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*The National Association of Clean Air Agencies (NACAA) represents air pollution control agencies in 53 states and territories and over 165 major metropolitan areas across the United States.

State and local air pollution control officials formed NACAA (formerly STAPPA/ALAPCO) over 30 years ago to improve their effectiveness as managers of air quality programs. The associations serve to encourage the exchange of information among air pollution control officials, to enhance communication and cooperation among federal, state, and local regulatory agencies, and to promote good management of our air resources.
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Particulate Matter Formation and Regulation

This chapter discusses and explains the PM regulations at the federal, state and local levels.

2.1 Particle Formation

The range of particle sizes formed in a process is largely dependent on the types of particle formation mechanisms present. It is possible to estimate the general size range simply by recognizing which of these is important in the process being evaluated. The most important particle formation mechanisms in air pollution sources include the following:

- Physical attrition/mechanical dispersion
- Combustion particle burnout
- Homogeneous condensation
- Heterogeneous nucleation
- Droplet evaporation

Physical attrition occurs when two surfaces rub together. For example, the grinding of a rod on a grinding wheel (as shown in Figure 2-1) yields small particles that break off from both surfaces. The compositions and densities of these particles are identical to the parent materials.

![Grinding wheel diagram](Image)

Figure 2-1. Grinding wheel
The tertiary stone crusher shown in Figure 2-2 is an example of an industrial source of particles that involves only physical attrition. The particles formed range from approximately 1 µm to almost 1,000 µm. However, because of the limited energy used in the crushing operation, very little of the particulate matter is less than 10 µm. Physical attrition generates primarily large particles.

In order for fuel to burn, it must be pulverized (solid fuel) or atomized (liquid fuel) so that sufficient surface area is exposed to oxygen and high temperature. The surface area of particles increases substantially as more and more of the material is reduced in size. Accordingly most solid fuel-fired industrial-scale combustion processes use one or more types of physical attrition in order to prepare or introduce the fuel into the furnace. For example, coal-fired boilers use pulverizers to reduce the chunks of coal to sizes that can be burned quickly. Oil-fired boilers use atomizers to disperse the oil as fine droplets. In both cases, the fuel particle size range is reduced primarily to the 100-1,000 µm range. Coal pulverizers and oil burner atomizers are examples of physical attrition and mechanical dispersion.

When the fuel particles are injected into the hot furnace area of the combustion process (Figure 2-3), most of the organic compounds are vaporized and oxidized in the gas stream. The fuel particles get smaller as the volatile matter leaves. The fuel particles are quickly reduced to only the noncombustible matter (ash) and slow burning char composed of organic compounds. Eventually, most of the char will also burn, leaving primarily the noncombustible material. As oxidation progresses, the fuel particles, which started as 100-1,000 µm particles, are reduced to ash and char particles that are
primarily in the 1 to 10 µm range. This mechanism for particle formation is termed combustion fuel burnout.

Homogeneous nucleation and heterogeneous nucleation involve the conversion of vapor phase materials to a particulate matter form. Homogeneous nucleation is the formation of new particles composed almost entirely of the vapor phase material. Heterogeneous nucleation is the accumulation of material on the surfaces of particles that have formed due to other mechanisms. In both cases, the vapor-containing gas streams must cool to the temperature at which nucleation can occur. The temperature at which vapors begin to condense is called the dew point, and it depends on the concentration of the vapors. The dew point increases with increases in the vapor concentration. Some compounds condense in relatively hot gas zones (>1,000°F), while others do not reach their dew point temperature until the gas stream cools below 300°F.

There are three main categories of vapor phase material that can nucleate in air pollution source gas streams: (1) organic compounds, (2) inorganic metals and metal compounds, and (3) chloride compounds. For example, in a waste incinerator organic vapor that has volatilized from the waste due to the high temperature is generally oxidized completely to carbon dioxide and water. However, if there is combustion upset, a portion of the organic compounds or their partial oxidation products remain in the gas stream as they leave the incinerator. These organic vapors can condense in downstream equipment. Volatile metals and metal compounds such as mercury, lead, lead oxide, cadmium, cadmium oxide, cadmium chloride, and arsenic trioxide can also volatilize in the hot incinerator. Once the gas stream passes through the heat exchange equipment used to produce steam, the organic vapors and metal vapors can
homogeneously or heterogeneously condense. Generally, the metals and metal compounds reach their dew point first and begin to nucleate in relatively hot zones of the unit. The organic vapors and/or chloride compounds begin to condense in downstream areas of the process where the gas temperatures are cooler. These particles must then be collected in the downstream air pollution control systems. Homogeneous and heterogeneous nucleation generally creates particles that are very small, often between 0.05 and 1.0 µm.

Heterogeneous nucleation facilitates a phenomenon called enrichment in particles in the submicrometer size range. The elemental metals and metal compounds volatilized during high temperature operations (e.g., fossil fuel combustion, incinerator, and metallurgical processes) nucleate preferentially on these very small particles. This means that these particles have more of these materials than the very large particles leaving the processes. These small particles are described as enriched with respect to their concentration of metals and metal compounds. Heterogeneous nucleation contributes to the formation of particle distributions that have quite different chemical compositions in different size ranges.

Another consequence of heterogeneous nucleation is that the metals are deposited in small quantities on the surfaces of a large number of small particles (Figure 2-4). In this form, the metals are available to participate in catalytic reactions with gases or other vapor phase materials that are continuing to nucleate. Accordingly, heterogeneous nucleation also increases the types of chemical reactions that can occur as the particles travel in the gas stream from the process source and through the air pollution control device.

Figure 2-4. Heterogeneous nucleation

Some air pollution control systems use solids-containing water recycled from wet scrubbers to cool the gas streams. This practice inadvertently creates another particle formation mechanism that is very similar to fuel burnout. The water streams are atomized during injection into the hot gas streams. As these small droplets evaporate to dryness, the suspended and dissolved solids are released as small particles. The particle size range created by this mechanism has not been extensively studied; however, it probably creates particles that range in size from 0.1-2.0 µm. All of these particles must then be collected in the downstream air pollution control systems.
A summary of the particle size ranges generated by the different formation mechanisms is provided in Figure 2.5. Several particle formation mechanisms can be present in many air pollution sources. As a result, the particles created can have a wide range of sizes and chemical compositions.

![Diagram showing particle size distribution](image)

Figure 2.5. Approximate size distributions for various formation mechanisms
2.2 Primary and Secondary Particulate Matter

Particulate matter in the atmosphere can be divided into the following two categories:

- Primary particulate matter
- Secondary particulate matter

Primary particulate matter includes both: (1) material emitted directly into the atmosphere, and (2) “condensable” particulate matter formed quickly from condensed vapors.

Direct-emitted primary particulate emissions have always been of concern to air quality programs. Primary particulate matter can consist of particles less than 0.1 micrometer to more than 100 micrometers. Very large particles have the potential for a dust nuisance in the near vicinity of their emissions. Smaller particles become airborne and are transported, thereby contributing to particulate levels in the atmosphere, both within urban areas and over broader regions.

High molecular weight volatile organic compounds and sulfuric acid are two common examples of emissions that are gaseous at stack conditions, but which condense to form particulate matter. These materials pass through particulate matter control systems, including high efficiency devices, due to their vapor form in the stationary source gas stream. However, at ambient temperature the vapor phase material condenses in the ambient air to form particles measured by ambient sampling systems.

EPA stack sampling methods for particulate matter include methods for collecting direct emitted particles on a filter (method 5) and for collecting condensable particulate matter by cooling the gas stream in impingers downstream of the filter (method 202). Direct-emitted particulate matter is sometimes referred to as “filterable” or “front half” particulate matter, while condensable particulate matter is sometimes referred to as the “back half.” EPA emissions inventory reporting systems contain separate reporting of filterable and condensable particulate matter.

Secondary particulate matter refers to particles formed due to atmospheric reactions of gaseous precursors. Ammonium sulfate and ammonium nitrate are two common examples of material present in secondary particles formed by atmospheric reactions. These materials form over periods of hours to days as gaseous precursors in plumes and in large air masses move across the country. With the promulgation of the PM$_{2.5}$ standard aimed at fine particles, there is increasing attention concerning secondary particulate matter. Secondary formation processes can result in the formation of new particles or the addition of material to pre-existing particles. The gases most commonly associated with secondary particulate matter formation include sulfur dioxide, nitrogen oxides, ammonia, and volatile organic compounds. Most of these gaseous precursors are emitted from anthropogenic sources; however, biogenic sources also contribute some nitrogen oxides, ammonia, and volatile organic compounds.
2.3 Sources of Particulate Matter

Primary PM is emitted from a wide variety of stationary sources, mobile sources, and fugitive dust sources. Figure 2-6 displays nationwide PM$_{2.5}$ emissions contributions from various source types. Similar data for PM$_{10}$ indicate greater contributions from fugitive dust sources.

![PM2.5 Annual Emissions (by Sector)](image)

Figure 2-6. Source contributions to nationwide annual PM2.5 emissions.

This course addresses industrial sources of both fine (PM$_{2.5}$) and coarse (PM$_{10}$ and greater than PM$_{10}$) particulate matter. The control devices discussed in subsequent chapters mitigated many of the industrial source categories in the above figure. It is important to note that in the near vicinity of an industrial source, the concentrations of PM$_{2.5}$ in the air can be dominated by that source. In addition, that local source may have the potential to create a serious dust nuisance problem from particles too large to be airborne for any appreciable length of time.

2.4 Particulate Matter Regulation

**Before the Clean Air Act**

The regulation of particulate matter emissions dates back to the early stages of the industrial revolution. Even in the 1600s, people could see the relationship between particulate matter emissions and problems such as solids deposition, fabric soiling, material corrosion, and building discoloration. As technology and public awareness expanded, it became apparent that particulate matter emissions also contributed to certain types of lung disease and related illnesses. Particulate matter emissions were an
important factor in the air pollution-related fatalities that occurred in Donora, Pennsylvania in 1948 and London in 1952-53. Since that time, particulate matter emissions have been identified as causal factors in many toxicological and epidemiological studies, and there continues to be a strong public demand for particulate matter control.

Conditions such as those shown in Figure 2-7 were common in the United States until particulate matter control devices were routinely required to be installed. Since the enactment of the Clean Air Act Amendments of 1970 (the first comprehensive Federal Clean Air law), many particulate control devices have been installed, and many new types of systems have been commercialized. Over time, particulate control requirements have become increasingly stringent as additional regulations have been developed, as more and more equipment has been replaced by new sources subject to stringent new source standards, and as national standards for particles in outdoor air have been changed to reflect the latest scientific health studies.

Figure 2-7. Northeast U.S. community near a steel mill, 1967

The Clean Air Act
Most of the provisions in the Federal Clean Air Act were put into the Act in the Clean Air Amendments of 1970, 1977 and 1990. The Clean Air Act contains a number of ways to regulate particulate matter, including:

- National ambient air quality standards (NAAQS) for particulate matter.
- State Implementation Plans (SIPs), regulations developed by State and local air quality agencies and approved by EPA, that provide the emissions reductions needed to bring “nonattainment areas” (areas with monitored air quality above the NAAQS) into “attainment”.
- New source performance standards (NSPS), national emissions standards for many source categories developed by EPA.
- Permitting requirements for new major-emitting sources (usually developed by State and local air agencies with EPA oversight) which provide for “best available control technology” (BACT) and “lowest
achievable emission rate” (LAER).

- State permitting requirements for new sources.
- National emissions standards for hazardous air pollutants (NESHAP) which are required by the Clean Air Act to apply maximum achievable control technology (MACT).
- Implementation plans to protect visibility in certain federally protected scenic areas, including requirements to apply best available retrofit technology (BART) to certain older sources.
- Title V operating permits, which provide a single repository for all federally-enforceable requirements and which provide for periodic monitoring and compliance assurance monitoring.

**National Ambient Air Quality Standards**

Over time, the NAAQS for particulate matter have reflected the growing evidence of health problems caused by particles of smaller sizes. The first standards, published in 1971, were for total suspended particulate matter (TSP). Due to increasing concerns about the possible health and welfare effects of ambient particulate matter, regulatory agencies in the late 1960s began to measure the ambient concentrations of TSP using High-Volume (Hi-Vol) ambient samplers that provided a single concentration value for a 24-hour sampling period. Particulate matter that was sufficiently small to remain suspended in the atmosphere and captured in the sampling systems of the Hi-Vol samplers was defined as TSP. TSP included particles smaller than approximately 35-45 micrometers—approximately the diameter of a human hair.

In 1987, the USEPA revised the NAAQS for particulate matter to include only particles equal to or smaller than 10 micrometers (µm). This change was made to focus regulatory attention on those particles that are sufficiently small to penetrate into the respiratory system and, therefore, contribute to adverse health effects. Particles larger than 10 µm are effectively filtered out by the nose and upper respiratory tract. Therefore, only particles equal to or smaller than 10 µm were measured in evaluating ambient air quality levels with respect to the particulate matter NAAQS. This size particulate matter is collectively designated PM$_{10}$ to differentiate it from TSP.

In 1997, the USEPA added a new NAAQS applicable to PM$_{2.5}$, that is, particulate matter equal to or less than 2.5 µm. The USEPA concluded that the PM$_{2.5}$ NAAQS was needed in response to health effects research indicating that particulate matter in this size category was most closely associated with adverse health effects. Many areas of the country showed measured exceedences of the 15 µg/m$^3$ annual standard, but only a few areas exceeded the 24-hour standard of 65 µg/m$^3$. Small size increases the probability that the particles will penetrate deeply into the respiratory tract and be retained. In 2006, the USEPA completed a review of the 1997 standards and reduced the 24-hour standard from 65 µg/m$^3$ to 35 mg/m$^3$. 
The NAAQS for PM\(_{10}\) and PM\(_{2.5}\) are given in Table 2-1. The TSP NAAQS was retired in 1987 when the PM\(_{10}\) standard was first adopted. Table 2-1 reflects the 2006 revision of the 24-hour standard.

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Health-based Standard</th>
<th>Type of Average</th>
<th>Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM(_{10})</td>
<td></td>
<td>Annual</td>
<td>50 µg/m(^3)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Arithmetic Mean</td>
<td></td>
</tr>
<tr>
<td>PM(_{2.5})</td>
<td></td>
<td>Annual</td>
<td>15 µg/m(^3)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Arithmetic Mean</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>24-hour(^a)</td>
<td>150 µg/m(^3)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>24-hour(^c)</td>
<td>35 µg/m(^3)</td>
</tr>
</tbody>
</table>

\(^a\) not to be exceeded more than once per year on average over a three year period

\(^b\) three-year average of the annual average

\(^c\) determined from the 98\(^{th}\) percentile, averaged over three years

As noted above, different particle formation mechanisms lead to different particle sizes. Distinct tri-modal ambient particle size distributions are generally observed in research studies. As indicated in Figure 2-8, there are ultrafine particles smaller than 0.1 micrometer (nuclei mode), fine particles approximately 0.1 to 2.5 micrometers (accumulated and nuclei modes), and coarse particles larger than 2.5 micrometers.

The particles in the ultrafine and fine distributions are formed mainly by chemical reactions between gases in the atmosphere. The particles in the coarse distribution are formed primarily by physical grinding (attrition) and by combustion burnout of ash particles.

Current particulate matter NAAQS standards do not have any special treatment of ultrafine particles.
State Implementation Plans

Control strategies for the achievement of the original TSP NAAQS were developed and adopted as part of the State Implementation Plans (SIPs) required by the Clean Air Act Amendments of 1970. These control strategies were designed by each state and local regulatory agency having areas above the NAAQS limits. Particulate matter emission regulations were adopted by the states and local agencies to implement the SIP control strategies, and approved by EPA.

These 1970s particulate matter emission limitations took many regulatory forms, many of which are still in effect today. Regulations included: (1) fuel burning regulations with allowable lb/MMBTU limits that became more stringent with increased boiler capacity (2) process-weight-based particulate matter equations for which an allowable emissions rate is calculated for a given process operating rate, and (3) opacity limitations.

Opacity is a measure of the extent to which the particulate matter emissions reduce the ambient light passing through the plume, as indicated in Figure 2-9. Opacity is a convenient indirect indicator of particulate matter emissions and can be determined by a trained visible emissions observer without the need for special instruments. Opacity can also be determined by continuous monitors. Generally, opacity is a separately enforceable emission characteristic. As PM limits become more stringent, EPA and States have greater concerns with reliance on opacity as a surrogate and have expressed a greater preference for methods that produce continuous measurement of PM stack concentrations.

In addition to regulations applying to particulate matter emitted from stacks and vents, the regulations included in the SIPs apply to fugitive particulate matter emissions. As illustrated in Figure 2-10, fugitive emission sources include sources where a portion of the particulate matter generated escapes collection hoods and is emitted directly to the atmosphere. Fugitive emissions also include unpaved roads, storage piles, dust from unpaved construction sites, and other similar dust sources that cannot be captured by hoods and controlled by air pollution control systems.
Fugitive emission regulations have been adopted to control process related fugitive emissions. Due to the diversity of these sources and the difficulty in measuring fugitive emissions, regulations have taken many forms. Regulations include but are not limited to (1) required work practices, (2) visible emission (opacity) limits at plant boundary lines, and (3) visible emission limits at the process source.

During the late 1980s after the PM$_{10}$ standards were published, EPA adopted a PM$_{10}$ policy dividing all areas of the country into three categories based upon their probability of violating the standards. The Clean Air Act amendments of 1990 set into motion substantially modified provisions, including the formal “designation” of nonattainment areas. The 1990 amendments also included certain minimum requirements for the content of PM$_{10}$ SIPs. It also required EPA to develop technology documents. This included guidance documents for reasonable available control measures (RACM) and best available control measures (BACM) for urban fugitive dust, residential wood combustion and prescribed silvicultural and agricultural burning. Many of the areas of the United States which violated the 1987 PM$_{10}$ standards were in the Western United States, with some areas in the industrialized Eastern United States. Because PM$_{10}$ includes both coarse and fine particles, the overall mass of PM$_{10}$ is usually dominated by coarse particles. Accordingly, the PM$_{10}$ SIPs gave considerable attention to coarse particle fugitive dust measures in most areas. Other areas of attention included woodstoves for certain areas of the West, particularly areas in mountain valleys. For a few areas, such as the San Joaquin Valley and Los Angeles, secondarily-formed particles from gases were important contributors.

In contrast to PM$_{10}$, many of the areas exceeding the 1997 PM$_{2.5}$ standards are in the Eastern United States. For PM$_{2.5}$, which includes only fine particles, both primary and secondarily formed particles from gaseous precursors are important as shown in Figure 2-11. Primary PM$_{2.5}$ consists of elemental carbon (soot) and organic matter (often referred to as “organic carbon”) emitted from cars, trucks, industrial sources, forest fires, and burning waste—and crustal material from unpaved roads, stone crushing, construction sites, and metallurgical operations such as steel mills and foundries.
Fugitive dust sources, which primarily emit coarse particles, tend to be much less important for PM$_{2.5}$ than for PM$_{10}$. Secondary PM$_{2.5}$ includes: (1) sulfates formed from sulfur dioxide emissions from power plants and industrial facilities (2) nitrates formed from nitrogen oxide emissions from cars, trucks, power plants, and other combustion sources, and (3) organic carbon formed from reactive organic gas emissions from cars, trucks, industrial facilities, solvent usage, forest fires, and biogenic sources such as trees. The due date for SIPs addressing PM$_{2.5}$ nonattainment areas (under the 1997 standards) is April 2008. For stationary sources, the SIPs will need to address Clean Air Act requirements for RACT and RACM for sources located within nonattainment areas.

![Automobiles, Power Generation, and Other Sources Contribute to Fine Particle Levels](http://www.epa.gov/airtrends/aqtrnd04/pm.html)

Likely, PM$_{2.5}$ SIPs will need to focus on a mix of regional and local strategies and control measures. In the troposphere, coarse and fine particles behave in different ways. Large coarse particles may settle out from the air more rapidly than fine particles and usually will be found relatively close to their emission sources. Fine particles, however, can be transported long distances by wind and weather and can be found in the air thousands of miles from where they were formed. Figure 2-12 provides estimates of regional versus local contributions for a number of U.S. cities.
EPA’s 2006 revisions to the PM$_{2.5}$ standards maintained the previous annual average standard of 15 µg/m$^3$, but lowered the 24-hour standard from 65 µg/m$^3$ to 35 µg/m$^3$. Very few areas violated the 65 ug/m$^3$ standard, but a number of areas show monitored violations of the lower standard. Many of the new areas added as a result of the new standard are in the Western United States. The SIPs addressing geographic areas violating the revised standards, but which did not violate the previous standards, will be due in approximately 2013.

**New Source Performance Standards and New Source Permitting**

The Clean Air Act Amendments of 1970 required EPA to develop emission limitations that would apply to new sources on a nationwide basis. These new source-oriented standards were titled New Source Performance Standards (NSPS). These standards, adopted by the USEPA for many source categories, are based on air pollution control systems that represent the best demonstrated technology for a particular type of industrial source category. For particulate matter, NSPS will include mass emission standards (variously expressed as lb PM per ton of process rate, grains/dry standard cubic foot stack concentration, or pounds per million BTU for combustion sources), and often will also include opacity limits and continuous opacity monitoring requirements. The NSPS emissions limits appear in the Code of Federal Regulations in 40 CFR part 60. Examples of regulated source categories are listed in Table 2-2.
Table 2-2. Examples of NSPS with PM limits

<table>
<thead>
<tr>
<th>Source Category</th>
<th>Which subpart of part 60?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industrial-Commercial-Institutional Steam Generating Units</td>
<td>Db</td>
</tr>
<tr>
<td>Small Industrial-Commercial-Institutional Steam Generating Unit</td>
<td>De</td>
</tr>
<tr>
<td>Large Municipal Waste Combustors</td>
<td>Eb</td>
</tr>
<tr>
<td>Hospital/Medical/Infectious Waste Incinerators</td>
<td>Ec</td>
</tr>
<tr>
<td>Portland Cement Plants</td>
<td>F</td>
</tr>
<tr>
<td>Hot Mix Asphalt Facilities</td>
<td>I</td>
</tr>
<tr>
<td>Petroleum Refineries</td>
<td>J</td>
</tr>
<tr>
<td>Secondary Brass and Bronze Production Plants</td>
<td>M</td>
</tr>
<tr>
<td>Secondary Emissions From Basic Oxygen Process Steelmaking</td>
<td>Na</td>
</tr>
<tr>
<td>Sewage Treatment Plants</td>
<td>O</td>
</tr>
<tr>
<td>Kraft Pulp Mills</td>
<td>BB</td>
</tr>
<tr>
<td>Glass Manufacturing Plants</td>
<td>CC</td>
</tr>
<tr>
<td>Grain Elevators</td>
<td>DD</td>
</tr>
<tr>
<td>Lime Manufacturing Plants</td>
<td>HH</td>
</tr>
<tr>
<td>Asphalt Processing and Asphalt Roofing Manufacture</td>
<td>UU</td>
</tr>
<tr>
<td>New Residential Wood Heaters</td>
<td>AAA</td>
</tr>
</tbody>
</table>

The Clean Air Act Amendments of 1977 included provisions for case-by-case permit reviews for sources in attainment areas, referred to as the “Prevention of Significant Deterioration (PSD) program, and in nonattainment areas, referred to as the “Nonattainment New Source Review (NSR)” program. For both PSD and nonattainment NSR programs, proposed new sources must exceed major source thresholds for the programs to apply. PSD and NSR permits are almost always issued by State and local air quality agencies, and require stringent technology levels to be approved—PSD permits must meet “best available control technology” (BACT) while nonattainment NSR permits must meet a somewhat more stringent level called the “lowest achievable emission rate” (LAER). Because PSD and NSR permits are a case-by-case review based upon up-to-date technology information, the resulting emissions limits tend to be more stringent than NSPS standards.

Proposed new emitting equipment that would emit less than major sources levels may require a minor source permit from State and local agencies. The permit will ensure that applicable State and federal regulations would be met.
National Emissions Standard for Hazardous Air Pollutants
The Clean Air Act of 1970 authorized EPA to issue regulations for air pollutants that are considered highly toxic or hazardous. This set of regulations is titled National Emission Standards for Hazardous Air Pollutants Sources (NESHAP). The Clean Air Act Amendments of 1990 required a major revision and expansion of these regulations. The 1990 Amendments specified 189 specific pollutants as “hazardous.” This list includes many compounds and elements such as heavy metals that are generally in particulate matter form. Title III provisions of the CAAA of 1990 require that EPA develop a list of source categories emitting HAPs, and develop an emissions standard for each category. Notably, NESHAP standards affect both new and existing sources, in contrast to NSPS/BACT/LAER limits which affect only new sources. Major-emitting HAP sources subject to the regulation are required to install Maximum Achievable Control Technology (MACT) for that source category. For existing sources, MACT standards must be as stringent as a “floor” defined by the best performing 12 percent of the category. Especially for the existing source population, MACT standards may be a driver for further control of particulate matter. While the MACT regulations are not directed at the control of particulate matter per se, they will require the high efficiency control of the hazardous air pollutants that are may be a constituent of the particulate matter. A number of NESHAP standards use PM as a surrogate emissions limit rather than emissions limits for individual HAPs.

Visibility
One of the most obvious effects of particulate pollution is a visibility impairment, which occurs when fine particles scatter and absorb light, creating a haze that limits the distance and clarity of what we can see. The Clean Air Act contains provisions providing for protection of visibility in a number of scenic areas collectively referred to as “Class I areas.” In 1999, EPA published a regulation requiring States to submit implementation plans that provide for “reasonable progress” towards the Act’s goal of natural background conditions. Another requirement of the regional haze rule is that older (i.e., too old to be covered by PSD or nonattainment NSR), major-emitting sources in 26 source categories meet a requirement to install best available retrofit technology (BART). Implementation plans are required by the end of 2007, and periodic implementation plans are due every 10 years thereafter.

Title V Operating Permits
Title V of the Clean Air Act requires all major sources and some other types of sources to obtain operating permits. Approximately 16,000 Title V permits have been issued by state permitting agencies, and several hundred by EPA to facilities on tribal lands. A Title V permit includes every “federally-enforceable” air pollution requirement that applies to a particular facility. A federally-enforceable requirement stems from the Clean Air Act and includes all federal and state air quality regulations that apply to a facility. After a Title V permit is issued for a facility, a member of the public who wants to know which air pollution requirements apply to that facility can simply request to see the facility’s Title V permit or obtain it online.

Every year, a representative from each facility with a Title V permit must sign a
statement certifying whether the facility is in compliance with its permit. For example, if the permit requires continuous monitoring and a company failed to perform monitoring for several days, this failure would show up on this compliance certification. The compliance statement is based on records, monitoring and other information that indicates whether the company has complied with its permit requirements. There are stiff fines—or even criminal charges—for a false statement.

Title V permits are required to add monitoring where the underlying requirement 1) requires no monitoring, 2) requires only a start-up test, or 3) does not specify a monitoring frequency. This is called "periodic monitoring," and it applies to control devices and uncontrolled units with air pollution control requirements. Periodic monitoring is created case-by-case, taking into account factors such as the margin of compliance, emissions variability and frequency of operation. For example, for an uncontrolled glass furnace with a 20% opacity standard and a 0.04 gr/scf PM emission limit, a state might determine that periodic monitoring is a weekly visible emission reading for the opacity standard and an annual stack test for the emission limit.

Title V permits must be renewed and updated every 5 years to incorporate any new requirements. As of 2007, almost all Title V permits have been issued, and several thousand have been renewed. Upon the first renewal, many Title V permits must include the compliance assurance monitoring (CAM) requirements. CAM requirements are found in 40 CFR part 64, and CAM applies only to relatively large units at major sources that have underlying federal or state requirements. For example, a large boiler subject to a NSPS and using a baghouse or Electrostatic Precipitator could be subject to CAM. CAM does not apply to facilities subject to MACT requirements because monitoring for MACT standards is presumed to meet CAM. CAM monitoring is proposed by the facility in its permit application and if approved by the state, incorporated into the Title V permit. CAM is determined case-by-case and relies on monitoring of representative parameters of a control device, such as pressure drop and liquid flow for a scrubber, or temperature for a thermal incinerator. Typically the indicator ranges for the parameters are set by testing. If parameter ranges are exceeded, this is not necessarily a violation, provided the facility takes steps to correct the problem.
Review Questions

1. EPA emissions inventory reporting systems contain separate reporting of filterable and condensable particulate.
   a. True
   b. False

2. Primarily generating large particles, __________ occurs when two surfaces rub together.
   a. fractional redistribution
   b. heterogeneous burn
   c. incompatible expatriation
   d. physical attrition

3. Particles larger than 10 μm are effectively filtered out by the nose and upper respiratory tract. These are the particles collectively designated as PM$_{10}$.
   a. True
   b. False

4. If a facility has a Title V permit, any member of the public can request and obtain a copy of the permit to check the facility’s air pollution requirements.
   a. True
   b. False

5. Within CAM requirements, parameters for indicator ranges are set by testing. Therefore if parameter ranges are exceeded, the facility is in violation and cannot renew its Title V designation.
   a. True
   b. False
Review Question Answers

1. EPA emissions inventory reporting systems contain separate reporting of filterable and condensable particulate. (page 6)
   a. True

2. Primarily generating large particles, ____________ occurs when two surfaces rub together. (pages 1 and 2)
   d. physical attrition

3. Particles larger than 10 µm are effectively filtered out by the nose and upper respiratory tract. These are the particles collectively designated as PM₁₀. (page 9)
   b. False

4. If a facility has a Title V permit, any member of the public can request and obtain a copy of the permit to check the facility’s air pollution requirements. (page 16)
   a. True

5. Within CAM requirements, parameters for indicator ranges are set by testing. Therefore if parameter ranges are exceeded, the facility is in violation and cannot renew its Title V designation. (page 17)
   b. False
References