses both the authority for plant entry and the protection of trade secrets and confidential information. For the observer's reference, the applicable paragraphs are included on the reverse side of the entry checklist in Figure 4.1.

4.2.6 Entry Refusal — In the event that an observer is refused entry by a plant official or that consent is withdrawn before the agreed-upon activities have been completed, the following procedural steps should be followed:

1. Tactfully discuss the reason(s) for denial with the plant official; this is to insure that the denial has not been based on some sort of misunderstanding. Discussion might lead to resolution of the problem and the observer may be given consent to enter the premises. If resolution is beyond his/her authority, the observer should withdraw from the premises and contact his/her supervisor to decide on a subsequent course of action.

2. Note the facility name and exact address, the name and title of the plant officials approached, the authority for plant entry and the protection of trade secrets and confidential information. For the observer's reference, the applicable paragraphs are included on the reverse side of the entry checklist in Figure 4.1.

3. The observer should be very careful to avoid any situations that might be construed as threatening or inflammatory. Under no circumstances should the potential penalties of entry denial be cited.

All evidence obtained prior to the withdrawal of consent is considered admissible in court.

*Any routine of selecting sites for observation that is not directed toward any company
When denied access only to certain parts of the plant, the observer should make note of the area(s) and the official’s reason for denial. After completing normal activities to the extent possible and leaving the facility, the observer should contact his/her supervisor for further instructions.

4.2.7 Confidentiality of Data — In conducting the VE investigation, the observer may occasionally obtain proprietary or confidential business data. It is essential that this information be handled properly.

The subject of confidential business information known as a “trade secret” is addressed in Section 114 of the Clean Air Act (see Subsection 4.2.5) and in the Code of Federal Regulations (40 CFR 2; 41 Federal Register 36902, September 1, 1976, as amended). The Code of Federal Regulations (40 CFR 2, Subpart B, 2.203) embodies a notice to be included in EPA information requests. This notice is paraphrased on the reverse side of the entry checklist (Figure 4.1) for the observer’s and plant official’s reference. The Code of Federal Regulations (40 CFR 2, Subpart B, 2.211) also includes the penalties for wrongful disclosure of confidential information by Federal employees, in addition to the penalties set forth in the United States Code, Title 18, Section 1905. Employees of other agencies should check with agency attorneys to determine their exact personal liability.

From the observer’s standpoint, confidential information may be defined as information received under a request of confidentiality which may concern or relate to trade secrets. A trade secret is interpreted as an unpatented secret, commercially valuable plan, appliance, formula, or process used in production. This information can be in written form, in photographs, or in the observer’s memory. Emissions data are not considered confidential information. Also the Agency reserves the right to determine if information submitted to it under an official request should be treated as confidential.

A good rule of thumb for the observer to follow is to collect only that information and operational information and to take only those photographs that are pertinent to the purpose of the plant visit. The plant official should be advised that he must request confidential treatment of specific information provided (see paragraph on claims of confidentiality on reverse side of entry checklist) before it will be treated as confidential pending legal determination. The plant official should inform the observer of any sensitive areas of the facility or processes where proprietary or trade secret information is indicated.

Photographs are often used to document visible emissions observations (see Subsection 4.3.4). Before taking photographs from inside the plant premises, the observer must have the consent of the plant official. Most of an observer’s photographs will be of emission points only; presumably, these should not include confidential areas of the plant. If any opposition is encountered regarding the use of a camera on the plant premises, the observer should explain that the plant official should request confidential treatment of any photographs taken. The observer must properly document each photograph and handle those for which confidential treatment has been requested in the same manner as other confidential data. Photographic documentation of VE observations from an area of public access outside of the plant premises does not require approval from a plant official, provided the documentation is accomplished without the use of highly sophisticated equipment or techniques. For example, use of a high-power telephoto lens (over 100 mm on a 35 mm camera) that yields extensive details (e.g., construction layout) might be construed as surreptitiously taking confidential business information. Thus, a good rule of thumb is to ensure that any pictures taken show only the details that could be seen with the naked eye from an area accessible to the public.

When preparing to leave the plant, the observer should allow the plant official to examine the data collected and make claims of confidentiality. All potentially confidential information should be so marked, and while on the road, the observer should keep it in a locked briefcase or file container. It should be noted that emission data are not considered confidential.

When the observer returns to the agency office, the potentially confidential information should be placed in a secure, lockable file cabinet designated especially for that purpose. The observer’s agency should have an established secure filing system and procedures for safeguarding confidential documents. In all cases, the observer should make no disclosure of potentially confidential information until a company has had full opportunity to declare its intentions regarding the information and the Agency has ruled that the information is not legally confidential.

4.2.8 Determination of Safety Requirements — The violation of a safety rule does not invalidate VE readings; however, the observer should always anticipate safety requirements by arriving at the plant with a hardhat, steel-toed safety shoes, safety glasses with side shields, and ear protectors. Safety equipment also should include any other equipment that is specified in the agency files and noted on the entry checklist form.

Some companies require unusual safety equipment, such as specific respirators for a particular kind of toxic gas. In many cases, these companies will provide the observer with the necessary equipment. In any event, the observer must be aware of and adhere to all safety requirements before entering the plant. Information on plant alarms and availability of first aid and medical help may be needed.

4.2.9 Observer Behavior — Observers must perform their duties in a professional, businesslike, and responsible manner. They should always consider the public relations liaison part of their role by seeking to develop or improve a good working relationship with plant officials through use of diplomacy, tact, and if necessary, gentle persuasion in all dealings with plant personnel.

Specifically, observers should be objective and impartial in conducting observations and interviews with plant officials. All information acquired during a plant visit is intended for official use only and should never be used for private gain. Observers must be careful never to speak of any person, agency, or facility in any manner that could be construed as derogatory. Lastly, observers should use discretion when asked to give a professional opinion on specific products or projects and should never make judgments or draw conclusions concerning a company’s compliance with applicable regulations. Upon giving the data to the plant the observer can tell the source; these are the data that were obtained and no judgment as to compliance can be made until all the data and the regulations are closely reviewed.
4.3 Visible Emission Determination

This subsection describes the preferred approach to VE determination. Because practical considerations do not always permit the observer to follow this procedure, however, special observation problems are discussed in Subsection 4.4.

4.3.1 Opacity Readings — The observer must be certified in accordance with Section 3.12.1. Subsection 1.3, and should use the following procedure for visually determining the opacity of emissions.

Observer Position

1. The observer must stand at a distance that provides a clear view of the emissions with the sun oriented in the 140° sector to his/her back. If the observer faces the emission/viewing point and places the point of a pencil on the sun location line such that the shadow crosses the observers position, the sun location (pencil) must be within the 140° sector of the line. During overcast weather conditions, the position of the sun is less important.

2. Consistent with number 1 above, when possible, the observer should, make observations from a position in which the line of vision is approximately perpendicular to the plume direction; when observing opacity of emissions from rectangular outlets (e.g., roof monitors, open baghouses, and noncircular stacks), the observer’s position should be approximately perpendicular to the longer axis of the outlet.

3. When multiple stacks are involved, the observer’s line of sight should not include more than one plume at a time, and in any case, during observations, the observer’s line of sight should be perpendicular to the longer axis of a set of multiple stacks (e.g., stub stacks on baghouses).

4. The observer must stand at a distance that provides total perspective and a good view.

5. In order to comply with the sun angle requirements (see item 1) it is recommended that the observer should try to avoid the noon hours (11:00 a.m. to 1:00 p.m.) in the summertime (when the sun is almost overhead). This is more critical in the southern continental United States. The preferred reading distance is between 3 stack heights and 1/4 mile from the base of the stack.

6. The reading location should be safe for the observer.

Opacity Observations

1. Opacity observations must be made at the point of greatest opacity in that portion of the plume where condensed water vapor is not present.

2. The observer must not look continuously at the plume (this causes eye fatigue), but should observe the plume momentarily at 15-s intervals. A 15-s beeper is recommended to aid in performing the VE readings.

3. When steam plumes are attached, i.e., when condensed water vapor is present within the plume as it emerges from the emission outlet, the opacity must be evaluated beyond the point in the plume at which condensed water vapor is no longer visible. The observer must record the approximate distance from the emission outlet to the point in the plume at which the observations are made.

4. When steam plumes are detached, i.e., when water vapor in the plume condenses and becomes visible at a distinct distance from the emission outlet, the opacity of emissions should be evaluated near the outlet, prior to the condensation of water vapor and the formation of the steam plume; unless the opacity is higher after dissipation.

5. Readings must be made to the nearest 5 percent opacity. A minimum of 24 observations must be recorded. It is advisable to read the plume for a reasonable period in excess of the time stipulated in the regulations (i.e., at least 10 readings more than the minimum required).

6. A clearly visible background of contrasting color is best for greatest reading accuracy. However, the probability of positive error (higher values) is greater under these conditions. Generally, the apparent plume opacity diminishes and tends to assume a negative bias as the background becomes less contrasting.

7. It is recommended the observer wear the same corrective lenses that were worn for certification. If sunglasses were not worn during certification, the observer should remove them and allow time for the eyes to adjust to the daylight before making VE determinations. It is recommended that the observer not wear photo compensating sunglasses.

8. The best viewing spot is usually within one stack diameter above the stack exit, where the plume is densest and the plume width is approximately equal to the stack’s diameter.

4.3.2 Field Data. The “Visible Emission Observation Form” — The 1977 revision of EPA Method 9 specifies the recording of certain information in the field documentation of a visible emission observation. The required information includes the name of the plant, the emission location, the type of facility, the observer’s name and affiliation, the date, the time, the estimated distance to the emission location, the approximate wind direction, the estimated windspeed, a description of the sky conditions (presence and color of clouds), and the plume background.

Experience gained from past enforcement litigation involving opacity readings as primary evidence of emission standards violations has demonstrated a need for additional documentation when making visual determinations of plume opacity. The Visible Emission Observation Form presented in Figure 4.2 is recommended. This form was developed after reviewing the opacity forms used in EPA Regional Offices and State and local air quality control agencies. The form includes not only the data required by Method 9, but also the information necessary for maximum legal acceptability. Valid data can be collected on any form; however, the recommended form may enhance observer efficiency and data documentation. A detailed description of the use of the recommended form is given in the following paragraphs.

The Visible Emission Observation Form can be functionally divided into 11 major sections, as shown in Figure 4.3. Each section documents one or two aspects of the opacity determination. The form endeavors to cover all the required and recommended areas of documentation in a typical opacity observation. A “comments” section is included for notation of any relevant information that is not listed on the form.
### Visible Emission Observation Form

<table>
<thead>
<tr>
<th>Source Name</th>
<th>Observation Date</th>
<th>Start Time</th>
<th>Stop Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADMIRAL POWER PLANT</td>
<td>15 JULY 1982</td>
<td>1330</td>
<td>1342</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Address</th>
<th>Source ID Number</th>
<th>Operating Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 OCEAN ROAD</td>
<td>NEDS 4572</td>
<td>BASE LOAD</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Process Equipment</th>
<th>Operating Mode</th>
<th>Control Equipment</th>
<th>Operating Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>OIL FIRED BOILER</td>
<td>RAPIDING</td>
<td>ELECTROSTATIC PRECIPITATOR</td>
<td>RAPIDING</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Describe Emission Point</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>START</td>
<td>BECKSTACK 25' DIA.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Height Above Ground Level</th>
<th>Height Relative To Observer</th>
</tr>
</thead>
<tbody>
<tr>
<td>START 100' STOP</td>
<td>START 100' STOP</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Distance From Observer</th>
<th>Direction From Observer</th>
</tr>
</thead>
<tbody>
<tr>
<td>START 400' STOP</td>
<td>START NINE STOP</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Describe Emissions</th>
<th>Start</th>
<th>STOP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start PLUME</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Emission Color</th>
<th>Emission Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>START WHITE</td>
<td>CONTINUOUS</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Water Droplets Present</th>
<th>If Water Droplet Plume:</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO</td>
<td>ATTACHED</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Point in the Plume at Which Opacity Was Determined</th>
</tr>
</thead>
<tbody>
<tr>
<td>START 9' ABOVE STACK EXIT STOP</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Describe Background</th>
<th>Sky Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>START SKY</td>
<td>START CLOUDY</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Background Color</th>
<th>Sky Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>START BLUE</td>
<td>START CLOUDY</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Wind Speed</th>
<th>Wind Direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>START 15 MPH STOP 20 MPH</td>
<td>START SW STOP</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ambient Temp.</th>
<th>Wet Bulb Temp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>START 85 F STOP</td>
<td>85 F</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>AMOUNT</th>
<th>DEGREE</th>
<th>HUMIDITY</th>
<th>PERCENT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>85%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sun Location Line</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range of Opacity Readings</td>
<td>40%</td>
<td>60%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Observer's Name (Print)</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.E. PROFFIT</td>
<td>15 JULY 1982</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Comments</th>
<th>Uses #6 Oil</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Title</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>SHIFT MANAGER</td>
<td>7-15-82</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Organization</th>
<th>Certified By</th>
</tr>
</thead>
<tbody>
<tr>
<td>STATE AIR POLLUTION CONTROL BOARD</td>
<td>EASTERN TECHNICAL ASSOC.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Signed</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>William T. Vance</td>
<td>7-15-82</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Verified By</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDA</td>
<td>7-15-82</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Observer’s Name (Print)</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.E. PROFFIT</td>
<td>15 JULY 1982</td>
</tr>
</tbody>
</table>

Figure 4.2. Visible emission observation form.
This form is designed to be used in conjunction with EPA Method 9, "Visual Determination of the Opacity of Emissions from Stationary Sources." Any deviations, unusual conditions, circumstances, difficulties, etc., not dealt with elsewhere on the form should be fully noted in the section provided for comments. Following are brief descriptions of the type of information that needs to be entered on the form; for a more detailed discussion of each part of the form, refer to the "User's Guide to the Visible Emission Observation Form."

*Source Name - full company name, parent company or division information, if necessary.

*Address - street (not mailing) address or physical location of facility where VE observation is being made.

Source ID Number - number from NEDS, CDS, agency file, etc.

*Process Equipment, Operating Mode - brief description of process equipment (include ID no.) and operating rate, % capacity utilization, and/or mode (e.g., charging, tapping).

*Control Equipment, Operating Mode - specify control device type(s) and % utilization, control efficiency.

*Describe Emission Point - stack or emission point location, geometry, diameter, color, for identification purposes.

*Height Above Ground Level - stack or emission point height, from files or engineering drawings.

*Height Relative to Observer - indicate vertical position of observation point relative to stack top.

*Distance From Observer - distance to stack ±10%; to determine, use rangefinder or map.

*Direction From Observer - direction to stack; use compass or map; be accurate to eight points of compass.

*Describe Emissions - include plume behavior and other physical characteristics (e.g., looping, lacy, condensing, fumigating, secondary particle formation, distance plume visible, etc).

*Emission Color - gray, brown, white, red, black, etc.

Plume Type:
Continuous - opacity cycle >6 minutes
Fugitive - no specifically designed outlet
Intermittent - opacity cycle <6 minutes

**Water Droplets Present - determine by observation or use wet sling psychrometer; water droplet plumes are very white, opaque, and billowy in appearance, and usually dissipate rapidly.

**If Water Droplet Plume:
Attached - forms prior to exiting stack
Detached - forms after exiting stack

**Point in the Plume at Which Opacity was Determined - describe physical location in plume where readings were made (e.g., 4 in. above stack exit or 10 ft after dissipation of water plume).

*Describe Background - object plume is read against, include atmospheric conditions (e.g., hazy).

*Background Color - blue, white, new leaf green, etc.

*Sky Conditions - indicate cloud cover by percentage or by description (clear, scattered, broken, overcast, and color of clouds).

*Wind Speed - use Beaufort wind scale or hand-held anemometer; be accurate to ±5 mph.

*Wind Direction - direction wind is from; use compass; be accurate to eight points.

*Ambient Temperature - in °F or °C.

**Wet Bulb Temperature - the wet bulb temperature from the sling psychrometer.

**Relative Humidity - use sling psychrometer; use local U.S. Weather Bureau only if nearby.

*Source Layout Sketch - include wind direction, associated stacks, roads, and other landmarks to fully identify location of emission point and observer position.

Draw North Arrow - point line of sight in direction of emission point, place compass beside circle, and draw in arrow parallel to compass needle.

Sun Location Line - point line of sight in direction of emission point, place pen upright on sun location line, and mark location of sun when pen's shadow crosses the observers position.

**Comments - factual implications, deviations, alterations, and/or problems not addressed elsewhere.

Acknowledgment - signature, title, and date of company official acknowledging receipt of a copy of VE observation form.

*Observation Date - date observations conducted.

*Start Time, Stop Time - beginning and end times of observation period (e.g., 1635 or 4:35 p.m.).

*Data Set - percent opacity to nearest 5%; enter from left to right starting in left column.

*Average Opacity for Highest Period - average of highest 24 consecutive opacity readings.

Number of Readings Above (Frequency Count) - count of total number of readings above a designated opacity.

*Range of Opacity Readings:
Minimum - lowest reading
Maximum - highest reading

*Observer’s Name - print in full.

Observer’s Signature, Date - sign and date after performing final calculations.

*Certifier, Date - name of "smoke school" certifying observer and date of most recent certification.

Verifier, Date - signature of person responsible for verifying observer's calculations and date of verification.
## Visible Emission Observation Form

### Source Name

<table>
<thead>
<tr>
<th>ADDRESS</th>
<th>OBSERVATION DATE</th>
<th>START TIME</th>
<th>STOP TIME</th>
</tr>
</thead>
<tbody>
<tr>
<td>CITY</td>
<td>STATE</td>
<td>ZIP</td>
<td>SEC</td>
</tr>
<tr>
<td>PHONE</td>
<td>SOURCE ID NUMBER</td>
<td>OPERATING MODE</td>
<td></td>
</tr>
<tr>
<td>CONTROL EQUIPMENT</td>
<td>OPERATING MODE</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Describe Emission Point

- **Start**: Start time and stop time for the emission point observation.
- **Height Above Ground Level**: Height relative to observer.
- **Height Relative To Observer**: Start and stop time for the height measurement.
- **Distance from Observer**: Distance from observer to emission point.
- **Direction from Observer**: Direction from observer.

### Describe Emissions

- **Start**: Start time and stop time for the emission.
- **Emission Color**: Description of the emission color.
- **Plume Type**: Continuous, Dispersive, or Intermittent.
- **Water Droplets Present**: Yes or No.
- **Water Droplet Plume**: Attached or Detached.
- **Point In The Plume At Which Opacity Was Determined**: Start and stop time.

### Describe Background

- **Start**: Start time and stop time for the background observation.
- **Background Color**: Description of the background color.
- **Sky Conditions**: Description of the sky conditions.
- **Wind Speed**: Wind speed and direction.
- **Ambient Temp**: Ambient temperature and RH percent.

---

**Source Layout Sketch**: Draw North Arrow

- **Emission Point**: Mark the emission point.
- **Sun**: Indicate the sun's position.
- **Wind**: Indicate the wind direction.
- **Observers Position**: Mark the observers position.
- **Stack**: Mark the stack location.
- **Sun Location Line**: Draw a line indicating the sun's location.

---

**Average Opacity for Highest Period**: Percentage of readings above a certain threshold.
**Number of Readings Above**: Percentage of readings above a certain threshold.
**Range of Opacity Readings**: Minimum and maximum opacity values.

### Comments

- **Observer's Signature**: Signature of the observer.
- **Date**: Date of the observation.
- **Organization**: Name of the organization.

---

**I Have Received A Copy Of These Opacity Observations**: Signature of the person verifying the observations.
**Date**: Date of verification.

---

**Observer's Name (Print)**

---

**Observer's Signature**: Signature of the observer.
**Date**: Date of the observation.

---

**Organization**: Name of the organization.
**Certified By**: Signature of the person certifying the observations.
**Date**: Date of certification.

---

**Verified By**: Signature of the person verifying the observations.
**Date**: Date of verification.

---

**Figure 4.3**: Functional sections of visible emission observation form.
Each major section of the form is discussed in the following text. A short explanation of each section’s purpose, a background explanation of each data element, a description of the type of information being sought, and in some cases, appropriate entries are included. These discussions are keyed to Figure 4.3 by corresponding capital letters, and it is clearly indicated whether information is required or recommended.

A. SOURCE IDENTIFICATION. Provides information that uniquely identifies the source and permits the observer to locate or make contact with the source.

<table>
<thead>
<tr>
<th>Source name</th>
<th>Address</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>City</td>
</tr>
<tr>
<td>Phone</td>
<td></td>
</tr>
</tbody>
</table>

Source Name (Required) - include the source’s complete name. If necessary for complete identification of the facility, the parent company name, division, or subsidiary name should be included.

Address (Required) - Indicate the street address of the source (not the mailing address or the home office address) so that the exact physical location of the source is known. If necessary, the mailing address or home office address may be listed elsewhere.

City, State, Zip, Phone (Recommended) - Self-explanatory.

Source ID Number (Recommended) - This space is provided for the use of agency personnel and should be used to enter the number the agency uses to identify that particular source, such as the State file number, Compliance Data System number, or National Emission Data System number.

B. PROCESS AND CONTROL DEVICE TYPE. Includes a several word descriptor of the process and control device, indication of current process operating capacity or mode, and operational status of control equipment.

<table>
<thead>
<tr>
<th>Process equipment</th>
<th>Operating mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control equipment</td>
<td>Operating mode</td>
</tr>
</tbody>
</table>

Process Equipment (Required) - Enter a description of the process equipment that emits the plume or emissions to be read. The description should be brief but should include as much information as possible, as indicated in the following examples:

- Coal-Fired Boiler
- #2 Oil-Fired Boiler
- Wood Waste Conical Incinerator
- Paint Spray Booth
- Primary Crusher
- Fiberglass Curing Oven
- Reverberatory Smelting Furnace
- Basic Oxygen Furnace

Operating Mode (Recommended) - Depending on the type of process equipment, this information may vary from a quantification of the current operating rate to a description of the portion of a batch-type process for which the emission opacity is being read. For example, entries could include “90 percent capacity” for a boiler or “85 percent production rate” for the shakeout area of a grey iron foundry. For a steel making furnace, entries would include the exact part of the process for which readings are being made, such as “charging” or “tapping.” In some cases, the observer may have to obtain this information from a plant official.

Control Equipment (Required) - Specify the type(s) of control equipment being used in the system after the process equipment in question (e.g., “hot-side electrostatic precipitator”).

Operating Mode (Recommended) - Indicate the degree to which the control equipment is being utilized at the time of the opacity observations (e.g., 75% capacity, full capacity, shut down, off line) and the operating mode (e.g., automatic). The observer will probably have to obtain this information from a plant official.

C. EMISSION POINT IDENTIFICATION. Contains information uniquely identifying the emission point and its spatial relationship with the observer’s position.

<table>
<thead>
<tr>
<th>Describe emission point</th>
<th>Start</th>
<th>Stop</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height above ground level (Required)</td>
<td>Height relative to observer</td>
<td></td>
</tr>
<tr>
<td>Start</td>
<td>Stop</td>
<td></td>
</tr>
<tr>
<td>Distance from observer</td>
<td>Direction from observer</td>
<td></td>
</tr>
<tr>
<td>Start</td>
<td>Stop</td>
<td></td>
</tr>
</tbody>
</table>

Describe Emission Point (Required) - Include the identifying physical characteristics of the point of release of emissions from the source. The description must be specific enough so that the emission outlet can be distinguished from all others at the source. In subsequent enforcement proceedings, the observer must be certain of the origin of the emissions that were being read.

Typical descriptions of the emission outlet include the color, geometry of the stack or other outlet, and the location in relation to other recognizable facility landmarks. Any special identification codes the agency or source uses to identify a particular stack or outlet should be noted along with the source code used by the observer. The source of this information should be recorded (e.g., plant layout map or engineering drawing).

Height Above Ground Level (Required) - Indicate the height of the stack or other emission outlet from its foundation base. This information is usually available from agency files, engineering drawings, or computer printouts (such as NEDS printouts). The information also may be obtained by using a combination of a rangefinder and an Abney level or clinometer. The height may also be estimated.

Height Relative to Observer (Required) - Indicate an estimate of the height of the stack outlet (or any other type of emission outlet) above the position of the observer. This measurement indicates the observer’s position in relation to the stack base (i.e., higher or lower than the base) and may later be used in slant angle calculations (see Section 3.12.6 and Subsection 4.4.6) if such calculations become necessary.

Distance From Observer (Required) - Record the distance from the point of observation to the emission outlet. This measurement may be made by using a rangefinder. If necessary, a map also may be used to estimate the distance.

It is important that this measurement be reasonably accurate if the observer is close to the stack (within 3 stack heights) because it is coupled with the outlet height relative to the observer to determine the slant angle at which the observations were made (see Figure 4.4). A precise determination of the slant angle may become important in calculating any positive bias inherent in the opacity readings.

Direction From Observer (Required) - Specify the direction of the emission point from the observer to the closest...
of the eight points of the compass (e.g., S, SE, NW, NE) or 45°. Use of a compass to make this determination in the following manner is suggested: hold the compass while facing the emission point; rotate the compass until the North compass point lies directly beneath the needle (which will be pointing towards magnetic North); then the point of the compass closest to the emission outlet will indicate the direction (Figure 4.5). A map (plant layout) also may be used to make this determination.

Describe Emissions (Required) - Include both the physical characteristics of the emissions not recorded elsewhere on the form and the behavior of the resultant plume. The description of the physical characteristics might include terms such as lacy, fluffy, and detached nonwater vapor condensibles.

The terminology illustrated in Figure 4.6 can be used to describe plume behavior. The behavior can be used to determine the atmospheric stability on the day of the opacity observations. Emission Color (Required) - Note the color of the emissions. The plume color can sometimes be useful in determining the composition of the emissions and will also serve to document the total contrast between the plume and its background as seen by the opacity observer during the observation period.

Plume Type (Recommended) - Check "continuous" if the duration of the emissions being observed is greater than 6 minutes. Check "intermittent" if the opacity cycle is less than 6 minutes. Check "fugitive" if the emissions have no specifically designated outlet.

Water Droplets Present (May be required) - Check "yes" or "no" as appropriate. In some cases, the presence of condensed water vapor in the plume can be easily observed.

Plumes containing condensed water vapor (or "steam plumes") are usually very white, billowy, and wispy at the point of dissipation, where the opacity decreases rapidly from a high value (usually 100%) to 0 percent if there is no residual opacity plume contributed by contaminant in the effluent.

To document the presence or absence of condensed water vapor in the plume, the observer must address two points. First, is sufficient moisture present (condensed or uncondensed) in the plume initially? Second, if enough moisture is present, are the in-stack and ambient conditions such that it will condense either before exiting the stack or after exiting (when it meets with the ambient air)? The first question can be answered by examining the process type and/or the treatment of the effluent gas after the process. Some common sources of moisture in the plume are:

- Water produced by combustion of fuels,
- Water from dryers,
- Water introduced by wet scrubbers,
- Water introduced for gas cooling prior to an electrostatic precipitator, or other control device, and
- Water used to control the temperature of chemical reactions.

If water is present in the plume, data from a sling psychrometer, which measures relative humidity, in combination with the moisture content and temperature of the effluent gas can be used to predict whether the formation of a steam plume is a possibility (see Section 3.12.6).

If Water Droplet Plume: (May be required) - Check "attached" if condensation of the moisture contained in the plume occurs within the stack and the steam plume is visible at the stack exit. Check "detached" if condensation occurs some distance downwind from the stack exit and the steam plume and the stack appear to be unconnected. Point in the Plume at Which Opacity was Determined (May be required) - Describe as succinctly as possible the physical location in the plume where the observations were made. This description is especially important in the case where condensed water vapor and/or secondary plume is present. For example, were the readings made prior to formation of the steam plume? If the readings were made subsequent to dissipation (e.g., in the case of an attached steam
Figure 4.6. Plume behavior descriptors.

Describe Background (Required) -
Describe the background that the plume is obscuring and against which the opacity is being read. While describing the background, note any imperfections or conditions, such as texture, that might affect the ease of making readings. Examples of background descriptions are roof of roof monitor, stand of pine trees, edge of jagged stony hillside, clear blue sky, stack scaffolding, and building obscured by haze.

Background Color (Required) -
Accurately note the background color (e.g., new leaf green, conifer green, brick red, sky blue, and gray stone).

E. OBSERVATION CONDITIONS.
Covers the background and ambient weather conditions that occur during the observation period and could affect observed opacity.

<table>
<thead>
<tr>
<th>Describe background</th>
<th>Start</th>
<th>Stop</th>
</tr>
</thead>
<tbody>
<tr>
<td>Background color</td>
<td>Start</td>
<td>Stop</td>
</tr>
<tr>
<td>Sky conditions</td>
<td>Start</td>
<td>Stop</td>
</tr>
<tr>
<td>Wind speed</td>
<td>Start</td>
<td>Stop</td>
</tr>
<tr>
<td>Wind direction</td>
<td>Start</td>
<td>Stop</td>
</tr>
<tr>
<td>Ambient temp</td>
<td>Start</td>
<td>Stop</td>
</tr>
<tr>
<td>Wet bulb temp</td>
<td>Relative humidity</td>
<td></td>
</tr>
</tbody>
</table>
Sky Conditions (Required) - Indicate the percent cloud cover of the sky. This information can be indicated by using straight percentages (e.g., 10% overcast, 100% overcast) or by description. As shown below.

<table>
<thead>
<tr>
<th>Term</th>
<th>Amount of cloud cover</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clear</td>
<td>&lt;10%</td>
</tr>
<tr>
<td>Scattered</td>
<td>10% to 50%</td>
</tr>
<tr>
<td>Broken</td>
<td>50% to 90%</td>
</tr>
<tr>
<td>Overcast</td>
<td>&gt;90%</td>
</tr>
</tbody>
</table>

Windspeed (Required) - Give the windspeed accurately to ±5 miles per hour. The windspeed can be determined using a hand-held anemometer (if available), or it can be estimated by using the Beaufort Scale of Windspeed Equivalents in Table 4.1.

Wind Direction (Required) - Indicate the direction from which the wind is blowing. The direction should be estimated at eight points of the compass by observing which way the plume is blowing. If the type of estimation is not possible, the direction may be determined by observing a blowing flag or by noting the direction a few blades of grass or handful of dust are blown when tossed into the air. Keep in mind that the wind direction at the observation point may be different from that at the emission point; the wind direction at the emission point is the one of interest.

Ambient Temperature (Required) - The outdoor temperature at the plant site is measured by a thermometer (in degrees Fahrenheit or centigrade) obtained from a local weather bureau or estimated. Be certain to note which temperature scale is used. This is done in conjunction with the wet bulb temperature and is only needed when there are indications of a condensing water droplet plume.

Wet Bulb Temperature (May be required) - Record the wet bulb temperature from the sling psychrometer. This is to be done only when there are indications of a condensing water droplet plume.

Relative Humidity (May be required) - Enter the relative humidity measured by using a sling psychrometer in conjunction with a psychrometric chart. This information can be used to determine if water vapor in the plume will condense to form a steam plume (see Section 3.12.6). If a sling psychrometer is not available, data can be substituted.

Table 4.1. The Beaufort Scale of Windspeed Equivalents

<table>
<thead>
<tr>
<th>General description</th>
<th>Specifications</th>
<th>Limits of velocity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calm</td>
<td>Smoke rises vertically</td>
<td>Under 1</td>
</tr>
<tr>
<td></td>
<td>Direction of wind shown by smoke drift but not by wind vanes</td>
<td>1 to 3</td>
</tr>
<tr>
<td>Light</td>
<td>Wind felt on face; leaves rustle; ordinary vane moved by wind</td>
<td>4 to 7</td>
</tr>
<tr>
<td>Gentle</td>
<td>Leaves and small twigs in constant motion; wind extends light flag</td>
<td>8 to 12</td>
</tr>
<tr>
<td>Moderate</td>
<td>Raises dust and loose paper; small branches are moved</td>
<td>13 to 18</td>
</tr>
<tr>
<td>Fresh</td>
<td>Small trees in leaf begin to sway; created waves form on inland waters</td>
<td>19 to 24</td>
</tr>
<tr>
<td></td>
<td>Large branches in motion; whistling heard in telegraph wires; umbrellas used with difficulty</td>
<td>25 to 31</td>
</tr>
<tr>
<td>Strong</td>
<td>Whole trees in motion; inconvenience felt in walking against the wind</td>
<td>32 to 38</td>
</tr>
<tr>
<td></td>
<td>Twigs broken off trees; progress generally impeded</td>
<td>39 to 46</td>
</tr>
<tr>
<td>Gale</td>
<td>Slight structural damage occurs (chimney pots and slate removed)</td>
<td>47 to 54</td>
</tr>
<tr>
<td></td>
<td>Trees uprooted; considerable structural damage occurs</td>
<td>55 to 63</td>
</tr>
<tr>
<td>Whole gale</td>
<td>Rarely experienced, accompanied by widespread damage</td>
<td>64 to 75</td>
</tr>
<tr>
<td>Hurricane</td>
<td>Above 75</td>
<td></td>
</tr>
</tbody>
</table>

F. OBSERVER POSITION AND SOURCE LAYOUT. Clearly identifies the observer’s position in relation to the emission point, plant landmarks, topographic features, sun position, and wind direction.

Source Layout Sketch (Required) - This sketch should include as many landmarks as possible. At the very least, the sketch should locate the relative position of the observed outlet in such a way that it will not be confused with others at a later date, and clearly locate the position of the observer while making the VE readings. The exact landmarks will depend on the specific source, but they might include:

- Other stacks
- Hills
- Roads
- Fences
- Buildings
- Stockpiles
- Rail heads
- Tree lines
- Background for readings

To assist in subsequent analysis of the reading conditions, sketch in the plume (indicate the direction of wind travel). The wind direction also must be indicated in the previous section.

Draw North Arrow (Recommended) - To determine the direction of north, point the line of sight in the source layout sketch in the direction of the actual emission point, place the compass next to the circle and draw an arrow in the circle parallel to the compass needle. A map (plant layout) may also be used to determine direction north.

Sun’s Location (Recommended) - It is important to verify this parameter before making any opacity readings. The sun’s location should be within the 140° sector indicated in the layout sketch; this confirms that the sun is within the 140° sector to the observer’s back.

To draw the sun’s location, point the line of sight in the source layout sketch in the direction of the actual emission point, place a pen upright along the “sun location line” until the...
shadow of the pen falls across the observer's position. Then draw the
sun at the point where the pen

touches the "sun location line.""

G. COMMENTS. Includes all
implications, deviations,
disagreement with plant personnel
and/or problems of a factual nature
that cannot be or have not been addressed
elsewhere on the form. Examples of

Reasons for missed readings.

Other observers present.

H. COMPANY ACKNOWLEDGMENT
Company acknowledgement of, but
not necessarily agreement with, the
opacity observations stated on the
form.

I. DATA SET. Opacity readings for the
observation period, organized by
minute and second. This section
also includes the actual date and
start and stop times for the
observation period.

Observation Date (Required) - Enter
the date on which the opacity
observations were made.

Start Time, Stop Time (Required) -
Indicate the times at the beginning
and the end of the actual observation
period. The times may be expressed in
12-hour and 24-hour time (i.e., 8:35
a.m. or 0835); however, 24-hour time
tends to be less confusing.

Data Set (Required) - Spaces are
provided for entering an opacity
reading every 15 s for up to a 1-hour
observation period. The readings
should be in percent opacity and
made for a particular 15-second
period, that space should be skipped
and an explanation should be provided
in the comments section. Also a dash
(-) should be placed in the space
which denotes that the space is not
just an oversight.

J. DATA REDUCTION. Basic analysis of
the opacity readings to allow
preliminary compliance appraisal in
accordance with EPA Reference
Method 9.

Average Opacity for the Highest
Period (Required) - Enter the average
of the sum of the highest 24
consecutive readings (6-minute set).
In other words, identify the 24
consecutive readings that would sum
to the greatest value and then divide
this value by 24 to get the average
opacity for that set of readings. Note:
The average should not include a time
lapse for which a valid reading could
have been taken but was not (see
Section 3.12.6).

Number of Readings Above ...% Were
(Recommended) - Indicate an
optional frequency count of the
opacity readings above a particular
value. The value is chosen according
to the opacity standard for the
emission point and is generally the
actual value of the standard.

Method 9 does not specify the use
of frequency counting to reduce data,
but many States use it to determine
compliance with their time exemption
opacity standards. For example, a
State regulation might specify that
opacity of a specific type of emission
source is not to exceed 20 percent for
more than 3 minutes in an hour. If
more than 12 readings out of 240 exceed
20 percent in an hour-long
observation period, that State may
consider that source out of
compliance. For example,
14 readings out of 240 readings (1
hour) are above 20 percent opacity
14 x 15 s per reading = 210 s
= 3.5 minutes of readings above the
standard.

Range of Opacity Readings (Required) -
Enter the highest and lowest opacity
readings taken during the specified
observation period.

K. OBSERVER DATA. Information
required to validate the opacity data

Observer's name (print)  
Observer's signature Date
Organization
Certified by Date
Verified by Date

I have received a copy of these opacity
observations

Signature

Title Date

Average opacity
for highest period
Number of readings above
Range of opacity readings

Minimum Maximum

Note:

Average

Opacity

for

highest

Period

Number of Readings Above ...% Were

(Recommended)

Indicate an

optional frequency count of the
opacity readings above a particular
value. The value is chosen according
to the opacity standard for the
emission point and is generally the
actual value of the standard.

Method 9 does not specify the use
of frequency counting to reduce data,
but many States use it to determine
compliance with their time exemption
opacity standards. For example, a
State regulation might specify that
opacity of a specific type of emission
source is not to exceed 20 percent for
more than 3 minutes in an hour. If
more than 12 readings out of 240 exceed
20 percent in an hour-long
observation period, that State may
consider that source out of
compliance. For example,
14 readings out of 240 readings (1
hour) are above 20 percent opacity
14 x 15 s per reading = 210 s
= 3.5 minutes of readings above the
standard.

Range of Opacity Readings (Required) -
Enter the highest and lowest opacity
readings taken during the specified
observation period.

K. OBSERVER DATA. Information
required to validate the opacity data

Observer's name (print)  
Observer's signature Date
Organization
Certified by Date
Verified by Date

I have received a copy of these opacity
observations

Signature

Title Date

Average opacity
for highest period
Number of readings above
Range of opacity readings

Minimum Maximum

Note:
Observer's Name (Required) - Print observer's entire name.
Observer's Signature/Date (Recommended) - Self-explanatory.
Organization (Required) - Provide the name of the agency or company that employs the observer.
Certified By (Recommended) - Identify the agency, company, or other organization that conducted the "smoke school" or VE training and certification course where the observer obtained his/her most current certification.
Date (Required) - Provide the date of the most current certification.
Verified By (Recommended) - The actual signature of someone who has verified the opacity readings and calculations, usually the observer's supervisor, or the individual who is responsible for his/her work.
Date (Recommended) - Provide the date of verification.

4.3.3 Facility Operating Data - It is strongly recommended that a VE inspection/observation conclude with a source inspection if opacity values are in excess of the standard. The observer would first follow the plant entry procedure in Subsection 4.1 and then follow the indicated procedure to obtain facility operating data.

After the VE determination, it is recommended that the following source information be determined:
1. Were the plant and the source of interest operating normally at the time of the VE evaluation?
2. Are there any control devices associated with the source?
3. Were the control devices operating properly?
4. Have there been any recent changes in the operation of the process or control devices?
5. Have any malfunctions or frequent upsets in the process or control devices been noted and reported (if required by the agency)?
6. Is the plant operator aware of excessive visible emissions and have any corrective steps been taken to alleviate the problems?
7. Are there any other sources of visible emissions in close proximity to the source in question that may interfere with reading the plume opacity or contribute to the appearance of the plume?

4.3.4 Photographs - It is suggested that photographs be taken before and after the observation is made, not during the observation period.

Conditions should be recorded as they existed at the time of the observation. The use of a 35-mm camera is recommended to ensure good photographs.

Each photograph should be identified with the date and time, the source, and the position from which the photograph was taken.

4.4 Special Observation Problems

The VE observer constantly should be aware that his/her observations may be used as the basis of a violation action and subject to questioning as to the reliability of the observations. Therefore, he/she must also be aware that under some conditions or situations it may be difficult or impossible to conduct a technically defensible visible emissions observation.

This section discusses some of the most prevalent difficult conditions or special problems associated with the visible emission observation. Each discussion is directed toward defining the problem, indicating how it might invalidate readings taken, and addressing possible solutions and/or ways to minimize the invalidating effects.

Not all of these discussions offer a complete solution for a particular problem; thus, it is important for the individual observer to keep in mind the purpose of the visible emission observation when considering exactly what action to take when faced with a special problem.

4.4.1 Positional Requirements - Valid VE evaluations can be conducted only when the sun is properly positioned at the observer's back. Failure to adhere to this positioning can result in significant positive bias caused by forward light scatter in opacity readings. Because of this overriding constraint, some times and locations make it difficult for the observer to meet other opacity reading criteria, e.g., reading the narrow axis of a rectangular stack, reading a series of stacks across a short axis to prevent multiple plume effects, and obtaining a contrasting background. Plant topography also may generate constraints that restrict viewing positions to one or more locations. The observer will be aided in determining the best observation location by following the criteria listed below.

1. Make sure that the emission point is north of the observation point.
2. Obtain a clear view of the emission point with no interfering plumes.
3. Be sure that rectangular stacks are read across the narrow axis and multiple stacks are read perpendicular to the line of stacks.
4. Minimize the slant angle by moving a sufficient distance from the stack or to an elevated position (see Subsection 4.4.4).
5. Find a contrasting background or a clear sky background.
6. Finally, determine the best time of day for observations based on the daily sun tracks at that location.

Collaborative studies of the performances of trained observers have indicated that, with the exception of the positive bias caused by having the improper sun angle, visible emission observation biases tend to be negative. Thus, if viewing conditions are not ideal and a negative bias (lower value) results, opacity readings may not provide the true measure of plume opacity required to correlate to mass emissions or control equipment efficiency. However, readings that indicate a violation can be regarded as the minimum opacity; therefore, documentation of the violation is valid.

In situations where the observer must make plume opacity readings when all the criteria for correct viewing cannot be met, all extenuating circumstances must be documented on the VE evaluation form.

4.4.2 Multiple Sources/Multiple Stacks - An observer is sometimes compelled to evaluate a stack that discharges emissions from more than one source or to evaluate a single source that has more than one emission point.

In the case where one stack serves more than one emission source, the observer may be able to isolate the emissions from one source as a result of intervals of operation, or by requesting the facility's cooperation in temporarily shutting down the other source(s). Otherwise, the observer should proceed with the VE observation and document the situation completely on the VE evaluation form.

In the case of multiple emission points for a single source (e.g., in positive-pressure baghouses and multiple vents in roof monitors), Section 2.1 of Method 9 directs the
observer to read multiple stacks independently if it is possible to do so while meeting sun position requirements. If it is necessary to get an overall reading for the group of stacks, the following set of formulas can be used to calculate this reading from the individual opacity values:

\[
1 - \frac{O_1}{100} = T_1
\]

\[
1 - \frac{O_2}{100} = T_2
\]

\[
1 - \frac{O_n}{100} = T_n
\]

\[
T_1 \times T_2 \times \ldots \times T_n = T_T
\]

\[
100 \times (1 - T_T) = O_T
\]

where

- \(O_1\) = % opacity of 1st plume
- \(O_2\) = % opacity of 2nd plume
- \(O_n\) = % opacity of nth plume
- \(T_1\) = Transmittance of 1st plume
- \(T_2\) = Transmittance of 2nd plume
- \(T_n\) = Transmittance of nth plume
- \(T_T\) = Total transmittance
- \(O_T\) = % total opacity

4.4.3 High Winds - Occasionally the crosswind conditions are unfavorable during field observations of plume opacity. When the winds are strong enough to shear the emissions at the stack outlet, it is difficult for the observer to make an accurate and fair VE observation. Strong crosswinds can have several effects on the plume:

1. The plume becomes essentially flattened and is no longer conical in shape, thus the path length and apparent opacity increases.
2. The plume is torn into fragments and becomes difficult to obtain a representative reading.
3. The plume becomes diluted, and the apparent opacity is lowered.

The observer can compensate somewhat for the effect of flattening by reading the plume downwind of the stack, after it has reformed into a cone. The dilution effect of high winds, which lowers the apparent opacity, presents more of a problem. Because of the negative bias introduced, the effectiveness of Method 9 as a control tool under these conditions is diminished. If a violation is still observed under these conditions, it should be considered valid. It is recommended that whenever feasible, VE observations be suspended until the wind-caused interferences have abated.

4.4.4 Poor Lighting - Poor lighting conditions for VE observations usually involve one or more of the following: (1) a totally overcast sky, (2) early morning or late afternoon hours, or (3) nighttime. Each of these three lighting conditions has the same net effect on the plume; they differ slightly only in the cause of the poor illumination. When the amount of available sunlight is below a certain level, the contrast between a white plume and the background decreases. Therefore, readings are not recommended in either the early morning hours (at or approaching dawn) or late afternoon hours (at or approaching dusk).

Nighttime viewing obviously represents the most severe of poor lighting conditions. Some agencies have attempted, with mixed results, to use night vision devices (light intensification scopes) for plume viewing and testing in the dark. Others have achieved better results by placing a light behind the emissions, which provides a very high contrast background. For this method, it is important to select a source of light of moderate strength that does not cause the iris of the eye to close.

4.4.5 Poor Background - The color contrast between the plume and the background against which it is viewed can affect the appearance of the plume as viewed by an observer. Field studies have corroborated predictions of the plume opacity theory by demonstrating that a plume is most visible and has the greatest apparent opacity when viewed against a contrasting background.

Consistent with these findings is the fact that with a high contrast background, the potential for positive observer bias is the greatest. However, field trials consisting of 769 sets of 25 opacity readings each have shown that for more than 99 percent of the sets, the positive observer error was no greater than 7.5 percent opacity.

Also consistent with these findings is the fact that as the contrast between the plume and its background decreases, the apparent opacity decreases; this greatly increases the chance for a negative observer bias. Under these conditions, the likelihoodless of a facility being cited for a violation of an opacity standard because of observer error.

When faced with a situation where there is a choice of backgrounds, the observer should always choose the one providing the highest contrast with the plume because it will permit the most accurate opacity reading. However, if a situation arises where other constraints make it impossible to locate an observation point that provides a high contrast background, the observer may read against a less contrasting one with confidence that a documented violation should be legally defensible.

4.4.6 Reduced Visibility - Environmental factors at the time of observation also are of concern to the visible emissions observer. Environmental considerations include rain, snow, or other forms of precipitation, and photochemical smog buildup, fog, sea spray, high humidity levels, or any other cause of haze. These environmental factors create a visual obscuration that can increase the apparent opacity of the plume, but more commonly reduce the background contrast and thus decrease the apparent opacity.

In recognition of the problems that could result from reduced visibility caused by environmental factors, the amended Method 9 (November 12, 1974) states, in paragraph 2.1 of the Procedures Section: "The qualified observer shall stand at a distance sufficient to provide a clear view of the emissions ..." A "clear view" must be interpreted as a view free from obstacles or interferences. Most problems caused by reduced visibility can be alleviated simply by making the observations on another day.

4.4.7 Tall Stacks/Slant Angle - When an observer's distance from the stack approaches 1/4 mile (approximately 1300 feet, or a little over four football fields), the ambient light scattering may begin to have an adverse effect on the contrast between the plume and the background. Also, if the sky is overcast or hazy on the day of observation, the farther the observer is from the emission point, the more the haze interferes with the view of the plume and hence, the less reliable the readings.

On the other hand, the recommendation that the observer stand at least three stack heights from the stack being observed is intended to ensure that the width of the plume as it is viewed is approximately the same as it is at the stack outlet. As the observer gets closer to the stack and the viewing (slant) angle...
increases, the observed path length also increases; this causes the observed opacity to increase because the observer is reading through more emissions. These relationships are shown in Figure 4.8. At an observer distance of three stack heights, which corresponds to a slant angle of 18°, the deviation of observed opacity from actual opacity decreases to 1 percent opacity, which is considered acceptable (see Section 3.12.6).

The three-stack-heights relationship only occurs if the observer and the base of the stack are in the same horizontal plane. If the observer is on a higher plane than the base of the stack, then the minimum distance for proper viewing can be reduced to less than three stack heights; conversely, if the observer’s plane is lower than that of the stack base, then the minimum suggested distance will be greater than three stack heights (see Figure 4.8). The real determining factor is the slant angle. To assure no more than a 1 percent opacity deviation of observed opacity from actual opacity, the observer must have a visual slant angle of 18° or less.

4.4.8 Steam Plumes - Under certain conditions, water vapor present in an effluent gas stream will condense to form a visible water droplet or “steam” plume. Because the NSPS (specifically Method 9) and almost all SIP’s exclude condensed, uncombined water vapor from opacity regulations, the VE observer must be careful that he/she does not knowingly read a plume at a point where condensed water vapor is present and record the value as representative of stack emissions.

Knowledge of the kind of process that generates the emissions being read and simple observation of the resultant plume almost always allows the observer to determine if a steam plume is present. Steam plumes are commonly associated with processes or control equipment that introduce water vapor into the gas stream. These sources include:
- Fuel combustion,
- Drying operations,
particulate ammonium sulfite or the condensation of sulfur trioxide and water vapor to form sulfuric acid mist.

- A physicochemical reaction between species in a plume and species in the atmosphere, such as the formation of HNO₃.

Secondary plumes are sometimes found in the following processes (with these suspected secondary reactions):
- Coal- and oil-fired cement kilns
  (SO₂ + NO₂ + H₂O → H₂SO₄ + HNO₃)
- or [NH₃ + SO₂ + H₂O → (NH₄)₂SO₃]
- Fossil-fuel-fired steam generators
  (SO₂ + H₂O → H₂SO₄)
- Sulfuric acid manufacturing
  (SO₃ + H₂O → H₂SO₄)
- Plywood and particleboard wood heating (organic vapor → organic mist)
- Glass manufacturing (inorganic vapor → organic aerosol).

As in the case of steam plumes, secondary plumes can be attached or detached, depending on the specific condensation reaction and the ambient conditions. For example, a secondary plume will be attached if a reaction between plume species occurs in the stack and the stack temperature is sufficiently low to cause condensation of the reaction products to a visible liquid or solid phase. A detached secondary plume will be evident when the reaction does not occur until the gas stream comes in contact with the atmosphere. The degree of detachment depends on the ambient conditions, the degree of mixing between the effluent and the atmosphere, and the specific reaction(s) involved.

Secondary plumes may occur with or without an accompanying steam plume, and it is important that the observer be able to distinguish between the two. Unlike steam plumes, secondary plumes are often persistent (they do not dissipate rapidly), are usually bluish white (due to the fine particles present), and are grainy rather than billowy.

To read a secondary plume, the observer must locate the densest point of the plume where water vapor is not evident and make the readings at that point. This point may occur in several different areas, depending on the type of secondary plume. An attached secondary plume will usually be read at the stack exit if an attached steam plume is not present; if an attached steam plume is present, the secondary plume must be read at the point of steam dissipation. A detached secondary plume will usually be read slightly downwind of the area of formation, assuming there is no interfering condensed water vapor. Under some conditions, a secondary plume may not fully condense until some distance downstream of the point of formation; in this case, the observer simply looks for the densest area of the plume and makes the reading at that point. It is especially important in reading a secondary formation plume to describe fully the point at which the reading was taken and the exact appearance of the plume. (Refer to Figure 4.7 for one example of where to read a secondary plume.)

4.4.10 Fugitive Emissions - Fugitive emissions are those emissions that do not emanate from a conventional smoke stack or vent. Examples of these nonconventional emissions include:
- Dusty or unpaved roads
- Stock or raw material piles under windy conditions or when moved by machinery
- Conveyor belts, pneumatic lifts, clamshells, and draglines
- Cutting, crushing, grinding, and sizing of minerals or other materials
- Plowing, tilling, and bulldozing
- Open incineration
- Demolition activities
- Roof monitors or building vents, especially in foundries, iron and steel facilities, and related industries.

Because of the irregular shape of their emission point or area, conducting a conventional Method 9 test on fugitive emissions may appear difficult; however, it usually involves only relatively minor adjustments. Commonly used procedures for observation of fugitive emissions are listed below:

1. If possible, isolate the particular emission from other emissions by choosing an appropriate position for observation.
2. Adhere to the lighting requirements of Method 9 by keeping the sun in the 140° sector to the observer's back.
3. Also adhere to Method 9 in selecting a position with regard to wind direction and a contrasting background.
4. Whenever possible, select the shortest path length through the plume.
5. Before taking readings, view the emission for several minutes to determine its characteristics.

Changes that may occur in the airborne particulate pattern over time are important to note and to consider in selecting a viewing point.

6. Select the line of sight and the viewing point in the emissions so that, on the average, the densest part of the emissions will be observed. It is recommended that all subsequent readings in a data set be taken at the same relative position to the emission source.

7. The configuration of the emission point or area may necessitate taking readings at a point downwind where the emissions have assumed a more conventional plume shape.

8. If the plume cannot be viewed through a nearly perpendicular angle, corrections may be necessary.

4.4.11 Intermittent Sources - Some sources release visible emissions intermittently rather than continuously; e.g., coke ovens, batch operations, single chamber incinerators, malfunctioning control equipment (in rapping, bag shaking, etc.), boilers during soot blowing, and process equipment during startup.

Intermittent emissions may have a high opacity for a short time and a low or negligible opacity at other times. This high-low cycle may be repeated at fairly regular intervals. If a source is in violation (or in continuous compliance) of the applicable standard over the 6-minute averaging time required by Method 9, it does not pose a problem to the visible emissions observer. If the pollutant-emitting operational cycle of a source is less than 6 minutes in duration, however, that source may be out of compliance only for a portion of each 6-minute averaging period, which will make it difficult or impossible to document a violation if the data is to be reduced to a 6-minute average.

If the source is not covered by a NSPS or a State Implementation Plan that specifies the explicit use of Method 9 or another specified modification to Method 9, another technique for reading intermittent emissions of less than a 6-minute duration is to use Method 9 procedures but reduce the averaging time to about 3 minutes. This reduction will allow the observer to tally the number of 3-minute violations that occur. Analysis of many data sets has confirmed that using this method sacrifices little or no accuracy.
In all cases where sources are not subject to NSPS or other federally promulgated standard, the existing State regulations and specified opacity observation methods (if any) must be used. Two other techniques that have been used to document intermittent emissions are the "stopwatch" technique (measuring the total accumulated time that the opacity exceeds the applicable standard) and the time-aggregate data reporting technique (taking readings every 15 seconds, tallying the number of readings exceeding the standard, and multiplying this number by 15 seconds to determine the amount of time the source is out of compliance during the observation period). Many State agencies use these latter techniques, and have adopted their methods in their SIP rules and regulations. EPA currently has studies underway to evaluate the accuracy and reliability of these nonaveraging techniques.

Table 4.2. Activity Matrix for Visible Emission Determination

<table>
<thead>
<tr>
<th>Activity</th>
<th>Acceptance limits</th>
<th>Frequency and method of measurement</th>
<th>Action if requirements are not met</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perimeter survey</td>
<td>Completed perimeter survey</td>
<td>Prior to, following, and during (if warranted) the VE determination</td>
<td>N/A</td>
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<tr>
<td>Plant entry</td>
<td>Observer should follow protocol as suggested in Subsec 4.2 and adhere to confidentiality of data</td>
<td>Entry prior to taking VE readings only if necessary; entry after VE readings to provide plant representative with data and/or to obtain necessary plant process data</td>
<td>N/A</td>
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<tr>
<td>VE Determination</td>
<td>In accordance with Subsec 4.3.1</td>
<td>Take a position for observation as described in Subsec 4.3.1 and document on data form</td>
<td>Follow instructions under special problems (Subsec 4.4) when a proper position cannot be assumed</td>
</tr>
<tr>
<td>1. Position</td>
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<td></td>
<td>As above</td>
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<tr>
<td>2. Observations</td>
<td>Taken in accordance with Subsec 4.3.1</td>
<td>Make VE determination as described in Subsec 4.3.1</td>
<td>Complete missing data (if possible) or give rationale for incomplete data</td>
</tr>
<tr>
<td>3. Field data: VE observation form</td>
<td>Completed data form</td>
<td>Complete data form as per instructions and examples in Subsec 4.3.2</td>
<td>Data must be obtained as soon as possible after VE observation</td>
</tr>
<tr>
<td>4. Facility operating data</td>
<td>Pertinent process data obtained</td>
<td>After VE observations, obtain facility data per Subsec 4.3.3</td>
<td>N/A</td>
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<tr>
<td>Special observation problems</td>
<td>N/A</td>
<td>Refer to Subsec 4.4 when conditions do not permit VE observation under proper position, etc.</td>
<td>N/A</td>
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N/A = not applicable.
5.0 Postobservation Operations

Table 5.1 at the end of this section summarizes the quality assurance activities for postobservation operations. These activities include preparation of reports and data summaries and validation.

5.1 Data Summary

The opacity observations are recorded on data forms such as those shown in Figures 4.1 and 4.2. Figure 5.1 is a summary data form for manual calculations. This form and the calculation procedures are discussed in detail in Section 3.12.6. It is recommended, however, that a computer be used when reducing large quantities of data and to avoid calculation errors.

5.2 Reporting Procedures

Recording opacity observation data on a three-part form is most convenient. One part can be given to the appropriate facility personnel immediately following the on-site field observation if this is the agency policy or procedure, one part should be given to the Agency, and one part should be maintained in the observer's file. The data form should be completed on-site and signed by the observer, the facility representative (if applicable), and the data validator. All corrections must be initialed. The file copy should be signed by the data validator.

Inspection forms alone may not be adequate for documenting an enforceable violation and can be supplemented by a narrative report. It is recommended that a summary report be made containing the following information:

1. Name and location of facility, date and time of inspection, name of inspector, and name of company official(s) contacted.
2. Brief description of the specific process information gathered.

Company: Admiral Power Plant  Date: 15 July 1982  Location: 26 Queen Rd, Admiral City, Va.
Start time: 1350  Emission point: Oil Fired Boiler

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Figure 5.1 Visible emission summary data sheet.
Section 3.12.5

April 1983

3. Description of the equipment that was inspected and its operating mode at the time of inspection.
4. Notation of any excessive emissions seen and corresponding data from opacity continuous emissions monitor if available.
5. Explanation of excessive emissions, if available, and corrective actions being taken.
6. Summary of emission points not in compliance.
7. Recommendations for followup action.

One copy of the report, an updated plot plan, photographs, and other pertinent data should be placed in the Agency file. Whenever a violation is noted, it is EPA policy to notify the facility of the alleged violation and to permit them to review the evidence against them in a meaningful way. The importance of a good file cannot be overstated. This file represents the official Agency documentation of compliance history, the latest information on the source’s operation and compliance status. The file also provides the means of communicating source conditions to other staff members. A thorough and accurate historical record on source inspections and opacity readings is essential to good operation and any necessary compliance/enforcement actions.

5.3 Data Validation

All opacity observation data obtained for compliance determination should be validated by senior staff assigned this responsibility. Data validation procedures are described in References 16 and 17. These data should be checked to the extent possible for their completeness, the correctness of source, the emission point and description, the background, and the process and control equipment in use. The calculation of the average opacities and highest average opacity also should be checked. All calculation checks should agree within acceptable roundoff errors. If possible, any questionable data should be reviewed with the observer. Ideally the data validation should occur as soon as possible after the observations are recorded so that questions may be resolved. Any other calculations made for the purpose of supporting the data (e.g., the effect of angle of observation on the observed opacity) should also be verified. Note: Any corrections in the data must be forwarded to all interested parties so that they may correct their records (a data form should have been given to them after the opacity observations were completed).

5.4 Equipment Check

A check of the equipment following the opacity observations helps to ensure the quality of the data. Any indication of equipment damage/malfunction should be recorded on an equipment log and noted for purposes of data validation. The malfunctioning equipment should be repaired, adjusted, or replaced so that the equipment will be available for subsequent on-site field observations.

Table 5.1  Activity Matrix for Postobservation Operations

<table>
<thead>
<tr>
<th>Activity</th>
<th>Acceptance limits</th>
<th>Frequency and method of measurement</th>
<th>Action if requirements are not met</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data summary</td>
<td>Completed data form</td>
<td>See Subsec 3.12.6 for instructions for calculations</td>
<td>Complete the data summary</td>
</tr>
<tr>
<td>Reporting procedures</td>
<td>Completed report and data forms</td>
<td>Use 3-part form as suggested in Subsec 5.2</td>
<td>Complete the necessary data forms and reporting procedure</td>
</tr>
<tr>
<td>Data validation</td>
<td>All checks should agree within acceptable roundoff error</td>
<td>Make data validation check as soon as possible after VE observation</td>
<td>Forward all corrections of the data/calculations to the interested parties</td>
</tr>
<tr>
<td>Equipment check</td>
<td>All equipment/apparatus should be checked for satisfactory operation after each VE observation day</td>
<td>Check equipment for damage/malfunctions</td>
<td>Note on equipment log and repair, adjust or replace the equipment</td>
</tr>
</tbody>
</table>
Three types of calculations are described in this section: (1) the calculation of the average opacity for the specified time period (usually 6 min, or 24 observations recorded at 15-s intervals), (2) the calculation of the path length through the plume (seldom needed), and (3) the prediction of steam plume formation (seldom needed). In the first calculation, the 6-min running (or rolling) averages may be required. To minimize errors in the calculations, another individual should check all calculations for each VE determination for compliance. If a difference greater than a typical roundoff error is detected, the corrections should be made and initialed by the individual making the correction. Table 6.3 at the end of this section summarizes the quality assurance activities for these calculations.

6.1 Calculation of Average Opacity

Figure 6.1 shows actual opacity data taken at one company (unspecified) for two 6-min periods. Note: Any corrections made by an observer must be initialed and the corrected value used in the computation of an average. The calculations can be checked by obtaining the row and column subtotals; the totals of these subtotals must be identical. Running 6-min averages are calculated from data on Figure 6.2 and reported as described below. Running averages can include a time-lapse break in opacity readings when caused by an element that makes taking a valid reading difficult (e.g., fugitive emissions, improper background, or process shutdown). Running averages should not contain time-lapse breaks in the readings as a result of the observer's desire not to take visible emission data for personnel reasons when conditions exist that would allow the observer to take valid opacity data (e.g., eye strain or no desire to continue readings). Figure 6.3 is included to provide an easy reference between the VE reading time on Figure 6.1 and the start number on Figure 6.2. The start numbers are used to find the corresponding observation time for the beginning of the calculated six-minute average.

6.0 Calculations

Determination of the running average is generally performed by computer or by a hand calculator. The main purpose of the calculations is to determine the number of 6-min periods in excess of the standard and the greatest value for any 6-min period. It is also suggested, but not required, that the opacity readings be plotted on a graph showing percent opacity versus time, with a straight line connecting each subsequent reading.

6.1.1 Use of Computer for Calculations - It is highly recommended that a computer be used to calculate and plot data. Programming will vary with the language used by the particular computer, but the basic principle is as follows:

Input:
1. Enter all VE readings with their corresponding start number or identifying start time.

Computation:
1. The first average opacity reading is obtained by averaging the first 24 opacity readings.
2. Each succeeding running average is obtained from the previous one by adding the next observation reading and subtracting the first observation in the series and then dividing by 24 (assuming 6-min running average).

Output:
1. The computer should print all VE readings with their corresponding number or time. This printing will ensure that all readings have been entered properly.
2. The computer should search for all nonoverlapping 6-minute periods in excess of the standard. Each interval's average opacity value and corresponding number or time should be printed out.
3. Starting at the first interval, the computer should search for all nonoverlapping 6-minute periods in excess of the standard. Each interval's average opacity value and corresponding number or time should be printed out.
4. Finally, the computer should plot VE readings versus time intervals. If the computer has a plotter, it should be used. If not, the values can be plotted without connecting lines. If desired, the computer can bracket intervals in excess of the standard.

6.1.2 Use of Hand Calculator for Calculations - When a hand calculator is used, the calculation procedures are the same as those for the computer, except that they must be performed manually. All data should be recorded on the VE Summary Data Sheet (see Figure 6.2) if desired. To avoid calculating average opacity values that are less than the standard, the following procedure can be used. The total value for the 24 readings should be calculated first, and the total opacity should be calculated at Start no. 1.

Each succeeding total value can be obtained and recorded by adding the difference between the value dropped and the one added. These calculations can be performed easily without a calculator. If desired, the average opacity reading could then be calculated only for those totals that exceed the total allowable opacity limit (e.g., 20% x 24 = 480). Therefore, a total opacity of 480 or greater would be an exceedance of a 20 percent opacity standard. Method 9 does, however, require that the accuracy of the method be taken into account when determining possible violations of applicable opacity standard. It is suggested that when the opacity standard has been exceeded for any 24 consecutive readings, the data be hand-plotted with each VE reading versus its time interval. These plots fit best on graph paper scaled 10 lines to the inch. Each 15-second reading can be plotted at 1/2 spacing, thereby allowing 20 readings per inch. If desired, intervals of opacity in excess of the standards can be marked on this plot. It is much easier to visualize a trend in opacity with time with such a graphical presentation than with tabulated numerical readings as shown in Figure 6.4.

6.2 Calculation of Path Length Through the Plume

The observer should be located so that only one plume diameter is being sighted through. In rare cases, the observer has no choice but to be relatively close to the stack so that the view is up through the plume rather than across it. In these cases, the extra width of plume should be
### Section 3.12.6

**Admiral Power Plant**

**Address:** 112 Ocean Road

<table>
<thead>
<tr>
<th>Source Name</th>
<th>Observation Date</th>
<th>Start Time</th>
<th>Stop Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Admiral Power Plant</td>
<td>15 July 1982</td>
<td>1330</td>
<td>1342</td>
</tr>
</tbody>
</table>

**Source ID Number:** NEDS 45721

**Operating Mode:** Base Load

**Process Equipment:**

**Control Equipment:**

**Electrostatic Precipitator:**

**Observation Date:** 15 July 1982

**Start Time:** 1330

**Stop Time:** 1342

**Wind Speed:** 15 mph

**Wind Direction:** SW

**Ambient Temp.:** 54°F

**Water Droplets Present:** No

**Water Droplet Plume:** No

**Emmission:** Continuous

**Plume Type:** Continuous

**Description:**

- **Background:**
- **Sky:** Clear
- **Sky Conditions:** Partly Cloudy

**Comments:**

- Uses #6 Oil

**Observer's Name:** V.E. Proffitt

**Date:** 15 July 1982

**Organization:** State Air Pollution Control Board

**Certification:**

- **Certified by:** Eastern Technical Assoc.
- **Date:** 18 May 1982

**Title:** Shift Manager

**Date:** 7/15/82

**Verified by:** RDA

**Date:** 15 Aug 1982

---

*Figure 6.1. Visible emission observation form.*
Visible Emission Summary Data Sheet

Company: ADMIRAL POWER PLANT  Date: 15 JULY 1982  Location: 112 OCEAN RD, ADMIRAL CITY

Start time: 12:30  Emission point: 6K FIXED BOILER

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<th>Total opacity</th>
<th>Average opacity</th>
<th>Start no.</th>
<th>Total opacity</th>
<th>Average opacity</th>
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</table>

Maximum average: 36.8  % Start number of six minute average: 1

Number of nonoverlapping averages in excess of standard: 3  Listing start number of these averages: 1, 12, 80, 175

Calculated by: DATE: REVIEWED BY: DATE: 16 JULY 1982

Figure 6.2. Visible emission summary data sheet.
## Visible Emission Observation Form

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<th>Observation Date</th>
<th>Start Time</th>
<th>Stop Time</th>
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<tr>
<td>Stop</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Water Droplets Present: If Water Droplet Plume: Attached □ Detached □</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Point In The Plume At Which Opacity Was Determined</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Start</td>
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<tr>
<td>Stop</td>
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<tr>
<td>Describe Background</td>
<td></td>
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</tr>
<tr>
<td>Background Color</td>
<td>Sky Conditions</td>
<td></td>
<td></td>
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<tr>
<td>Start</td>
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<tr>
<td>Stop</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wind Speed</td>
<td>Wind Direction</td>
<td></td>
<td></td>
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<tr>
<td>Start</td>
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<td></td>
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<tr>
<td>Stop</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ambient Temp.</td>
<td>Wet Bulb Temp.</td>
<td>Relative Hum. %</td>
<td></td>
</tr>
<tr>
<td>Start</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stop</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

### Source Layout Sketch

<table>
<thead>
<tr>
<th>Observation Date</th>
<th>Start Time</th>
<th>Stop Time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Comments

- Observer's Name (Print)
- Organization
- I have received a copy of these opacity observations
- Certified by
- Title

### Figure 6.3.

Opacity data form with start numbers shown.
the known height of the stack and the distance from the observer to the base of the stack.
Method 1 (when slant angle $\theta$ is known)

$$1 - \left( \frac{O_o}{100} \right) = T \quad \text{Equation 6-1}$$

$$\frac{(1 - T_o) \times 100}{100} = O_c$$

where

- $O_o$ = observed opacity in %
- $T_o$ = observed transmittance
- $F$ = cosine of $\theta$
- $O_c$ = corrected opacity in %.

Method 2 (where distances are known)

$$\frac{1}{100} \left( \frac{O_o}{100} \right) = T$$

$$\frac{(1 - T_o) \times 100}{100} = O_c$$

where

- $O_o$ = observed opacity in %
- $T_o$ = observed transmittance
- $F$ = cosine of $\theta$
- $O_c$ = corrected opacity in %
- $H$ = height of stack
- $Y$ = distance of observer from stack.

Note: Since the correction is a power function, the correction must be made on each opacity reading and the corrected values used for calculations, in lieu of the correction being conducted on the reduced (averaged) data.

Table 6.1 presents the opacity corrected for slant angle or viewing angle $\theta$ versus the full range of opacity readings. For angles less than approximately 18° the adjustment is relatively insignificant.

6.3 Predicting Steam Plume Formation

The psychrometric chart can be used in conjunction with a simple...
Table 6.1. Opacity Correction for Slant Angle

<table>
<thead>
<tr>
<th>Measured opacity</th>
<th>Slant angle 8, degrees</th>
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</thead>
<tbody>
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<td>5</td>
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<tr>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

The equation to predict the formation of a visible water vapor (steam) plume. The psychrometric chart is a graphical representation of the solutions of various equations of the state of air and water vapor mixtures (see Figure 6.6). Both the ambient and stack emission data points on the chart are referred to as their “state point” and represent one unique combination of the following five atmospheric properties:

Dry bulb temperature - The actual ambient temperature; represented by the horizontal axis.

Wet bulb temperature - The temperature indicated by a “wet bulb” thermometer (a regular thermometer that has its bulb covered with a wet wick and exposed to a moving air stream); represented by the curved axis on the left side of the chart (saturation temperature).

Relative humidity - The ratio of the partial pressure of the water vapor to the vapor pressure of water at the same temperature; values are represented by the set of curved lines originating in the lower left portion of the chart.

Absolute humidity (humidity ratio) - The mass of water vapor per unit mass of air; expressed as grains per pound or pound per pound; represented by the vertical axes.

Specific volume - The volume occupied by a unit mass of air, expressed as cubic feet per pound; represented by the diagonal lines running from lower right to upper left. The relationships shown in the chart differ with changes in barometric pressure. The chart included in this section is for a barometric pressure of 29.92 inches of mercury. Therefore, with use of wet bulb dry bulb technique, if the actual pressure is less than about 29.5 inches of mercury, the humidity ratio should be calculated from the equation and not the chart.

Plotting the values for any two of the five atmospheric properties determines the values for the remaining three properties. For example, by using a sling psychrometer to measure the wet and dry bulb temperatures, one can determine the relative humidity, the absolute humidity, and the specific volume of the air.

To predict the occurrence of a visible steam plume, both the ambient air conditions and the stack gas conditions must be known or calculated and located on the psychrometric chart. If any portion of the line connecting the two points lies to the left of the 100 percent relative humidity line, it is an indication that the change of the exhaust gas from the stack state conditions to the ambient air state will be accompanied by the condensation of the water vapor present in the exhaust stream and a resultant visible steam plume.

Obtaining the state point for the ambient air conditions is relatively simple; as previously indicated, the wet and dry bulb temperatures, which will determine a unique state point, can be measured by using a sling psychrometer. Often the only data available for determining the state point of the stack gas are the dry bulb temperature of the exhaust gas stream and its moisture content. However, a relationship exists between the moisture content and the humidity ratio (or absolute humidity), as shown in the following equation:

$$\text{HR} = \frac{\text{MC}}{100} \times \frac{1}{\text{MC}} \text{ Equation 6-3}$$

where
- $\text{HH}$ = humidity ratio, in pound of water vapor per pound of dry air
- $\text{MC}$ = % moisture content, expressed as a decimal.

The following sample problem demonstrates the use of this equation.

**Given:**

- Ambient conditions:
  - Dry bulb temperature = 70°F
  - Wet bulb temperature = 60°F
  - Barometric pressure = 29.92 in Hg

- Effluent gas conditions:
  - Moisture content = 16.8% = 0.168

**Find:**

- Ambient relative humidity
- Exhaust gas humidity ratio
- Determine whether or not condensed water (steam plume) will form

*These are usually obtained from plant records or are estimated from recent source test data.*
Solution:
Plot ambient wet bulb and dry bulb temperatures (see Figure 6.5).
Ambient relative humidity = 55%.
Exhaust gas humidity ratio = HR

\[ HR = \frac{0.62 (\text{MC})}{1 - \text{MC}} \]

1 - 0.168 = 0.125 lb/lb dry air

Plot humidity ratio and stack dry bulb temperature (see Figure 6.6). Connect the ambient state point and stack gas state point with a straight line (see Figure 6.5). The line crosses the 100 percent relative humidity line; thus, formation of a visible water vapor plume is probable.

When the wet bulb/dry bulb technique is used and the barometric pressure is less than 29.5 in. Hg, it is suggested that Equation 6-5 be used to calculate the moisture content (MC).

\[ \text{MC} = \frac{V.P.}{P_{\text{sat}}} \quad \text{Equation 6-5} \]

where
\[ V.P. = \text{Vapor pressure of H}_2\text{O using Equation 6-6} \]
\[ P_{\text{sat}} = \text{Barometric pressure} \]

\[ VP = SVP - (3.57 \times 10^{-4}) (P_{\text{sat}}) (T_d - T_w) \]
\[ 1571 \quad \text{Equation 6-6} \]

Table 6.3: Activity Matrix for Calculations

<table>
<thead>
<tr>
<th>Calculation</th>
<th>Acceptance limits</th>
<th>Frequency and method of measurement</th>
<th>Action if requirements are not met</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average opacity</td>
<td>Data in Fig 6.1 completed and checked to within roundoff error</td>
<td>For each compliance test, perform independent check of data form and calculations</td>
<td>Complete the data and initial any changes in calculations</td>
</tr>
<tr>
<td>Running average opacity</td>
<td>Data in Fig 6.2 completed and checked</td>
<td>As above</td>
<td>As above</td>
</tr>
<tr>
<td>Path length through the plume</td>
<td>No limits have been set</td>
<td>For each compliance test with the slant angle &gt;18°, calculate using Eq. 6-1</td>
<td>Perform calculations</td>
</tr>
<tr>
<td>Predicting steam plume</td>
<td>No limits have been set</td>
<td>Use psychrometric chart and Equation 6-3</td>
<td>Perform calculations</td>
</tr>
</tbody>
</table>

Figure 6.6: Psychrometric chart for problem solution
7.0 Auditing Procedures

An audit is an independent assessment of data quality. Independence is achieved by using observers and data analysts other than the original observer/analyst. Routine QA checks for proper observer positioning and documentation are necessary to obtain good quality data. Table 7.1 at the end of this section summarizes the QA activities for auditing.

Two performance audits are recommended for VE readings:
1. Audit of observer by having an experienced observer make independent readings.
2. Audit of data forms and calculations.

In addition, it is recommended that a systems audit be conducted by an experienced observer at the same time the performance audit of visible emissions is conducted. The two performance audits are described in Subsection 7.1 and the systems audit is described in Subsection 7.2.

7.1 Performance Audits

Performance audits are quantitative evaluations of the quality of visible emission data.

7.1.1 Performance Audit of Visible Emissions - In this audit, an experienced observer goes with the observer being audited and both observers take the readings simultaneously (using the same time piece) and complete the data forms as independently as is practical. The audit is intended for observers in their first year and observers who have not made opacity observation in the field in over a year. The differences between the two readings serve as a measure of accuracy assuming the experienced observer reads the "true opacity." Because this assumption is not necessarily correct, the difference between the two readings is a combined measure of accuracy of both observers. For a minimum of six minutes (24 readings), the average of the absolute differences should be less than 10 percent, and no individual differences should exceed 20 percent. The values of 10% and 20% suggested for the limits are the approximate results of combining the allowable errors of the two observers; e.g., $\sqrt{10^2 + 15^2} = 10.6\%$, and $\sqrt{15^2 + 15^2} = 21.2\%$. This audit should be performed twice in a year for the first year of an observer and whenever conditions tend to warrant them thereafter. Calculate $%A$ using Equation 7-1:

$$%A = \frac{|VE (observer) - VE (auditor)|}{VE (observer)} \times 100\%$$  

where

- $VE (observer)$ = average and individual VE reading(s) of the observer being audited
- $VE (auditor)$ = average and individual VE reading(s) of the auditor.

7.1.2 Performance Audit of Data Calculations - This audit is an independent check of all calculations performed for the summary VE report. Every calculation should be checked within round-off error. This audit should be conducted on at least 7 percent of the annual numbers of VE summary reports.

7.2 System Audit

A system audit provides an on-site qualitative inspection and review of the total inspection. This audit includes a check of the "Record of Visual Determination of Opacity," Figure 9.1 of Section 3.12.8, and the top portion of the "Observation Record," Figure 9.2 of Section 3.12.8. In addition, the auditor should assess the visible emission inspection technique used by the auditee. This portion of the system audit is best handled in conjunction with the performance audit described in the previous Subsection 7.1.1. Therefore, the frequency of the system audit should coincide with the frequency of the performance audits of visible emissions. Some observations to be made by the auditor are listed in Figure 7.1.

<table>
<thead>
<tr>
<th>Audit</th>
<th>Acceptance limits</th>
<th>Frequency and method of measurement</th>
<th>Action if requirements are not met</th>
</tr>
</thead>
<tbody>
<tr>
<td>Performance audit of visible emissions</td>
<td>Individual observations within ±20%; average absolute deviation within ±10%</td>
<td>At least two times during the first year; simultaneous observation and data recording</td>
<td>Review observation techniques</td>
</tr>
<tr>
<td>Performance audit of data calculations</td>
<td>Original and check calculations agree within round-off error</td>
<td>Seven percent of tests for compliance, perform independent check on all calculations</td>
<td>Check and correct all calculated results (averages)</td>
</tr>
<tr>
<td>System audit</td>
<td>Conduct observations as described in this section of the Handbook</td>
<td>At least two times during the first year; use audit checklist (Fig 7.1)</td>
<td>Explain to observer the deviations from recommended procedures; note the deviations on Fig 7.1</td>
</tr>
</tbody>
</table>
### Section 3.12.7

**Name of individual(s) audited:** Buff A. Law  
**Affiliation:** New York State Agency

**Auditor name:** N. Jersey  
**Affiliation:** Region II EPA  
**Date of audit:** 12-25-82  
**Auditor signature:** New Jersey

<table>
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<th>Yes</th>
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<th>Comment</th>
<th>Operation</th>
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<tr>
<td>√</td>
<td></td>
<td></td>
<td>1. Equipment satisfactory</td>
</tr>
<tr>
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<td></td>
<td></td>
<td>2. Data forms completed</td>
</tr>
<tr>
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<td></td>
<td></td>
<td>3. Post-notification (courtesy obligation) performed</td>
</tr>
<tr>
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<td></td>
<td></td>
<td>4. Correct identification of point of emissions</td>
</tr>
<tr>
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<td></td>
<td></td>
<td>5. Plume associated with process generation point</td>
</tr>
<tr>
<td>√</td>
<td></td>
<td></td>
<td>6. Credentials okay</td>
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<tr>
<td>√</td>
<td></td>
<td></td>
<td>7. Observer acted in professional and courteous manner</td>
</tr>
<tr>
<td>√</td>
<td></td>
<td></td>
<td>8. Proper observer position</td>
</tr>
<tr>
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<td></td>
<td></td>
<td>9. Opacity readings complete</td>
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<tr>
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<td></td>
<td></td>
<td>10. Ancillary measurements available</td>
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<tr>
<td>√</td>
<td></td>
<td></td>
<td>11. Camera used to validate sightings/source identification</td>
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<tr>
<td>√</td>
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<td></td>
<td>12. Facility personnel given a copy of raw data</td>
</tr>
<tr>
<td>√</td>
<td></td>
<td></td>
<td>13. Multiple sources/plumes/outlets</td>
</tr>
<tr>
<td>√</td>
<td></td>
<td></td>
<td>14. Lighting conditions satisfactory</td>
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<tr>
<td>√</td>
<td></td>
<td></td>
<td>15. Background conditions (raining, etc.) satisfactory</td>
</tr>
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<td></td>
<td></td>
<td>16. Slant angle recorded</td>
</tr>
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<td></td>
<td>17. Fugitive emissions</td>
</tr>
<tr>
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<td></td>
<td>18. Time of day recorded</td>
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<tr>
<td>√</td>
<td></td>
<td></td>
<td>19. Recertified within last 6 months</td>
</tr>
</tbody>
</table>

**General comments:**

Performance Audit of VE Readings Were Acceptable. However, All of the VE Readings were less than 20% in Opacity from the source.

*Figure 7.1. Method 9 checklist for auditors.*
Method 9—Visual Determination of the Opacity of Emissions from Stationary Sources

Many stationary sources discharge visible emissions into the atmosphere; these emissions are usually in the shape of a plume. This method involves the determination of plume opacity by qualified observers. The method includes procedures for the training and certification of observers, and procedures to be used in the field for determination of plume opacity. The appearance of a plume as viewed by an observer depends upon a number of variables, some of which may be controllable and some of which may not be controllable in the field. Variables which can be controlled to an extent to which they no longer exert a significant influence upon plume appearance include: Angle of the observer with respect to the plume, angle of the observer with respect to the sun; point of observation of attached and detached steam plume; and angle of the observer with respect to a plume emitted from a rectangular stack with a large length to width ratio. The method includes specific criteria applicable to these variables. Other variables which may not be controllable in the field are luminescence and color contrast between the plume and the background against which the plume is viewed. These variables exert an influence upon the appearance of a plume as viewed by an observer, and can affect the ability of the observer to accurately assign opacity values to the observed plume. Studies of the theory of plume opacity and field studies have demonstrated that a plume is most visible and presents the greatest apparent opacity when viewed against a contrasting background. It follows from this, and is confirmed by field trials, that the opacity of a plume, viewed under conditions where a contrasting background is present can be assigned with the greatest degree of accuracy. However, the potential for a positive error is also the greatest when a plume is viewed under such contrasting conditions. Under conditions presenting a less contrasting background, the apparent opacity of a plume is less and approaches zero as the color and luminescence contrast decrease toward zero. As a result, significant negative bias and negative errors can be made when a plume is viewed under less contrasting conditions. A negative bias decreases rather than increases the possibility that a plant operator will be cited for a violation of opacity standards due to observer error. Studies have been undertaken to determine the magnitude of positive errors which can be made by qualified observers while reading plumes under contrasting conditions and using the procedures set forth in this method. The results of these studies (field trials) which involve a total of 769 sets of 25 readings each are as follows:

(1) For black plumes (133 sets at a smoke generator), 100 percent of the sets were read with a positive error1 of less than 7.5 percent opacity; 99 percent were read with a positive error of less than 5 percent opacity.

(2) For white plumes (170 sets at a smoke generator, 168 sets at a coal-fired power plant, 298 sets at a sulfuric acid plant), 99 percent of the sets were read with a positive error of less than 7.5 percent opacity; 95 percent were read with a positive error of less than 5 percent opacity.

The positive observational error associated with an average of twenty-five readings is therefore established. The accuracy of the method must be taken into account when determining possible violations of applicable opacity standards.

1. Principle and applicability.

1.1 Principle. The opacity of emissions from stationary sources is determined visually by a qualified observer.

1.2 Applicability. This method is applicable for the determination of the opacity of emissions from stationary sources pursuant to § 60.11(b) and for qualifying observers for visually determining opacity of emissions.

2. Procedures.

The observer qualified in accordance with paragraph 3 of this method shall use the following procedures for visually determining the opacity of emissions:

2.1 Position. The qualified observer shall stand at a distance sufficient to provide a clear view of the emissions with the sun oriented in the 140° sector to his back. Consistent with maintaining the above requirement, the observer shall, as much as possible, make his observations from a position with his line of vision is approximately perpendicular to the plume direction, and when observing opacity of emissions from rectangular outlets (e.g. roof monitors, open baghouses, noncircular stacks), approximately perpendicular to the longer axis of the outlet. The observer’s line of sight should not include more than one plume at a time when multiple stacks are involved, and in any case the observer should make his observations with his line of sight perpendicular to the longer axis of such a set of multiple stacks (e.g. stub-stacks on baghouses).

2.2 Field records. The observer shall record the name of the plant, emission location, type facility, observer’s name and affiliation, and the date on a field data sheet (Figure 9-1). The estimated time from the emission location, approximate wind direction, estimated wind speed, description of the sky condition (presence and color of clouds), and plume background are recorded on a field data sheet at the time opacity readings are initiated and completed.

2.3 Observations. Opacity observations shall be made at the point of greatest opacity in that portion of the plume where condensed water vapor is not present. The observer shall not look continuously at the plume, but instead shall observe the plume momentarily at 15-second intervals.

2.3.1. Attached steam plumes. When condensed water vapor is present within the plume as it emerges from the emission outlet, opacity observations shall be made beyond the point in the plume at which
condensed water vapor is no longer visible. The observer shall record the approximate distance from the emission outlet to the point in the plume at which the observations are made.

2.3.2 Detached steam plume. When water vapor in the plume condenses and becomes visible at a distinct distance from the emission outlet, the opacity of emissions should be evaluated at the emission outlet prior to the condensation of water vapor and the formation of the steam plume.

2.4 Recording observations. Opacity observations shall be recorded to the nearest 5 percent at 15-second intervals on an observational record sheet. (See Figure 9-2 for an example.) A minimum of 24 observations shall be recorded. Each momentary observation recorded shall be deemed to represent the average opacity of emissions for a 15-second period.

2.5 Data Reduction. Opacity shall be determined as an average of 24 consecutive observations recorded at 15-second intervals. Divide the observations recorded on the record sheet into sets of 24 consecutive observations. A set is composed of any 24 consecutive observations. Sets need not be consecutive in time and in no case shall two sets overlap. For each set of 24 observations, calculate the average by summing the opacity of the 24 observations and dividing this sum by 24. If an applicable
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Figure 9.2 Observation Record
standard specifies an averaging time requiring more than 24 observations, calculate the average for all observations made during the specified time period. Record the average opacity on a record sheet. (See Figure 9-1 for an example.)

3. Qualifications and testing.

3.1 Certification requirements. To receive certification as a qualified observer, a candidate must be tested and demonstrate the ability to assign opacity readings in 5 percent increments to 25 different black plumes and 25 different white plumes, with an error not to exceed 15 percent opacity on any one reading and an average error not to exceed 7.5 percent opacity in each category. Candidates shall be tested according to the procedures described in paragraph 3.2. Smoke generators used pursuant to paragraph 3.2 shall be equipped with a smoke meter which meets the requirements of paragraph 3.3.

The certification shall be valid for a period of 6 months, at which time the qualification procedure must be repeated by any observer in order to retain certification.

3.2 Certification procedure. The certification test consists of showing the candidate a complete run of 50 plumes—25 black plumes and 25 white plumes—generated by a smoke generator. Plumes within each set of 25 black and 25 white runs shall be presented in random order. The candidate assigns an opacity value to each plume and records his observation on a suitable form. At the completion of each run of 50 readings, the score of the candidate is determined. If a candidate fails to qualify, the complete run of 50 readings must be repeated in any retest. The smoke test may be administered as part of a smoke school or training program, and may be preceded by training or familiarization runs of the smoke generator during which candidates are shown black and white plumes of known opacity.

3.3 Smoke generator specifications. Any smoke generator used for the purposes of paragraph 3.2 shall be equipped with a smoke meter installed to measure opacity across the diameter of the smoke generator stack. The smoke meter output shall display instack opacity based upon a path length equal to the stack exit diameter, on a full 0 to 100 percent chart recorder scale. The smoke meter optical design and performance shall meet the specifications shown in Table 3.1 prior to the conduct of each smoke reading test. At the completion of each test, the zero and span drift shall be checked and if the drift exceeds ±1 percent opacity, the conditions shall be corrected prior to conducting any subsequent test runs. The smoke meter shall be demonstrated, at the time of installation, to meet the specifications listed in Table 9-1. This demonstration shall be repeated following any subsequent repair or replacement of the photocell or associated electronic circuitry including the chart recorder or output meter, or every 6 months, whichever occurs first.

Table 9-1. Smoke Meter Design and Performance Specifications

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
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<tbody>
<tr>
<td>a. Light source</td>
<td>Incandescent lamp operated at nominal rated voltage.</td>
</tr>
<tr>
<td>b. Spectral response of photocell</td>
<td>Daylight spectral response of the human eye—see reference 4.3.</td>
</tr>
<tr>
<td>c. Angle of view</td>
<td>15° maximum total angle.</td>
</tr>
<tr>
<td>d. Angle of projection</td>
<td>15° maximum total angle.</td>
</tr>
<tr>
<td>e. Calibration error</td>
<td>≤3% opacity, maximum ±2 percent.</td>
</tr>
<tr>
<td>f. Zero and span drift</td>
<td>≤5 seconds.</td>
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<tr>
<td>g. Response time</td>
<td>≤15 minutes.</td>
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</table>

3.3.1 Calibration. The smoke meter is calibrated after allowing a minimum of 30 minutes warmup by alternately producing simulated opacity of 0 percent and 100 percent. When stable response at 0 percent or 100 percent is noted, the smoke meter is adjusted to produce an output of 0 percent or 100 percent, as appropriate. This calibration shall be repeated until stable 0 percent and 100 percent readings are produced without adjustment. Simulated 0 percent and 100 percent opacity values may be produced by alternately switching the power to the light source on and off while the smoke generator is not producing smoke.

3.3.2 Smoke meter evaluation. The smoke meter design and performance are to be evaluated as follows:

3.3.2.1 Light source. Verify from manufacturer’s data and from voltage measurements made at the lamp, as installed, that the lamp is operated within ±5 percent of the nominal rated voltage.

3.3.2.2 Spectral response of photocell. Verify from manufacturer’s data that the photocell has a photopic response; i.e., the spectral sensitivity of the cell shall closely approximate the standard spectral-luminosity curve for photopic vision which is referenced in (b) of Table 9-1.

3.3.2.3 Angle of view. Check construction geometry to ensure that the total angle of view of the smoke plume, as seen by the photocell, does not exceed 15°. The total angle of view may be calculated from: θ = 2 tan⁻¹ d/2L, where θ = total angle of view; d = the sum of the photocell diameter + the diameter of the limiting aperture, and L = the distance from the photocell to the limiting aperture. The limiting aperture is the point in the path between the photocell and the smoke plume where the angle of view is most restricted. In smoke generator smoke meters this is normally an orifice plate.

3.3.2.4 Angle of projection. Check construction geometry to ensure that the total angle of projection of the lamp on the smoke plume does not exceed 15°. The total angle of projection may be calculated from: θ = 2 tan⁻¹ d/2L, where θ = total angle of projection; d = the sum of the length of the lamp filament + the diameter of the limiting aperture, and L = the distance from the lamp to the limiting aperture.

3.3.2.5 Calibration error. Using neutral-density filters of known opacity, check the error between the actual response and the theoretical linear response of the smoke meter. This check is accomplished by first calibrating the smoke meter according to 3.3.1 and then inserting a series of three neutral-density filters of nominal opacity of 20, 50, and 75 percent in the smoke meter path length. Filters calibrated within ±2 percent shall be used. Care should be taken when inserting the filters to prevent stray light from affecting the meter. Make a total of five nonconsecutive readings for each filter. The maximum error on any one reading shall be 3 percent opacity.

3.3.2.6 Zero and span drift. Determine the zero and span drift by calibrating and operating the smoke
generator in a normal manner over a 1-hour period. The drift is measured by checking the zero and span at the end of this period.

3.3.2.7 Response time. Determine the response time by producing the series of five simulated 0 percent and 100 percent opacity values and observing the time required to reach stable response. Opacity values of 0 percent and 100 percent may be simulated by alternately switching the power to the light source off and on while the smoke generator is not operating.

4. References.

4.1 Air Pollution Control District Rules and Regulations, Los Angeles County Air Pollution Control District, Regulation IV, Prohibitions, Rule 50.


9.0 References and Bibliography


Blank data forms are provided on the following pages for the convenience of the QA Handbook user. No documentation is given on these forms because it would detract from their usefulness. Also, the titles are placed at the top of the figures, as is customary for a data form. These forms are not required format, but are intended as guides for the development of an organization's own program. To relate the form to the text, a form number is also indicated in the lower right-hand corner (e.g., Form M9-1.1, which implies that the form is Figure 1.1. in Section 3.12.1 of the Method 9 Handbook). Any future revisions of this form can be documented by adding A, B, C (e.g., 1.1A, 1.1B). The data forms included in this section are listed below.

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<thead>
<tr>
<th>Form</th>
<th>Title</th>
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<td>1.2</td>
<td>Sample Certification Test Form</td>
</tr>
<tr>
<td>2.1</td>
<td>Procurement Log</td>
</tr>
<tr>
<td>4.1</td>
<td>Visible Emission Observer's Plant Entry Checklist</td>
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<tr>
<td>4.1</td>
<td>Visible Emission Observer's Plant Entry Checklist (Reverse Side)</td>
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<tr>
<td>4.2</td>
<td>Visible Emission Observation Form</td>
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<td>4.2</td>
<td>Visible Emission Observation Form (Reverse Side)</td>
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<td>Visible Emission Summary Data Sheet</td>
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<td>Visible Emission Summary Data Sheet (same as Figure 5.1)</td>
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<td>Method 9 Checklist for Auditors</td>
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## Sample Certification Test Form

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Deviation

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Quality Assurance Handbook M9-1.2
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April 1983 3 Section 3.12.10

Quality Assurance Handbook M9-2.1
**Visible Emission Observer's Plant Entry Checklist**

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<td>Date of VE observation</td>
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**Previous company contact (if applicable)**

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<th>Title</th>
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**Purpose of visit**

**Emission points at which VE observations to be conducted**

**Authority for entry (see reverse side)**

**Plant safety requirements**

- [ ] Hardhat
- [ ] Safety glasses
- [ ] Side shields (on glasses)
- [ ] Goggles
- [ ] Hearing protection
- [ ] Specify
- [ ] Safety shoes (steel-toed)
- [ ] Insulated shoes
- [ ] Gloves
- [ ] Coveralls
- [ ] Dust mask suggested
- [ ] Respirator(s)
  - Specify
- [ ] Other
  - Specify

**Company official contacted (on this visit)**

<table>
<thead>
<tr>
<th>Title</th>
</tr>
</thead>
</table>
Visible Emission Observer's Plant Checklist (Continued)

Authority for Plant Entry: Clean Air Act, Section 114

(a)(2) the Administrator or his authorized representative upon presentation of his credentials -
(A) shall have a right of entry to, upon or through any premises of such person or in which any records required to be
maintained under paragraph (1) of this section are located, and

(B) may at reasonable times have access to, and copy of any records, inspect any monitoring equipment or methods
required under paragraph (1), and sample any emissions which such person is required to sample under
paragraph (1).

(b)(1) Each State may develop and submit to the Administrator a procedure for carrying out this section in such State. If the
Administrator finds the State procedure is adequate, he may delegate to such State any authority he has to carry out this
section.

(2) Nothing in this subsection shall prohibit the Administrator from carrying out this section in a State.
(c) Any records, reports or information obtained under subsection (a) shall be available to the public except that upon a showing
satisfactory to the Administrator by any person that records, reports, or information, or particular part thereof, (other than
emission data) to which the Administrator has access under this section if made public would divulge methods or processes
entitled to protection as trade secrets of such person: the Administrator shall consider such record, report, or information or
particular portion thereof confidential in accordance with the purposes of Section 7905 of Title 18 of the United States
concerned with carrying out this Act or when relevant in any proceeding under this Act.

Confidential Information: Clean Air Act, Section 114 (see above) 41 Federal Register 36902, September 1, 1976

If you believe that any of the information required to be submitted pursuant to this request is entitled to be treated as
confidential, you may assert a claim of business confidentiality, covering all or any part of the information, by placing on (or
attaching to) the information a cover sheet, stamped or typed legend, or other suitable notice, employing language such as
"trade secret," "proprietary," or "company confidential." Allegedly confidential portions of otherwise nonconfidential
information should be clearly identified. If you desire confidential treatment only until the occurrence of a certain event; the
notice should so state. Information so covered by a claim will be disclosed by EPA only to the extent, and through the procedures,
set forth at 40 CFR, Part 2, Subpart B (41 Federal Register 36902, September 1, 1976.)

If no confidentiality claim accompanies this information when it is received by EPA, it may be made available to the public by
EPA without further notice to you.

Quality Assurance Handbook M9-4.1
Visible Emission Observation Form

<table>
<thead>
<tr>
<th>SOURCE NAME</th>
<th>OBSERVATION DATE</th>
<th>START TIME</th>
<th>STOP TIME</th>
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<td>PHONE</td>
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<td>OPERATING MODE</td>
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<td>CONTROL EQUIPMENT</td>
<td>OPERATING MODE</td>
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<tr>
<td>DESCRIBE EMISSION POINT</td>
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<td>STOP</td>
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<td>HEIGHT ABOVE GROUND LEVEL</td>
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<td>DISTANCE FROM OBSERVER</td>
<td>DIRECTION FROM OBSERVER</td>
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<td>DESCRIPTION EMISSIONS</td>
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<td>STOP</td>
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<td>EMISSION COLOR</td>
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<tr>
<td>WATER DROPLETS PRESENT:</td>
<td>IF WATER DROPLET PLUME:</td>
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<td></td>
</tr>
<tr>
<td>NO YES ATTACHED DETACHED</td>
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<tr>
<td>POINT IN THE PLUME AT WHICH OPACITY WAS DETERMINED</td>
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<td>START</td>
<td>STOP</td>
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<td>BACKGROUND COLOR</td>
<td>SKY CONDITIONS</td>
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<td>WIND SPEED</td>
<td>WIND DIRECTION</td>
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<td>AMBIENT TEMP.</td>
<td>WET BULB TEMP.</td>
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<td>START</td>
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</tr>
<tr>
<td>Source Layout Sketch</td>
<td>Draw North Arrow</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sun Wind Plume and Stack</td>
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<tr>
<td>Sun Location Line</td>
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<td>X Emission Point</td>
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<td></td>
</tr>
<tr>
<td>Observers Position</td>
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<td></td>
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<tr>
<td>140°</td>
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<td></td>
</tr>
</tbody>
</table>

COMMENTS

I HAVE RECEIVED A COPY OF THESE OPACITY OBSERVATIONS CERTIFIED BY
SIGNATURE DATE

TITLE DATE

ORGANIZATION

QUALITY ASSURANCE HANDBOOK M9-4.2
Visible Emission Observation Form

This form is designed to be used in conjunction with EPA Method 9, “Visual Determination of the Opacity of Emissions from Stationary Sources.” Any deviations, unusual conditions, circumstances, difficulties, etc., not dealt with elsewhere on the form should be fully noted in the section provided for comments. Following are brief descriptions of the type of information that needs to be entered on the form; for a more detailed discussion of each part of the form, refer to the “User’s Guide to the Visible Emission Observation Form.”

*Source Name - full company name, parent company or division information, if necessary.

*Address - street (not mailing) address or physical location of facility where VE observation is being made.

Phone - self-explanatory.

Source ID Number - number from NEDS, COS, agency file, etc.

*Process Equipment, Operating Mode - brief description of process equipment (include ID no.) and operating rate, % capacity utilization, and/or mode (e.g., charging, tapping).

*Control Equipment, Operating Mode - specify control device type(s) and % utilization, control efficiency.

*Describe Emission Point - stack or emission point location, geometry, diameter, color; for identification, purposes.

*Height Above Ground Level - stack or emission point height, from files or engineering drawings.

*Height Relative to Observer - indicate vertical position of observation point relative to stack top.

*Distance From Observer - distance to stack & 10%; to determine, use rangefinder or map.

*Direction From Observer - direction to stack; use compass or map; be accurate to eight points of compass.

*Describe Emissions - include plume behavior and other physical characteristics (e.g., looping, lacy, condensing, fumigating, secondary particle formation, distance plume visible, etc.).

*Emission Color - gray, brown, white, red, black, etc.

Plume Type:
- Continuous - opacity cycle >6 minutes
- Fugitive - no specifically designed outlet
- Intermittent - opacity cycle <6 minutes

**Water Droplets Present - determine by observation or use wet sling psychrometer; water droplet plumes are very white, opaque, and billowy in appearance, and usually dissipate rapidly.

**If Water Droplet Plume:
- Attached - forms prior to exiting stack
- Detached - forms after exiting stack

**Point in the Plume at Which Opacity was Determined - describe physical location in plume where readings were made (e.g., 4 in. above stack exit or 10 ft after dissipation of water plumes).

*Describe Background - object plume is read against, include atmospheric conditions (e.g., hazy).

*Background Color - blue, white, new leaf green, etc.

*Sky Conditions - indicate cloud cover by percentage or by description (clear, scattered, broken, overcast, and color of clouds).

*Windspeed - use Beaufort wind scale or hand-held anemometer; be accurate to ±5 mph.

*Wind Direction - direction wind is from; use compass; be accurate to eight points.

*Ambient Temperature - in °F or °C.

**Wet Bulb Temperature - the wet bulb temperature from the sling psychrometer.

**Relative Humidity - use sling psychrometer; use local U.S. Weather Bureau only if nearby.

*Source Layout Sketch - include wind direction, associated stacks, roads, and other landmarks to fully identify location of emission point and observer position.

Draw North Arrow - point line of sight in direction of emission point, place compass beside circle, and draw in arrow parallel to compass needle.

Sun Location Line - point line of sight in direction of emission point, place pen upright on sun location line, and mark location of sun when pen's shadow crosses the observers position.

**Comments - factual implications, deviations, alterations, and/or problems not addressed elsewhere.

Acknowledgment - signature, title, and date of company official acknowledging receipt of a copy of VE observation form.

*Observation Date - date observations conducted.

*Start Time, Stop Time - beginning and end times of observation period (e.g., 1635 or 4:35 p.m.).

*Data Set - percent opacity to nearest 5%; enter from left to right starting in left column.

*Average Opacity for Highest Period - average of highest 24 consecutive opacity readings.

Number of Readings Above (Frequency Count) count of total number of readings above a designated opacity

*Range of Opacity Readings:
- Minimum - lowest reading
- Maximum - highest reading

*Observer's Name - print in full.

Observer's Signature. Date - sign and date after performing final calculations.

*Organization - observer's employer.

*Certifier, Date - name of "smoke school" certifying observer and date of most recent certification.

Verifier. Date - signature of person responsible for verifying observer's calculations and date of verification.

Quality Assurance Handbook M.9-4.2
### Visible Emission Summary Data Sheet

**Company**

**Date**

**Location**

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<tr>
<th>Start no.</th>
<th>Total opacity</th>
<th>Average opacity</th>
<th>Start no.</th>
<th>Total opacity</th>
<th>Average opacity</th>
<th>Start no.</th>
<th>Total opacity</th>
<th>Average opacity</th>
<th>Start no.</th>
<th>Total opacity</th>
<th>Average opacity</th>
<th>Start no.</th>
<th>Total opacity</th>
<th>Average opacity</th>
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</table>

- Maximum average
- % Start number of six minute average
- Number of nonoverlapping averages in excess of standard
- Listing start number of these averages
- Calculated by
- Date
- Reviewed by
- Date

*Quality Assurance Handbook M9-5.1 and M9-6.2*
# Method B Checklist for Auditors

Name of individual(s) audited

Affiliation

Auditor name

Affiliation

Date of audit

Auditor signature

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<thead>
<tr>
<th>Yes</th>
<th>No</th>
<th>Comment</th>
<th>Operation</th>
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</thead>
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<td>2. Data forms completed</td>
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<td>3. Post-notification (courtesy obligation) performed</td>
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<td>4. Correct identification of point of emissions</td>
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<td></td>
<td>5. Plume associated with process generation point</td>
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<td></td>
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<td>6. Credentials okay</td>
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</tr>
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<td>7. Observer acted in professional and courteous manner</td>
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<td>8. Proper observer position</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>9. Opacity readings complete</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>10. Ancillary measurements available</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>11. Camera used to validate sightings/source identification</td>
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<tr>
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<td>12. Facility personnel given a copy of raw data</td>
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<td>13. Multiple sources/plumes/outlets</td>
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<tr>
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<td>14. Lighting conditions satisfactory</td>
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<td>15. Background conditions (training, etc.) satisfactory</td>
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<tr>
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<td>16. Slant angle recorded</td>
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<td>17. Fugitive emissions</td>
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<td></td>
<td>18. Time of day recorded</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>19. Recertified within last 6 months</td>
<td></td>
</tr>
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</table>

**General comments:**

Quality Assurance Handbook MS-7.1
INSTRUCTIONS FOR USE OF
THE VISIBLE EMISSION OBSERVATION FORM

INTRODUCTION

Federal Reference Method 9 - Visible Determination of the Opacity of Emissions from Stationary Sources (Federal Register 39 39872, November 12, 1974) requires the recording of certain specific information in the field documentation of a visible emission observation. The required information includes the name of the plant, the emission location, the type of facility, the observer's name and affiliation, the date, the time, the estimated distance to the emission location, the approximate wind direction, the estimated wind speed, a description of the sky conditions, the plume background, in addition to a minimum of 24 opacity observations.

Field experience gained from past use of Method 9 in determining compliance of sources subject to opacity standards has demonstrated a need for additional documentation when making visible emissions (VE) observations. The attached Visible Emissions Observation Form was developed to assist in the collection of information required by Method 9 and suggested additional information. The form was developed after a review of the opacity forms in use in EPA Regional Offices and State and local air quality control agencies. The form includes not only the data required by Method 9, but also more descriptive information on observation conditions.

The Visible Emissions Observation Form as designed is a three-part form; the top copy (original) goes to the agency files, the second copy is for the VE observer's file, and it is intended that the third copy be given to the appropriate facility personnel immediately following the onsite field observation if this is the agency policy or procedure. The forms are numbered serially with a 5-digit number and each copy of the three part form is imprinted with the same number. The form should be completed onsite and signed by the observer. It is recommended that waterproof black ink always be used with these forms.

The Visible Emissions Observation Form (see Figure 1) can be functionally divided into 10 major sections, with each section documenting one or two aspects of the opacity determination. An "additional information" section is included for notation of relevant information not covered elsewhere on the form. Spaces for temporal change entries (e.g. "start," end" and the "comments" section of the data set) are used to record new information when the observation conditions change during the observation period.

The following guidelines discuss the major sections and each data element found on the VE Observation Form. This includes a short explanation of each section's purpose, an explanation of each data element, a description of the type of information being sought, and in some cases, examples of appropriate entries. Discussions are keyed to Figure 1 by corresponding capital letters, and starred items indicate that the information is required by Method 9.

Separate companion forms including a company notification record and sheets for data reduction calculations are being prepared to accompany the VE Observation Form. To tie all these forms

September 1993
together, all companion forms will include a space for recording the 5-digit number(s) of the VE Observation Form(s) to which they relate. Each companion form will be accompanied by a set of instructions, which like the instructions which follow, will address each data element on the form and will include examples of appropriate entries.

A. COMPANY IDENTIFICATION. Provides information that uniquely identifies the company and permits the observer to locate or make contact with the company.

<table>
<thead>
<tr>
<th>COMPANY NAME</th>
</tr>
</thead>
<tbody>
<tr>
<td>STREET ADDRESS</td>
</tr>
<tr>
<td>CITY</td>
</tr>
<tr>
<td>PHONE (KEY CONTACT)</td>
</tr>
</tbody>
</table>

Company Name* - Include the facility's complete name. For positive identification of the facility, the parent company name, division, or subsidiary name should be included.

Street Address* - Indicate the street address of the facility (not the mailing address or the home office address) so that the exact physical location of the source is known. If necessary, the mailing address or home office address may be listed elsewhere.

Phone (Key Contact) - List the phone number for the appropriate contact person at the facility such as the plant manager or environmental officer.

Source ID Number - This space is provided for the use of agency personnel and may be used to enter the number the agency uses to identify that particular source, such as the State file number, Compliance Data System number, or National Emission Data System number.

B. PROCESS AND CONTROL DEVICE TYPE. Includes a several-word descriptor of the process and control device, indication of current process operating capacity or mode, and operational status of control equipment. Note: This section, in particular, includes information that will probably have to be obtained from a plant official. EPA personnel asking a plant official for information requires the approval of OMB, an active case investigation, or a prominent disclaimer that the official is under no obligation to answer. Since a facility may consider their production rate or other process information as proprietary, the inspector shall specifically inform them that they have the right to request that this information be submitted subject to the "confidential business information" provisions of 40 CFR 2 Subpart B.

* Required by Reference Method 9; other items recommended.
Process Equipment - Enter a description which clearly identifies the process equipment and type of facility that emits the plume or emissions to be read. The description should be brief, but should include as much information as possible, as indicated in the following examples:

- Coal-Fired Boiler - Unit 4/Power Plant
- #2 Oil-Fired Boiler/Chemical Plant
- Wood Waste Conical Incinerator
- Paint Spray Booth/Auto Plant
- Primary Crusher at Rock Quarry
- Fiberglass Curing Oven
- Reverb Furnace/Copper Smelter
- Basic Oxygen Furnace/Steel Mill
- Cement Plant Kiln

Operating Mode - Depending on the type of process equipment, this information may vary from a quantification of the current operating rate or a description of the portion of a batch-type process for which the emission opacity is being read to an explanation of how the equipment is currently operating such as "upset conditions," "startup," or "shutdown." Other examples include "90 percent capacity" for a boiler or "85 percent production rate" for the shakeout area of a grey iron foundry. For a steel making furnace, entries should include the exact part of the process cycle for which readings are being made, such as "charging" or "tapping." In most cases, this information will have to be obtained from a plant official.

Control Equipment - Specify the type(s) of control equipment being used in the system after the process equipment in question (e.g., "hot-side electrostatic precipitator").

Operating Mode - Indicate the manner in which the control equipment is being utilized at the time of the opacity observations (e.g., 1 field of 8 tripped on ESP, scrubber operating without water, shut down, off line) and the operating mode (e.g., automatic, manual, bypass). This information should be obtained from a plant official.

C. EMISSION POINT IDENTIFICATION. Contains information uniquely identifying the emission point and its spatial relationship with the observer's position. It is recommended that distances and heights in this section be noted in consistent units.
### DESCRIBE EMISSION POINT

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>HEIGHT ABOVE GROUND LEVEL</strong></td>
<td><strong>HEIGHT RELATIVE TO OBSERVER</strong></td>
</tr>
<tr>
<td>Start</td>
<td>End</td>
</tr>
<tr>
<td><strong>DISTANCE FROM OBSERVER</strong></td>
<td><strong>DIRECTION FROM OBSERVER</strong></td>
</tr>
<tr>
<td>Start</td>
<td>End</td>
</tr>
</tbody>
</table>

**Describe Emission Point** - Describe the type and physical characteristics of the emission point. The description must be specific enough so that the emission outlet can be distinguished from all others at the source. The description of the type of emission point should address whether it is (1) a specifically designed outlet such as tacks, vents, and roof monitors (having confined emissions) or (2) an emission source having unconfined emissions such as storage piles, chemical tanks, and non-ducted material handling operations. Description of the physical characteristics of the emission point should include the appearance (such as color, texture, etc.) and geometry (size, shape, etc.) of the stack or other outlet, and its location in relation to other recognizable facility landmarks.

Any special identification codes the agency or source uses to identify a particular stack or outlet should be noted along with the description; the source of the code should also be recorded. A special identification code should not be used alone to describe the emission point, since they are sometimes incorrect and also require a secondary reference. The observer must be certain of the origin of the emissions that were being read. A description of the emission point coupled with the identification of the process equipment and control equipment should accomplish that purpose.

**Height Above Ground Level** * - Indicate the height of the stack or other emission outlet from its foundation base. This information is usually available from agency files, engineering drawings, or computer printouts (such as NEDS printouts). The information may also be obtained by using a combination of a rangefinder and an Abney level or clinometer. The height may also be estimated.

**Height Relative to Observer** * - Indicate an estimate of the height of the stack outlet (or of any other type of emission outlet) above the position of the observer. This measurement indicates the observer's position in relation to the stack base (i.e. higher or lower than the base) and is necessary if slant angle calculations are performed.

**Distance from Observer** * - Record the distance from the point of observation to the emission outlet. This measurement may be made by using a rangefinder. A map may also be used to estimate the distance.

This measurement must be reasonably accurate when the observer is close to the stack (within 3 stack heights) because it may be used in conjunction with the outlet height relative to the observer to determine the slant angle at which the observations are made. A precise determination of the slant angle is necessary for accurate readings.

* Required by Reference Method 9; other items recommended.
angle becomes important in calculating the positive bias inherent in opacity readings made when the observer is within three stack heights of the stack.

**Direction From Observer** - Specify the direction of the emission point from the observer. It is suggested that this be done to the closest of the eight points of the compass (e.g. S, SE, NW, NE) and that a compass be used to make the determination. To accomplish this: hold the compass while facing the emission point; rotate the compass until the North compass point lies directly beneath the needle (which will be pointing towards magnetic North); then the point of the compass closest to the emission outlet will indicate the direction (Figure 3). A map may also be used to make this determination.

D. EMISSIONS DESCRIPTION. Includes information that definitely establishes what was observed while making the visible emissions determination. Note: Items called for in this section may change a number of times during the observation period. It is recommended that these changes be noted in the Comment space beside the appropriate opacity readings and reference to this be made in the corresponding space in this section.

<table>
<thead>
<tr>
<th>DESCRIPTIVE EMISSIONS</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Start</td>
<td>End</td>
</tr>
<tr>
<td><strong>EMISSION COLOR</strong></td>
<td>IF WATER DROPLET PLUME</td>
</tr>
<tr>
<td>Start</td>
<td>End</td>
</tr>
<tr>
<td>Attached □</td>
<td>Detached □</td>
</tr>
<tr>
<td>POINT IN THE PLUME AT WHICH OPACITY WAS DETERMINED</td>
<td></td>
</tr>
<tr>
<td>Start</td>
<td>End</td>
</tr>
</tbody>
</table>

**Describe Emissions** - Include the physical characteristics and behavior of the plume (not addressed elsewhere on the form) and the distance it is visible. Physical descriptions may include such things as texture, gradation, and contents, examples are "lacy," "fluffy," "copious," "mushrooming," "spreading over horizon," and "detached nonwater vapor condensibles." The standard plume terminology illustrated in Figure 4 may be used to describe plume behavior. The behavior is generally used to determine the atmospheric stability on the day of the opacity observations.

**Emission Color** - Note the color of the emissions. The plume color can sometimes be useful in determining the composition of the emissions and also serves to document the total contrast between the plume and its background as seen by the opacity observer. For emissions that change color a number of times during the observation period (such as those from a basic oxygen furnace), the color changes should be noted in the comments space next to the opacity readings themselves.

**If Water Droplet Plume** - This box is only completed if visible water droplets are present. Check "attached" if condensation of the moisture contained in the plume occurs within the stack and the water droplet plume is visible at the stack exit. Check "detached" if condensation occurs some distance downwind from the stack exit and the water droplet plume and the stack appear to be unconnected.

---

* Required by Reference Method 9; other items recommended.

September 1993
Plumes containing condensed water vapor ("water droplet plumes" or "steam plumes") are usually very white and billowy, and then wispy at the point of dissipation, where the opacity decreases rapidly from a high value (usually 100%) to zero if there is not residual opacity contributed by the contaminant in the plume.

To document the presence or absence of condensed water vapor in the plume, two points must be addressed. First, is sufficient moisture present (condensed or uncondensed) in the effluent to produce water droplets at in-stack or ambient conditions? Second, if enough moisture is present, are the in-stack and ambient conditions such that it will condense either before exiting the stack or after exiting (when it meets with the ambient air)? The first question can be answered by examining the process type and/or the treatment of the effluent gas after the process. Some common sources or moisture in the plume are:

- Water produced by combustion fuels,
- Water from dryers,
- Water introduced by wet scrubbers,
- Water introduced for gas cooling prior to an electrostatic precipitator or other control device, and
- Water used to control temperature of chemical reactions.

If water is present in the plume, data from a sling psychrometer, which measures relative humidity, in combination with the moisture content and temperature of the effluent gas can be used to predict whether the formation of a steam plume is probable.

**Point in the Plume at Which Opacity Was Determined** - Describe as accurately as possible the physical location in the plume such as the distance from the emission point where the observations were made. This is necessary to establish that nothing interfered with the observer's clear view of the contaminant plume itself, such as condensed water vapor; it is also important in the case of secondary plume formation. Therefore, the observer must specify 1) if the readings were made prior to water droplet plume formation or after water droplet plume dissipation and 2) the distance from the emission point and/or water droplet plume. Descriptions such as "4 feet above outlet" and "80 feet downstream from outlet," "10 feet after steam dissipation" are appropriate. Figure 5 shows some examples of the correct location for making opacity readings in various steam plume and secondary plume situations.

**E. OBSERVATION CONDITIONS.** Covers the background and ambient weather conditions that occur during the observation period and could affect observed opacity.

<table>
<thead>
<tr>
<th>DESCRIBE PLUME BACKGROUND</th>
<th>End</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BACKGROUND COLOR</strong></td>
<td></td>
</tr>
<tr>
<td>Start</td>
<td>End</td>
</tr>
<tr>
<td><strong>SKY CONDITIONS</strong></td>
<td></td>
</tr>
<tr>
<td>Start</td>
<td>End</td>
</tr>
<tr>
<td><strong>WIND SPEED</strong></td>
<td></td>
</tr>
<tr>
<td>Start</td>
<td>End</td>
</tr>
<tr>
<td><strong>WIND DIRECTION</strong></td>
<td></td>
</tr>
<tr>
<td>Start</td>
<td>End</td>
</tr>
<tr>
<td><strong>AMBIENT TEMP</strong></td>
<td></td>
</tr>
<tr>
<td>Start</td>
<td>End</td>
</tr>
<tr>
<td><strong>WET BULB TEMP</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>RH Percent</td>
</tr>
</tbody>
</table>
Describe Plume Background* - Describe the background that the plume is obscuring and against which the opacity is being read. When describing the background, include characteristics such as texture. Examples of background descriptions are "structure behind roof monitor," "stand of pine trees," "edge of jagged stony hill side," "clear blue sky," "stack scaffolding," and "building obscured by haze."

Background Color* - Describe the background color including the shade of the color (e.g., new leaf green, conifer green, dark brick red, sky blue, and light gray stone). In general, the background chosen to read against should contrast with the color of the plume.

Sky Conditions* - Indicate the percent cloud cover of the sky. This information can be indicated by using straight percentages (e.g., 10% overcast, 100% overcast) or by description, as shown below:

<table>
<thead>
<tr>
<th>Term</th>
<th>Amount of Cloud Cover</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clear</td>
<td>&lt; 10%</td>
</tr>
<tr>
<td>Scattered</td>
<td>10% to 50%</td>
</tr>
<tr>
<td>Broken</td>
<td>50% to 90%</td>
</tr>
<tr>
<td>Overcast</td>
<td>&gt; 90%</td>
</tr>
</tbody>
</table>

Wind Speed* - Record the wind speed. It is recommended that it be measured or estimated to + or - 5 miles per hour. The wind speed may be measured using a hand-held anemometer (if available), or it can be estimated by using the Beaufort Scale of Wind Speed Equivalents shown in Table 1.

**TABLE 1. THE BEAUFORT SCALE OF WIND SPEED EQUIVALENTS**

<table>
<thead>
<tr>
<th>General Description</th>
<th>Specifications</th>
<th>Limits of Velocity 33 ft (10 m) above Level ground, mph</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calm</td>
<td>Smoke rises vertically</td>
<td>Under 1</td>
</tr>
<tr>
<td></td>
<td>Direction of wind shown by smoke drift but not by wind vanes</td>
<td>1 to 3</td>
</tr>
<tr>
<td>Light</td>
<td>Wind felt on face; leaves rustle; ordinary vane moved by wind</td>
<td>4 to 7</td>
</tr>
<tr>
<td>Gentle</td>
<td>Leaves and small twigs in constant motion; wind extends light flag</td>
<td>8 to 12</td>
</tr>
<tr>
<td>Moderate</td>
<td>Raises dust and loose paper; small branches are moved</td>
<td>13 to 18</td>
</tr>
<tr>
<td>Fresh</td>
<td>Small trees in leaf begin to sway; crested wavelets form on inland waters</td>
<td>19 to 24</td>
</tr>
<tr>
<td></td>
<td>Large branches in motion; whistling heard in telegraph wires; umbrellas used with difficulty</td>
<td>25 to 31</td>
</tr>
</tbody>
</table>
Wind Direction* - Indicate the direction from which the wind is blowing. It is suggested that the
direction should be estimated to eight points of the compass. This can be accomplished by observ-
ing which way the plume is blowing. If this is not possible, the wind direction may be determined
by observing a blowing flag or by noting the direction a few blades of grass or handful of dust are
blown when tossed into the air. Keep in mind that the wind direction at the observation point may
be different from that at the emission point; the wind direction at the emission point is the one of
interest.

Ambient Temperature* - The outdoor temperature at the plant site is measured by a thermometer (in
degrees Fahrenheit or centigrade). Be certain to note which temperature scale is used. The ambient
temperature is used in conjunction with the wet bulb temperature when there are indications of a
condensing water droplet plume.

Wet Bulb Temperature - Record the wet bulb temperature from the sling psychrometer. This is done
when there is a possibility of a condensing water droplet plume.

Relative Humidity - Enter the relative humidity measured by using a sling psychrometer in conjunc-
tion with a psychrometric chart. This information is used to determine if water vapor in the plume
will condense to form a steam plume.

F. OBSERVER POSITION AND SOURCE LAYOUT. Clearly identifies the observer's position in
relation to the emission point, plant landmarks, topographic features, sun position, and wind direc-
tion.
Source Layout Sketch* - This sketch should be drawn as a rough plan view and should include as many landmarks as possible. At the very least, the sketch should locate the relative positions of the observed outlet and associated buildings in such a way that they will not be confused with others at a later date, and clearly locate the position of the observer while making the VE readings. The exact landmarks will depend on the specific source, but they might include:

- Other Stacks
- Mills
- Roads
- Fences
- Buildings

- Stockpiles
- Rail heads
- Tree lines
- Background for readings
- Interfering plumes from other sources

To assist in subsequent analysis of the reading conditions, sketch in the plume (indicate the direction of wind travel). The wind direction also must be indicated in the previous section.

Draw North Arrow - To determine the direction of north, point the line of sight in the source layout sketch in the direction of the actual emission point, place the compass next to the circle and draw an arrow in the circle parallel to the compass needle (which points north). A map may also be used to determine direction to north.

Sun's Location - It is important to verify this parameter before making any opacity readings. The sun's location should be within the 140° sector indicated in the layout sketch; this confirms that the sun is within the 140° sector to the observer's back.

To draw the sun's location, point the line of sight in the source layout sketch in the direction of the actual emission point, move a pen upright along the "sun location line" until the shadow of the pen falls across the observer's position. Then draw the sun at the point where the pen touches the "sun location line."

ADDITIONAL INFORMATION - Includes conditions and/or deviations of a factual nature that have bearing on the opacity observations and that cannot be addressed elsewhere on the form.

Additional Information - Note conditions or deviations of a factual nature that cannot be addressed elsewhere on the form such as in the comments section of the data set. These must be purely factual in nature and specific to the particular source. Examples of information that may be included in this section are:

- Description of unusual stack configuration (to show multiple stacks or stack in relation to roof line); attach drawing, if necessary.
- References to attachments.
- Observed or reported changes to the emissions or process during observation that are not noted in the comments area of the form.
- Additional source identification information.

H. DATA SET. Opacity readings for the observation period, organized by minute and second. This section also includes the actual date and start and end times for the observation period and space next to each minute of readings for noting relevant comments.

<table>
<thead>
<tr>
<th>MIN</th>
<th>SEC</th>
<th>0</th>
<th>15</th>
<th>30</th>
<th>45</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>26</td>
<td></td>
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<td></td>
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<tr>
<td>27</td>
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<td></td>
<td></td>
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<tr>
<td>28</td>
<td></td>
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<td></td>
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<td></td>
<td></td>
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<tr>
<td>29</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Observation Date** - Enter the date on which the opacity observations were made.

**Start Time, End Time** - Indicate the times at the beginning and the end of the actual observation period. The times may be expressed in 12-hour or 24-hour time (i.e., 8:35 a.m. or 0835); however, 24-hour time tends to be less confusing.

**Data Set** - Spaces are provided on one form for entering an opacity reading every 15 seconds for up to a 30-minute observation period. If observations continue beyond 30 minutes, a second form (and third, etc.) should be used to record additional readings. The readings should be in percent opacity and made to the nearest 5 percent. The readings are entered from left to right for each numbered minute, beginning at the upper left corner of the left-hand column, labeled row "MIN 1" (minute 1) and column "SEC 0" (0 seconds). The next readings are entered consecutively in the spaces labeled MIN 1, SEC 15; MIN 1, SEC 30; MIN 1, SEC 45; MIN 2, SEC 0; MIN 2, SEC 15; etc.

If for any reason, a reading is not made for a particular 15-second period, a dash (-) should be placed in the space showing that the space is not just an oversight. The comment section beside that reading should be used for an explanation of why the reading was missed.

**Comments** - Spaces for comments are provided next to the data for each minute of opacity readings. These are intended to provide space to note changing observation conditions and/or reasons for missed readings in direct conjunction with the readings themselves. Items to be noted include:

- Changes in ambient conditions from the time of the start of readings
- Changes in plume color, behavior, or other characteristics
- Presence of interfering plumes from other sources
- Changes in observer position and indication that a new form is initiated
- Conditions that might interfere with readings or cause them to be biased high or low
- Unusual process conditions
- Reasons for missed readings

I. **OBSERVER DATA.** Information required to validate the opacity data.

<table>
<thead>
<tr>
<th>OBSERVER'S NAME (PRINT)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>OBSERVER'S SIGNATURE</td>
<td>DATE</td>
</tr>
<tr>
<td>ORGANIZATION</td>
<td></td>
</tr>
<tr>
<td>CERTIFIED BY</td>
<td>DATE</td>
</tr>
</tbody>
</table>

* Required by Reference Method 9; other items recommended.

September 1993
Observer's Name* - Print observer's entire name.

Observer's Signature - Self-explanatory.

Date - Enter the date on which the form was signed.

Organization* - Provide the name of the agency or company that employs the observer.

Certified By - Identify the agency, company, or other organization that conducted the "smoke school" or VE training and certification course where the observer obtained his/her current certification.

Date* - Provide the date of the current certification.

J. FORMS INTERRELATION. Provides space for recording another VE Observation Form number so that forms concerning the same observation can be interrelated.

Continued on VEO Form Number - Fill in the 5-digit number of the VE Observation Form, if any, where the observations from the form in use are continued. Each form of a series that has a form coming after it will have the number of the next form noted in this section.

* Required by Reference Method 9; other items recommended.
Baghouses:

Samples of Pre-inspection Worksheet,
Inspection Checklist,
and
Troubleshooting Guidelines
Pre-Inspection Worksheet

Source ID No. _____________________________ SIC _____________________________
Inspector(s) _____________________________ Date _____________________________
Inspection Announced? _____________________________

A. General Plant Data from District File

Plant name, address, and phone number ____________________________________________
______________________________________________________________________________
______________________________________________________________________________
Name of plant contact, title, and phone number ______________________________________
______________________________________________________________________________
______________________________________________________________________________
Type of process ________________________________________________________________
______________________________________________________________________________
Allowable emission rate and opacity ______________________________________________
______________________________________________________________________________
______________________________________________________________________________
Date baghouse installation approved ______________________________________________
______________________________________________________________________________
______________________________________________________________________________
Prior complaints or episodes of excess emissions ____________________________________
______________________________________________________________________________
______________________________________________________________________________
Last inspection date ______________________________________________________________
______________________________________________________________________________
Purpose of inspection ___________________________________________________________
______________________________________________________________________________

B. Process Information

Confidential? Yes____ No____
______________________________________________________________________________
Person supplying process information and title _______________________________________
______________________________________________________________________________
Product(s) 

Production rate(s) 

Raw materials used 

Portion of process controlled by baghouse 

Average uncontrolled emission rate or concentration (indicate whether obtained from stack test, mass balance, AP-42 emission factor, other, etc.) 

Date of last stack test and average emission rate obtained 

Is cleaned effluent recirculated back into plant? Yes No 

Dust Characteristics 

Is material toxic or otherwise hazardous or does it require special handling? 
Yes No Describe 

Moisture content or other gaseous constituents 

Abrasiveness or other properties 

Particle size data - indicate how measured 

June 1994
### E. Collection System(s)

<table>
<thead>
<tr>
<th></th>
<th>#1</th>
<th>#2</th>
<th>#3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Baghouse</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manufacturer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type or trade name</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model No.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of Compartments</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bags / compartment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bag l x d</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total cloth area</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Fan</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manufacturer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model No.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blade type</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Belt or direct drive</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power rating</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Positive or negative</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pressure</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Fabric</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manufacturer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Material</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Woven or felted</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weave</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weight</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Permeability</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating temp. range</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surface treatment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coating upon startup</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Guaranteed life</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Actual life</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Cleaning System</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Method</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequency</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Actuated by</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anticollapse rings</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wire mesh cages</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### F. Dust handling system(s)

- **Type of dust transport system**: 
- **Fate of collected material**: 

**June 1994**
Inspection Checklist

This checklist is designed to serve as an example of the information gathering process that a regulatory agency inspector may follow in order to make a compliance determination. District inspectors may wish to use this checklist as a guide in drawing up their own baghouse inspection sheets.

Step 1  Observe the Stack Effluent
Step 2  Check the Continuous Emission Monitors
Step 3  Measure the Fan Operating Parameters
Step 4  Record and Evaluate Baghouse Parameter Monitors
Step 5  Inspect Baghouse Exterior
Step 6  Inspect Dust Capture System
Step 7  Evaluate Process Operating Records
Step 8  Internal Inspection
Step 9  Review of Operating Records
### Visible Emission Observation Form

<table>
<thead>
<tr>
<th>Observation Date</th>
<th>Start Time</th>
<th>End Time</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>15</td>
<td>30</td>
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<tr>
<td></td>
<td>1</td>
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<td>28</td>
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<td></td>
<td>29</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>30</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Describe Emission Point**

- Height Above Ground Level
- Height Relative to Observer
- Distance from Observer
- Direction from Observer

**Describe Emissions**

- Emission Color
- If Water Droplet Plume
- Point in the Plume at Which Opacity Was Determined

**Describe Plume Background**

- Background Color
- Sky Conditions
- Wind Speed
- Wind Direction
- Ambient Temp
- Wet Bulb Temp
- RH Percent

**Source Layout Sketch**

- Draw North Arrow
- Emission Point
- Observer's Position

**Additional Information**

**Observer's Name (Print)**

**Observer's Signature**

**Organization**

**Certified By**

**Continued on VED Form Number**
Step 2 Check the Continuous Emission Monitors

Opacity monitor readings

Operating: Yes____ No____
Minimum, %__________
Average, %__________
Maximum, %__________

Spikes (Characterize frequency, duration, intensity)

________________________
________________________
________________________

Calibration spikes (Characterize levels, frequency)

________________________
________________________
________________________

Calibrated according to required schedule: Yes____ No____

Gas temperature

________________________
________________________

O₂ inlet level, %: Baseline_____ Present_____  
O₂ outlet level, %: Baseline_____ Present_____  
Difference in present values greater than 1%? Yes____ No____  
(If "Yes" inleakage is probably occurring)

CO₂ inlet level, %: Baseline_____ Present_____  
CO₂ outlet level, %: Baseline_____ Present_____  

Comments

________________________
________________________
________________________
________________________
Step 3 Measure the Fan Operating Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Baseline</th>
<th>Present</th>
<th>Change, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Increase in total static pressure across fan</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Electric current drawn by fan motor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Fan wheel rotation speed (rpm)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Gas temperature at fan inlet</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Flue gas oxygen level at fan inlet</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A. Baseline and present values of Parameters 1, 2, 3, differ by less than 10%: Yes____ No____
B. Baseline and Present values for Parameter 4 differ by less than 20 °F: Yes____ No____

(If answers to questions A and B are both 'Yes' then mass emissions have probably not changed significantly.)

Mass emissions may have increased significantly: Yes____ No____

(Increased oxygen levels in flue gas indicate air inleakage.)

(Reduced gas temperature and increased electric current indicate air inleakage.)

Air inleakage may be significant: Yes____ No____

D - 8 June 1994
### Step 4 Record and Evaluate Baghouse Parameter Monitor Readings

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Baseline</th>
<th>Present</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pressure drop</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gas volume flow</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moisture content</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Compressed air pressure</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reverse air pressure</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air-to-cloth ratio, gross</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A/C ratio, net</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(2 compartments off-line)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Efficiency</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emission rate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Opacity</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

June 1994
Step 5 Inspect Baghouse Exterior

Check the following items:

Access doors

Top access hatches

Expansion joints

Ducts

Condition of exterior housing

Look and listen for the following:

- Air inleakage
- Corrosion
- Missing parts
- Unusual odors
- Loose bolts
- Air leakage or fugitive emissions
- Warping
- Unusual noises
- Elevated temperatures

Bag cleaning system:

Air reservoir pressure: Baseline________  Present________

Valves-actuating: Yes____  No____

Compressed air system:

- Aftercoolers: Yes____  No____
- Automatic condensate trap: Yes____  No____
- Filters: Yes____  No____
- Water or rust deposits present in system? Yes____  No____
- Water or other material retained in oil traps, if any? Yes____  No____
Step 6  Ash Handling Procedures

Vibrators: Yes____ No____
Operating: Yes____ No____

Heaters: Yes____ No____
Operating: Yes____ No____

Level indicators / alarms: Yes____ No____
Operating: Yes____ No____

Transport equipment: Screws____ Pneumatic____ Other____
Operating: Yes____ No____

Evidence of inleakage


Comments


Step 7  Process Operating Conditions

<table>
<thead>
<tr>
<th></th>
<th>Baseline or Permitted Values</th>
<th>Present Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process weight</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gas flow rate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Excess air</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gas temperature</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pressure drop across baghouse</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moisture content</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flue gas analysis (% O₂, CO₂, ...)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Comments:  


June 1994
Step 8. Internal Inspection (Optional)

Internal inspection should be scheduled for a time when plant is shut down.

Caution: Before performing internal inspection, personnel should ensure that all safety measures are observed.

The inspector may be able to peer into a baghouse while it is operating. Permission from the operator must be obtained first. Make sure compartment is isolated.

View from clean-side access hatch:

Clean-side dust deposits? Yes No Comments

Poor bag tension? Yes No Comments

View from dirty-side access hatch (use caution!):

Bags being blinded? Yes No Comments

Any holes in bags visible? Yes No Comments

When conducting a full internal inspection, the following items should also be checked:

Inlet plenum
Baffles
Solenoid valves
Poppet valves
Bag clamps
Mechanical linkages
Thickness of dust layer in bags
Pinholes in any bags?
More than 1/4 inch dust layer on floor plates?
Bags wearing prematurely?
Perform screwdriver rip test on bags removed from service. Results:
## Step 9 Review Operating Records

### Recordkeeping Requirements

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Yes</th>
<th>No</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Opacity meter</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baghouse inlet gas temperature</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baghouse outlet gas temperature</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pressure drop across baghouse</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Maintenance Logs Kept

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Yes</th>
<th>No</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location of failed bags</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bag replacement frequency</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cause of bag failure</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Records Kept Satisfactorily

- Percent of time baghouse has been fully operational when process is in operation:

  - Has a detailed maintenance schedule been instituted?
  - Is maintenance schedule as recommended by baghouse manufacturer or by plant?
  - How long are records kept on file?
  - Are spare parts kept on hand?

---

June 1994
Which of the following problem areas have led to periods of excess emissions or caused the process to be shut down?

<table>
<thead>
<tr>
<th>Problem area</th>
<th>Duration</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insufficient dust pickup and/or transport (fugitive emissions)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Duct abrasion or corrosion</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature excursions, high or low</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moisture</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fan abrasion, vibration, etc.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gross bag failure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inadequate bag tension</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bag chafing or abrasion</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pressure loss</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Compartment isolation dampers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cleaning mechanism</td>
<td></td>
<td></td>
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<tr>
<td>Visible emissions</td>
<td></td>
<td></td>
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<tr>
<td>Plugged hoppers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hopper fires</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dust discharge system</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

If frequent breakdowns have occurred, can the source show maintenance records to demonstrate they have made good faith efforts to treat causes of operating problems?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
Conclusions / Recommendation

Compliance status

Need for further action

Corrective actions to be taken

Time required to rectify problems

Need for follow-up inspection

Inspector's signature

Date

Approved by

Title
## Troubleshooting Guidelines for Common Baghouse Operating Problems

<table>
<thead>
<tr>
<th>Problem or Symptom</th>
<th>Probable Cause</th>
<th>Remedy</th>
</tr>
</thead>
</table>
| 1. Visible discharge/dust in clean air plenum | a. Bags improperly installed  
  b. Bag clamps too loose  
  c. Torn or damaged bags  
  d. Leakage at tube sheet (field assembled units)  
  e. Venturi fasteners loose or missing (PJ)  
  f. Insufficient filter cake  
  g. Bags too porous  
  h. Inadequate bag tension | - Check bag installation procedures; repair as necessary.  
  - Tighten bag clamps.  
  - Replace or tie off and replace at later date.  
  - Check tube sheet joints; repair as necessary.  
  - Repair as necessary  
  - Allow more dust to build up on bags by cleaning less frequently. Use a precoat (startup only).  
  - Send bag out for permeability test and consult with manufacturer.  
  - Check tension and/or springs for compression to proper length.  
  - Check fan speed and damper positions; adjust to specified ratings. Check system design. Check isolation dampers, valves, linkage and seals. Check air supply on pneumatic operators. |
| 2. Excessive pressure drop (a differential pressure of 1 to 6 in. W.C. can be considered normal) | a. Gas flow too high |  |
## Troubleshooting Guidelines for Common Baghouse Operating Problems (contd.)

<table>
<thead>
<tr>
<th>Problem or Symptom</th>
<th>Probable Cause</th>
<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>b. Improper bag cleaning action.</td>
<td>- Refer to problem 6.</td>
<td></td>
</tr>
<tr>
<td>c. Improper dust discharge from hopper</td>
<td>- Check seal around slide gate (or in airlock); reseal if leakage is occurring. Ensure continuous dust removal from hoppers.</td>
<td></td>
</tr>
<tr>
<td>d. Moisture blinding of filter bags</td>
<td>- Correct cause of excess moisture and replace bags. Recovery of bag is sometimes possible by running cleaning system (without moving air through collector) from 1 to 30 hours.</td>
<td></td>
</tr>
<tr>
<td>e. Clogging of filter bags</td>
<td>- Eliminate oil or static charges from collector. Control airflow during startup. Check for excessive operating temperature. Check to see that dust characteristics have not changed. If using laundered bags, check for shrinkage.</td>
<td></td>
</tr>
<tr>
<td>f. Static electricity in collector</td>
<td>- Increase relative humidity if possible. Use grounded filter bags.</td>
<td></td>
</tr>
<tr>
<td>g. Excessive dust in clean air plenum (can diminish cleaning effectiveness by plugging the bags in the reverse direction). Damaged or inefficient bags.</td>
<td>- Clean plenum, check bags for dirt on clean side; clean or replace bags.</td>
<td></td>
</tr>
</tbody>
</table>
## Troubleshooting Guidelines for Common Baghouse Operating Problems (contd.)

<table>
<thead>
<tr>
<th>Problem or Symptom</th>
<th>Probable Cause</th>
<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>h. Insufficient blowring air (RJ)</td>
<td>Check drive belts on blower, blower speed, blower rotation; replace inlet blower filter; check blowring hose; check blowring for clogged slots.</td>
<td></td>
</tr>
<tr>
<td>i. Nonoperative blowring drive (RJ)</td>
<td>Check belts on reversing motor; check for broken chains or chain off sprocket; check sheaves or sprockets for loose set screws, check setting of tripper pins; check tripper lever for bend, looseness, or binding.</td>
<td></td>
</tr>
<tr>
<td>j. Incorrect pressure reading</td>
<td>Clean out pressure taps; check hoses for leaks; check for proper fluid in manometer; check diaphragm in gauge.</td>
<td></td>
</tr>
</tbody>
</table>

### 3. High bag failure rate

<table>
<thead>
<tr>
<th>a. Deterioration/decomposition</th>
<th>a. Improper bag material for dust chemical composition</th>
</tr>
</thead>
<tbody>
<tr>
<td>b. Operating below acid dewpoint</td>
<td>b. Baffle plate worn out</td>
</tr>
<tr>
<td>b. Wearing out/abrasion</td>
<td>b. Excessive dust loading and/or large abrasive metallic particles</td>
</tr>
</tbody>
</table>

- Analyze dust and check with manufacturer. Treat with neutralizer prior to collector.
- Increase gas temperature. Bypass collector during startup/shutdown.
- Replace baffle plate.
- Install primary collector upstream of baghouse.

June '994
<table>
<thead>
<tr>
<th><strong>Problem or Symptom</strong></th>
<th><strong>Probable Cause</strong></th>
<th><strong>Remedy</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>c. Cleaning cycle too frequent (PJ)</td>
<td><strong>c.</strong> Increase cleaning interval.</td>
<td></td>
</tr>
<tr>
<td>d. Shaking too violent (S)</td>
<td><strong>d.</strong> Decrease shaking frequency and/or amplitude.</td>
<td></td>
</tr>
<tr>
<td>e. Inlet air not properly baffled from bags</td>
<td><strong>e.</strong> Consult manufacturer.</td>
<td></td>
</tr>
<tr>
<td>f. Pulse pressure too high (PJ)</td>
<td><strong>f.</strong> Reduce pressure.</td>
<td></td>
</tr>
<tr>
<td>g. Bag cages have barbs (PJ)</td>
<td><strong>g.</strong> Remove or smoothe barbs.</td>
<td></td>
</tr>
<tr>
<td>a. Stratification of hot and cold gases</td>
<td><strong>a.</strong> Install baffles to create turbulence.</td>
<td></td>
</tr>
<tr>
<td>b. Sparks entering collector</td>
<td><strong>b.</strong> Install spark arrestor.</td>
<td></td>
</tr>
<tr>
<td>c. Failure of cooling or dilution system.</td>
<td><strong>c.</strong> Check design with manufacturer.</td>
<td></td>
</tr>
<tr>
<td>d. Excessive temperature</td>
<td><strong>d.</strong> Reduce operating temperature or use filter bags of higher temperature rating.</td>
<td></td>
</tr>
<tr>
<td>a. Hopper bridging</td>
<td><strong>a.</strong> Material buildup into the bag area can overstress filter elements. Locate cause of bridging and correct; clean out hopper.</td>
<td></td>
</tr>
<tr>
<td>Problem or Symptom</td>
<td>Probable Cause</td>
<td>Remedy</td>
</tr>
<tr>
<td>--------------------------------------------------------</td>
<td>-----------------------------------------------------</td>
<td>------------------------------------------------------------------------</td>
</tr>
<tr>
<td>4. Filtering action impaired</td>
<td>a. Improper cleaning system operation.</td>
<td>• Refer to Item 6.</td>
</tr>
<tr>
<td></td>
<td>b. Excessive moisture entering collector blinding bags.</td>
<td>• Refer to item 2.d.</td>
</tr>
<tr>
<td></td>
<td>c. Incorrect gas flow</td>
<td>• Refer to Item 5.</td>
</tr>
<tr>
<td></td>
<td>d. Incorrect bag material for gas composition</td>
<td>• Replace with bags of proper material for type of dust.</td>
</tr>
<tr>
<td></td>
<td>e. Gas temperature higher than specified.</td>
<td>• Refer to Item 3.c.d.</td>
</tr>
<tr>
<td></td>
<td>f. Static electricity buildup in collector</td>
<td>• Refer to Item 2.f.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Check rotation, correct if wrong, change sheave ratio.</td>
</tr>
<tr>
<td>5. Gas flow through system below design rating/low fan amperage.</td>
<td>a. Incorrect fan speed or direction</td>
<td>• Refer to Item 2.</td>
</tr>
<tr>
<td></td>
<td>b. High differential pressure drop</td>
<td>• Check tension on fan belts and adjust if necessary.</td>
</tr>
<tr>
<td></td>
<td>c. Fan belts slipping</td>
<td>• Check access doors, plenum, manifolds, ductwork; repair leaks.</td>
</tr>
<tr>
<td></td>
<td>d. Air leakage in gas system</td>
<td></td>
</tr>
<tr>
<td>Problem or Symptom</td>
<td>Probable Cause</td>
<td>Remedy</td>
</tr>
<tr>
<td>--------------------</td>
<td>----------------</td>
<td>--------</td>
</tr>
<tr>
<td>e. Leakage in dust collection system</td>
<td>• Check for hopper or discharge system leakage; repair as necessary.</td>
<td></td>
</tr>
<tr>
<td>f. Blocked gas system</td>
<td>• Check bags for blinding, obstruction in duct passages, or closed damper; clean or repair as necessary.</td>
<td></td>
</tr>
<tr>
<td>g. Fan and motor sheaves reversed</td>
<td>• Check drawings and reverse sheaves.</td>
<td></td>
</tr>
<tr>
<td>h. System static pressure too high</td>
<td>• Measure static pressure on both sides of fan and discuss with designer of duct velocity and configuration.</td>
<td></td>
</tr>
<tr>
<td>i. Excessive moisture</td>
<td>• Refer to Item 2.d.</td>
<td></td>
</tr>
<tr>
<td>j. Infrequent cleaning</td>
<td>• Refer to Item 6.</td>
<td></td>
</tr>
<tr>
<td>6. Improper cleaning system operation</td>
<td>a. Worn cams or rollers</td>
<td>• Repair or replace switch assembly.</td>
</tr>
<tr>
<td>a. Blowring reversing switch failure (RJ)</td>
<td>b. Improperly set tripper level</td>
<td>• Adjust arc of movement for approximately 60° above or below horizontal; uneven arc will cause switch to work in only one direction.</td>
</tr>
<tr>
<td></td>
<td>c. Dirt in switch</td>
<td>• Check to see that enclosure is properly installed.</td>
</tr>
</tbody>
</table>
# Troubleshooting Guidelines for Common Baghouse Operating Problems (contd.)

<table>
<thead>
<tr>
<th>Problem or Symptom</th>
<th>Probable Cause</th>
<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>b. Inability to maintain compressed air</td>
<td>a. Faulty or undersized compressor</td>
<td>• Check compressor manual. Pressure should normally be maintained</td>
</tr>
<tr>
<td>pressure (PJ)</td>
<td></td>
<td>between 80 to 110 psig.</td>
</tr>
<tr>
<td></td>
<td>b. Leakage or restriction in main line.</td>
<td>• Locate and repair leak or restriction.</td>
</tr>
<tr>
<td></td>
<td>c. Defective timer operation</td>
<td>• Make sure all valves are being activated. Check for sticking timer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>relay or pulse longer than 0.15 second. Replace timer if necessary.</td>
</tr>
<tr>
<td></td>
<td>d. Improper operation of solenoid or diaphragm</td>
<td>• Examine valves for dirt or short circuit in wiring which can cause</td>
</tr>
<tr>
<td></td>
<td>valves</td>
<td>valves to stick open. Clean and check pilot plunger.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>NOTE: Steady rush of air indicates open valve; no air pulse indicates</td>
</tr>
<tr>
<td></td>
<td></td>
<td>plugged valve. Solenoid valves require a minimum of 5 psig to close.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A long compressed air run after the shutoff valve has clogged can</td>
</tr>
<tr>
<td></td>
<td></td>
<td>prevent the required 5 psig from developing. The solution would be</td>
</tr>
<tr>
<td></td>
<td></td>
<td>provision of reservoir and shutoff valve near the collector.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>e. Compressed air consumption too high</td>
<td>• Reduce cleaning cycle, duration of pulse, or supply pressure, if</td>
</tr>
<tr>
<td></td>
<td></td>
<td>possible.</td>
</tr>
</tbody>
</table>

June 1994
## Troubleshooting Guidelines for Common Baghouse Operating Problems (contd.)

<table>
<thead>
<tr>
<th>Problem or Symptom</th>
<th>Probable Cause</th>
<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>f. Plugged dryer</td>
<td>• Replace dessicant or bypass dryer if permitted.</td>
</tr>
<tr>
<td></td>
<td>g. Supply line too small</td>
<td>• Consult design.</td>
</tr>
<tr>
<td></td>
<td>h. Compressor worn</td>
<td>• Replace rings.</td>
</tr>
<tr>
<td>c. Reduced compressed air consumption</td>
<td>a. Pulsing (solenoid) valves not working</td>
<td>• Check diaphragms, springs, and pilot valves.</td>
</tr>
<tr>
<td>(PJ)</td>
<td>b. Failed timer</td>
<td>• Check terminal outputs.</td>
</tr>
<tr>
<td></td>
<td>a. Defective shaker mechanism</td>
<td>• Check shaker speed, amplitude, and bag tension; adjust if required. Check for broken linkage and lost pins connecting linkage.</td>
</tr>
<tr>
<td></td>
<td>b. Failed timer</td>
<td>• Run system with hot air prior to starting process gas flow.</td>
</tr>
<tr>
<td></td>
<td>a. Insufficient preheating</td>
<td>• Keep fan running for 5 to 10 minutes after process is shut down.</td>
</tr>
<tr>
<td>7. Moisture in baghouse</td>
<td>b. System not purged after shutdown</td>
<td>• Raise gas temperature, insulate unit, install auxiliary heaters. Lower dewpoint by keeping moisture out of system.</td>
</tr>
<tr>
<td></td>
<td>c. Wall temperature below dewpoint</td>
<td>• Eliminate direct metal lines through insulation.</td>
</tr>
<tr>
<td></td>
<td>d. Cold spots through insulation</td>
<td></td>
</tr>
</tbody>
</table>
### Troubleshooting Guidelines for Common Baghouse Operating Problems (contd.)

<table>
<thead>
<tr>
<th>Problem or Symptom</th>
<th>Probable Cause</th>
<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>8. Insufficient dust pickup at</td>
<td>e. Compressed air introducing water (RJ)</td>
<td>• Check automatic drains, install aftercooler, install dryer.</td>
</tr>
<tr>
<td>emission points</td>
<td>f. Repressuring air causing condensation (RA)</td>
<td>• Preheat repressuring air; use process gas as source of repressuring air.</td>
</tr>
<tr>
<td></td>
<td>g. Moisture in compressed air line</td>
<td>• Make sure cooler or water trap is functioning.</td>
</tr>
<tr>
<td></td>
<td>a. Leaks in ductwork, access doors, and/or hopper discharge valves.</td>
<td>• Repair leaks so that air does not bypass source.</td>
</tr>
<tr>
<td></td>
<td>b. High differential pressure</td>
<td>• Refer to Item 2.</td>
</tr>
<tr>
<td></td>
<td>c. Slipping fan belts or fan rotating in wrong direction.</td>
<td>• Check fan and repair as necessary.</td>
</tr>
<tr>
<td></td>
<td>d. Clogged duct or closed or partially closed gate or damper</td>
<td>• Check all ductwork and damper positions and operation.</td>
</tr>
<tr>
<td></td>
<td>e. Duct size or run other than original design/inadequate system design</td>
<td>• Check design specifications with manufacturer. Close open areas around dust source. Check for cross drafts that overcome suction.</td>
</tr>
<tr>
<td>9. Fan problems -- excessive wear, noise, vibration, or motor overloading</td>
<td>a. Improper fan</td>
<td>• Check with fan manufacturer to see if fan is of proper design for application.</td>
</tr>
<tr>
<td>Problem or Symptom</td>
<td>Probable Cause</td>
<td>Remedy</td>
</tr>
<tr>
<td>--------------------</td>
<td>----------------</td>
<td>--------</td>
</tr>
<tr>
<td>b. Fan speed too high</td>
<td>c. Dust buildup on fan blades.</td>
<td>- Consult fan manufacturer.</td>
</tr>
<tr>
<td>d. Improper fan wheel</td>
<td>e. Sheaves not balanced</td>
<td>- Clean fan and check for water.</td>
</tr>
<tr>
<td>f. Worn bearings</td>
<td>g. Air volume too high</td>
<td>- Check with manufacturer.</td>
</tr>
<tr>
<td>h. Motor not sized for cold start</td>
<td></td>
<td>- Have sheaves dynamically balanced.</td>
</tr>
<tr>
<td>i. Have sheaves dynamically balanced</td>
<td></td>
<td>- Replace bearings.</td>
</tr>
<tr>
<td>j. Dampen fan at startup, reduce fan speed, provide heat faster, or replace motor.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

10. Hopper/dust discharge system failure or excessive wear

<table>
<thead>
<tr>
<th>Probable Cause</th>
<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Screw conveyor or airlock undersized</td>
<td>- Measure hourly collection of dust and consult manufacturer.</td>
</tr>
<tr>
<td>b. Conveyor or airlock speed too high</td>
<td>- Check and reduce speed.</td>
</tr>
<tr>
<td>c. Thermal expansion</td>
<td>- Consult manufacturer.</td>
</tr>
<tr>
<td>d. Undersized equipment</td>
<td>- Consult manufacturer.</td>
</tr>
</tbody>
</table>
## Troubleshooting Guidelines for Common Baghouse Operating Problems (cont'd.)

<table>
<thead>
<tr>
<th>Problem or Symptom</th>
<th>Probable Cause</th>
<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>b. Misaligned screw conveyor</td>
<td>• Check and align.</td>
</tr>
<tr>
<td></td>
<td>c. Overloading components</td>
<td>• Check sizing and design of all components versus dust delivery rates.</td>
</tr>
<tr>
<td>c. High pneumatic conveyor wear</td>
<td>a. Blower set too fast</td>
<td>• Check and reduce speed.</td>
</tr>
<tr>
<td></td>
<td>b. Undersized piping</td>
<td>• Review design -- slow down blower or increase pipe size.</td>
</tr>
<tr>
<td>d. Pneumatic conveyor pipes plugging</td>
<td>a. Elbows designed with too short a radius</td>
<td>• Replace with long radius elbows.</td>
</tr>
<tr>
<td></td>
<td>b. Overloading pneumatic conveyor</td>
<td>• Review design.</td>
</tr>
<tr>
<td></td>
<td>c. Slug loading of dust</td>
<td>• Feed dust gradually.</td>
</tr>
<tr>
<td></td>
<td>d. Moisture in dust</td>
<td>• Refer to Item 7.</td>
</tr>
<tr>
<td>e. Material bridging in hopper</td>
<td>a. Moisture in baghouse</td>
<td>• Refer to Item 7.</td>
</tr>
<tr>
<td></td>
<td>b. Dust being stored in hopper</td>
<td>• Ensure that dust is removed continuously.</td>
</tr>
<tr>
<td></td>
<td>c. Insufficient hopper slope</td>
<td>• Rework or replace hoppers.</td>
</tr>
<tr>
<td></td>
<td>d. Conveyor opening too small</td>
<td>• Use a wide flared trough.</td>
</tr>
</tbody>
</table>
### Troubleshooting Guidelines for Common Baghouse Operating Problems (contd.)

<table>
<thead>
<tr>
<th>Problem or Symptom</th>
<th>Probable Cause</th>
<th>Remedy</th>
</tr>
</thead>
</table>
| f. Excessive corrosion of baghouse structure, bag mountings, wire cages | a. Air inleakage through defective gaskets  
b. Missing or damaged insulation  
c. Frequent dewpoint excursions | • Proper inspection and maintenance.  
• Replace and repair insulation.  
• Heat tracing and/or gas temperature elevation. |

PJ = pulse jet  
RA = reverse air  
RJ = reverse jet  
S = shaker
### Typical Maintenance Schedule for a Fabric Filter System

<table>
<thead>
<tr>
<th>Inspection Frequency</th>
<th>Component</th>
<th>Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daily</td>
<td>Stack and opacity meter</td>
<td>Check exhaust for visible dust</td>
</tr>
<tr>
<td></td>
<td>Manometer</td>
<td>Check and record fabric pressure loss and fan static pressure. Watch for trends.</td>
</tr>
<tr>
<td></td>
<td>Compressed air system</td>
<td>Check for air leakage (low pressure). Check valves.</td>
</tr>
<tr>
<td></td>
<td>Collector</td>
<td>Observe all dials, meters, charts, and gauges etc. on control panel and listen to system for properly operating subsystems.</td>
</tr>
<tr>
<td></td>
<td>Damper valves</td>
<td>Check all isolation, bypass, and cleaning damper valves for synchronization and proper operation based upon manufacturer guidelines.</td>
</tr>
<tr>
<td></td>
<td>Rotating equipment and drives</td>
<td>Check for signs of jamming, leakage, broken parts, wear, etc.</td>
</tr>
<tr>
<td>Weekly</td>
<td>Filter bags</td>
<td>Check for tears, holes, abrasion, proper fastening, bag tension, dust accumulation on surface or in creases and folds.</td>
</tr>
<tr>
<td></td>
<td>Cleaning system</td>
<td>Check cleaning sequence and cycle times for proper valve and timer operation. Check compressed air lines including oilers and filters. Inspect shaker mechanisms for proper operation.</td>
</tr>
<tr>
<td></td>
<td>Hoppers</td>
<td>Check for bridging or plugging. Inspect screw conveyor flighting for proper operation and lubrication.</td>
</tr>
</tbody>
</table>

June 1994
<table>
<thead>
<tr>
<th>Inspection Frequency</th>
<th>Component</th>
<th>Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monthly</td>
<td>Shaker mechanism</td>
<td>Inspect for loose bolts.</td>
</tr>
<tr>
<td></td>
<td>Fan(s)</td>
<td>Check for corrosion and material buildup and check V-belt drives and chains for tension and wear.</td>
</tr>
<tr>
<td></td>
<td>Monitor(s)</td>
<td>Check accuracy of all indicating equipment.</td>
</tr>
<tr>
<td>Quarterly</td>
<td>Inlet plenum</td>
<td>Check baffle plate for wear; if appreciable wear is evident, replace. Check for dust deposits.</td>
</tr>
<tr>
<td></td>
<td>Access doors</td>
<td>Check all gaskets.</td>
</tr>
<tr>
<td></td>
<td>Shaker mechanism</td>
<td><strong>Tube type</strong> (tube hooks suspended from a tubular assembly): inspect nylon bushings in shaker bars and clevis (hanger) assembly for wear. <strong>Channel shakers</strong> (tube hooks suspended from a channel bar assembly): inspect drill bushings in tie bars, shaker bars, and connecting rods for wear.</td>
</tr>
<tr>
<td>Semi-annually</td>
<td>Motors, fans, etc.</td>
<td>Lubricate all electric motors, speed reducers, exhaust and reverse air fans, and similar equipment.</td>
</tr>
<tr>
<td>Annually</td>
<td>Collector</td>
<td>Check all bolts and welds. Inspect entire collector thoroughly, clean and touch up paint where necessary.</td>
</tr>
</tbody>
</table>
Electrostatic Precipitators:

Sample Inspection Checklist

and

Summary of Common Problems
**Inspection Checklist**

This checklist is designed to serve as an example of the information gathering process that a regulatory agency inspector may follow in order to make a compliance determination. District inspectors may wish to use this checklist as a guide in drawing up their own electrostatic precipitator inspection sheets.

Step 1  Stack Effluent  
Step 2  Continuous Emission Monitors  
Step 3  Fan Operating Parameters  
Step 4  ESP Performance Analysis from Electrical Readings  
Step 5  External Inspection  
Step 6  Ash Handling Procedures  
Step 7  Process Operating Conditions  
Step 8  Internal Inspection  
Step 9  Review Operating Records
# Visible Emission Observation Form

**Company Name**

**Street Address**

<table>
<thead>
<tr>
<th><strong>City</strong></th>
<th><strong>State</strong></th>
<th><strong>Zip</strong></th>
</tr>
</thead>
</table>

**Phone (Key Contact)**

**Source ID Number**

**Process Equipment**

**Operating Mode**

**Control Equipment**

**Operating Mode**

## Describe Emission Point

<table>
<thead>
<tr>
<th>Height Above Ground Level</th>
<th>Height Relative to Observer</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Start</strong></td>
<td><strong>End</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Distance from Observer</th>
<th>Direction from Observer</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Start</strong></td>
<td><strong>End</strong></td>
</tr>
</tbody>
</table>

## Describe Emissions

<table>
<thead>
<tr>
<th>Start</th>
<th>End</th>
</tr>
</thead>
</table>

**Emission Color**

**If Water Droplet Plume**

<table>
<thead>
<tr>
<th>Start</th>
<th>End</th>
<th>Attached</th>
<th>Detached</th>
</tr>
</thead>
</table>

**Point in the Plume at Which Opacity was Determined**

<table>
<thead>
<tr>
<th>Start</th>
<th>End</th>
</tr>
</thead>
</table>

## Describe Plume Background

<table>
<thead>
<tr>
<th>Start</th>
<th>End</th>
</tr>
</thead>
</table>

**Background Color**

**Sky Conditions**

<table>
<thead>
<tr>
<th>Start</th>
<th>End</th>
</tr>
</thead>
</table>

**Wind Speed**

**Wind Direction**

<table>
<thead>
<tr>
<th>Start</th>
<th>End</th>
</tr>
</thead>
</table>

**Ambient Temp**

**Wet Bulb Temp**

**RH, percent**

<table>
<thead>
<tr>
<th>Start</th>
<th>End</th>
</tr>
</thead>
</table>

## Source Layout Sketch

- Stack
- Plume
- Sun
- Wind

- Emission Point
- Observer's Position
- Sun Location Line

## Additional Information

**Observer's Name (Print)**

**Observer's Signature**

**Date**

**Organization**

**Certified By**

**Date**

**continued on veo form number**
Step 2. Continuous Emission Monitors

Opacity monitor readings

Operating: Yes ___ No ___
Minimum, % ______
Average, % ______
Maximum, % ______

Spikes (Characterize frequency, duration, intensity)

Calibration spikes (Characterize levels, frequency)

Calibrated according to required schedule: Yes ___ No ___

Gas temperature

Comments
Step 3 Fan Operating Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Baseline</th>
<th>Present</th>
<th>Change, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Increase in total static pressure across fan</td>
<td>______</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>2. Electric current drawn by fan motor</td>
<td>______</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>3. Fan wheel rotation speed (rpm)</td>
<td>______</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>4. Gas temperature at fan inlet</td>
<td>______</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>5. Flue gas oxygen level at fan inlet</td>
<td>______</td>
<td>______</td>
<td>______</td>
</tr>
</tbody>
</table>

A. Baseline and Present values of Parameters 1, 2, 3 differ by less than 10%: Yes____ No____
B. Baseline and Present values for differ by less than 20 °F:           Yes____ No____

(If answers to questions A and B are both 'Yes' then mass emissions have probably not changed significantly.)

Mass emissions may have increased significantly: Yes____ No____

(Increased oxygen levels in flue gas indicate air inleakage.)
(Reduced gas temperature and increased electric current indicate air inleakage.)

Air inleakage may be significant: Yes____ No____

Generally, the inspector performs Steps 4 onwards to confirm the evaluations of Steps 1 - 3. The inspector may skip over to Step 9 if the answers to the following 3 questions are 'Yes.'

1. Gas flowrate has increased or decreased substantially: Yes____ No____
   Basis for determination: Opacity - Steps 1, 2
   Gas temperature - Steps 2, 3
   System Pressure Drop - Step 3
   Fan Motor Current - Step 3

2. Mass loading has increased: Yes____ No____
   Basis for determination: Opacity - Steps 1, 2
   System Pressure Drop - Step 3

3. Particle outlet size distribution has changed: Yes____ No____
   Basis for determination: Opacity - Steps 1, 2
   Color of plume Step 1
Step 4: ESP Performance Analysis from Electrical Readings

Compare V, A and sparkrate values for all T-Rs with baseline values.

Note all inoperative meters

<table>
<thead>
<tr>
<th>T-R Set No.</th>
<th>Present Primary Voltage</th>
<th>Baseline Primary Voltage</th>
<th>Present Primary Current</th>
<th>Baseline Primary Current</th>
<th>Present Spark Rate</th>
<th>Baseline Spark Rate</th>
<th>Present Sec. Voltage</th>
<th>Baseline Sec. Voltage</th>
<th>Present Sec. Current</th>
<th>Baseline Sec. Current</th>
</tr>
</thead>
</table>

Any bus sections not operating at design levels?
ESP Layout

Inspector should identify T-R sets that power bus sections.

<table>
<thead>
<tr>
<th>Chamber A</th>
<th>Chamber B</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Chamber C</th>
<th>Chamber D</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Evaluation of ESP Performance By Corona Power Method

Electrical Parameters
1. What is K, for this facility?   ____
2. What is C (Coefficient of Proportionality) for this facility?   ____
   \[ C = \frac{\text{emission level}}{\text{penetration}} \]
   Use values from a previous source test
3. What is the volume flowrate for each chamber?   ____
4. Is particulate resistivity moderate to high?   Yes___ No___
5. Is power input to ESP less than 1000W per 1000 ACFM?   Yes___ No___

If the answers to either questions 4 or 5 above are 'No,' you cannot determine ESP performance by the Corona Power method.
Calculate Corona Power

If the ESP has secondary voltage and secondary current meters, fill out Table A. If not, use primary voltage and primary current values and fill out Table B.

<table>
<thead>
<tr>
<th>Chamber A</th>
<th>Chamber B</th>
</tr>
</thead>
<tbody>
<tr>
<td>T-R Set #</td>
<td>T-R Set #</td>
</tr>
<tr>
<td>Secondary Current mA</td>
<td>Secondary Current mA</td>
</tr>
<tr>
<td>Secondary Voltage kV</td>
<td>Secondary Voltage kV</td>
</tr>
<tr>
<td>Corona Power mA x kV</td>
<td>Corona Power mA x kV</td>
</tr>
</tbody>
</table>

\[ P_c = \text{Total Corona Power} \]
Table B

<table>
<thead>
<tr>
<th>T-R Set #</th>
<th>Primary Current mA</th>
<th>Primary Voltage kV</th>
<th>Corona Power mA x kV x 0.75</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Chamber B

<table>
<thead>
<tr>
<th>T-R Set #</th>
<th>Primary Current mA</th>
<th>Primary Voltage kV</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$P_c = \text{Total Corona Power}$

Do permit conditions require a minimum power level to the ESP or to each chamber?
\[ P_t = e^{-0.06K_t(P_{c}/V)} \]

\[ E.L. = P_t \times C \]

<table>
<thead>
<tr>
<th>Chamber</th>
<th>Corona Power $P_c$</th>
<th>Gas Flow Rate</th>
<th>Specific Corona Power</th>
<th>$K_t$</th>
<th>Penetration $P_t$</th>
<th>C</th>
<th>Emission Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>D</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

Combined calculated emission level values for all chambers ducted to the same stack: 

Allowable maximum emission level for this facility: 

Is calculated E.L. value greater than allowable maximum emission level? Yes____ No____ 

If yes, a source test should be ordered to determine emission level more exactly.

Comments:

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________
Step 5 External Inspection

Insulators:

Evidence of tracking: Yes___ No___

Corrosion of insulator compartment: Yes___ No___

Fan working properly: Yes___ No___

Air filters for compartment clogged: Yes___ No___

Heater working: Yes___ No___

Rappers all operating: ____________________________

<table>
<thead>
<tr>
<th>Access doors</th>
<th>Top access hatches</th>
<th>Expansion joints</th>
<th>Rapper shafts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Infiltration</td>
<td>Comments</td>
<td>Corrosion</td>
<td>Comments</td>
</tr>
<tr>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

Fugitive emissions from ESP or ductwork: Yes___ No___

Comments ____________________________
Step 6 Ash Handling Procedures

Vibrators: Yes____ No____
  Operating: Yes____ No____

Heaters: Yes____ No____
  Operating: Yes____ No____

Level indicators / alarms: Yes____ No____
  Operating: Yes____ No____

Transport equipment: Screws____ Pneumatic____ Other____
  Operating: Yes____ No____

Evidence of inleakage

_________________________________________________________________
_________________________________________________________________
_________________________________________________________________
_________________________________________________________________

Comments

_________________________________________________________________
_________________________________________________________________
_________________________________________________________________
_________________________________________________________________
Step 7 Process Operating Conditions

<table>
<thead>
<tr>
<th>Condition</th>
<th>Baseline or Permitted Values</th>
<th>Present Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas flow rate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Excess air</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gas temperature</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pressure drop across ESP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moisture content</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soot blowing intervals</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flue gas analysis (% O₂, CO₂, ...)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Comments

Step 8 Internal Inspection

For information to be gathered when conducting an internal inspection, see checklist provided for operators of ESPs for their annual internal inspection, in appendix D of CAP ESP manual.
Step 9. Review Operating Records

<table>
<thead>
<tr>
<th>Recordkeeping Requirements</th>
<th>Records Kept Satisfactorily</th>
</tr>
</thead>
<tbody>
<tr>
<td>Opacity meter</td>
<td>Yes</td>
</tr>
<tr>
<td>ESP inlet gas temperature</td>
<td>Yes</td>
</tr>
<tr>
<td>ESP outlet gas temperature</td>
<td>Yes</td>
</tr>
<tr>
<td>Pressure drop across ESP</td>
<td>Yes</td>
</tr>
</tbody>
</table>

If frequent breakdowns have occurred, can the source show maintenance records to demonstrate they have made good faith efforts to treat causes of operating problems?

Inspection findings:

Compliance determination:

Maintenance recommendations:
# Electrostatic Precipitator Baseline Comparison

<table>
<thead>
<tr>
<th>Possible Operating Problems</th>
<th>Average Baseline (Specify Value)</th>
<th>Observed (Specify Value)</th>
<th>Location</th>
<th>Abnormal (Check)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. ELECTRICAL</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. Particle Resistivity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Peak voltage low (down 5-10 kV)</td>
<td></td>
<td></td>
<td>E</td>
<td></td>
</tr>
<tr>
<td>2. Rapping intensity (increased)</td>
<td></td>
<td></td>
<td>E</td>
<td></td>
</tr>
<tr>
<td>3. Temp. changed (± 50 °F)</td>
<td></td>
<td></td>
<td>E</td>
<td></td>
</tr>
<tr>
<td>4. Spark rate increased (± 50 sparks/min)</td>
<td></td>
<td></td>
<td>E</td>
<td></td>
</tr>
<tr>
<td>5. Opacity high</td>
<td></td>
<td></td>
<td>E</td>
<td></td>
</tr>
<tr>
<td>B. Transformer-Rectifier set problems</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. No secondary current</td>
<td>N/A</td>
<td></td>
<td>E</td>
<td></td>
</tr>
<tr>
<td>2. No penthouse purge</td>
<td>N/A</td>
<td>N/A</td>
<td>E</td>
<td></td>
</tr>
<tr>
<td>3. Voltage zero, current high</td>
<td></td>
<td>N/A</td>
<td>E</td>
<td></td>
</tr>
<tr>
<td>4. Opacity high</td>
<td></td>
<td></td>
<td>E</td>
<td></td>
</tr>
<tr>
<td>C. Insulator failure</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Peak voltage low</td>
<td>N/A</td>
<td></td>
<td>E</td>
<td></td>
</tr>
<tr>
<td>2. Penthouse purge (not used)</td>
<td></td>
<td>N/A</td>
<td>E</td>
<td></td>
</tr>
<tr>
<td>3. Penthouse temp. high (± 20 °F)</td>
<td></td>
<td>N/A</td>
<td>E</td>
<td></td>
</tr>
<tr>
<td>4. Opacity high</td>
<td></td>
<td>N/A</td>
<td>E</td>
<td></td>
</tr>
<tr>
<td>5. Cracks visible</td>
<td>N/A</td>
<td>N/A</td>
<td>I</td>
<td></td>
</tr>
</tbody>
</table>

*E is external, I is internal.
Possible Operating Problems

<table>
<thead>
<tr>
<th>Possible Operating Problems</th>
<th>Average Baseline (Specify Value)</th>
<th>Observed (Specify Value)</th>
<th>Location *</th>
<th>Abnormal (Check)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. ELECTRICAL (continued)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D. Broken discharge wires</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Deposits on wires</td>
<td>N/A</td>
<td>N/A</td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>2. Violent matter fluctuating</td>
<td>N/A</td>
<td>N/A</td>
<td>E</td>
<td></td>
</tr>
<tr>
<td>3. Hopper level indicator not used</td>
<td>N/A</td>
<td>N/A</td>
<td>E</td>
<td></td>
</tr>
<tr>
<td>4. Spark rate high (± 50 sparks/min.)</td>
<td></td>
<td>N/A</td>
<td>E</td>
<td></td>
</tr>
<tr>
<td>5. Opacity high</td>
<td></td>
<td>N/A</td>
<td>E</td>
<td></td>
</tr>
<tr>
<td>6. Broken discharge wires</td>
<td></td>
<td>N/A</td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>II. GAS FLOW</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. Excessive velocity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Flow rate high</td>
<td></td>
<td></td>
<td>E</td>
<td></td>
</tr>
<tr>
<td>2. Voltages high, currents, low</td>
<td></td>
<td></td>
<td>E</td>
<td></td>
</tr>
<tr>
<td>3. Opacity high</td>
<td></td>
<td></td>
<td>E</td>
<td></td>
</tr>
<tr>
<td>B. Nonuniform distribution</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Flow rate increased</td>
<td>N/A</td>
<td>N/A</td>
<td>E</td>
<td></td>
</tr>
<tr>
<td>2. Secondary currents nonparallel</td>
<td></td>
<td></td>
<td>E</td>
<td></td>
</tr>
<tr>
<td>3. Hopper level differences on parallel branches</td>
<td></td>
<td></td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>4. Rappers on distribution plates not used</td>
<td></td>
<td></td>
<td>N/A</td>
<td></td>
</tr>
</tbody>
</table>

* E is external, I is internal.
### Possible Operating Problems

#### Average Baseline (Specify Value) | Observed (Specify Value) | Location * | Abnormal (Check)

#### MECHANICAL

**A. Rapper Problems**
1. Puffs visible
2. Peak voltage changes, secondary current constant
3. Spark rate changed
4. Dust sticky

**B. Hopper solids removal**
1. Broken discharge wires
2. Mass loading probably increased
3. Nonuniform gas distribution
4. Hoppers not emptied continuously
5. Level indicators not used
6. Heaters not used
7. Vibrators not used
8. Hoppers not insulated
9. Corrosion around outlet valves
10. Hopper slope < 60°
11. Hoppers full or bridged

**C. Collection plate warpage and misalignment**
1. Change in air load
2. Repeated hopper overflow
3. Air inleakage
4. Misalignment visible

*E is external, I is internal.*
### Possible Operating Problems

IV. **EFFLUENT CHARACTERISTICS**

A. **Mass loading increases**
   1. Opacity high
   2. Inlet section, secondary currents, low
   3. Hopper unloading frequency increased

<table>
<thead>
<tr>
<th>Average Baseline (Specify Value)</th>
<th>Observed (Specify Value)</th>
<th>Location</th>
<th>Abnormal (Check)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>E</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>E</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>E</td>
<td></td>
</tr>
</tbody>
</table>

* E is external, I is internal.
<table>
<thead>
<tr>
<th>Malfunction</th>
<th>Cause</th>
<th>Effect on ESP Efficiency</th>
<th>Corrective Action</th>
<th>Preventive Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poor electrode</td>
<td>Poor design</td>
<td>Can drastically affect performance and lower efficiency</td>
<td>Realign electrodes.</td>
<td>Check hoppers frequently for proper operation</td>
</tr>
<tr>
<td>alignment</td>
<td>Ash buildup on frame and hoppers</td>
<td>Correct gas flow.</td>
<td>Replace electrode.</td>
<td>Boiler problems: check for insufficient excess air, insufficient pressure reading on gages, fouled screen tubes, and fouled air preheater</td>
</tr>
<tr>
<td></td>
<td>Poor gas flow</td>
<td>Reduction in efficiency due to reduced power input, bus section unavailability</td>
<td></td>
<td>Inspect hoppers; check electrodes frequently for wear; inspect rappers frequently.</td>
</tr>
<tr>
<td>Broken electrodes</td>
<td>Wire not rapped clean, causes an arc that embrittles and burns through the wire</td>
<td>Clinkered wire. Causes: poor flow area, distribution through unit is uneven; excess free carbon due to excess air above combustion requirements or fan capacity insufficient for demand required; wires not properly centered; ash buildup resulting in bent frame, same as above; clinker bridges the plates and wire shorts out; ash buildup, pushes bottle weight up causing sag in the wire; &quot;J&quot; hooks have improper clearances to the hanging wire; bottle weight hangs up during cooling causing a buckled wire; and ash buildup on bottle weight to the frame forms a clinker and burns off the wire.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Summary of Problems Associated With ESPs (contd.)

<table>
<thead>
<tr>
<th>Malfunction</th>
<th>Cause</th>
<th>Effect on ESP Efficiency</th>
<th>Corrective Action</th>
<th>Preventive Measures</th>
</tr>
</thead>
</table>
| Distorted or skewed electrode plates             | Ash buildup in hoppers  
Gas flow irregularities  
High temperatures | Reduced efficiency                                                  | Repair or replace plates.  
Correct gas flow.                      | Check hoppers frequently for proper operation; check electrode plates during outages. |
| Vibrating or swinging electrodes                 | Uneven gas flow  
Broken electrodes                                                  | Decrease in efficiency due to reduced power input | Repair electrode.                                                                      | Check electrode frequently for wear.                                               |
| Inadequate level of power input (voltage too low) | High dust resistivity  
Excessive ash on electrodes  
Unusually fine particle size  
Inadequate power supply  
Inadequate sectionalization  
Improper rectifier and control operation  
Misalignment of electrodes | Reduction in efficiency                                              | Clean electrodes; gas conditioning or alterations in temperature to reduce resistivity; increase sectionalization. | Check range of voltages frequently to make sure they are correct. In situ resistivity measurements. |
| Back corona                                      | Ash accumulation on electrodes causes excessive sparking, requiring reduction in voltage charge. | Reduction in efficiency | Same as above                                                                       | Same as above                                                                      |
| Broken or cracked insulator or flower pot bushing leakage | Ash buildup during operation causes leakage to ground.  
Moisture gathered during shutdown or low-load operation | Reduction in efficiency | Clean or replace insulators and bushings                                             | Check frequently; clean and dry as needed; check for adequate pressurization of top housing. |
### Summary of Problems Associated With ESPs (contd.)

<table>
<thead>
<tr>
<th>Malfunction</th>
<th>Cause</th>
<th>Effect on ESP Efficiency</th>
<th>Corrective action</th>
<th>Preventive Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air inleakage through hoppers</td>
<td>From dust conveyor</td>
<td>Lower efficiency - dust reentrained through ESP</td>
<td>Seal leaks</td>
<td>Identify early by increase in ash concentration at bottom of exit to ESP</td>
</tr>
<tr>
<td>Air inleakage through ESP shell</td>
<td>Flange expansion, improper sealing of inspection hatches</td>
<td>Same as above, also causes intense sparking.</td>
<td>Seal leaks</td>
<td>Check frequently for corrosion around inspection doors and for flange expansion</td>
</tr>
<tr>
<td>Gas bypass around ESP: dead passage above plates and tension frame</td>
<td>Poor design - improper isolation of active portion of ESP</td>
<td>Only a small drop in efficiency unless severe</td>
<td>Baffling to direct gas into active ESP section</td>
<td>Identify early by measurement of gas flow in suspected area</td>
</tr>
<tr>
<td>Corrosion</td>
<td>Temperature goes below dew point</td>
<td>Negligible until precipitator interior plugs or plates are eaten away; air leaks may develop causing significant drops in performance.</td>
<td>Maintain flue gas temperature above dew point.</td>
<td>Energize precipitator after process has been on line for ample period to raise flue gas temperature above acid dew point.</td>
</tr>
<tr>
<td>Malfunction</td>
<td>Cause</td>
<td>Effect on ESP Efficiency</td>
<td>Corrective Action</td>
<td>Preventive Measures</td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>-------------------------------------------------------------------------------------------</td>
<td>-------------------------------------------</td>
<td>----------------------------------------</td>
<td>--------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Hopper pluggage</td>
<td>Wires, plates and insulators fouled because of low temperature</td>
<td>Reduction in efficiency</td>
<td>Provide proper flow of ash</td>
<td>Frequent checks for adequate operation of hoppers; provide heaters and/or thermal insulation to avoid moisture condensation.</td>
</tr>
<tr>
<td></td>
<td>Inadequate hopper insulation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Improper maintenance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Process leaks causing excess moisture</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ash-conveying system malfunction:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- gas leakage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- blower malfunctions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- solenoid valves</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Material dropped into hopper from bottle weights</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Solenoid and timer malfunction</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Suction blower filter not changed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inadequate rapping, vibrators fail</td>
<td>Ash buildup</td>
<td>Resulting buildup on electrodes may reduce efficiency</td>
<td>Adjust rappers with optical dust measuring instrument in ESP exit stream</td>
<td>Frequent checks for adequate operation of rappers</td>
</tr>
<tr>
<td></td>
<td>Poor design</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rappers misadjusted</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rapping too intense</td>
<td>Poor design</td>
<td>Reentrains ash and reduces efficiency</td>
<td>Same as above</td>
<td>Same as above; reduce vibrating or impact force</td>
</tr>
<tr>
<td></td>
<td>Rappers misadjusted</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Improper rapping force</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Malfunctions</td>
<td>Cause</td>
<td>Effect on ESP Efficiency</td>
<td>Corrective Action</td>
<td>Preventive Measures</td>
</tr>
<tr>
<td>--------------------</td>
<td>------------------------------------------------------------------------</td>
<td>--------------------------</td>
<td>-----------------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------</td>
</tr>
<tr>
<td>Control failures</td>
<td>Power failure in primary system</td>
<td>Reduced efficiency</td>
<td>Find source of failure and repair or replace</td>
<td>Pay close attention to daily readings of control room instrumentation to spot deviations from normal readings</td>
</tr>
<tr>
<td></td>
<td>Transformer or rectifier failure:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- insulation breakdown in transformer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- arcing in transformer between high-voltage switch contacts</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- leaks or shorts in high-voltage structure</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- insulating field contamination</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sparking</td>
<td>Inspection door ajar</td>
<td>Reduced efficiency</td>
<td>Close inspection doors; repair leaks in boiler; unplug hoppers; clean insulators</td>
<td>Regular preventive maintenance will alleviate these problems.</td>
</tr>
<tr>
<td></td>
<td>Boiler leaks</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Plugging of hoppers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dirty insulators</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX F

Cement Kilns

SAMPLES OF PERMIT TO OPERATE AND AUTHORITY TO CONSTRUCT
Crushing & Storage

B000137 - Crushing System (010)
  C000136
  C000138
  C000140
  C001713
  C001714  } Fabric Dust Collector
  C001715
  C001716
  C003888

B000135 - Rock Transfer System (020)
  C001717
  C001718
  C001719  } Fabric Dust Collector
  C001773
  C002222
If construction is not completed by the expiration date of this permit, it may be renewed for one additional year upon payment of applicable fees. Any additional extension will require the written approval of the Air Pollution Control Officer. This Authority to Construct may serve as a temporary Permit to Operate provided the APCO is given prior notice of such intent to operate. However, this Authority to Construct is not valid if the Permit to Operate is denied.

EXPIRES LAST DAY OF: AUGUST 1995

LEGAL OWNER OR OPERATOR: (012)

EQUIPMENT LOCATION: (0003)

DESCRIPTION:
CRUSHING SYSTEM (010) consisting of:

<table>
<thead>
<tr>
<th>HP</th>
<th>Description</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>602.5</td>
<td>Belt Conveyor (12)</td>
<td>36-011</td>
</tr>
<tr>
<td>90.0</td>
<td>Vibratory Screen (6 @ 15 HP)</td>
<td>36-031-036</td>
</tr>
<tr>
<td>5.0</td>
<td>Air Compressor</td>
<td>36-040</td>
</tr>
<tr>
<td>354.0</td>
<td>Primary Crusher (1600 Tph)</td>
<td>36-041</td>
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<tr>
<td>1.5</td>
<td>Surge Bin</td>
<td>36-042</td>
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<tr>
<td>1600.0</td>
<td>Secondary Crusher [2 Hammer Mill (N&amp;S)] (1000 Tph)</td>
<td>36-051-052</td>
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<tr>
<td>20.0</td>
<td>Wobbler Feeder</td>
<td>36-053</td>
</tr>
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<td>1.5</td>
<td>Wobbler Oiler</td>
<td>36-053</td>
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<td>27.5</td>
<td>Pump (2)</td>
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<td>5.0</td>
<td>Air Compressor</td>
<td>36-070</td>
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<td>5.0</td>
<td>Blower</td>
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<td>New Conveyor, 160 ft</td>
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<td>130.0</td>
<td>Stacker</td>
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<td>10.0</td>
<td>Clay Feeder</td>
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<td>7.5</td>
<td>Air Compressor No. 3</td>
<td>11-092</td>
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<td>1.0</td>
<td>Water spray system over piles numbers 1 &amp; 2.</td>
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<tr>
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<td>Surge Bin Feeders 2 @ 40 HP ea.</td>
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CONTROL:

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<tr>
<td>C000136 (41-025) 10 HP</td>
<td></td>
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<tr>
<td>C000140 (36-002) 50 HP</td>
<td></td>
</tr>
<tr>
<td>C001714 (36-004) 15 HP</td>
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</tr>
<tr>
<td>C001716 (41-027) 5 HP</td>
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</tr>
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</table>

Fee Schedule: 1(D): Rating: 3317.0

This permit does not authorize the emission of air contaminants in excess of those allowed by law, including Division 36 of the Health and Safety Code of the State of California and the Rules and Regulations of this District. This permit cannot be construed as permission to violate existing laws, ordinances, statutes or regulations of this or other governmental agencies. This Permit to Operate must be renewed by the expiration date above or an earlier date if equipment is moved, altered, or changes ownership. If billing for annual renewal fee required by Rule 381(c) is not received by expiration date, please contact the District office above.

DATE: 7/20/94

Air Pollution Control Officer

Charles M. Pettit
MOJAVE DESERT
AIR QUALITY MANAGEMENT DISTRICT
15428 CIVIC DRIVE, VICTORVILLE, CA 92392 (619) 245-1661

PERMIT TO OPERATE

Operation under this permit must be conducted in compliance with all information included with the initial application, initial permit conditions, and conditions contained herein. The equipment must be maintained and kept in good operating condition at all times. This Permit to Operate or copy must be posted on or within 5 meters of equipment. If copy is posted, original must be maintained on site in central file available for inspection at all times.

EXPIRES LAST DAY OF: AUGUST 1995

LEGAL OWNER OR OPERATOR: (012)
EQUIPMENT LOCATION: (0003)

DESCRIPTION:
AIR POLLUTION CONTROL serving Crushing System (010), valid District permit B000137. consisting of:

41-025 Fabric Dust Collector DC-5, "Nor-Dlo", 156A-10′, 5,600 ACFM, 2.0 A/C, Stack 0.7′ x 44′H, 70′ F., fan size 40.

Total HP = 10

CONDITIONS:

1. The owner/operator (o/o) shall operate this control equipment in strict accord with manufacturer's specification and/or sound engineering principles.

2. The o/o shall maintain a log of all inspections, repairs and maintenance on this equipment and submit it to the District upon request. The log shall be kept for a minimum period of 2 years.

3. The o/o shall maintain on-site, as a minimum, an inventory of replacement bags that assures compliance with applicable Rules of District Regulation IV.

Fee Schedule: 7(H): Rating: 1.0
This permit does not authorize the emission of air contaminants in excess of those allowed by law, including Division 26 of the Health and Safety Code of the State of California and the Rules and Regulations of this District. This permit cannot be construed as permission to violate existing laws, ordinances, statutes or regulations of this or other governmental agencies. This Permit to Operate must be renewed by the expiration date above or an earlier date if equipment is moved, altered, or changes ownership. If billing for annual renewal fee required by Rule 301(c) is not received by expiration date, please contact the District office above.

BY: Charles L. Fryxell
Air Pollution Control Officer
DATE: 7/20/94
PERMIT TO OPERATE

Operation under this permit must be conducted in compliance with all information included with the initial application, initial permit conditions, and conditions contained herein. The equipment must be maintained and kept in good operating condition at all times. This Permit to Operate or copy must be posted on or within 8 meters of equipment. If copy is posted, original must be maintained on site in central file available for inspection at all times.

EXPIRES LAST DAY OF: AUGUST 1995

LEGAL OWNER OR OPERATOR: (012) EQUIPMENT LOCATION: (0003)

DESCRIPTION:
AIR POLLUTION CONTROL serving Crushing System (010), valid District permit B000137, consisting of:

36-001 Fabric Dust Collector DC-1. "Nor-Blo" 390A-25, 14,000 ACFM, 3.0 A/C. Stack 2.0'D x 10' H, 90°F, fan size 60.

Total HP = 25

CONDITIONS:

1. The owner/operator (o/o) shall operate this control equipment in strict accord with manufacturer's specification and/or sound engineering principles.

2. The o/o shall maintain a log of all inspections, repairs and maintenance on this equipment and submit it to the District upon request. The log shall be kept for a minimum period of 2 years.

3. The o/o shall maintain on-site, as a minimum, an inventory of replacement bags that assures compliance with applicable Rules of District Regulation IV.
Operation under this permit must be conducted in compliance with all information included with the initial application, initial permit conditions, and conditions contained herein. The equipment must be maintained and kept in good operating condition at all times. This Permit to Operate or copy must be posted on or within 8 meters of equipment. If copy is posted, original must be maintained on site in central file available for inspection at all times.

EXPIRES LAST DAY OF: AUGUST 1995

LEGAL OWNER OR OPERATOR: (012)  
EQUIPMENT LOCATION: (0003)  

DESCRIPTION:
AIR POLLUTION CONTROL serving Crushing System (010), valid District permit 8000137, consisting of:

3G-002 Fabric Dust Collector DC-2, "Nor-Blo" 624A-40', 22,000 ACFM, 3.0 A/C, Stack 2.6'D x 57'H, 90° F, fan size 80.
Total HP = 50

CONDITIONS:

1. The owner/operator (o/o) shall operate this control equipment in strict accord with manufacturer's specification and/or sound engineering principles.

2. The o/o shall maintain a log of all inspections, repairs and maintenance on this equipment and submit it to the District upon request. The log shall be kept for a minimum period of 2 years.

3. The o/o shall maintain on-site, as a minimum, an inventory of replacement bags that assures compliance with applicable Rules of District Regulation IV.
Permit to Operate

Operation under this permit must be conducted in compliance with all information included with the initial application, initial permit conditions, and conditions contained herein. The equipment must be maintained and kept in good operating condition at all times. This Permit to Operate or copy must be posted on or within 8 meters of equipment. If copy is posted, original must be maintained on site in central file available for inspection at all times.

Expires last day of: August 1995

Legal owner or operator: (012)

Equipment location: (0003)

Description:
Air Pollution Control serving Crushing System (010), valid District permit B000137, consisting of:

36-003 Fabric Dust Collector DC-3, "Nor-Blot" 624A-40', 22,000 ACFM, 3.0 A/C, Stack 2.6'D x 57'H, 90° F., fan size 80.

HP = 50
Includes AS Blower #2 10

Total HP = 60

Conditions:

1. The owner/operator (o/o) shall operate this control equipment in strict accord with manufacturer’s specification and/or sound engineering principles.

2. The o/o shall maintain a log of all inspections, repairs and maintenance on this equipment and submit it to the District upon request. The log shall be kept for a minimum period of 2 years.

3. The o/o shall maintain on-site, as a minimum, an inventory of replacement bags that assures compliance with applicable Rules of District Regulation IV.
Operation under this permit must be conducted in compliance with all information included with the initial application, initial permit conditions, and conditions contained herein. The equipment must be maintained and kept in good operating condition at all times. This Permit to Operate or copy must be posted on or within 8 meters of equipment. If copy is posted, original must be maintained on site in central file available for inspection at all times. 

EXPIRES LAST DAY OF: AUGUST 1995

LEGAL OWNER OR OPERATOR: (012) EQUIPMENT LOCATION: (0003)

DESCRIPTION:
AIR POLLUTION CONTROL serving Crushing System (010), valid District permit B000137, consisting of:

36-004 Fabric Dust Collector DC-4, "Nor-Blo" 234A-15', 6,600 ACFM, 2.4 A/C, 90° F., fan size 45.

Total HP = 15

CONDITIONS:

1. The owner/operator (o/o) shall operate this control equipment in strict accord with manufacturer's specification and/or sound engineering principles.

2. The o/o shall maintain a log of all inspections, repairs and maintenance on this equipment and submit it to the District upon request. The log shall be kept for a minimum period of 2 years.

3. The o/o shall maintain on-site, as a minimum, an inventory of replacement bags that assures compliance with applicable Rules of District Regulation IV.

Fee Schedule: 7(H); Rating: 1.0

This permit does not authorize the emission of air contaminants in excess of those allowed by law, including Division 26 of the Health and Safety Code of the State of California and the Rules and Regulations of this District. This permit cannot be construed as permission to violate existing laws, ordinances, statutes or regulations of this or other governmental agencies. This Permit to Operate must be renewed by the expiration date above or an earlier date if equipment is moved, altered, or changed ownership. If billing for annual renewal fee required by Rule 301(c) is not received by expiration date, please contact the District office above.
PERMIT TO OPERATE

Operation under this permit must be conducted in compliance with all information included with the initial application, initial permit conditions, and conditions contained herein. The equipment must be maintained and kept in good operating condition at all times. This Permit to Operate or copy must be posted or within 8 meters of any equipment. If copy is posted, original must be maintained on site in a central file available for inspection at all times.

EXPIRES LAST DAY OF: AUGUST 1995

LEGAL OWNER OR OPERATOR: (012)
EQUIPMENT LOCATION: (0003)

DESCRIPTION:
AIR POLLUTION CONTROL serving Crushing System (010), valid District permit B000137, consisting of:

Fabric Dust Collector DC-6, "MicroPul" 30-9', 2,000 ACFM, 7.0 A/C, Stack 0.7'D x 44'H, 90° F. and 2 hp Rotary Feeder

Total HP = 4

CONDITIONS:

1. The owner/operator (o/o) shall operate this control equipment in strict accord with manufacturer's specification and/or sound engineering principles.

2. The o/o shall maintain a log of all inspections, repairs and maintenance on this equipment and submit it to the District upon request. The log shall be kept for a minimum period of 2 years.

3. The o/o shall maintain on-site, as a minimum, an inventory of replacement bags that assures compliance with applicable Rules of District Regulation IV.

Fee Schedule: 7(H); Rating: 1.0

This permit does not authorize the emission of air contaminants in excess of those allowed by law, including Division 26 of the Health and Safety Code of the State of California and the rules and regulations of this District. This permit cannot be construed as permission to violate existing laws, ordinances, statutes or regulations of this or other governmental agencies. This Permit to Operate must be renewed by the expiration date above or an earlier date if equipment is moved, altered, or changed ownership. If failing to annual renewal fee required by Rule 301(c) is not received by expiration date, please contact the District office above.
MOJAVE DESERT
AIR QUALITY MANAGEMENT DISTRICT
15428 CIVIC DRIVE, VICTORVILLE, CA 92392 (619) 245-1661

PERMIT TO OPERATE

Operation under this permit must be conducted in compliance with all information included with the initial application, initial permit conditions, and conditions contained herein. The equipment must be maintained and kept in good operating condition at all times. This Permit to Operate or copy must be posted on or within 8 meters of equipment. If copy is posted, original must be maintained on site in central file available for inspection at all times.

EXPIRES LAST DAY OF: AUGUST 1995

LEGAL OWNER OR OPERATOR: (012) EQUIPMENT LOCATION: (0003)

DESCRIPTION:
AIR POLLUTION CONTROL serving Crushing System (010), valid District permit B000137, consisting of:

41-027 Fabric Dust Collector DC-7, "Volkes" 16/15/F6, 1,780 ACFM, 9.0 A/C, 90° F., fan size F-6

Total HP = 5

CONDITIONS:

1. The owner/operator (o/o) shall operate this control equipment in strict accord with manufacturer's specification and/or sound engineering principles.

2. The o/o shall maintain a log of all inspections, repairs and maintenance on this equipment and submit it to the District upon request. The log shall be kept for a minimum period of 2 years.

3. The o/o shall maintain on-site, as a minimum, an inventory of replacement bags that ensures compliance with applicable Rules of District Regulation IV.

Fee Schedule: 7(H); Rating: 1.0
This permit does not authorize the emission of air contaminants in excess of those allowed by law, including Division 26 of the Health and Safety Code of the State of California and the Rules and Regulations of this District. This permit cannot be construed as permission to violate existing laws, ordinances, statutes or regulations of this or other governmental agencies. This Permit to Operate must be renewed by the expiration date above or an earlier date if equipment is moved, altered, or changes ownership. A billing for annual renewal fee required by Rule 301(c) is not received by expiration date, please contact the District Office above.

3241/540 300/018 469E/3828N
SIC/ process Emission, Location UTM (Km)

BY: Charles L. Pryzmal
Air Pollution Control Officer
DATE: 7/20/94
AUTHORITY TO CONSTRUCT

If construction is not completed by the expiration date of this permit, it may be renewed for one additional year upon payment of applicable fees. Any additional extension will require the written approval of the Air Pollution Control Officer. This Authority to Construct may serve as a temporary Permit to Operate provided the APCO is given prior notice of such intent to operate. However, this Authority to Construct is not valid if the Permit to Operate is denied.

EXPIRES LAST DAY OF: AUGUST 1995

LEGAL OWNER OR OPERATOR: (012)

DESCRIPTION: AIR POLLUTION CONTROL (Baghouse) which serves the Crushing System (010), valid District permit B000137, and has the pre-construction parameters of a 40 hp motor powering the fan. This fan induces a flow rate of approximately 3000 ACFM, with cotton bags (coated) with an Air:Cloth ratio of approximately 6:1.

CONDITIONS:

1. The owner/operator (o/o) shall operate this control equipment in strict accord with manufacturer's specification and/or sound engineering principles.

2. The o/o shall maintain a log of all inspections, repairs and maintenance on this equipment. The log shall be kept on-site for a minimum of 2 years and provided to District personnel on request.

3. The o/o shall maintain on-site, as a minimum, an inventory of replacement bags that ensures compliance with applicable Rules of District Regulation IV.

Fee Schedule: 7(H); Rating: 1.0

This permit does not authorize the emission of air contaminants in excess of those allowed by law, including Division 26 of the Health and Safety Code of the State of California and the Rules and Regulations of this District. This permit cannot be construed as permission to violate existing laws, ordinances, rules or regulations of this or other governmental agencies. This Permit to Operate must be renewed by the expiration date above or an earlier date if equipment is moved, altered, or changes ownership. If billing for annual renewal fee required by Rule 301(c) is not received by expiration date, please contact the District office above.

SIC/ process Type/ID Location UTM (Km)
3241/540 300/000 4695/3828 N

Air Pollution Control Officer

DATE: 7/20/94
PERMIT TO OPERATE

Operation under this permit must be conducted in compliance with all information included with the initial application, initial permit conditions, and conditions contained herein. The equipment must be maintained and kept in good operating condition at all times. This Permit to Operate or copy must be posted on or within 8 meters of equipment. If copy is posted, original must be maintained on site in central file available for inspection at all times.

EXPIRES LAST DAY OF: AUGUST 1995

LEGAL OWNER OR OPERATOR: (012)

EQUIPMENT LOCATION: (0003)

DESCRIPTION:

ROCK TRANSFER SYSTEM (020), consisting of:

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<th>Equipment</th>
<th>HP</th>
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<tbody>
<tr>
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<td>42-133.124 Stacker Trailers Nos. 1,2 on Belts 11.12</td>
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<td>42-134 Transfer Car</td>
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<td>42-136 Jr. Reclaimer serving Belt No. 11</td>
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<td>42-140 Hopper. Additive with belt</td>
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<td>42-145 Rock Reclaimer off Belt No. 11</td>
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CONTROL:

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<td>C001773 (41-028)</td>
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CONDITIONS:

1. This equipment shall not be operated unless it is vented to operating air pollution control equipment covered by all 5 District valid permits C001717, C001719, C001773 and C002222.

2. The owner/operator (o/o) shall comply with all District Rules and Regulations including, but not limited to, malfunction/breakdown notifications.

3. The o/o shall have a continuing program of maintenance/inspections in accord with manufacturer's recommendations and specifications which ensures compliance with District Rules.

4. The o/o shall maintain a log of all inspections, repairs and maintenance on this equipment and submit it to the District upon request. The log shall be kept for a minimum period of 2 years.

Fee Schedule: 1(C); Rating: 432.5

This permit does not authorize the emission of air contaminants in excess of those allowed by law, including Division 26 of the Health and Safety Code of the State of California and the Rules and Regulations of this District. This permit cannot be construed as permission to violate existing laws, statutes or regulations of this or other governmental agencies. This Permit to Operate must be renewed by the expiration date above or an earlier date if equipment is moved, altered, or changes ownership. If billing for annual renewal fee required by Rule 201(c) is not received by expiration date, please contact the District Office above.

By: Charles L. Wyckoff
Air Pollution Control Officer

DATE: 7/20/94
Operation under this permit must be conducted in compliance with all information included with the initial application, initial permit conditions, and conditions contained herein. The equipment must be maintained and kept in good operating condition at all times. This Permit to Operate or copy must be posted on or within 8 meters of equipment. If copy is posted, original must be maintained on site in central file available for inspection at all times.

EXPIRES LAST DAY OF: AUGUST 1995

LEGAL OWNER OR OPERATOR: (012) EQUIPMENT LOCATION: (0003)

DESCRIPTION:
AIR POLLUTION CONTROL serving Rock Transfer System (020), District permit B000135, consisting of:

41-021 Fabric Dust Collector DC-1, "Nor-Blo" 156A-10: 2,750 ACFM, 15.0 A/C, Stack 1.2'D x 32'H, 120°F, fan size 40.

Total HP = 10

CONDITIONS:
1. The owner/operator (o/o) shall operate this control equipment in strict accord with manufacturer's specification and/or sound engineering principles.

2. The o/o shall maintain a log of all inspections, repairs and maintenance on this equipment and submit it to the District upon request. The log shall be kept for a minimum period of 2 years.

3. The o/o shall maintain on-site as a minimum, an inventory of replacement bags that assures compliance with applicable Rules of District Regulation IV.

Fee Schedule: 7(H); Rating: 1.0

This permit does not authorize the emission of air contaminants in excess of those allowed by law, including Division 26 of the Health and Safety Code of the State of California and the Rules and Regulations of this District. This permit cannot be construed as permission to violate existing laws, ordinances, statutes or regulations of this or other governmental agencies. This Permit to Operate must be renewed by the expiration date above or an earlier date if equipment is moved, altered, or changed ownership. If hitting the annual renewal fee required by Rule 301(c) is not received by expiration date, please contact the District office above.

SIC/ process Emission Type/ID Location UTM (Km) FOR DATE: 7/20/94
2241/440 500/018 4053/3828N
Air Pollution Control Officer dec 7-1-94
PERMIT TO OPERATE

Operation under this permit must be conducted in compliance with all information included with the initial application, initial permit conditions, and conditions contained herein. The equipment must be maintained and kept in good operating condition at all times. This Permit to Operate or copy must be posted on or within 8 meters of equipment. If copy is posted, original must be maintained on site in central file available for inspection at all times.

EXPIRES LAST DAY OF: AUGUST 1995
LEGAL OWNER OR OPERATOR: (012)
EQUIPMENT LOCATION: (0003)

DESCRIPTION:
AIR POLLUTION CONTROL serving Rock Transfer System (O20), valid District permit B000135, consisting of:

41-022 Fabric Dust Collector DC-2, "Nor-Blo" 156A-10: 3.130 ACFM, 17.0 A/C, Stack 1.2'D x 30'H, 150°F., fan size 40.

Total HP = 10

CONDITIONS:
1. The owner/operator (o/o) shall operate this control equipment in strict accord with manufacturer's specification and/or sound engineering principles.

2. The o/o shall maintain a log of all inspections, repairs and maintenance on this equipment and submit it to the District upon request. The log shall be kept for a minimum period of 2 years.

3. The o/o shall maintain on-site, as a minimum, an inventory of replacement bags that assures compliance with applicable Rules of District Regulation IV.

Fee Schedule: 7(H): Rating: 1.0
This permit does not authorize the emission of air contaminants in excess of those allowed by law, including Division 26 of the Health and Safety Code of the State of California and the Rules and Regulations of this District. This permit cannot be construed as permission to violate existing laws, ordinances, statutes or regulations of this or other governmental agencies. This Permit to Operate must be renewed by the expiration date above or an earlier date if equipment is moved, altered, or changes ownership. If billing for annual renewal fee required by Rule 291(e) is not received by expiration date, please contact the District office above.

By: Charles L. Frye
Air Pollution Control Officer
For: 
Date: 7/20/94

3241/540  100/018  4696/3828N
SIC/ Emission Location
process Type/ID UTM (Km)
Operation under this permit must be conducted in compliance with all information included with the initial application, initial permit conditions, and conditions contained herein. The equipment must be maintained and kept in good operating condition at all times. This Permit to Operate or copy must be posted on or within 8 meters of equipment. If copy is posted, original must be maintained on site in central file available for inspection at all times.

EXPIRES LAST DAY OF: AUGUST 1995

LEGAL OWNER OR OPERATOR: (012) 
EQUIPMENT LOCATION: (0003).

DESCRIPTION:
AIR POLLUTION CONTROL serving Rock Transfer System (020), valid District permit B000135, consisting of:

42-022 Fabric Dust Collector DC-22, "Nor-Blo" 463A-30; 5,620 ACFM, 1.0 A/C, Stack 2.0'D x 55'H, 90°F., fan size 70.

Total HP = 50

CONDITIONS:

1. The owner/operator (o/o) shall operate this control equipment in strict accord with manufacturer's specification and/or sound engineering principles.

2. The o/o shall maintain a log of all inspections, repairs and maintenance on this equipment and submit it to the District upon request. The log shall be kept for a minimum period of 2 years.

3. The o/o shall maintain on-site, as a minimum, an inventory of replacement bags that assures compliance with applicable Rules of District Regulation IV.

Fee Schedule: 7(H); Rating: 1.0

This permit does not authorize the emission of air contaminants in excess of those allowed by law, including Division 26 of the health and safety code of the State of California and the Rules and Regulations of this District. This permit cannot be construed as permission to violate existing laws, ordinances, statutes or regulations of this or other governmental agencies. This Permit to Operate must be renewed by the expiration date above or an earlier date if equipment is moved, altered, or changes ownership. If billing for annual renewal fee required by Rule 301(c) is not received by expiration date, please contact the District office above.
Operation under this permit must be conducted in compliance with all information included with the initial application, initial permit conditions, and conditions contained herein. The equipment must be maintained and kept in good operating condition at all times. This Permit to Operate or copy must be posted on or within 8 meters of equipment. If copy is posted, original must be maintained on site in central file available for inspection at all times.

EXPIRES LAST DAY OF: AUGUST 1995

LEGAL OWNER OR OPERATOR: (012)

EQUIPMENT LOCATION: (0003)

DESCRIPTION:
AIR POLLUTION CONTROL serving Rock Transfer System (020), valid District permit B000135 consisting of:

41-028 Fabric Dust Collector DC-22, "Volkes" 30/10/F6; 2,250 ACFM, 8.0 A/C, 80° F., fan size F-6.

Total HP = 7.5

CONDITIONS:
1. The owner/operator (o/o) shall operate this control equipment in strict accord with manufacturer's specification and/or sound engineering principles.
2. The o/o shall maintain a log of all inspections, repairs and maintenance on this equipment and submit it to the District upon request. The log shall be kept for a minimum period of 2 years.
3. The o/o shall maintain on-site, as a minimum, an inventory of replacement bags that assures compliance with applicable Rules of District Regulation IV.

Fee Schedule: 7(H); Rating: 1.0

This permit does not authorize the emission of air contaminants in excess of those allowed by law, including Division 26 of the Health and Safety Code of the State of California and the Rules and Regulations of this District. This permit cannot be construed as permission to violate existing laws, ordinances, statutes or regulations of this or other governmental agencies. This Permit to Operate must be renewed by the expiration date above or an earlier date if equipment is moved, altered, or changes ownership. If billing for annual renewal fee required by Rule 301(c) is not received by expiration date, please contact the District Office above.

SIC/ Emission Type/ID UTM (Km)
process Type/ID UTM (Km)

Charles L. Fryxell
Air Pollution Control Officer
dec 7-1-94
PERMIT TO OPERATE

Operation under this permit must be conducted in compliance with all information included with the initial application, initial permit conditions, and conditions contained herein. The equipment must be maintained and kept in good operating condition at all times. This Permit to Operate or copy must be posted on or within 8 meters of the equipment. If copy is posted, original must be maintained on site in central file available for inspection at all times.

EXPIRES LAST DAY OF: AUGUST 1995

LEGAL OWNER OR OPERATOR: (012)
EQUIPMENT LOCATION: (0003)

DESCRIPTION:
AIR POLLUTION CONTROL serving Rock Transfer System (020), valid District permit B000135, consisting of:

41-029 Fabric Duct Collector DC-9, "Volkes" 30/10/F6; 2,250 ACFM, 8.0 A/C, 80° F., fan size F-6.

Total HP = 7.5

CONDITIONS:

1. The owner/operator (o/o) shall operate this control equipment in strict accord with manufacturer's specification and/or sound engineering principles.

2. The o/o shall maintain a log of all inspections, repairs and maintenance on this equipment and submit it to the District upon request. The log shall be kept for a minimum period of 2 years.

3. The o/o shall maintain on-site, as a minimum, an inventory of replacement bags that assures compliance with applicable Rules of District Regulation IV.

Fee Schedule: 7(H); Rating: 1.0
REFERENCES


Compilation of Air Pollutant Emission Factors

AP - 42
11.6 Portland Cement Manufacturing

11.6.1 Process Description

Portland cement is a fine powder, gray or white in color, that consists of a mixture of hydraulic cement materials comprising primarily calcium silicates, aluminates and aluminoferrites. More than 30 raw materials are known to be used in the manufacture of portland cement, and these materials can be divided into four distinct categories: calcareous, siliceous, argillaceous, and ferrifrous. These materials are chemically combined through pyroprocessing and subjected to subsequent mechanical processing operations to form gray and white portland cement. Gray portland cement is used for structural applications and is the more common type of cement produced. White portland cement has lower iron and manganese contents than gray portland cement and is used primarily for decorative purposes. Portland cement manufacturing plants are part of hydraulic cement manufacturing, which also includes natural, masonry, and pozzolanic cement. The six-digit Source Classification Code (SCC) for portland cement plants with wet process kilns is 3-05-006, and the six-digit SCC for plants with dry process kilns is 3-05-007.

Portland cement accounts for 95 percent of the hydraulic cement production in the United States. The balance of domestic cement production is primarily masonry cement. Both of these materials are produced in portland cement manufacturing plants. A diagram of the process, which encompasses production of both portland and masonry cement, is shown in Figure 11.6-1. As shown in the figure, the process can be divided into the following primary components: raw materials acquisition and handling, kiln feed preparation, pyroprocessing, and finished cement grinding. Each of these process components is described briefly below. The primary focus of this discussion is on pyroprocessing operations, which constitute the core of a portland cement plant.

The initial production step in portland cement manufacturing is raw materials acquisition. Calcium, the element of highest concentration in portland cement, is obtained from a variety of calcareous raw materials, including limestone, chalk, marl, sea shells, aragonite, and an impure limestone known as "natural cement rock". Typically, these raw materials are obtained from open-face quarries, but underground mines or dredging operations are also used. Raw materials vary from facility to facility. Some quarries produce relatively pure limestone that requires the use of additional raw materials to provide the correct chemical blend in the raw mix. In other quarries, all or part of the noncalcareous constituents are found naturally in the limestone. Occasionally, pockets of pyrite, which can significantly increase emissions of sulfur dioxide (SO₂), are found in deposits of limestone, clays, and shales used as raw materials for portland cement. Because a large fraction (approximately one third) of the mass of this primary material is lost as carbon dioxide (CO₂) in the kiln, portland cement plants are located close to a calcareous raw material source whenever possible. Other elements included in the raw mix are silicon, aluminum, and iron. These materials are obtained from ores and minerals such as sand, shale, clay, and iron ore. Again, these materials are most commonly from-open-pit quarries or mines, but they may be dredged or excavated from underwater deposits.

Either gypsum or natural anhydrite, both of which are forms of calcium sulfate, is introduced to the process during the finish grinding operations described below. These materials, also excavated from quarries or mines, are generally purchased from an external source, rather than obtained directly from a captive operation by the cement plant. The portland cement manufacturing industry is relying increasingly on replacing virgin materials with waste materials or byproducts from other manufacturing operations, to the extent that such replacement can be implemented without adversely...
Figure 11.6-1. Process flow diagram for portland cement manufacturing.
(SCC = Source Classification Code.)
affecting plant operations, product quality or the environment. Materials that have been used include fly ash, mill scale, and metal smelting slags.

The second step in Portland cement manufacture is preparing the raw mix, or kiln feed, for the pyroprocessing operation. Raw material preparation includes a variety of blending and sizing operations that are designed to provide a feed with appropriate chemical and physical properties. The raw material processing operations differ somewhat for wet and dry processes, as described below.

Cement raw materials are received with an initial moisture content varying from 1 to more than 50 percent. If the facility uses dry process kilns, this moisture is usually reduced to less than 1 percent before or during grinding. Drying alone can be accomplished in impact dryers, drum dryers, paddle-equipped rapid dryers, air separators, or autogenous mills. However, drying can also be accomplished during grinding in ball-and-tube mills or roller mills. While thermal energy for drying can be supplied by exhaust gases from separate, direct-fired coal, oil, or gas burners, the most efficient and widely used source of heat for drying is the hot exit gases from the pyroprocessing system.

Materials transport associated with dry raw milling systems can be accomplished by a variety of mechanisms, including screw conveyors, belt conveyors, drag conveyors, bucket elevators, air slide conveyors, and pneumatic conveying systems. The dry raw mix is pneumatically blended and stored in specially constructed silos until it is fed to the pyroprocessing system.

In the wet process, water is added to the raw mill during the grinding of the raw materials in ball or tube mills, thereby producing a pumpable slurry, or slip, of approximately 65 percent solids. The slurry is agitated, blended, and stored in various kinds and sizes of cylindrical tanks or slurry basins until it is fed to the pyroprocessing system.

The heart of the Portland cement manufacturing process is the pyroprocessing system. This system transforms the raw mix into clinkers, which are gray, glass-hard, spherically shaped nodules that range from 0.32 to 5.1 centimeters (cm) (0.125 to 2.0 inches [in.]) in diameter. The chemical reactions and physical processes that constitute the transformation are quite complex, but they can be viewed conceptually as the following sequential events:

1. Evaporation of free water;
2. Evolution of combined water in the argillaceous components;
3. Calcination of the calcium carbonate (CaCO₃) to calcium oxide (CaO);
4. Reaction of CaO with silica to form dicalcium silicate;
5. Reaction of CaO with the aluminum and iron-bearing constituents to form the liquid phase;
6. Formation of the clinker nodules;
7. Evaporation of volatile constituents (e.g., sodium, potassium, chlorides, and sulfates); and
8. Reaction of excess CaO with dicalcium silicate to form tricalcium silicate.
This sequence of events may be conveniently divided into four stages, as a function of location and temperature of the materials in the rotary kiln.

1. Evaporation of uncombined water from raw materials, as material temperature increases to 100°C (212°F);

2. Dehydration, as the material temperature increases from 100°C to approximately 430°C (800°F) to form oxides of silicon, aluminum, and iron;

3. Calcination, during which carbon dioxide (CO₂) is evolved, between 900°C (1650°F) and 982°C (1800°F), to form CaO; and

4. Reaction, of the oxides in the burning zone of the rotary kiln, to form cement clinker at temperatures of approximately 1510°C (2750°F).

Rotary kilns are long, cylindrical, slightly inclined furnaces that are lined with refractory to protect the steel shell and retain heat within the kiln. The raw material mix enters the kiln at the elevated end, and the combustion fuels generally are introduced into the lower end of the kiln in a countercurrent manner. The materials are continuously and slowly moved to the lower end by rotation of the kiln. As they move down the kiln, the raw materials are changed to cementitious or hydraulic minerals as a result of the increasing temperature within the kiln. The most commonly used kiln fuels are coal, natural gas, and occasionally oil. The use of supplemental fuels such as waste solvents, scrap rubber, and petroleum coke has expanded in recent years.

Five different processes are used in the portland cement industry to accomplish the pyroprocessing step: the wet process, the dry process (long dry process), the semidry process, the dry process with a preheater, and the dry process with a preheater/precalciner. Each of these processes accomplishes the physical/chemical steps defined above. However, the processes vary with respect to equipment design, method of operation, and fuel consumption. Generally, fuel consumption decreases in the order of the processes listed. The paragraphs below briefly describe the process, starting with the wet process and then noting differences in the other processes.

In the wet process and long dry process, all of the pyroprocessing activity occurs in the rotary kiln. Depending on the process type, kilns have length-to-diameter ratios in the range of 15:1 to 40:1. While some wet process kilns may be as long as 210 m (700 ft), many wet process kilns and all dry process kilns are shorter. Wet process and long dry process pyroprocessing systems consist solely of the simple rotary kiln. Usually, a system of chains is provided at the feed end of the kiln in the drying or preheat zones to improve heat transfer from the hot gases to the solid materials. As the kiln rotates, the chains are raised and exposed to the hot gases. Further kiln rotation causes the hot chains to fall into the cooler materials at the bottom of the kiln, thereby transferring the heat to the load.

Dry process pyroprocessing systems have been improved in thermal efficiency and productive capacity through the addition of one or more cyclone-type preheater vessels in the gas stream exiting the rotary kiln. This system is called the preheater process. The vessels are arranged vertically, in series, and are supported by a structure known as the preheater tower. Hot exhaust gases from the rotary kiln pass countercurrently through the downward-moving raw materials in the preheater vessels. Compared to the simple rotary kiln, the heat transfer rate is significantly increased, the degree of heat utilization is greater, and the process time is markedly reduced by the intimate contact of the solid particles with the hot gases. The improved heat transfer allows the length of the rotary kiln to be reduced. The hot gases from the preheater tower are often used as a source of heat for
drying raw materials in the raw mill. Because the catch from the mechanical collectors, fabric filters, and/or electrostatic precipitators (ESP) that follow the raw mill is returned to the process, these devices are considered to be production machines as well as pollution control devices.

Additional thermal efficiencies and productivity gains have been achieved by diverting some fuel to a calciner vessel at the base of the preheater tower. This system is called the preheater/precalciner process. While a substantial amount of fuel is used in the precalciner, at least 40 percent of the thermal energy is required in the rotary kiln. The amount of fuel that is introduced to the calciner is determined by the availability and source of the oxygen for combustion in the calciner. Calciner systems sometimes use lower-quality fuels (e.g., less-volatile matter) as a means of improving process economics.

Preheater and precalciner kiln systems often have an alkali bypass system between the feed end of the rotary kiln and the preheater tower to remove the undesirable volatile constituents. Otherwise, the volatile constituents condense in the preheater tower and subsequently recirculate to the kiln. Buildup of these condensed materials can restrict process and gas flows. The alkali content of portland cement is often limited by product specifications because excessive alkali metals (i.e., sodium and potassium) can cause deleterious reactions in concrete. In a bypass system, a portion of the kiln exit gas stream is withdrawn and quickly cooled by air or water to condense the volatile constituents to fine particles. The solid particles, containing the undesirable volatile constituents, are removed from the gas stream and thus the process by fabric filters and ESPs.

The semidry process is a variation of the dry process. In the semidry process, the water is added to the dry raw mix in a pelletizer to form moist nodules or pellets. The pellets then are conveyed on a moving grate preheater before being fed to the rotary kiln. The pellets are dried and partially calcined by hot kiln exhaust gases passing through the moving grate.

Regardless of the type of pyroprocess used, the last component of the pyroprocessing system is the clinker cooler. This process step recoups up to 30 percent of the heat input to the kiln system, locks in desirable product qualities by freezing mineralogy, and makes it possible to handle the cooled clinker with conventional conveying equipment. The more common types of clinker coolers are (1) reciprocating grate, (2) planetary, and (3) rotary. In these coolers, the clinker is cooled from about 1100°C to 93°C (2000°F to 200°F) by ambient air that passes through the clinker and into the rotary kiln for use as combustion air. However, in the reciprocating grate cooler, lower clinker discharge temperatures are achieved by passing an additional quantity of air through the clinker. Because this additional air cannot be utilized in the kiln for efficient combustion, it is vented to the atmosphere, used for drying coal or raw materials, or used as a combustion air source for the precalciner.

The final step in portland cement manufacturing involves a sequence of blending and grinding operations that transforms clinker to finished portland cement. Up to 5 percent gypsum or natural anhydrite is added to the clinker during grinding to control the cement setting time, and other specialty chemicals are added as needed to impart specific product properties. This finish milling is accomplished almost exclusively in ball or tube mills. Typically, finishing is conducted in a closed-circuit system, with product sizing by air separation.

11.6.2 Emissions And Controls

Particulate matter (PM and PM-10), nitrogen oxides (NOx), sulfur dioxide (SO2), carbon monoxide (CO), and CO2 are the primary emissions in the manufacture of portland cement. Small quantities of volatile organic compounds (VOC), ammonia (NH3), chlorine, and hydrogen chloride
(HCl), also may be emitted. Emissions may also include residual materials from the fuel and raw materials or products of incomplete combustion that are considered to be hazardous. Because some facilities burn waste fuels, particularly spent solvents in the kiln, these systems also may emit small quantities of additional hazardous organic pollutants. Also, raw material feeds and fuels typically contain trace amounts of heavy metals that may be emitted as a particulate or vapor.

Sources of PM at cement plants include (1) quarrying and crushing, (2) raw material storage, (3) grinding and blending (in the dry process only), (4) clinker production, (5) finish grinding, and (6) packaging and loading. The largest emission source of PM within cement plants is the pyroprocessing system that includes the kiln and clinker cooler exhaust stacks. Often, dust from the kiln is collected and recycled into the kiln, thereby producing clinker from the dust. However, if the alkali content of the raw materials is too high, some or all of the dust is discarded or leached before being returned to the kiln. In many instances, the maximum allowable cement alkali content of 0.6 percent (calculated as sodium oxide) restricts the amount of dust that can be recycled. Bypass systems sometimes have a separate exhaust stack. Additional sources of PM are raw material storage piles, conveyors, storage silos, and unloading facilities. Emissions from portland cement plants constructed or modified after August 17, 1971 are regulated to limit PM emissions from portland cement kilns to 0.15 kg/Mg (0.30 lb/ton) of feed (dry basis), and to limit PM emissions from clinker coolers to 0.050 kg/Mg (0.10 lb/ton) of feed (dry basis).

Oxides of nitrogen are generated during fuel combustion by oxidation of chemically-bound nitrogen in the fuel and by thermal fixation of nitrogen in the combustion air. As flame temperature increases, the amount of thermally generated NOx increases. The amount of NOx generated from fuel increases with the quantity of nitrogen in the fuel. In the cement manufacturing process, NOx is generated in both the burning zone of the kiln and the burning zone of a precalcining vessel. Fuel use affects the quantity and type of NOx generated. For example, in the kiln, natural gas combustion with a high flame temperature and low fuel nitrogen generates a larger quantity of NOx than does oil or coal, which have higher fuel nitrogen but which burn with lower flame temperatures. The opposite may be true in a precalciner. Types of fuels used vary across the industry. Historically, some combination of coal, oil, and natural gas was used, but over the last 15 years, most plants have switched to coal, which generates less NOx than does oil or gas. However, in recent years a number of plants have switched to systems that burn a combination of coal and waste fuel. The effect of waste fuel use on NOx emissions is not clearly established.

Sulfur dioxide may be generated both from the sulfur compounds in the raw materials and from sulfur in the fuel. The sulfur content of both raw materials and fuels varies from plant to plant and with geographic location. However, the alkaline nature of the cement provides for direct absorption of SO2 into the product, thereby mitigating the quantity of SO2 emissions in the exhaust stream. Depending on the process and the source of the sulfur, SO2 absorption ranges from about 70 percent to more than 95 percent.

The CO2 emissions from portland cement manufacturing are generated by two mechanisms. As with most high-temperature, energy-intensive industrial processes, combusting fuels to generate process energy releases substantial quantities of CO2. Substantial quantities of CO2 also are generated through calcining of limestone or other calcareous material. This calcining process thermally decomposes CaCO3 to CaO and CO2. Typically, portland cement contains the equivalent of about 63.5 percent CaO. Consequently, about 1.135 units of CaCO3 are required to produce 1 unit of cement, and the amount of CO2 released in the calcining process is about 500 kilograms (kg) per Mg of portland cement produced (1,000 pounds [lb] per ton of cement). Total CO2 emissions from the pyroprocess depend on energy consumption and generally fall in the range of 0.85 to 1.35 Mg of CO2 per Mg of clinker.
In addition to CO₂ emissions, fuel combustion at portland cement plants can emit a wide range of pollutants in smaller quantities. If the combustion reactions do not reach completion, CO and volatile organic pollutants, typically measured as total organic compounds (TOC), VOC, or organic condensable particulate, can be emitted. Incomplete combustion also can lead to emissions of specific hazardous organic air pollutants, although these pollutants are generally emitted at substantially lower levels than CO or TOC.

Emissions of metal compounds from portland cement kilns can be grouped into three general classes: volatile metals, including mercury (Hg) and thallium (Tl); semivolatile metals, including antimony (Sb), cadmium (Cd), lead (Pb), selenium (Se), zinc (Zn), potassium (K), and sodium (Na); and refractory or nonvolatile metals, including barium (Ba), chromium (Cr), arsenic (As), nickel (Ni), vanadium (V), manganese (Mn), copper (Cu), and silver (Ag). Although the partitioning of these metal groups is affected by kiln operating conditions, the refractory metals tend to concentrate in the clinker, while the volatile and semivolatile metals tend to be discharged through the primary exhaust stack and the bypass stack, respectively.

Fugitive dust sources in the industry include quarrying and mining operations, vehicle traffic during mineral extraction and at the manufacturing site, raw materials storage piles, and clinker storage piles. The measures used to control emissions from these fugitive dust sources are comparable to those used throughout the mineral products industries. Vehicle traffic controls include paving and road wetting. Controls that are applied to other open dust sources include water sprays with and without surfactants, chemical dust suppressants, wind screens, and process modifications to reduce drop heights or enclose storage operations. Additional information on these control measures can be found in Chapter 13 of AP-42, "Miscellaneous Sources".

Process fugitive emission sources include materials handling and transfer, raw milling operations in dry process facilities, and finish milling operations. Typically, emissions from these processes are captured by a ventilation system and collected in fabric filters. Some facilities use an air pollution control system comprising one or more mechanical collectors with a fabric filter in series. Because the dust from these units is returned to the process, they are considered to be process units as well as air pollution control devices. The industry uses shaker, reverse air, and pulse jet filters as well as some cartridge units, but most newer facilities use pulse jet filters. For process fugitive operations, the different systems are reported to achieve typical outlet PM loadings of 45 milligrams per cubic meter (mg/m³) (0.02 grains per actual cubic foot [gr/acf]).

In the pyroprocessing units, PM emissions are controlled by fabric filters (reverse air, pulse jet, or pulse plenum) and electrostatic precipitators (ESP). Typical control measures for the kiln exhaust are reverse air fabric filters with an air-to-cloth ratio of 0.41:1 m³/min/m² (1.5:1 acfm/ft²) and ESP with a net surface collection area of 1,140 to 1,620 m²/1,000 m³ (350 to 500 ft²/1,000 ft³). These systems are reported to achieve outlet PM loadings of 45 mg/m³ (0.02 gr/acf). Clinker cooler systems are controlled most frequently with pulse jet or pulse plenum fabric filters. A few gravel bed filters also have been used to control clinker cooler emissions. Typical outlet PM loadings are identical to those reported for kilns.

Cement kiln systems have highly alkaline internal environments that can absorb up to 95 percent of potential SO₂ emissions. However, in systems that have sulfide sulfur (pyrites) in the kiln feed, the sulfur absorption rate may be as low as 70 percent without unique design considerations or changes in raw materials. The cement kiln system itself has been determined to provide substantial SO₂ control. Fabric filters on cement kilns are also reported to absorb SO₂. Generally, substantial control is not achieved. An absorbing reagent (e.g., CaO) must be present in the filter cake for SO₂ capture to occur. Without the presence of water, which is undesirable in the operation of a fabric
filter, CaCO$_3$ is not an absorbing reagent. It has been observed that as much as 50 percent of the SO$_2$ can be removed from the pyroprocessing system exhaust gases when this gas stream is used in a raw mill for heat recovery and drying. In this case, moisture and calcium carbonate are simultaneously present for sufficient time to accomplish the chemical reaction with SO$_2$.

Tables 11.6-1 and 11.6-2 present emission factors for PM emissions from portland cement manufacturing kilns and clinker coolers. Tables 11.6-3 and 11.6-4 present emission factors for PM emissions from raw material and product processing and handling. Particle size distributions for emissions from wet process and dry process kilns are presented in Table 11.6-5, and Table 11.6-6 presents the particle size distributions for emissions from clinker coolers. Emission factors for SO$_2$, NO$_x$, CO, CO$_2$, and TOC emissions from portland cement kilns are summarized in Tables 11.6-7 and 11.6-8. Table 11.6-9 summarizes emission factors for other pollutant emissions from portland cement kilns.

Because of differences in the sulfur content of the raw material and fuel and in process operations, a mass balance for sulfur may yield a more representative emission factor for a specific facility than the SO$_2$ emission factors presented in Tables 11.6-7 and 11.6-8. In addition, CO$_2$ emission factors estimated using a mass balance on carbon may be more representative for a specific facility than the CO$_2$ emission factors presented in Tables 11.6-7 and 11.6-8.
<table>
<thead>
<tr>
<th>Process</th>
<th>Filterable&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Condensable&lt;sup&gt;c&lt;/sup&gt;</th>
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<tr>
<td>Wet process kiln</td>
<td>PM</td>
<td>EMISSION FACTOR RATING</td>
</tr>
<tr>
<td>Wet process kiln with ESP</td>
<td>0.38&lt;sup&gt;1&lt;/sup&gt;</td>
<td>C</td>
</tr>
<tr>
<td>Wet process kiln with fabric filter</td>
<td>0.23&lt;sup&gt;1&lt;/sup&gt;</td>
<td>E</td>
</tr>
<tr>
<td>Wet process kiln with cooling tower,</td>
<td>0.10&lt;sup&gt;h&lt;/sup&gt;</td>
<td>E</td>
</tr>
<tr>
<td>Dry process kiln with ESP</td>
<td>0.50&lt;sup&gt;u&lt;/sup&gt;</td>
<td>D</td>
</tr>
<tr>
<td>Dry process kiln with fabric filter</td>
<td>0.10&lt;sup&gt;u&lt;/sup&gt;</td>
<td>D</td>
</tr>
<tr>
<td>Preheater kiln</td>
<td>130&lt;sup&gt;j&lt;/sup&gt;</td>
<td>D</td>
</tr>
<tr>
<td>Preheater kiln with ESP</td>
<td>0.13&lt;sup&gt;f&lt;/sup&gt;</td>
<td>D</td>
</tr>
<tr>
<td>Preheater kiln with fabric filter</td>
<td>0.13&lt;sup&gt;g&lt;/sup&gt;</td>
<td>C</td>
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<tr>
<td>Preheater/precalciner kiln with ESP</td>
<td>0.024&lt;sup&gt;u&lt;/sup&gt;</td>
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<tr>
<td>Preheater/precalciner process kiln with</td>
<td>0.10&lt;sup&gt;r&lt;/sup&gt;</td>
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<tr>
<td>Preheater/precalciner process kiln with</td>
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</table>

<sup>a</sup> Table 11.6-1 (Metric Units). EMISSION FACTORS FOR PORTLAND CEMENT MANUFACTURING KILNS AND CLINKER COOLERS

<sup>b</sup> Filterable:
- PM: PM-10
- EMISSION FACTOR RATING: D, C, E, ND

<sup>c</sup> Condensable:
- Inorganic
- EMISSION FACTOR RATING: D, C, E, ND
- Organic
- EMISSION FACTOR RATING: D, C, E, ND
<table>
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<tr>
<td></td>
<td>PM</td>
<td>EMISSION FACTOR RATING</td>
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<tr>
<td>Clinker cooler with ESP</td>
<td>0.048&lt;sup&gt;x&lt;/sup&gt;</td>
<td>D</td>
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<tr>
<td>Clinker cooker with fabric filter</td>
<td>0.068&lt;sup&gt;y&lt;/sup&gt;</td>
<td>D</td>
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<td>(SCC 3-05-006-14)</td>
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<tr>
<td>Clinker cooler with gravel bed filter</td>
<td>0.11&lt;sup&gt;aa&lt;/sup&gt;</td>
<td>D</td>
</tr>
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<td>(SCC 3-05-006-14)</td>
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</table>

<sup>a</sup> Factors represent uncontrolled emissions unless, otherwise noted. Factors are kg/Mg of clinker produced, unless noted. SCC = Source Classification Code. ND = no data. ESP = electrostatic precipitator.

<sup>b</sup> Filterable PM is that collected on or before the filter of an EPA Method 5 (or equivalent) sampling train.

<sup>c</sup> Condensable PM is that collected in the impinger portion of a PM sampling train.

<sup>d</sup> References 20,26.
<sup>e</sup> References 3,20,26.
<sup>f</sup> References 8-9,18,20,25-26,32,34-36,41-44,60,64.
<sup>g</sup> References 3,8-9,18,20,25-26,32,34-36,41-44,60,64.
<sup>h</sup> References 8-9,20,64.
<sup>i</sup> Reference 14.
<sup>j</sup> Reference 21.
<sup>k</sup> References 19,21.
<sup>l</sup> Reference 23.
<sup>m</sup> References 3,23.
<sup>n</sup> Reference 17.
<sup>o</sup> Reference 31.
<sup>p</sup> References 17,47-50,61.
<sup>q</sup> Reference 51.
<sup>r</sup> Reference 37.
<sup>s</sup> References 30,33,51,56-59,63
<sup>t</sup> References 30,33,37,51,59.
<sup>u</sup> Reference 8.
y References 9,12,27,30,33.
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<th>Condensable&lt;sup&gt;c&lt;/sup&gt;</th>
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<td>Inorganic</td>
</tr>
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<td>ND</td>
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<td>Wet process kiln with ESP (SCC 3-05-007-06)</td>
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<td>0.15&lt;sup&gt;b&lt;/sup&gt;</td>
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<td>0.20&lt;sup&gt;j&lt;/sup&gt;</td>
</tr>
<tr>
<td>Wet process kiln with cooling tower, multiclone, and ESP (SCC 3-05-007-06)</td>
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<td>0.29&lt;sup&gt;k&lt;/sup&gt;</td>
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<td>1.0&lt;sup&gt;m&lt;/sup&gt;</td>
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<td>250&lt;sup&gt;m&lt;/sup&gt;</td>
<td>ND</td>
</tr>
<tr>
<td>Preheater kiln with ESP (SCC 3-05-006-22)</td>
<td>0.26&lt;sup&gt;e&lt;/sup&gt;</td>
<td>ND</td>
</tr>
<tr>
<td>Preheater kiln with fabric filter (SCC 3-05-006-22)</td>
<td>0.25&lt;sup&gt;s&lt;/sup&gt;</td>
<td>0.033&lt;sup&gt;t&lt;/sup&gt;</td>
</tr>
<tr>
<td>Preheater/precalciner kiln with ESP (SCC 3-05-006-23)</td>
<td>0.048&lt;sup&gt;u&lt;/sup&gt;</td>
<td>ND</td>
</tr>
<tr>
<td>Preheater/precalciner process kiln with fabric filter (SCC 3-05-006-23)</td>
<td>0.21&lt;sup&gt;v&lt;/sup&gt;</td>
<td>ND</td>
</tr>
<tr>
<td>Preheater/precalciner process kiln with PM controls (SCC 3-05-006-23)</td>
<td>ND</td>
<td>0.16&lt;sup&gt;w&lt;/sup&gt;</td>
</tr>
</tbody>
</table>
# Table 11.6-2 (cont.)

<table>
<thead>
<tr>
<th>Process</th>
<th>PM</th>
<th>EMISSION FACTOR RATING</th>
<th>PM-10</th>
<th>EMISSION FACTOR RATING</th>
<th>Inorganic</th>
<th>EMISSION FACTOR RATING</th>
<th>Condensable</th>
<th>EMISSION FACTOR RATING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinker cooler with ESP (SCC 3-05-006-14)</td>
<td>0.096&lt;sup&gt;a&lt;/sup&gt;</td>
<td>D</td>
<td>ND</td>
<td>0.0075&lt;sup&gt;a&lt;/sup&gt;</td>
<td>D</td>
<td>ND</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clinker cooker with fabric filter (SCC 3-05-006-14)</td>
<td>0.13&lt;sup&gt;b&lt;/sup&gt;</td>
<td>D</td>
<td>ND</td>
<td>0.017&lt;sup&gt;c&lt;/sup&gt;</td>
<td>D</td>
<td>ND</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clinker cooler with gravel bed filter (SCC 3-05-006-14)</td>
<td>0.21&lt;sup&gt;aa&lt;/sup&gt;</td>
<td>D</td>
<td>0.16&lt;sup&gt;bb&lt;/sup&gt;</td>
<td>0.0090&lt;sup&gt;cc&lt;/sup&gt;</td>
<td>D</td>
<td>ND</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup> Factors represent uncontrolled emissions unless otherwise noted. Factors are lb/ton of clinker produced unless noted. SCC = Source Classification Code, ND = no data. ESP = electrostatic precipitator.

<sup>b</sup> Filterable PM is that collected on or before the filter of an EPA Method 5 (or equivalent) sampling train.

<sup>c</sup> Condensable PM is that collected in the impinger portion of a PM sampling train.

<sup>aa</sup> References 22,29,31

<sup>bb</sup> References 3,22,29,31

<sup>cc</sup> References 22,29
Table 11.6-3 (Metric Units). EMISSION FACTORS FOR PORTLAND CEMENT MANUFACTURING RAW MATERIAL AND PRODUCT PROCESSING AND HANDLING<sup>a</sup>

<table>
<thead>
<tr>
<th>Process</th>
<th>Filterable&lt;sup&gt;b&lt;/sup&gt;</th>
<th>PM</th>
<th>EMISSION FACTOR RATING</th>
<th>PM-10</th>
<th>EMISSION FACTOR RATING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw mill with fabric filter</td>
<td>0.0062&lt;sup&gt;c&lt;/sup&gt;</td>
<td>D</td>
<td>ND</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(SCC 3-05-006-13)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Raw mill feed belt with fabric filter</td>
<td>0.0016&lt;sup&gt;d&lt;/sup&gt;</td>
<td>E</td>
<td>ND</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(SCC 3-05-006-24)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Raw mill weigh hopper with fabric filter</td>
<td>0.010&lt;sup&gt;e&lt;/sup&gt;</td>
<td>E</td>
<td>ND</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(SCC 3-05-006-25)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Raw mill air separator with fabric filter</td>
<td>0.016&lt;sup&gt;g&lt;/sup&gt;</td>
<td>E</td>
<td>ND</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(SCC 3-05-006-26)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Finish grinding mill with fabric filter</td>
<td>0.0042&lt;sup&gt;f&lt;/sup&gt;</td>
<td>D</td>
<td>ND</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(SCC 3-05-006-17, 3-05-007-17)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Finish grinding mill feed belt with fabric filter</td>
<td>0.0012&lt;sup&gt;d&lt;/sup&gt;</td>
<td>E</td>
<td>ND</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(SCC 3-05-006-27, 3-05-007-27)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Finish grinding mill weigh hopper with fabric filter</td>
<td>0.0047&lt;sup&gt;e&lt;/sup&gt;</td>
<td>E</td>
<td>ND</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(SCC 3-05-006-28, 3-05-007-28)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Finish grinding mill air separator with fabric filter</td>
<td>0.014&lt;sup&gt;g&lt;/sup&gt;</td>
<td>D</td>
<td>ND</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(SCC 3-05-006-29, 3-05-007-29)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary limestone crushing with fabric filter</td>
<td>0.00050</td>
<td>E</td>
<td>ND</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(SCC 3-05-006-09)&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary limestone screening with fabric filter</td>
<td>0.00011</td>
<td>E</td>
<td>ND</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(SCC 3-05-006-11)&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Limestone transfer with fabric filter</td>
<td>1.5 x 10&lt;sup&gt;-5&lt;/sup&gt;</td>
<td>E</td>
<td>ND</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(SCC 3-05-006-12)&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Secondary limestone screening and crushing with fabric filter</td>
<td>0.00016</td>
<td>E</td>
<td>ND</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(SCC 3-05-006-10 + -11, 3-05-007-10 + -11)&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup> Factors represent uncontrolled emissions, unless otherwise noted. Factors are kg/Mg of material process, unless noted. SCC = Source Classification Code. ND = no data.

<sup>b</sup> Filterable PM is that collected on or before the filter of an EPA Method 5 (or equivalent) sampling train.

<sup>c</sup> References 15,56-57.

<sup>d</sup> Reference 57.

<sup>e</sup> Reference 15.

<sup>f</sup> References 10,12,15,56-57.

<sup>g</sup> References 10,15.

<sup>h</sup> Reference 16. Alternatively, emission factors from Section 11.19.2, "Crushed Stone Processing", can be used for similar processes and equipment.
Table 11.6-4 (English Units). EMISSION FACTORS FOR PORTLAND CEMENT MANUFACTURING RAW MATERIAL AND PRODUCT PROCESSING AND HANDLING

<table>
<thead>
<tr>
<th>Process</th>
<th>Filterable&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PM</td>
</tr>
<tr>
<td>Raw mill with fabric filter (SCC 3-05-006-13)</td>
<td></td>
</tr>
<tr>
<td>Raw mill feed belt with fabric filter (SCC 3-05-006-24)</td>
<td>0.0031&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>Raw mill weigh hopper with fabric filter (SCC 3-05-006-25)</td>
<td>0.019&lt;sup&gt;e&lt;/sup&gt;</td>
</tr>
<tr>
<td>Raw mill air separator with fabric filter (SCC 3-05-006-26)</td>
<td>0.032&lt;sup&gt;e&lt;/sup&gt;</td>
</tr>
<tr>
<td>Finish grinding mill with fabric filter (SCC 3-05-006-17, 3-05-007-17)</td>
<td>0.0080&lt;sup&gt;f&lt;/sup&gt;</td>
</tr>
<tr>
<td>Finish grinding mill feed belt with fabric filter (SCC 3-05-006-27, 3-05-007-27)</td>
<td>0.0024&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>Finish grinding mill weigh hopper with fabric filter (SCC 3-05-006-28, 3-05-007-28)</td>
<td>0.0094&lt;sup&gt;e&lt;/sup&gt;</td>
</tr>
<tr>
<td>Finish grinding mill air separator with fabric filter (SCC 3-05-006-29, 3-05-007-29)</td>
<td>0.028&lt;sup&gt;e&lt;/sup&gt;</td>
</tr>
<tr>
<td>Primary limestone crushing with fabric filter (SCC 3-05-006-09)&lt;sup&gt;h&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>Primary limestone screening with fabric filter (SCC 3-05-006-11)&lt;sup&gt;h&lt;/sup&gt;</td>
<td>0.00022</td>
</tr>
<tr>
<td>Limestone transfer with fabric filter (SCC 3-05-006-12)&lt;sup&gt;h&lt;/sup&gt;</td>
<td>2.9 x 10&lt;sup&gt;-5&lt;/sup&gt;</td>
</tr>
<tr>
<td>Secondary limestone screening and crushing with fabric filter (SCC 3-05-006-10 + -11, 3-05-007-10 + -11)&lt;sup&gt;h&lt;/sup&gt;</td>
<td>0.00031</td>
</tr>
</tbody>
</table>

<sup>a</sup> Factors represent uncontrolled emissions, unless otherwise noted. Factors are lb/ton of material processed, unless noted. SCC = Source Classification Code. ND = no data.

<sup>b</sup> Filterable PM is that collected on or before the filter of an EPA Method 5 (or equivalent) sampling train.

<sup>c</sup> References 15, 56-57.

<sup>d</sup> Reference 57.

<sup>e</sup> Reference 15.

<sup>f</sup> References 10, 12, 15, 56-57.

<sup>g</sup> References 10, 15.

<sup>h</sup> Reference 16. Alternatively, emission factors from the Section 11.19.2, "Crushed Stone Processing", can be used for similar processes and equipment.
Table 11.6-5. SUMMARY OF AVERAGE PARTICLE SIZE DISTRIBUTION FOR PORTLAND CEMENT KILNS

<table>
<thead>
<tr>
<th>Particle Size, μm</th>
<th>Cumulative Mass Percent Equal To Or Less Than Stated Size</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Uncontrolled</td>
<td>Controlled</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Wet process (SCC 3-05-007-06)</td>
<td>Dry process (SCC 3-05-006-06)</td>
<td>Wet process With ESP (SCC 3-05-007-06)</td>
</tr>
<tr>
<td>2.5</td>
<td>7</td>
<td>18</td>
<td>64</td>
</tr>
<tr>
<td>5.0</td>
<td>20</td>
<td>ND</td>
<td>83</td>
</tr>
<tr>
<td>10.0</td>
<td>24</td>
<td>42</td>
<td>85</td>
</tr>
<tr>
<td>15.0</td>
<td>35</td>
<td>44</td>
<td>91</td>
</tr>
<tr>
<td>20.0</td>
<td>57</td>
<td>ND</td>
<td>98</td>
</tr>
</tbody>
</table>

* Reference 3. SCC = Source Classification Code. ND = no data.

Table 11.6-6. SUMMARY OF AVERAGE PARTICLE SIZE DISTRIBUTION FOR PORTLAND CEMENT CLINKER COOLERS

<table>
<thead>
<tr>
<th>Particle Size, μm</th>
<th>Cumulative Mass Percent Equal To Or Less Than Stated Size</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Uncontrolled (SCC 3-05-006-14, 3-05-007-14)</td>
</tr>
<tr>
<td>2.5</td>
<td>0.54</td>
</tr>
<tr>
<td>5.0</td>
<td>1.5</td>
</tr>
<tr>
<td>10.0</td>
<td>8.6</td>
</tr>
<tr>
<td>15.0</td>
<td>21</td>
</tr>
<tr>
<td>20.0</td>
<td>34</td>
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</table>

* Reference 3. SCC = Source Classification Code.
Table 11.6-7 (Metric Units). EMISSION FACTORS FOR PORTLAND CEMENT MANUFACTURING

<table>
<thead>
<tr>
<th>Process</th>
<th>SO₂</th>
<th>EMISSION FACTOR RATING</th>
<th>NOₓ</th>
<th>EMISSION FACTOR RATING</th>
<th>CO</th>
<th>EMISSION FACTOR RATING</th>
<th>CO₂</th>
<th>EMISSION FACTOR RATING</th>
<th>TOC</th>
<th>EMISSION FACTOR RATING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wet process kiln (SCC 3-05-007-06)</td>
<td>4.1d</td>
<td>C</td>
<td>3.7a</td>
<td>D</td>
<td>0.060f</td>
<td>D</td>
<td>1,100f</td>
<td>D</td>
<td>0.014d</td>
<td>D</td>
</tr>
<tr>
<td>Long dry process kiln (SCC 3-05-006-06)</td>
<td>4.9h</td>
<td>D</td>
<td>3.0j</td>
<td>D</td>
<td>0.11k</td>
<td>E</td>
<td>900m</td>
<td>D</td>
<td>0.014a</td>
<td>E</td>
</tr>
<tr>
<td>Preheater process kiln (SCC 3-05-006-22)</td>
<td>0.27f</td>
<td>D</td>
<td>2.4g</td>
<td>D</td>
<td>0.49f</td>
<td>D</td>
<td>900x</td>
<td>C</td>
<td>0.090f</td>
<td>D</td>
</tr>
<tr>
<td>Preheater/precalciner kiln (SCC 3-05-006-23)</td>
<td>0.54p</td>
<td>D</td>
<td>2.1p</td>
<td>D</td>
<td>1.8wp</td>
<td>D</td>
<td>900x</td>
<td>E</td>
<td>0.059p</td>
<td>D</td>
</tr>
<tr>
<td>Preheater/precalciner kiln with spray tower</td>
<td>0.50s</td>
<td>E</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
</tbody>
</table>

* Factors represent uncontrolled emissions unless otherwise noted. Factors are kg/Mg of clinker produced, unless noted. SCC = Source Classification Code. ND = no data.

** Mass balance on sulfur may yield a more representative emission factor for a specific facility than the SO₂ emission factors presented in this table.

*** Mass balance on carbon may yield a more representative emission factor for a specific facility than the CO₂ emission factors presented in this table.

References:
- 20, 25-26, 32, 34-36, 41-44, 60, 64.
- 26, 34-36, 43, 64.
- 47-50.
- 49.
- 24, 31, 47-50, 61.
Table 11.6-7 (cont.).

<table>
<thead>
<tr>
<th>Note</th>
<th>Reference(s)</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>Reference 49; total organic compounds as measured by Method 25A or equivalent.</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>References 28, 30, 33, 37, 53, 56-59.</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>References 28, 30, 33, 37, 45, 56-59.</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>References 28, 30, 37, 56-58, 63.</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>References 24, 31, 47-50, 61. Based on test data for preheater kilns; should be considered an upper limit.</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>References 30, 33, 56, 63; total organic compounds as measured using Method 25A or equivalent.</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Reference 54.</td>
<td></td>
</tr>
<tr>
<td>Process</td>
<td>$SO_2$</td>
<td>$NO_x$</td>
</tr>
<tr>
<td>--------------------------------------------------------------</td>
<td>--------</td>
<td>--------</td>
</tr>
<tr>
<td>Wet process kiln (SCC 3-05-007-06)</td>
<td>8.2$^d$</td>
<td>C</td>
</tr>
<tr>
<td>Long dry process kiln (SCC 3-05-006-06)</td>
<td>10$^h$</td>
<td>D</td>
</tr>
<tr>
<td>Preheater process kiln (SCC 3-05-006-22)</td>
<td>0.55$^p$</td>
<td>D</td>
</tr>
<tr>
<td>Preheater/precalciner kiln (SCC 3-05-006-23)</td>
<td>1.1$^m$</td>
<td>D</td>
</tr>
<tr>
<td>Preheater/precalciner kiln with spray tower</td>
<td>1.0$^m$</td>
<td>E</td>
</tr>
</tbody>
</table>

$^a$ Factors represent uncontrolled emissions unless otherwise noted. Factors are lb/ton of clinker produced, unless noted.

$^b$ Mass balance on sulfur may yield a more representative emission factor for a specific facility than the $SO_2$ emission factors presented in this table.

$^c$ Mass balance on carbon may yield a more representative emission factor for a specific facility than the $CO_2$ emission factors presented in this table.

$^d$ References 20,25-26,32,34-36,41-44,60,64.

$^e$ References 26,34-36,43,64.

$^f$ Reference 64.

$^g$ References 25-26,32,34-36,44,60,64.

$^h$ References 11,19,39-40.

$^i$ References 11,38-40,65.

$^j$ References 39,65.

$^k$ References 11,21,23,65.

$^l$ References 40,65. TOC as measured by Method 25A or equivalent.

$^m$ References 40,65. TOC as measured by Method 25A or equivalent.

$^n$ References 47-50.

$^o$ References 48-50.

$^p$ Reference 49.

$^q$ References 24,31,47-50,61.

$^r$ Reference 49, total organic compounds as measured by Method 25A or equivalent.
Table 11.6-8 (cont.).

- References 28, 30, 33, 37, 53, 56-59.
- References 28, 30, 33, 37, 45, and 56 to 59.
- References 28, 30, 37, 56-58, 63.
- References 24, 31, 47-50, 61. Based on test data for preheater kilns; should be considered an upper limit.
- References 30, 33, 56, 63; total organic compounds as measured using Method 25A or equivalent.
- Reference 54.
Table 11.6-9 (Metric And English Units): SUMMARY OF NONCRITERIA POLLUTANT
EMISSION FACTORS FOR PORTLAND CEMENT KILNS
(SCC 3-05-006-06, 3-05-007-06, 3-05-006-22, 3-05-006-23)

<table>
<thead>
<tr>
<th>Pollutant Name</th>
<th>Type Of Control</th>
<th>Average Emission Factor</th>
<th>EMISSION FACTOR RATING</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inorganic Pollutants</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Silver (Ag)</td>
<td>FF</td>
<td>3.1x10^{-7}</td>
<td>6.1x10^{-7}</td>
<td>D</td>
</tr>
<tr>
<td>Aluminum (Al)</td>
<td>ESP</td>
<td>0.0065</td>
<td>0.013</td>
<td>E</td>
</tr>
<tr>
<td>Arsenic (As)</td>
<td>ESP</td>
<td>6.5x10^{-6}</td>
<td>1.3x10^{-5}</td>
<td>E</td>
</tr>
<tr>
<td>Arsenic (As)</td>
<td>FF</td>
<td>6.0x10^{-6}</td>
<td>1.2x10^{-5}</td>
<td>D</td>
</tr>
<tr>
<td>Barium (Ba)</td>
<td>ESP</td>
<td>0.00018</td>
<td>0.00035</td>
<td>D</td>
</tr>
<tr>
<td>Barium (Ba)</td>
<td>FF</td>
<td>0.00023</td>
<td>0.00046</td>
<td>D</td>
</tr>
<tr>
<td>Beryllium (Be)</td>
<td>FF</td>
<td>3.3x10^{-7}</td>
<td>6.6x10^{-7}</td>
<td>D</td>
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<tr>
<td>Calcium (Ca)</td>
<td>ESP</td>
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<td>Cadmium (Cd)</td>
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<td>2.2x10^{-6}</td>
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<td>Chloride (Cl)</td>
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<td>0.34</td>
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<td>Chromium (Cr)</td>
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<td>Chromium (Cr)</td>
<td>FF</td>
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<td>Copper (Cu)</td>
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<td>0.0026</td>
<td>0.0053</td>
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<td>Fluoride (F)</td>
<td>ESP</td>
<td>0.0045</td>
<td>0.0090</td>
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<td>Iron (Fe)</td>
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<td>0.0085</td>
<td>0.017</td>
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<td>Hydrogen chloride (HCl)</td>
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<td>0.025</td>
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<td>Mercury (Hg)</td>
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<td>Potassium (K)</td>
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<td>Manganese (Mn)</td>
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<td>Ammonia (NH₃)</td>
<td>FF</td>
<td>0.0051</td>
<td>0.010</td>
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<tr>
<td>Ammonium (NH₄⁺)</td>
<td>ESP</td>
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<td>0.11</td>
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<tr>
<td>Nitrate (NO₃⁻)</td>
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<td>0.0023</td>
<td>0.0046</td>
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<td>Sodium (Na)</td>
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<td>0.020</td>
<td>0.038</td>
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<td>Lead (Pb)</td>
<td>ESP</td>
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<td>Sulfur trioxide (SO₃)</td>
<td>ESP</td>
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<td>Sulfur trioxide (SO₃)</td>
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Table 11.6-9 (cont.).

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<th>EMISSION FACTOR</th>
<th>References</th>
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<td></td>
<td></td>
<td>kg/Mg</td>
<td>lb/ton</td>
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<td>Selenium (Se)</td>
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<td>Thallium (Th)</td>
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<td>Titanium (Ti)</td>
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<td>Zinc (Zn)</td>
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<tr>
<th>CASRN</th>
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<th>EMISSION FACTOR</th>
<th>References</th>
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<tr>
<td>35822-46-9</td>
<td>1,2,3,4,6,7,8 HpCDD</td>
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<td>C3 benzenes</td>
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<td>208-96-8</td>
<td>acenaphthylene</td>
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<td>67-64-1</td>
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<td>50-32-8</td>
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<td>bis(2-ethylhexyl)phthalate</td>
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<td>CASRN&lt;sup&gt;a&lt;/sup&gt;</td>
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<td>193-39-5</td>
<td>isocyanato(1,2,3-oxadi)pyrene</td>
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<td>78-93-3</td>
<td>methyl ethyl ketone</td>
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<td>methylene chloride</td>
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<td>75-09-2</td>
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<td>4.3x10&lt;sup&gt;-8&lt;/sup&gt;</td>
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<td>xylene</td>
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<td>2.2x10&lt;sup&gt;-6&lt;/sup&gt;</td>
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<td>total HxCDD</td>
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<sup>a</sup> Factors are kg/Mg and lb/ton of clinker produced. SCC = Source Classification Code. ESP = electrostatic precipitator. FF = fabric filter.

<sup>b</sup> Chemical Abstract Service Registry Number (organic compounds only).

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